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Transportation Management with SAP S/4HANA®

- Implement basic and advanced TM in SAP S/4HANA
- Master transportation planning, freight order management, carrier selection, and more
- Calculate and settle charges with LSPs and customers

4th edition, updated and expanded

Lauterbach · Gottlieb
Helwig · Sürie · Benz

Rheinwerk Publishing

Bernd Lauterbach, Jens Gottlieb, Meike Helwig,
Christopher Sürie, Ulrich Benz

Transportation Management with SAP S/4HANA®

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Dear Reader,

Transportation is transforming.

Per global shipper Pitney Bowes, more than 159 billion parcel shipments took place around the world in 2021 as the global supply chain experienced unprecedented demand and disruption. To keep up with such traffic, the way we transport goods is changing. For example, you've likely heard about next-gen technologies in the shipping industry—delivery by drone, autonomous trucks and vessels, the use of robotics in shipyards and warehouses, and so on. An ever-growing amount of labor, money, and innovation goes into delivering a package from point A to point B.

Organizations that transport goods rely on cutting-edge software to manage their supply chain. SAP S/4HANA offers a comprehensive transportation management (TM) solution that's always evolving to meet increasingly complex requirements. Consignment orders, event management, business networks, geographical information systems, last-mile delivery, advanced shipping and receiving, and more—the list of new and improved functionalities is growing.

And so is this book. Now in its fourth edition, this guide is updated for the latest and greatest TM capabilities thanks to the combined knowledge of supply chain experts Bernd Lauterbach, Jens Gottlieb, Meike Helwig, Christopher Sürie, and Ulrich Benz. In these pages, you'll find the information you need to keep your organization up to speed with the pace of global transportation.

What did you think about *Transportation Management with SAP S/4HANA*? Your comments and suggestions are the most useful tools to help us make our books the best they can be. Please feel free to contact me and share any praise or criticism you may have.

Thank you for purchasing a book from SAP PRESS!

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Preface

Transportation of goods is one of mankind's oldest businesses when trading. Today, transportation is an integral part of each supply chain, that is, its business processes, which is challenged by the ongoing necessity of digital transformation of businesses.

Historically, transportation started with the necessity of individuals to live and trade on more than just locally available, daily goods. People began to reach out to a wider range of merchandise, which they could consume themselves, use as a status symbol for their urbanity, or simply push to earn higher profits in trading the goods.

The regional, countrywide, or worldwide wishes and demand of people for goods also fueled production adjustments, as decisions on where, how, and what to produce were no longer based on local resources alone but could be made on a foundation of production, labor cost, and legal requirements. This again resulted in higher requirements to distribute raw materials, semifinished goods, and finished goods.

From the early beginnings of trading, it took a long time before "logistics" and "supply chain" became hot topic terms in arranging the form of production, storage, trading, transportation, customer centricity, and adaptability we see today. Logistics emerged in the early 1800s with a major focus on war supplies. A huge push forward started from the middle of the 1900s with process improvements, such as mass production and material requirements planning, as well as first technological achievements, such as bar coding of goods. Subsequently, legal regulations and councils enforced the definition and adherence to processes, standards, and performance goals, which affected a huge part of transportation activities in logistics.

Increasing globalization made it apparent to companies that required or were involved in transportation that related processes can't be managed without the support of software tools for handling the following, closely correlated aspects:

- Cost-effective and service level–compliant organization of all movements of goods that are necessary to fulfill demand within the supply chain
- Availability of affordable transportation capacity for all required movements of goods
- Proper communication with partners and peers in the logistics network
- Subcontracting of transportation requirements and settlement of all related payments
- Legal compliance of all transportation-related movements of goods
- Transparency to the customers of a business on related logistics processes
- Ability to adapt utilized transportation networks and processes efficiently to the scope demanded by the business and data handling in line with required processes

The software and methodology we describe in this book should give you the tools to master the art of transportation logistic as well as understand how to innovate your logistics organization to make use of a state-of-the-art digital platform called SAP S/4HANA.

Companies that offer and execute logistics and transportation as a third-party service for others (logistics service providers [LSPs]) have an even more widespread set of qualifications to fulfill in addition to those listed before:

- Evaluate, price, and handle requests of other parties to move their cargo in an end-to-end process or as part of the logistics chain.
- Properly bill other parties and companies for delivered logistics and transportation services.
- Operate their own company in a profitable way, so that selling, buying, and executing logistics services yields a profit that allows market expansion.

Our book is about SAP Transportation Management (SAP TM) in SAP S/4HANA (we'll refer to it as the *transportation management [TM]* functionality in this book). The described processes and software are in many ways embedded into an overarching operation of a supply chain, meaning that transportation usually can't be seen as an isolated topic. Due to the intensive interaction with the preceding and subsequent logistics and financial processes, a proper integration is of utmost importance. This is where the best-of-breed approach of many standalone transportation systems fails and where the integrated platform approach of an SAP S/4HANA system results in a major difference and leads to a multitude of benefits.

The process integration aspect, in conjunction with the power and capabilities of TM, is an important part of the end-to-end business of an enterprise or company that has to move goods in order to trade, to ship, or to receive, whether it's running a manufacturing or mining business, trading or retailing company, or a professional LSP. The scope of TM can be used advantageously in any of the supported industries.

For all processes related to the supply chain, collaboration and tight coordination is required for in-house, intercompany, and customer-focused operations and processes. Today's companies need to be extremely flexible, as the speed of change in product development, logistics, and technology opportunities is increasing more than ever before. On top of that, the long-standing "business as usual" is often interrupted by mergers and acquisitions, which brings completely new strategies to procured companies and the burden of efficient business and logistics integration to the buying enterprise.

A relatively new development in logistics and transportation is the massive digital transformation of businesses and their information systems. Sensors, Internet of Things (IoT), and machine learning have long been topics of research and are now quickly evolving to daily utilization and swarming over the entire logistics area. Enterprise software for logistics must deal with this effect. SAP S/4HANA as a digital logistics platform is a well-suited enabler for the transition into the digital age.

The SAP components that can solve this puzzle are centered around TM, which is the focus of this book. Its environment is provided based on an integrated platform, which can be classified in three layers, contributing to its overall functionality:

- Logistics core solutions and the supply chain execution (SCE) platform include the following:
  - SAP TM
  - SAP Extended Warehouse Management (SAP EWM)
  - SAP Yard Logistics
  - SAP Event Management
  - SAP Business Network Global Track and Trace
- SAP complementing logistics solutions enable flexible and specialized processes around the logistics core, for example, SAP Global Trade Services (SAP GTS) or product safety and stewardship (PS&S). Although some of these solutions will be highlighted or mentioned within this book in terms of their integration with TM, a deeper functional description can be found in other SAP PRESS books.
- The SAP enterprise solutions, such as SAP S/4HANA Finance, SAP SuccessFactors for human resource management, or SAP Ariba for procurement, form a foundation to run the backbone of an enterprise. Where required, we'll refer to this foundation.

TM is the central enterprise software element of efficient transportation logistics. Its modern architecture provides the ideal platform for future-proof operation. TM is a comprehensive system offering a powerful set of options and functionality to adapt the software to all kinds of relevant logistics requirements. Since September 2017, TM has been an integral part of SAP S/4HANA.

How This Book Is Organized

This book is the fourth edition of a universal work on transportation management in SAP, and it's based on the functionality and integration capabilities of SAP S/4HANA 2022 as released in October 2022.

Transportation Management Release Coverage

This book will describe SAP S/4HANA as its base system; therefore, we'll refer to *transportation management* in SAP S/4HANA throughout (subsequently, just *TM*). The previously marketed, SAP Business Suite–based SAP TM 9.6 standalone software will not be referred to any more in this edition, as there is no change in scope compared to the third edition of our book. Furthermore, due to the digital transformation requirements, there are very few customers who are still actively starting a project based on the SAP TM 9.6 release.

This book first provides the necessary background information on transportation and logistics in general and subsequently introduces SAP S/4HANA as the system foundation. In the main part of the book, we take a deep dive into TM and the functionality of its ecosystem. The final chapters of the book deal with migration opportunities and best practices to be mindful of.

The goal of this book is to provide a big picture on TM and its components, including how they work and integrate, as well as how transportation business requirements map to available software functionality. However, it should not replace online resources such as the SAP Help Portal, but rather give you a better understanding of how the different aspects of TM can be connected to a sensible overall view. The following chapters are presented:

- **Introduction**
  The introduction will give you an overview of typical transportation processes, contributing roles to this business, and common methods of organizing varied business demands.
- **Chapter 1: Transportation Management Foundation**
  The first chapter gives you an overview of the basics of business software, the new SAP S/4HANA architecture, including SAP Business Technology Platform (SAP BTP), how the TM functionality is structured, and how TM can be used in various ways. In addition, you get an overview of the SAP components that enhance the functional scope beyond pure transportation processes.
- **Chapter 2: Solution Architecture and Technological Concepts**
  The second chapter gives you an overview of the technical architecture of TM and how it integrates into business processes. We explain business object foundations provided by the Business Object Processing Framework (BOPF) and how it provides business object modeling. Furthermore, we describe the important tools of TM, which are referenced in various subsequent chapters. These tools include Business Rules Framework plus (BRFplus, the SAP rules engine), Post Processing Framework (PPF; printing/message output), and user interface technologies (e.g., Floorplan Manager [FPM] and SAP Fiori) as a central means to provide interaction and workflow capabilities. The third section describes technical integration by services and change handling within TM (Process Controller Framework).
- **Chapter 3: Master Data**
  This chapter explains the general master data of SAP S/4HANA as related to TM (e.g., business partners) and transportation-specific master data, such as networks and resources. It also gives an overview of remodeled master data usage of SAP S/4HANA, which replaces the previously used transmission-based technology of SAP Business Suite and TM.
- **Chapter 4: Transportation Requirements and Order Management**
  The requirements chapter illustrates how to create and manage transportation demand in TM. For shipper scenarios, it focuses on the direct integration between

SAP S/4HANA order/procurement processes and transportation. In forwarder/carrier scenarios, we'll describe the capabilities of the customer order objects and quotations, as well as the provision of their functionality for customer service and sales.

- **Chapter 5: Transportation Planning**
  Transportation planning deals with the activities involved in the assignment of cargo items to vehicles or reserved capacities on trucks, trains, planes, or vessels. This chapter describes freight units as the basis for planning, package units and consignment orders as groupage elements, and transportation units for modeling truck, trailer, container, or railcar scenarios. You'll get an overview of the interactive and optimized planning capabilities of TM with an explanation of how to configure and use the transportation cockpit, the optimizer, Gantt charts, load planning, transportation proposals, package building, and planning-related configuration profiles.
- **Chapter 6: Freight Order Management and Subcontracting**
  This chapter explains freight orders and freight bookings, including their use as subcontracting documents to carriers or other service providers. Management of freight capacities and schedules is an important aspect of moving cargo. Capacity management describes how to make use of allocations, how allocations interplay with schedules, and how to create business shares.

  Relevant carriers are determined through carrier selection. Subsequently, a tendering process can be executed to determine the best available price, conditions, and availability of the selected carriers. Carrier selection is a part of the optimization process that allows you to propose and select one or multiple carriers for subcontracting.
- **Chapter 7: Transportation Execution and Monitoring**
  Execution and monitoring deals with handling freight and providing visibility of shipments. In this chapter, we explain the different options for managing and surveying the cargo execution processes (i.e., freight document functions, discrepancy handling in TM, loading status, and paperwork). In addition, we describe aspects of export and import handling in international supply chains and the corresponding setup in TM. This chapter highlights the tracking features of SAP Event Management as well as SAP Business Network Global Track and Trace, which allows you to add cloud and collaboration aspects to track and trace.
- **Chapter 8: Transportation Compliance**
  This chapter deals with compliance issues arising from trade regulations and hazardous cargo. It explains the integration and functionality of SAP Global Trade Services (SAP GTS), which supports various functions from blacklist screening to export and import compliance handling. Furthermore, the integration with external customs, security, and booking services, such as Descartes Global Logistics Network (Descartes GLN), is described. Various tasks involved in handling, checking, and documenting hazardous cargo are done using an SAP S/4HANA functionality called product safety and stewardship (PS&S). Like SAP GTS, SAP S/4HANA PS&S is integrated with the TM processes.

- **Chapter 9: Transportation Charge Management**
  The chapter highlights the general aspects of cost and price calculation within TM and provides details on how to use it for shipper processes, including setting up agreements (contracts) and defining tariffs and rates. Calculation of charges within forwarding and freight orders is described in detail as well as charge calculation master data with service products, forwarding and freight agreements (contracts), calculation sheets, rate tables, scales, maintenance functions, upload and download, and contract determination.

  Creation of contracts with vendors is often a lengthy and distributed process, especially with strategic business partnerships. In this chapter, we also describe the tools provided by TM to manage vendor request for quotations (RFQs) and to evaluate vendor responses. The tools are the core of strategic freight procurement and allow efficient implementation of new contracts and the extension of existing contracts.
- **Chapter 10: Charge Settlement**
  This chapter deals with the payables process that shippers face with their subcontractors. After the charges of a subcontracted freight order are calculated, the individual characteristics of forwarding and freight orders are provided and generate a list of charge items to be paid in the charge settlement process. We also cover the main aspects of invoice verification and payment in SAP S/4HANA as well as mass invoice verification.
- **Chapter 11: Charge Calculation and Settlement for Logistics Service Providers**
  In Chapter 9 and Chapter 10, we explain the foundation and processes around charge calculation and freight settlement, giving you a view on general capabilities and the usage by shippers, as customers of LSPs and carriers. In this chapter, we'll look at the specifics of charge calculation from the view of an LSP, which sells transportation services and needs to deal with customer revenue calculation, customer billing, cost distribution, and profitability. We also build a link to the global service product catalog because the service product is used as a core element of agreements. Finally, we describe strategic customer contract management, which allows LSPs to negotiate new contracts and renegotiate contracts with their customers.

  Additional covered topics are mass rebate calculations and customer RFQ processes for contracts.
- **Chapter 12: Integration with Other Components**
  This chapter describes the integration between TM and analytics applications of SAP S/4HANA, as well as SAP EWM for traditional and transit warehouse management. In the transportation domain, additional components support the TM processes in terms of equipment management and planning (SAP Transportation Resource Planning), yard management (SAP Yard Logistics), vendor portals (SAP Business Network for Logistics), and last-mile distribution (SAP Direct Distribution).
- **Chapter 13: Migrating to and Running TM in SAP S/4HANA**
  The move from an SAP Business Suite–based SAP TM to an SAP S/4HANA-based system is supported by migration tools and practical steps, which are explained and

highlighted in this migration chapter. To master the TM production system, we give you practical hints on how to manage performance, data volumes, and monitoring.

- **Chapter 14: Implementation Best Practices**
  This chapter highlights specific topics to keep in mind when you implement a TM process at a customer site. It gives you guidance on important entities in Customizing as well as a sensible configuration sequence.
- **Chapter 15: Summary and Outlook**
  This chapter concludes the coverage of TM by providing a synopsis of the challenges the industry faces and the future direction of TM.

Target Audience

SAP provides in-depth system documentation, solution manager content, release notes, and installation guides at a very granular level. These documents are publicly available and include scenario descriptions and detailed explanations on how to deploy and configure TM. In this book, we avoid repeating this information as much as possible in favor of explaining how features interrelate and the purpose and effect of settings and process steps.

Therefore, the intention of this book isn't to document all necessary configuration steps of TM. Instead, the book mainly focuses on making process and configuration options transparent and acting as a tool to better understand the essential functionality and issues involved. We have written it for the following audiences:

- Everyone looking for a comprehensive introduction to transportation management with TM will find that each chapter describes in detail specific functional areas or business processes and provides an overview of the underlying functionality and its use. We address SAP beginners and employees in departments where TM is to be implemented, as well as students getting an understanding of core processes in transportation management and how they map to SAP software.
- SAP logistics consultants and other ambitious users will get a deeper understanding of transportation management processes, including their integration, configuration, dependencies, upstream and downstream functions, and mapping in TM.
- Enterprise management members and IT decision-makers who are considering the implementation of TM will obtain an overview of its functional richness and building blocks.

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Sincerely,
Dr. Bernd Lauterbach, **Dr. Jens Gottlieb**, **Meike Helwig**, **Dr. Christopher Sürie**, and **Ulrich Benz**

Introduction

Efficiency, reliability, cost, and speed in cargo transportation are the most important factors to move any kind of goods between sources, suppliers, manufacturers, traders, and final customers. As an introduction to the vast topic, we provide an overview of typical transportation activities and processes as well as the needs of the participating parties.

Transportation as a general term is defined as moving cargo or people from one place to another. This general definition doesn't really unfold the complexity and importance of the processes and the networks behind the scenes. Transportation today is a highly significant factor in logistics, as it's related to a large amount of logistics cost and is a major contributor to the reliable delivery of any kind of cargo.

The *transportation management* (TM) component of SAP S/4HANA systems doesn't consider passenger transportation. Therefore, we won't elaborate on managing the movement of people but concentrate on the needs and aspects of cargo transportation, as this corresponds to the solution scope of TM. The movement of people has its own complexity and challenges, such as missed schedules, crowded subways, and overbooked flights or trains, as well as highly dynamic pricing. TM, as we describe it in this book, deals with the movement of goods, that is, cargo transportation, and the services required to facilitate it. However, especially in current times, cargo transportation is facing a high volume of disruption, availability, scheduling, price, and capacity challenges due to pandemic and war situations, which put a higher emphasis on proper planning tools such as TM. Nevertheless, you should be aware that even the best planning tools can't provide a 100% solution to all logistical challenges.

In general, transportation can be considered the backbone of the global supply chain. Essentially, no daily process works well without the use of transportation services connecting the partners in a supply chain. Whether it's procuring a supply of raw materials, manufacturing goods from procured components, shipping goods from an online store, restocking groceries in our favorite supermarket, getting fuel for our cars, or buying toys for Christmas gifts via online shops, if transportation doesn't work in the background, supplies will falter.

In our daily life, transportation is part of a process that we often only realize marginally, such as when waiting in a traffic jam caused by trucks or being annoyed by the noise of a passing cargo train. Transportation is a mandatory part of a complex network we're all extremely dependent on today. What we see with our own eyes is just a small part of this network, which is formed by supply chain processes in the background. To procure our daily goods, some company must ship it to us. However, someone else previously had to manufacture these goods and ship them to the store. The manufacturer won't be able to produce the goods without getting a proper supply of required components or semifinished materials from other companies, and that business of course needs some raw materials shipped from, for example, a mining enterprise. Finally—and often taken for granted—holding the goods in our hands comes from this long supply chain, and a huge percentage of intercompany and internal moves require a form of organized transportation, except those handled by internal company conveyors or pipelines.

In Figure 1, you can see a schematic example of the transportation processes and contributors in a supply chain. A vendor or supplier delivers materials or goods to a manufacturer or distributor, which then transports the goods to a production plant. The manufacturer/distributor transforms the materials or goods into finished products, which then are transported to the final receiver. However, each company may also have a need for internal logistics, which again can involve transportation. External transportation logistics can be done directly or via transfer facilities, which would include international movements. With many supply chain players in a row or network, it becomes clearer that a lot is at stake if the processes aren't properly managed. The chain below with three contributors is just a simple example, as there may be more contributors in a row if processes are more complex.

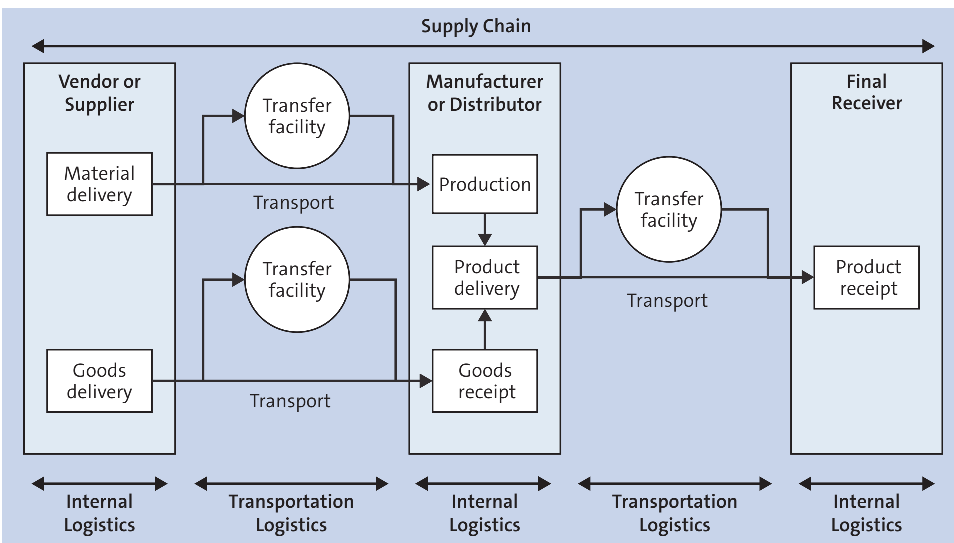


Figure 1 Contributors to Supply Chain, Logistics, and Transportation

Figure 1 also shows the three interrelated terms that will be used throughout this book:

- **Supply chain**
  Defines the entire value chain of all goods-related activities from the first vendor or supplier over a sequence of manufacturers or distributors to the final receiver.
- **Logistics**
  Defines the operations process of procuring, receiving, storing, internally moving for manufacturing, transforming, trading, and shipping of goods from the viewpoint of a supply chain participant.
- **Transportation**
  Defines the movement of materials or goods between participants of the supply chain. However, transportation can also happen as part of the logistics functionality within a company (internal logistics) and is often heavily related to the shipping and receiving processes (e.g., a large chemical plant needs internal transfers of materials from an unloading dock to a production storage facility).

Transportation as Part of Industry Processes

Transportation and its management in a company are highly dependent on influencing factors coming from the industry ecosystem and from integrated business activities in the company itself or in collaborating companies. Transportation management supports the organization of cargo transfers between or within the domain of business partners. It can be viewed in two general dimensions:

- **Transportation connection type**
  The transportation connection type can be either of the following:
  - Domestic (inland): Cargo is moved within a country or trade zone and doesn't cross its border. Cargo moves aren't relevant for any trade compliance processes (export and import).
  - International: Cargo is moved across borders or trade zones and may be relevant for trade compliance processes.
- **Transportation mode**
  The transportation mode defines the types of transport used for the cargo move, which can be executed with one or multiple modes of transport. Transportation modes include the following:
  - Road transportation: Transportation takes place on public or private roads. Means of transport for road modes are, for example, trucks, trailers, semitrailers, and chassis.
  - Rail transportation: Transportation takes place on public or private rail tracks. Means of transport for rail modes are trains with different kinds of railcars, such as flatbeds, hopper cars, container stack cars, and so on. In some regions (e.g., Europe), rail cargo is sometimes actually moved on the road but sold as rail.

- Ocean or sea transportation: Transportation takes place on oceangoing vessels. Means of transport are container vessels, bulk vessels, or tramp ships. Although feeder vessels service smaller ports that aren't on the main lines, they are also considered ocean transportation.
- Barge transportation: Transportation is usually done on river barges and often carried out either as domestic moves (e.g., in China on the Yangtze River) or within economic trade unions (e.g., Germany to Netherlands).
- Air transportation: Transportation occurs via aircraft, which are either pure cargo aircraft or passenger aircraft that also provide cargo capacity. The latter are controlled very strictly concerning cargo security. In some regions (e.g., Europe), air cargo is sometimes actually moved on the road for shorter trips.
- Intermodal transportation: If cargo in containers is moved across multiple modes, the term *intermodal* is used. It's usually applied to rail and ocean (e.g., a container on a road-based chassis going to a rail-based container stack car), but not air. An intermodal move is usually considered to be a main mode-related move with roads at its ends, in our example, a rail move with roads at both ends.
- Courier, express, and parcel (CEP) transportation: CEP isn't an explicit transportation mode, but it's often used as such to differentiate it from other modes of cargo transportation. CEP can be moved by road, air, or rail, but indicates that a usually small piece of cargo (parcel size) is moved between locations. The mode of movement isn't necessarily predefined; rather, the service level (e.g., 24-hour delivery) demands the use of a particular mode combination (e.g., road-air-road) as the service can't be guaranteed otherwise.

Transportation Mode: Unimodal versus Multimodal

Unimodal transportation means that cargo is moved on a single mode of transport, for example, on the road only, but it doesn't mean that only one means of transport is used. For example, three consecutive truck moves can occur with a load transfer in between, and it's still unimodal.

Multimodal means the movement of cargo involves more than one mode of transportation, for example, an initial truck move, a rail move, and a subsequent truck move. Even if the carrier decides to use a truck instead of a railcar (because it's cheaper), the move is still sold as and considered to be multimodal.

Another common term that we'll use throughout the book is *shipment*. A shipment is the movement of a defined quantity of cargo from its origin to its destination. The cargo can be transported as unimodal or multimodal, and it can potentially be split and transported independently; however, in significant locations or for substantial processes, it must be handled together. Potential handling processes for cargo in its entirety are as follows:

- Cargo is only considered shipped if all cargo left the origin site.
- Cargo is only considered received if all cargo arrived properly at the destination site.
- Cargo must be handled as a single unit when executing legal processes, such as the following:
  - Shipment documentation creation (e.g., house waybill printing, which is the legal shipping document)
  - Shipment trade declaration and checks (e.g., export and import handling)
  - Shipment compliance checks (e.g., dangerous goods check)

From an industry perspective, companies can be separated into two large groups that have a joint view of the set of general requirements they need to focus on when performing transportation management:

- **Shipping industries**
  Shipping industries or *shippers*, as used quite often throughout this book, refer to a company or a functional unit of a company that organizes the transportation of goods in the following business contexts:
  - Goods that are sold by that company or one of its subsidiaries
  - Goods that are to be distributed by that company across or beyond its partner network
  - Goods that have been purchased by that company if the buyer and the vendor have agreed that the vendor isn't responsible for organizing the transportation

  Shippers typically don't manage logistics and transportation needs as their main business; instead, their profit as a company is achieved by producing and selling or trading goods and materials. For them, transportation is a necessary medium to physically network with their partners. In a general view, shippers are sometimes called first-party logistics providers (1PLs) because they formerly tended to do their own logistics. Typical industries that you'll see as shippers in transportation management processes are as follows:
  - Consumer products companies that need to procure and receive materials and manufacture and ship finished goods (e.g., body care product companies)
  - Retail and wholesale distribution companies that receive consumer and other goods, repack the goods according to the needs of their stores, and ship them out to replenish stores (e.g., supermarket chains)
  - High-tech companies that receive raw and semifinished materials to produce technology goods to be shipped out to distributors (e.g., semiconductor or computer companies)
  - Oil and gas companies that extract fossil energy sources, transport the material to refineries (upstream), and produce finished fuels to be distributed to storage tanks or gas stations (downstream) (e.g., gasoline corporations)

  - Mining industry companies that excavate or produce minerals and ship them to raw material handling facilities (e.g., rare earth element mining companies)
  - Other industries with transportation needs (e.g., the mill products industry, automotive industry, chemical industry, aerospace and defense industry, agribusiness industry, military organizations, and fashion industry)

- **Logistics service providing industries**

  The term *logistic service provider* (LSP) encompasses all companies that provide management and execution capabilities to shippers and other LSPs. This is regarding the flow of goods and materials between origin and destination points, which may be end or intermediate points. Besides pure shipping or its organization, the LSP will often handle compliance, inventory, warehousing, packaging, and security functions for shipments. The main difference from shippers is that transportation is the main business for LSPs, instead of achieving revenue from selling goods. Therefore, an LSP needs to be profitable by selling, buying, organizing, and executing logistics services.

  LSPs can be categorized into the following different groups:

  - Carriers or second-party logistics providers (2PL): These companies directly execute transportation and logistics processes for others using their own capabilities, that is, their own fleet and storage capacities. In many cases, carriers focus on a single transportation mode (e.g., railway, container shipping line [CSL], trucking company, airline), but multimodal capabilities are a typical extension area for such companies.
  - Freight forwarders, third-party logistics providers (3PL): These companies usually don't operate their own fleet; that is, they are much less asset-focused than carriers. Their profession is more to organize end-to-end shipments for shippers, offer them the best way to execute complex moves (e.g., international, and multimodal transports), and then subcontract to carriers who are specialized to execute a specific part of a shipment.
  - Fourth-party logistics providers (4PL), fifth-party LSPs (5PL), or sixth-party LSPs (6PL): A 4PL is a logistics consultant that usually brings the behavior of a 3PL to a higher level and offers services not only to execute complex shipments but also to redesign and consult for the supply chain of a shipper, so that it best fits their business requirements. Therefore, the consultant uses a set of capabilities to optimize the logistics business of the client. A 5PL even goes further by not only relying on the created network of partners but rather being open to building the logistics optimization from the whole available portfolio of logistics service available on the market. By doing so, price advantages may be achieved.

    In some definitions, even higher levels of provided logistics are named, such as 6PL. Additional aspects such as management of ecology, sustainability, or renewability come into scope here, which go beyond the view of transportation.

– Contract LSPs: These companies focus on providing sales, storage, maintenance, and transportation-oriented services to shippers so that they can concentrate on their main business goal (e.g., manufacture products). The contract LSP operates general or customized warehouses for shippers, stores and moves their goods, and may also provide services around the sales cycle, such as ordering hotlines. If done with a certain level of integration, contract logistics can be a mixture of the operations of 3PL and 4PL, so it's sometimes called 7PL (see, e.g., *https://redstagfulfillment.com/3pl-4pl-5pl-explained*).
– CEP service providers: These companies usually concentrate on the movement of small freight items, such as packages. Their processes are organized to ship standardized freight items in large quantities through their own network of facilities (stations, sorting centers) by making use of a pattern of how to ship freight for a service (e.g., 24-hour delivery). CEP providers can be associated either with transportation or postal industries.

Looking at the various industries and modes involved in transportation, there is unfortunately also a multitude of terms around what commonly is regarded as an order for a shipment. Keeping this in mind, Table 1 provides a list of the different terms used for the same things (an order to move cargo) in different industry contexts.

Order Term	Industry Context
Transport order	General term, but used to sell and buy freight
Forwarding order	Sales order for forwarding service used in TM and the forwarding industry (3PL)
Booking	Term for an order used by ocean carriers and air carriers
Waybill	Term for an order used by American railways
Customer order	General term, but doesn't indicate transportation relation
Shipment	Term used in courier business or from a shipper view

Table 1 Different Terms for an Order to Move Cargo

The different levels of LSPs are shown in Figure 2 in an aggregated form. A 1PL (shipper) traditionally uses either a 2PL directly (carrier) to provide transportation on single moves or contracts with a 3PL to orchestrate the end-to-end transportation movement. The 3PL may then contract various 2PLs to move the cargo. The 4PL and 5PL aims to orchestrate and optimize the whole supply chain of the shipper.

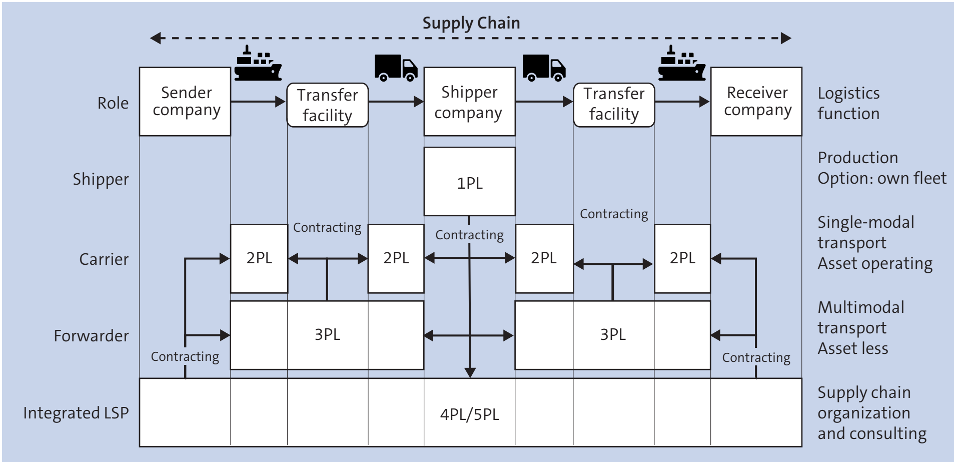


Figure 2 Level of Logistics Providers and Capabilities

Following is a set of operational requirements that all companies—shippers as well as LSPs—should follow when attempting to manage their transportation processes efficiently:

- Transportation processes should be organized in a way that minimizes transportation costs.
- Service-level agreements (SLAs) with business partners should be complied with.
- Available vendors providing transportation services need to be subcontracted in a cost-efficient and contract-conforming manner.
- All cargo needs to be moved in a legally compliant way under recognition of, for example, dangerous goods or trade compliance rules.
- If a company doing transportation manages its own fleet, the available vehicles need to be used in an optimal way, meaning a high percentage of efficiently consolidated loads should be placed on the company's own vehicles while reducing empty vehicle moves.
- When deploying its own fleet, a company also may have to attend to driver and fuel cost efficiency.

These criteria are valid for any company involved in transportation. However, if an LSP owns the process, its major business goal is to provide transportation services successfully and profitably. As you may have noticed, the preceding criteria didn't include sales-oriented goals. These come into focus when they are the business of the LSP, which needs to balance and consider the following aspects when doing business:

- Achievable price settings, market requirements, and long-term contracting commitments when selling transportation services to customers (shippers and other LSPs)

- Cost of operating and maintaining a fleet as part of the offered transportation services
- Cost of subcontracting transportation services to other vendors (typically carriers)
- Cost of subcontracting additional services (e.g., customs clearance, transshipment of cargo in port terminals) to other vendors
- Internal cost and profit sharing among organizational units of an LSP leading to a lack of transparency (e.g., a US LSP ships to Europe and orders the vessel transport, but the European LSP should pay for the vessel price to the US organization and get this money from the European recipient)

The preceding considerations are of tremendous importance for LSPs to work profitably and achieve overall growth. As the logistics market can change seasonally, issues around nonavailability of shipment space and options, overcapacity of carriers due to missing transport orders, and long-term commitments to investments and the related risks (e.g., already ordered large vessels, war risks requiring larger network changes, health situations impacting networks) are quite common, and the related price fluctuation can easily lead to bankruptcy. Therefore, a good overview is necessary of the targeted market, the company's and the network's capabilities, and the situations of competitors.

In addition to the operational requirements for all transporting companies mentioned previously, LSPs can also manage the following essential functions:

- Negotiate prices and contracts with customers and manifest these agreements in a price and contract database.
- Capture quotes and orders for transportation services based on established customer contracts and prices. The orders are the foundation for price calculation, routing of shipments, compliance checks, transportation documents, and customer invoice creation, as well as internal collaboration of organizational units.
- Validate prices derived for transportation orders against the overall cost of executing a shipment to guarantee profitable operation.

Discussing transportation modes, shippers, LSPs, and their contracting relations and requirements shows the complexity of transportation. Regarding LSPs, Figure 3 shows the categorization into their different transportation mode priorities and modes of operation. The companies considered to be freight forwarders, 3PL, and 4PL are grouped together as they typically work with fewer of their own assets but potentially move goods end to end across transportation modes. On the other hand, those operating their own fleets and concentrating on a mode are grouped as carriers or 2PL. Today, many carriers have a strategy to extend their footprint into end-to-end logistics by starting/buying a new business unit or better integrating a logistics company they are already running today by separating it from a process perspective (i.e., the rail, ocean, and air logistics companies).

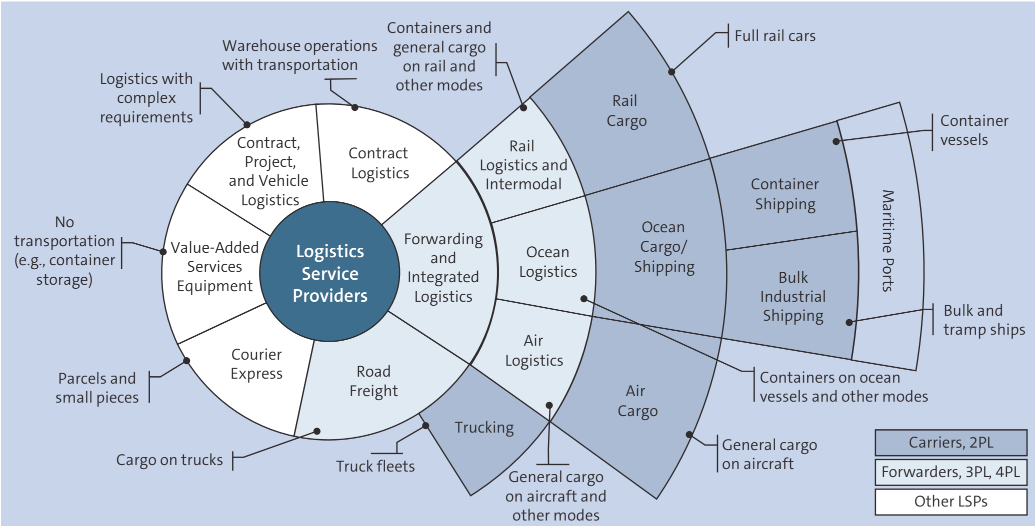


Figure 3 Categorization of LSPs

Transportation Processes, Movements, and Roles

Looking at transportation processes and their variety, steps, and participants, we can say that LSPs usually implement a superset of what shippers do. LSPs are confronted with a large diversification of ways to ship cargo and optimize according to a multitude of different goals driven by the requirements of shipper customers and by the need to operate profitably. Therefore, many of the process variances are explained based on LSP processes, which in the end are, of course, driven by the shippers.

The first variable in shipping is the type of cargo that needs to be moved. Following are the typical cargo categories:

- **General cargo (also packaged goods or break-bulk cargo)**
  Refers to individual cargo items that need to be shipped and individually handled. General cargo usually doesn't contain materials requiring special handling, such as dangerous goods, but complies to general shipping rules. Examples for general cargo are crates with televisions, pallets with cereal boxes, or cartons with screws. In some cases, general cargo items may be shipped together or broken apart into their individual items (hence, the term "break-bulk").
- **Bulk cargo**
  Refers to any kind of solid materials or goods that are shipped in a loose form. For transportation purposes, bulk cargo can be loaded into a vehicle, such as a suitable railcar or compartment vessel (bulker), or it can be prepackaged in containers. Examples for bulk cargo are grain or iron ore. Bulk cargo can easily change weight

and volume during transportation (discrepancy) as it never can be loaded or unloaded with the same quantity.

- **Fluid bulk cargo**
  Refers to cargo that is like solid bulk but requires special tank resources or containers to be transported. Some of the fluid bulk transports can also be done via pipeline, which won't be described in this book. Especially for fluid, the bulk, weight, and volume changes due to temperature or vaporization need to be considered as they directly relate to changes in value.
- **Containerized cargo or prepackaged cargo**
  Usually refers to general cargo items that are already loaded into a container or other transportation equipment when being handed over by the shipper. The container is then moved along the whole transportation chain and delivered to the final receiver in an unbroken manner.
- **Piece cargo**
  Refers to cargo made of individual pieces or packages of small size as handled by postal or express services. Piece cargo transportation is usually a mass business that may need millions of individual deliveries per day. Transportation and load transfer of piece cargo in transfer facilities happens along predefined patterns. Individual planning for each piece, as often done for general cargo, isn't common practice.
- **Out of gauge (OOG) cargo**
  Refers to any kind of large items that are shipped and don't fit into standardized sizes of containments or compartments. OOG cargo requires special handling in load transfer and shipping, and it may need special equipment and vehicles. Examples are huge chemical factory components or large mechanical diggers.

When transporting some of these cargo categories (general cargo, containerized cargo, or piece cargo), specific shipping types may be used. In Figure 4, you can see four very common shipping types:

- **Less than truckload (LTL)**
  General cargo or pieces are moved on a truck together with cargo from other shippers.
- **Full truckload (FTL)**
  A complete truck is filled with the cargo of a single shipper.
- **Less than container load (LCL)**
  General cargo or pieces are moved in a container together with cargo from other shippers. This shipping type is usually related to ocean shipments and sometimes to rail shipments.
- **Full container load (FCL)**
  A complete container is filled with the cargo of a single shipper. This shipping type is usually related to ocean shipments.

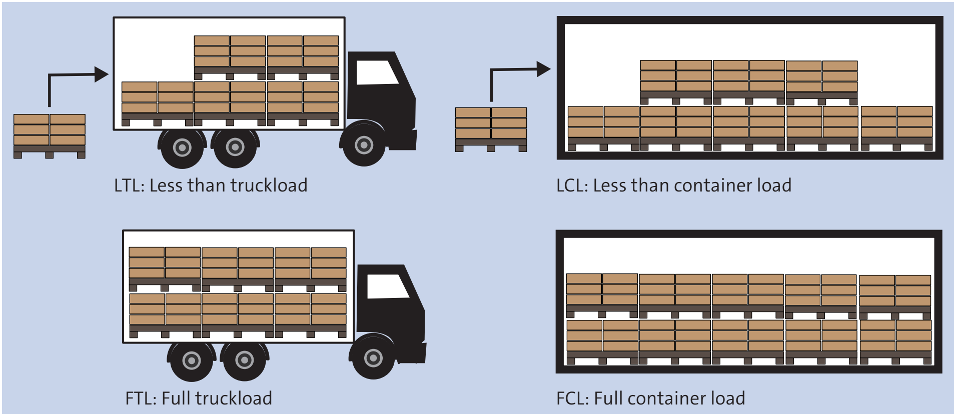


Figure 4 Some Transportation Shipping Types

In some cases, other shipping types are used; for example, wagon load is often used for full railcar shipments with bulk commodities.

Cargo is usually moved as a single shipment when it's either shipped by the shipper as a full truck or container, so that no further consolidation happens. On the contrary, consolidated shipments can either be driven by a shipper who intentionally transports multiple individual shipments together in a containment or can be initiated by a carrier or forwarder that moves cargo for a part of its journey in a joint containment. This is usually the case with LTL or LCL shipments.

Consolidation of shipments in LTL or LCL cases is sometimes driven by a shipper, but it's done intentionally in most cases by an LSP as part of its service. Shippers often explicitly declare their shipments to be consolidated. An LSP uses consolidation as a service offering to their customers to ship smaller quantities without exclusively providing containment. In addition, LSPs will reduce the offered rate to a reasonable level, as the price to be paid by a forwarder to a carrier for shipping a container from Europe to the United States can be split, for example, by weight when recharging the rates plus a profit to each single shipper.

Figure 5 illustrates the consolidation of shipments from a forwarder's perspective. Multiple shippers (A, B) need to move cargo from Europe to the United States. The forwarder consolidates the cargo in an LCL container and subcontracts the move to a CSL. The carrier has a cost of $1,800 to move the container and charges $2,200 to the forwarder (for a $400 profit). The forwarder, which sold the container space to its customers, adds its own profit ($300), and then splits the resulting container rate of $2,500, for example, by weight to the shippers. In this example, shipper A pays $1,000, and shipper B pays $1,500. Other split criteria are also applicable.

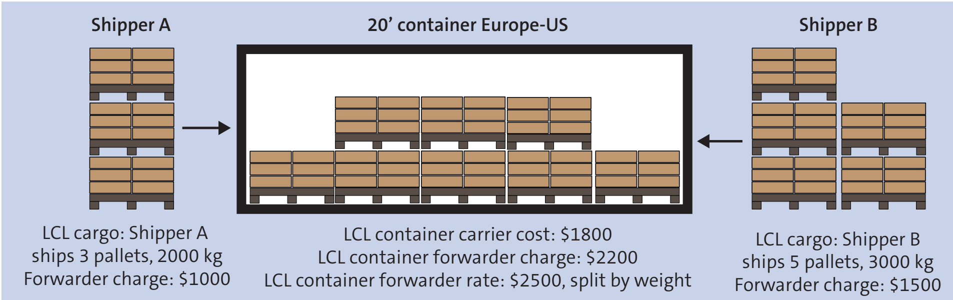


Figure 5 Cargo Consolidation for LCL: Pricing Example

Besides consolidation, shipments can be moved in many ways from their origin to their destination. In Figure 6, you can see some selected options for how the movement can be organized, although many more options are also possible. The way a shipment is moved is defined by its movement type, which is related to the transport order that is specified by the shipper.

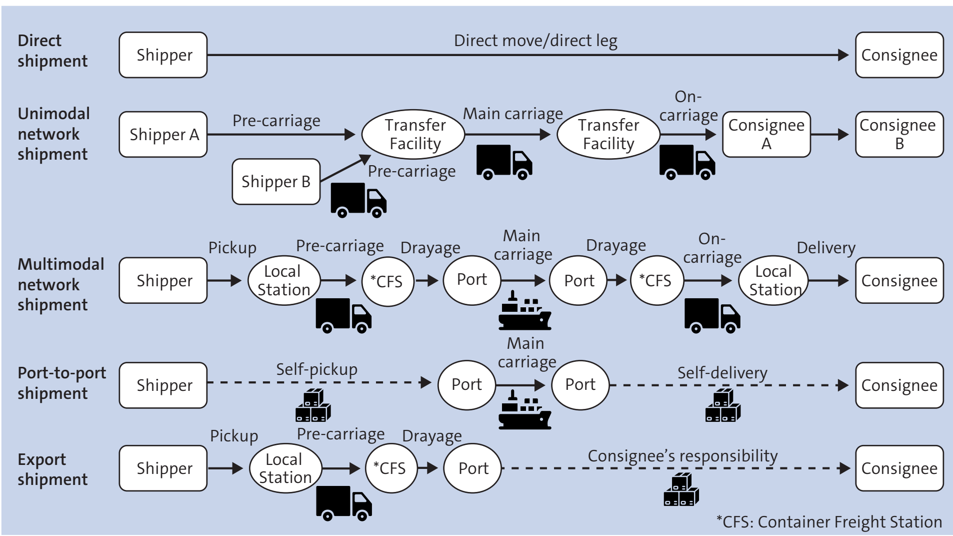


Figure 6 Examples of Movement Types in Shipments

In Figure 6, all moves expressed by the continuous arrows are related to the movement type, that is, part of the responsibility to fulfill the shipper's order. The dashed arrows aren't part of the order and should be organized either by the shipper or the consignee apart from the order. The movement types shown in Figure 6 are as follows:

- **Direct shipment**
  The shipment is an order for cargo that is moved directly from an origin to a destination with a single means of transport (e.g., truck). This movement type is common

for full truckloads but also for smaller shipments in a local geographical context (e.g., courier shipments in the same city).

- **Unimodal network shipments**
  These shipments are moved using a single mode of transport (usually road), but they are routed via the transfer facilities of the LSP. The shipments may be moved to or from the transfer facility in a single or consolidated way. The trip between the transfer facilities is often executed on a scheduled or regular basis (e.g., a scheduled truck in the morning and afternoon between Atlanta and Boston).
- **Multimodal network shipment**
  In this very common movement type, cargo is often moved in a consolidated way; for example, cargo is locally picked up by truck and then transferred in a local station to a consolidated truck that runs to the container freight station (CFS) close to a vessel port or to an airport (ground handling facility [GHF]). In such a consolidation facility, cargo items are packed into ocean containers, air containers, or pallets, and they become part of a consolidated shipment, which first is delivered to the port or airport facility for handover to the main carrier (CSL or airline). Most of these means of transport run on a regular, that is, scheduled, basis (e.g., daily flights, weekly vessel port calls), but individual operation is possible as well (e.g., charter flight). The carrier then moves the consolidated cargo to its destination, where it's unloaded from the main means of transport and moved to the related CFS/GHF for deconsolidation. The single shipments are then moved on in trucks, for example, to their local destination stations, where they finally are distributed to be delivered to the consignees.
- **Port-to-port shipments**
  When getting an order for a port-to-port shipment, the forwarder or carrier receives an FCL cargo container (ocean) or a prepacked air cargo container in its port facility (terminal) or airport facility and moves the complete unit to its destination facility. The shipper should take care to hand in the cargo at the origin. Upon arrival, the carrier then sends release information to the recipient (consignee) in the form of a delivery note. The recipient uses this document to release the cargo unit from the port facility and move it to its destination on the recipient's own behalf.
- **Export shipments/import shipments**
  This movement type is often used in international trade when the shipper only is responsible to move cargo to a county border, for example, a port terminal. The shipper asks the forwarder to execute and organize all steps to get the cargo safely loaded on board the vessel or airplane (shipped on board). From this point on, the responsibility of organizing further cargo movement belongs to the recipient. The export forwarder informs the receiving forwarder of the cargo, so that the receiving forwarder can arrange further transport. Similar processes apply when importing shipments.

Figure 6 also shows the related stage types, which are the types of segments that cargo is moved along during its transport. The following stage types are found in end-to-end movements:

- **Pickup**
  Pickup refers to a local stage from the shipper's origin to a local transfer facility or station.
- **Pre-carriage**
  Pre-carriage has a larger scope in that it can be used to pick up shipments at a shipper or at a local station and move them—often in a consolidated way—to a more remote transfer facility.
- **Main carriage**
  Main carriage defines the stage on which cargo is moved on its long haul, which can include one or multiple stages and a change of transport mode. A main carriage can, for example, be by vessel from Singapore to Dubai and subsequently by air cargo to Frankfurt (sea-air shipment). The main carriage mode of transport usually takes over as the relevant mode for the whole shipment.
- **On-carriage**
  On-carriage is like pre-carriage, but it refers to moving from the destination facility of the main carriage to a local station in the consignee's area or to the consignee itself.
- **Delivery**
  Delivery is related to a local distribution of cargo from a local station to its destination.
- **Drayage**
  Drayage refers to the move of consolidated or containerized cargo from the consolidation facility of a forwarder (CFS/GHF) to a port terminal/airline facility or vice versa. Drayage usually has a local context.
- **Haulage**
  Haulage is also often referred to in transportation. Long-haul transportation implies going over one or more main carriages, and short-haul transportation is done on pre-carriage or on-carriage.

Another characteristic is the responsibility for cargo and its movement. As shown in Figure 6, a shipper isn't always responsible for the whole move, which means the shipper may not pay for every aspect of the end-to-end move nor be responsible for risk or cost of the cargo transportation the whole way. The *Incoterm* regulation on transport obligations, risk, and cost of cargo movement, as described in the Incoterms 2020 standard, is quite important for international transportation. Further details can be found in the corresponding documents at *http://s-prs.co/v557500*. Here, we'll highlight just two examples:

- **Free on board (FOB) Hamburg**
  FOB is a common term for ocean and barge transportation, which means that the shipper and the forwarder bear the transport obligation up to a location (here, Hamburg), including risk and cost, and are also responsible to hand it over on board a vessel in the Hamburg port.
- **Delivered, duty paid (DDP) receiver warehouse**
  DDP is a general term for all modes of cargo transportation (ship, road, air, rail). The shipper/seller is obliged to organize the cargo move, bear the risk and the cost, including import duties, so that the consignee/buyer receives cargo at the indicated place (e.g., receiver warehouse) without being responsible for any transport issues.

In all transportation processes, contributing parties and their roles are important. In some cases, roles may be collectively assigned to a single party, but, in general, they can be assigned to individual participants. The most common roles are as follows:

- **Ordering party**
  The party who orders the movement of the cargo and usually is the contracting party for the move.
- **Shipper or sender**
  The party who ships the cargo. In many cases, the shipper is also the seller of the goods and the ordering party of the shipment.
- **Consignee or recipient**
  The party who receives the cargo. In many cases, the consignee is also the buyer of the goods, but sometimes it needs to be delivered somewhere else.
- **Invoicing party**
  The party to whom the invoice for the shipment is sent. In many cases, a single party isn't assigned, but the overall charges are split to multiple invoices to individual participants, which may be driven by the Incoterms of the shipment.
- **Payment party**
  The party who pays the invoice for a shipment, which can be the ordering party, the invoicing party, or another clearing company.
- **Beneficial cargo owner**
  The party that holds ownership for the cargo to be transported. This is especially valid if neither shipper not consignee owns the goods.
- **Notifying party**
  The party that needs to be notified on certain shipment milestones, for example, on arrival in the destination country.
- **Contracting or agreement party**
  The party under whose contract the cargo is shipped. In many cases, it's the same as the ordering party, but for a larger enterprise, a subsidiary company may ship under the contract of the head branch.

- **Importer or exporter**
  The agents who take care of trade compliance for a shipment.
- **Forwarder or carrier**
  The LSPs that provide the complete service or parts of the service to the shipper.

The parties related to a transportation process need to be properly involved and need to receive the correct legal documentation for handling, proof of ownership, or processing. The following documents are important and are used in many versions throughout the transportation process:

- **House bill of lading (HBL)**
  This document is the legal proof and shipment definition between a shipper and the commissioned LSP. It defines what is moved for this shipper, from where and to where, and who is the main contractor. HBLs are usually the basis for customs declaration—if one part fails, the whole shipment stays in customs until clarification. The HBL is common for ocean shipping.

  On the other hand, house air waybills (HAWB) are used for air shipments, road waybills are used for road shipments, and rail waybills are used for rail shipments. However, the significance and content of these documents are very similar.
- **Master bill of lading (MBL)**
  The MBL document is usually issued by carriers or forwarders to define the consolidation of multiple shipments into a unit (e.g., container), which is then physically handled. As such, it's a legal document between the forwarder and the carrier. Security measures are driven by the MBL, and vessels and aircrafts take MBLs as proof of their loaded cargo. For air shipments, it's defined as a master air waybill (MAWB) and may be issued by an authorized forwarder. A forwarder may have multiple MBLs with a carrier on a single voyage or flight.
- **Manifests**
  Manifests declare the load composition of a means of transport from the carrier's perspective. It can also be provided with respect to certain load and unload ports, for example, all cargo items to be loaded onto a vessel in a port. Manifests may overarch multiple MBLs.
- **Delivery notes**
  Delivery notes are legal documents provided by carriers that are sent to the recipients of cargo. These recipients then use the document to identify themselves and their cargo when picking it up in the port of arrival.

Besides the previously mentioned movement types that define how a shipment must be organized and moved physically, a forwarder usually offers a variety of commercial transportation forms to customers. Customers may differ depending on what kind of commercial service is addressed: it may be a shipper, a consignee, or a third party. Figure 7 shows examples of buyer's consolidation, purchase order management, and triangular trades.

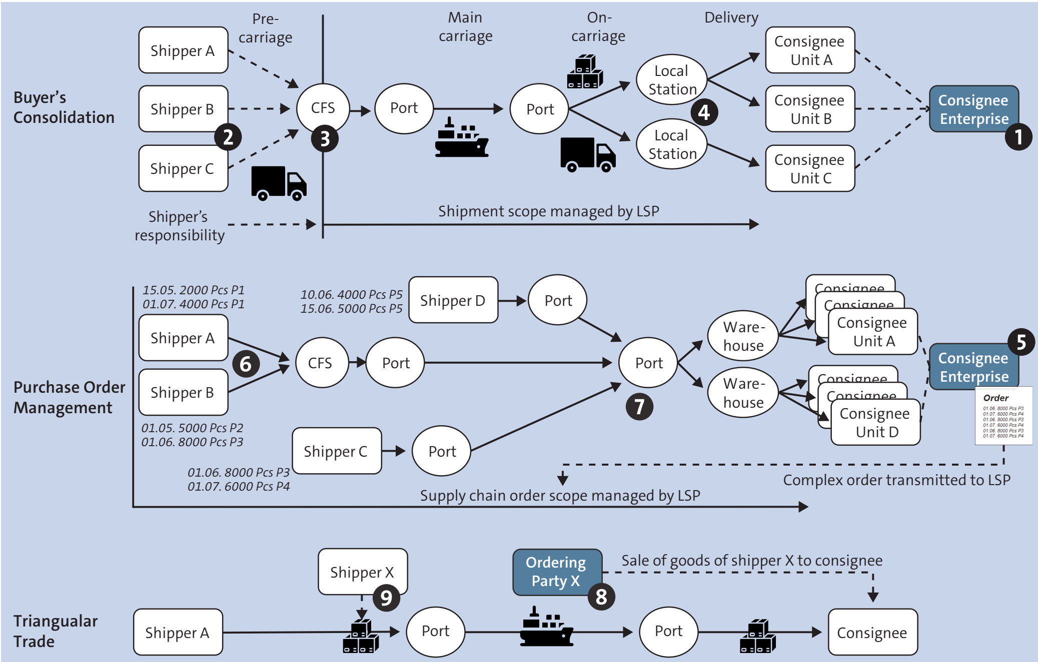


Figure 7 Examples of Complex Commercial Forms in Transportation

The commercial forms of transportation shown in Figure 7 are examples of the complex processes forwarders face in the daily business of logistics that they must resolve with a transportation management system (TMS). Let's explore each a bit further:

- **Buyer's consolidation**
  The buyer of the cargo, which is also the ordering party and legal receiver (e.g., a large toy store chain), instructs the LSP to consolidate goods from multiple shippers in joint containers to be distributed to different warehouses ❶. The LSP is responsible for shipping from its CFS in the country of origin; therefore, each shipper must deliver to the CFS according to that shipper's received order ❷. The LSP consolidates multiple shipments of the various shippers in containers and creates HBLs according to the instruction of the ordering party ❸. The cargo is then moved and distributed into the advised consignee's destination locations ❹. The LSP is responsible for correct consolidation, HBL creation, import, and inland distribution.

  Buyer's consolidations can also be handled as seller's consolidations, where a single seller instructs the LSP to consolidate the load and distribute it to various consignees.

- **Purchase order management**
  This process is a more complex variant of a buyer's consolidation. The LSP not only ships consolidated cargo for a buyer but also handles the logistics for a complete procurement cycle, for example, the seasonal fashion campaign logistics of an apparel company. The middle part of the scenarios in Figure 7 visualizes purchase order management.

The consignee instructs the LSP to handle a complex procurement process ❺. This process may not only contain the arrangement of shipments but also negotiation, tracking, and reporting of proper delivery times, quantities, and qualities from each shipper, so that the overall requirement of the ordering party for the campaign can be fulfilled ❻. After calling off and arranging these partial shipments, the LSP takes care that all shipments are moved according to the plan ❼ and arrive on time and of good quality in the consignee's warehouses.

- **Triangular trade**
  In the triangular trade scenario, also known as cross trade, the ordering party, which sells goods to the consignee, needs to arrange transportation from the shipper to the consignee; in other words, the ordering party doesn't touch the cargo ❽. As an additional step, the ordering party needs to conceal the real origin of the goods and act as the owner of the sold goods ❾. In some cases, specific documents are created that support this obfuscation (switched bill of lading).

Other scenarios include project shipments, where an LSP arranges the transportation for an entire sequence of project deliveries that need to be on time (e.g., rail tracks, locomotives, and railcars from China to Brazil to build a new metro), or charter shipments, where an entire vessel is chartered to a company for a set of voyages.

No matter the level of complexity of a shipment scenario, it always needs to be broken down into its components, which then need to be coordinated. These pickups, pre-carriages, main carriages, on-carriages, deliveries, load transfers, consolidations, shipment documents, and so on need to be planned, created, and used as the basis for operation, which is the focus of a TMS.

Transportation Management System Functional Areas

A TMS fulfills the main tasks to coordinate transportation demand with the available and achievable resources and produces a solution to the transportation scenarios to fulfill customer requirements and—in the case of an LSP—profitability goals. The main support and solution areas of a TMS are as follows:

- Selling shipment services to customers or receiving shipment demand from the company's own sales and procurement systems
- Planning, optimization, and decision-making to achieve a cost-efficient and well-executable solution for any transportation and transit storage demand fulfillment
- Transportation execution, including provision of all necessary documents and information required to physically perform the movements and all legally required activities
- Efficient subcontracting of transportation services to the company's own fleet or external service providers

- Transport tracking with the capability of disclosing and visualizing the required information to all customers, partners, and event management with the capability to mitigate any situation that endangers the initial plan and commitment
- Ability to get instantaneous insight into analytics information on transportation processes, cost, sales, and profitability by providing real-time visibility on logistics and financial key performance indicators (KPIs)

In Figure 8, you can see a component view of such a TMS. The major components are used in a process flow from the left to the right side. The dark boxes will be addressed in the following chapters of this book. The medium gray boxes are also part of the functionality covered in this book; however, as they refer to independent SAP components, more in-depth information can be found in specialized publications. The light gray boxes can be important elements in the ecosystem of a TMS, but we won't go into details on these topics in the later chapters. Figure 8 lists the chapter numbers of each addressed component via the small number in the bottom-right corner of each box.

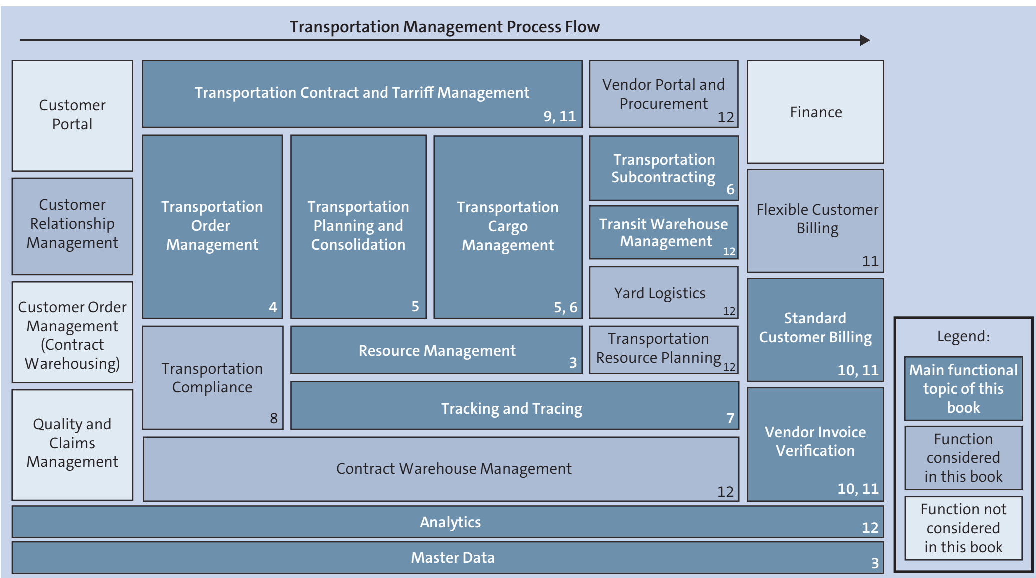


Figure 8 Components of a TMS and Coverage in This Book

The content and functional scope of a TMS can be separated into three areas, which will be addressed in the chapters of this book:

- Foundational data stored and processed in a TMS:
  - Business partner master data, for example, customers, vendors, shippers, and consignees
  - Network master data, for example, customer and transfer locations, network connections, schedules, and carrier availability

  - Resources to move cargo, which may be either a definition of the company's own fleet instances (truck, vessels, railcars, containers, etc.) or fleet capabilities a partner can provide
  - Cargo master data, for example, dangerous goods or trade compliance characteristics
  - Pricing and rating rules and tariffs
- Processes and business objects handled in a TMS:
  - Quote and order management process with business objects to store and process quote and order data. Process steps around quotes and orders are, for example, validity and completeness checks, route determination, price calculation, or profitability calculation
  - Planning and consolidation with capability to store characteristics of cargo to be moved and planned, as well as cargo consolidation
  - Cargo management processes with definition of master files, which represent voyages and tours as well as processes to manage these master files and handle their execution and progress
  - Transit warehouse management processes to receive, deconsolidate, store, cross-dock, consolidate, and dispatch cargo in transfer facilities
  - Subcontracting of master files to carriers and other partners with the ability to calculate and settle the expected cost
  - Billing to customers and settlement of invoices with carriers/vendors with the corresponding invoices and integration into the financial processes
- Engines and automatisms to support processing of TMS data and objects:
  - Planning and optimization engines to do scheduling, route planning, carrier selection, and load optimization in the transportation network
  - Charge calculation engines to do computation of prices and costs based on customer and vendor orders, the contracts they are based on, and the rules and tariffs referred to in these contracts
  - Condition evaluation rules to be used in a variety of decision tools everywhere in the TMS processes

Transportation in the Digital Age

The digital age in transportation brings changes to all companies involved in logistics processes. The availability of cloud offerings and digital technology, as well as its maturity for transportation and other supply chain processes, has made a big leap forward within recent years. On the other hand, integration of various technologies into business processes and the TMS can be difficult if the system isn't flexible enough or enabled to work with these devices and technologies. Many companies are trying to achieve improvements with digital technologies, for example:

- Productivity improvements with lower maintenance and operations cost, such as higher asset availability through better maintenance
- New business models to reach markets that allow more growth
- People and process optimizations with productivity increases
- More reliable logistics planning by taking more factors and potential solutions into account and using more advanced technology for solution determination
- Risk reduction through improved supply chain control, resulting in fewer claims and charges

Whichever area of business improvement is targeted by a logistics company, several foundational technologies can be used to advance capabilities:

- Machine learning and artificial intelligence (AI) can improve a company's decision and planning algorithms. These technologies learn from past decisions and successes to include factors such as weather patterns, logistics disruptions, traffic congestion data, and historical traffic reaction patterns into a planning cycle and to achieve better results through optimization.
- Innovative production technologies can completely change a shipment move, for example, by enabling local production of specialized goods with 3D printing, so that many items can be manufactured on demand close to the consignee and only require short-haul shipping.
- Predictive processes allow better detection of risk of failure for a company's own assets and enable the scheduling of required maintenance to avoid unnecessary parts replacement.
- Real-time data availability enables users to make faster decisions and to respond more quickly to changed environments.
- Products are generally smarter due to their own sensors that allow them to report on individual situations and needs, for example, temperature requirements and history, geofencing position data, or shock sensors for sensible cargo.
- New transparency and communication technologies, such as blockchain, change the pattern of interaction between the players in a logistics process. Selected documents can be made accessible and immutable so that trust between all parties is improved.

All these new opportunities require a company to be able to adapt their processes and systems to this new world. TM is an open, flexible, and powerful platform to solve today's transportation challenges and leap into the digital age of logistics.

Next, in Chapter 1, we'll provide an overview of the foundations of TM. You'll learn how SAP provides the infrastructure to run your transportation business processes and how TM is used and integrated to handle your end-to-end transportation demand and services.

Chapter 1

Transportation Management Foundation

SAP S/4HANA is a comprehensive, fully integrated, and flexible platform providing business software applications. It enables enterprises to manage their business processes with up-to-date technology. Transportation management (TM) is an essential part of SAP S/4HANA. In this chapter, we give you an overview of TM in SAP S/4HANA and how it revolutionizes the potential of business IT.

SAP S/4HANA comprises all products and applications that an enterprise needs to support its full scope of IT processes, including human resource management, procurement and sales, logistics, and manufacturing, as well as financials. From the perspective of this book, TM is the SAP S/4HANA logistics component that allows you to manage all transportation processes.

Enterprise suite software such as SAP S/4HANA enables companies to plan and execute processes within and between enterprises, to achieve cost efficiency and transparency, to be flexible enough to easily move into new business areas, and to enter the digital world. The applications are built on SAP S/4HANA, which provides a powerful basis to smoothly run all technical operations required by the various business areas.

TM in SAP S/4HANA consists of business processes that drive the offering, selling, demand handling, assignment, planning, procurement, subcontracting, steering, documenting, and settling of transportation services within companies and for service providers. To help you become familiar with the core concepts of the system and the role of TM in the SAP S/4HANA supply chain execution (SCE) platform, this chapter is divided into the following sections:

- Section 1.1 explains the benefits of using standard software systems. It also clarifies how and why the move from SAP Business Suite to SAP S/4HANA happened.
- Section 1.2 describes how SAP S/4HANA, as a future-proof platform, supports and enables all foundational features to run the required transportation business processes with high flexibility.
- Section 1.3 explains the digital integration with solutions like SAP Business Technology Platform (SAP BTP).

- Section 1.4 introduces important TM principles and business objects, explains how TM works on a high level, and shows how it interacts with various SAP S/4HANA products and components. At the end of the section, we'll give you a preview of the content of the following chapters.

1.1 Standard Software for Transportation

Looking at the logistics service provider (LSP) market as well as the shipper community and their IT foundation, specifically designed transportation software is still widespread. There are cases where handcrafted transportation software, sometimes also built on top of SAP systems, is in use for 30 and more years. In general, software used for transportation management can be assigned to one of the following categories:

- **Legacy systems**
  Legacy systems are specialized IT systems that are either developed by a company's IT department for its own purposes or tailor-made to the company's needs by a consulting firm. Depending on the system's age, the software can be based on client-server or mainframe technology and thus often can be a dead end, as either the technology is old and gets out of maintenance, or the knowledgeable people for such a system retire and nobody dares to touch it anymore.
- **Best-of-breed systems**
  Best-of-breed software is produced by companies specializing in transportation or logistics applications. They are often created to cover very specific market requirements, such as truck transportation in North America only or air cargo transportation, but are targeted to a larger user group in that segment. Creating synergies between different business units (BUs) of an enterprise (e.g., usage of one software for an integrated process for air, ocean, and road transport) or simple integration into backend processes (e.g., financials) may be challenging as it can become a continuous change process due to the various software packages and their releases and interfaces.
- **Standard software systems**
  Standard software is often part of an enterprise suite that not only covers transportation or logistics processes but also allows integration into other enterprise areas such as sales, production, or finance. Transportation coverage targets a wider scope than best-of-breed software.

While LSPs often still use legacy or best-of-breed software, shippers usually tend to use standard software, as they already run many integrated processes in their enterprise via such a system. In this section, we'll take a closer look at standard software and the transition to SAP S/4HANA.

1.1.1 Standard Software as a Foundation of Enterprise IT

The term *standard software* describes a group of programs and applications (e.g., SAP S/4HANA) used to solve or process many similar tasks in an enterprise. In most cases, the programs can be configured. Configuration of the software means that process chains, process steps, and individual functions can be adjusted to meet company-specific and user-specific requirements by setting control parameters, table or file entries, and values to meet specified characteristics and program flows. The SAP terminology for the configuration process is called *Customizing*.

By using standard software, companies can avoid covering common processes, such as transportation management or controlling, by individually developed applications, as these often lead to fragmented or hard-to-maintain system landscapes. In addition, individual software solutions often indicate that integration efforts and the complexity of data exchange and data consistency increase. Even the use of best-of-breed software bears the risk that different areas of an enterprise using different software solutions split further apart and lead to increased effort and cost, as the release development of those tools is completely independent with no guarantee that they will always fit together. Large companies may end up with 500+ systems in their landscape that need to be maintained and integrated in terms of master data consistency, release levels, interfaces, and cross-application processes.

In the long term, standard software can be implemented and integrated in an enterprise much more efficiently than multiple self-developed or independently designed best-of-breed tools. The expensive, error-prone, and cost-pushing software development process is done by an experienced standard software company so that the procured solution can be implemented directly. In many cases, the implementation project can concentrate on process definition, system configuration, master data maintenance and cleansing, migration from the previous software tool, and user training. As many other companies—especially shippers—already use, SAP standard software, for example, a lot of solution expertise is available either in a company itself or in the market for the benefit of the applying company. This can be further optimized by using a template-based approach. Maintenance services and special support activities are available for SAP customers on a 24/7 basis.

Enterprises need to consider whether to use standard software versus individual software. The flexibility of standard software and its regular road map developments by the vendor entails a lot of advantages without losing the option of company-specific enhancements and configurations. A disadvantage, however, may be that only 60% to 80% of the required individual processes are covered by the standard, while the rest needs to be provided by enhancements, additional software products, or business process redesign.

The existence of an old legacy system within a company that will no longer be maintained in a foreseeable future is a risk that can be mitigated by the use of standard software as a joint platform for IT. In addition, the recent market developments in digitalization, are a strong hint toward a standard platform, as digitalization brings an additional level of complication into the processes and IT. These complications can be handled reliably by a well-integrated and open technology, such as that offered by SAP S/4HANA and SAP BTP out of the box.

1.1.2 The Move from SAP Business Suite to SAP S/4HANA

Standard software is a very important contribution and foundation to successful and well-integrated enterprise processes. It prevents unnecessary data duplication and guarantees cross-application data integrity.

Such benefits have been reason enough for companies to choose an SAP system as foundation, although those advantages are no longer a guarantee for long-term success as—unlike in the 1960s, where an S&P 500 company had an approximate 40-year success record—this period is now fewer than 14 years. Company success is very much related to the ability of an enterprise to adjust, merge, and adapt. Digitalization and the ongoing changes in logistics processes require companies to be highly flexible, which is directly mirrored by the IT specification and landscape.

These process changes resulted in SAP rethinking the foundations of the enterprise suite and launching SAP S/4HANA and SAP BTP as the long-term successor of the well-known SAP Business Suite.

The name SAP S/4HANA has been defined following the well-known SAP R/3, the predecessor of SAP Business Suite:

- S represents *simplicity* and the *suite*, and it also represents the follower of "R" in SAP R/3.
- 4 represents the successor of "3" in SAP R/3.
- HANA indicates operation on the in-memory technology of SAP HANA.

Simplicity is one of the major topics of SAP S/4HANA:

- **Simple usage with best usability**
  The system and its processes are easy to use, and you can integrate people, devices, technologies, and networks.
- **Simple business processes**
  Easy execution of business processes allows users to concentrate on changes without being confronted with distracting data.
- **Simple decisions**
  Insight is provided into significant data, trends, and business processes to make decisions.
- **Simple process optimization**
  By using machine learning and artificial intelligence (AI) on an in-memory system, processes can be improved compared to slow SAP ERP instances.

- **Simple configuration**
  The system is easy to configure, providing a guided implementation process.
- **Simple data models**
  Based on in-memory technology and very fast data access, technical auxiliaries, such as indexes, aggregation, and redundancy, aren't required any more.
- **Simple access**
  Many centralized processes don't have to be on-premise any more but are available via a cloud service.

SAP S/4HANA is based on the in-memory platform SAP HANA, which went through a step-wise transition starting as a database and development platform via analytics, then a foundation for SAP Business Suite and new implementation of finance processes, and finally as the successor of SAP Business Suite with an integrated in-memory processing and digitalization technology. Figure 1.1 shows the steps of this journey.

In addition to the on-premise version of SAP S/4HANA, SAP S/4HANA Cloud, public edition was established as a public cloud service offering comparable functionality. However, looking at SAP S/4HANA version 2022, there are still components that aren't offered in the public cloud yet, including TM, which was provided as public cloud service in 2019 with limited scope compared to TM on-premise.

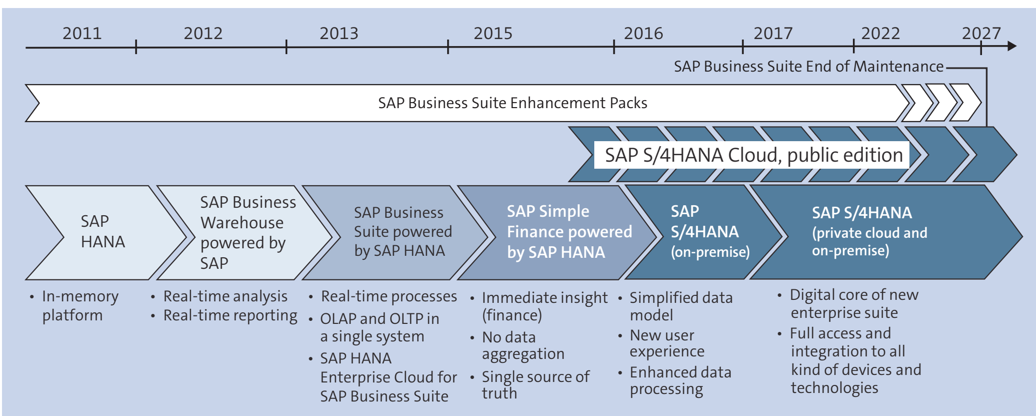


Figure 1.1 History and Development of SAP S/4HANA

Another essential aspect besides the convenience of SAP S/4HANA is its capability to integrate all areas and influences of modern business life, including traditional and digital. Different types of devices, Internet of Things (IoT) technologies, business networks and social networks, people, and big data sources can be joined smoothly with existing processes. Figure 1.2 shows this capability as an overview.

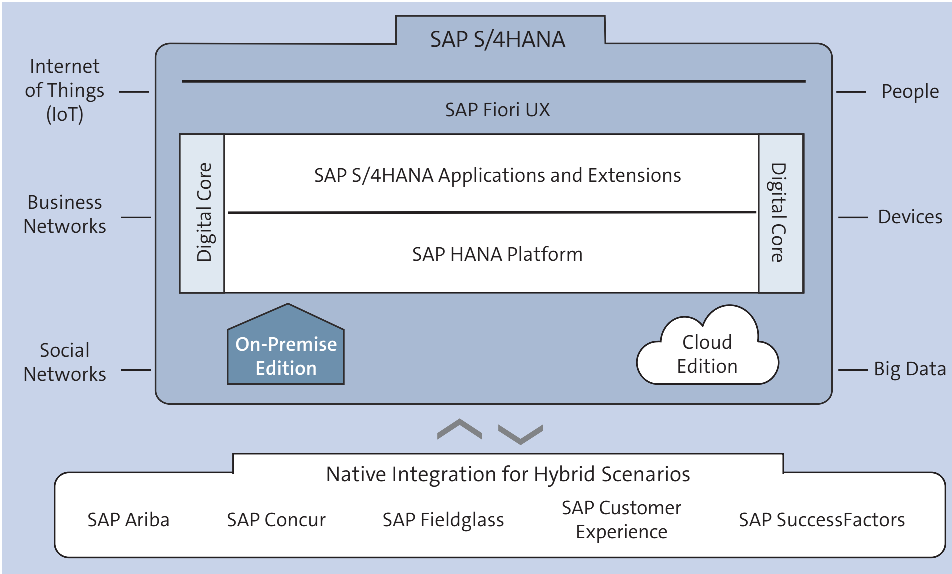


Figure 1.2 SAP S/4HANA's Digital Core: Integrating Processes and Digital Technologies across All Lines of Business and Industries

1.2 SAP S/4HANA as a Future-Proof Platform

The innovative in-memory technology of SAP S/4HANA enables a variety of new process and transaction concepts. Because the SAP HANA database is an integral part of the suite, the availability of all relevant data in the main memory allows for processing benefits that come without previous data replication or aggregation. SAP S/4HANA is built on some guiding principles:

- **Modern architecture**
  The architecture is robust and scalable. The simple data structures deliver high speed because they are working on primary data. Data forms a single source of truth, and consumption of data can be flexibly managed.
- **Role-based design**
  All functions are designed to be people centric and should run on any browser-based device. Flexible workflows allow for better collaboration and decision support.
- **Smart business**
  The suite is built for scalability, automation, and integration of digital technologies. Cockpits provide an exception-based style of working with embedded analytics, prediction analytics, and simulation capabilities.

This section will dive into SAP S/4HANA and its foundation. We'll also explore SAP S/4HANA's intersection with SAP BTP as well as the cloud versus on-premise deployment options.

1.2.1 Features and Concepts of an SAP S/4HANA System

SAP S/4HANA is a comprehensive and fully integrated family of business software applications that allows large and small organizations to perform transactional planning, execution, and documentation of end-to-end business processes. Fast, safe, and flawless process execution makes it possible to achieve cost savings and ensure a seamless audit trail. The built-in configurability and flexibility of SAP S/4HANA enables easy adoption of business processes and development of new business portfolios.

Built on SAP S/4HANA, the SAP S/4HANA applications support the best practices of various industries. The integrated components for financials, controlling, production, procurement, marketing, sales, service, supply chain management, and risk and compliance management interact in a powerful way to facilitate transportation management processes in the manufacturing and shipper-focused industries (e.g., consumer products, retail, mill, and chemicals), as well as in the logistics services industry (e.g., freight-forwarding and carriers). LSPs are especially dependent on the robustness and completeness of the transportation management–related applications because the software is used to manage their core business.

Business Object

The term *business object* is used in many places and contexts throughout this book. A business object such as a purchase order, sales order, invoice, business partner, or equipment is a representation of a real-world business document or a related process in an IT system. It encloses and structures data belonging to a business-related context and provides a set of methods to create, update, and delete the object or parts of it and to exchange the data via interfaces. No activities ever breach the integrity of the business object.

The whole application suite and its components are based on a configurable interaction of business objects, which can be used in the context of the necessary business processes to represent the logical flow of work tasks and data required to manage the business successfully.

In-Memory Database

The in-memory technology of SAP HANA enables completely new process concepts and transactional processing. Data is available in the main memory of the system. Due to data models largely abstaining from replication or aggregation of data, processes can operate faster and increase data consistency. Memory space can be saved by avoiding data replication and using efficient compression techniques.

Transactional processing of data (online transaction processing [OLTP]) is done in main memory with SAP S/4HANA, instead of retrieving information from a database and writing it back after the transaction. Using in-memory technology, data is retained in direct access and later evaluations don't have to retrieve and load data again. An analytical system (online analytical processing [OLAP]) can directly work on real-time data instead of relying on hours-old or days-old extracts.

Access to in-memory data also allows much faster and better algorithms for calculations, simulations, forecasts, and machine learning, which would be quite difficult with conventional enterprise resource planning (ERP) systems. Where a traditional ERP system has the status of being a system of record, an SAP S/4HANA system stands out as a system of intelligence.

SAP Fiori and SAP Fiori Launchpad

Simplifications of SAP S/4HANA include the user interface (UI) and user experience (UX). With SAP Business Suite, the intelligence and expertise has been with the user. Even though the use of the system was simple, the user must have a good understanding of how to operate the system and which fields were important.

The philosophy of SAP S/4HANA goes further in that intelligence is now an intrinsic part of the system, and the expertise stays with the user who can concentrate fully on his actual task using the SAP Fiori UX. The system supports the user with important, relevant information in a suitable representation without requiring a lot of technical background knowledge.

The SAP S/4HANA UI provides four levels of working (see Figure 1.3):

❶ The SAP Fiori launchpad provides a role-specific and configurable overview of user activities, delivering important key performance indicators (KPIs) as part of the tiles that guide the user's attention. An example is a tile to launch an overview of freight orders with a KPI of orders still to be processed today.

❷ The overview page of a tile provides the user with additional details and relationships of a selected business context or process. An example is a list of today's open road freight orders with information giving important information to the user and indicating the priority of individual business objects.

❸ By selecting details on the overview page, the user can view, update, delete, or analyze data more deeply or in a classic way. The user still gets full system support in terms of machine intelligence or process integration. An example is the detailed maintenance of a road freight order and a function to update the transportation plan.

❹ From the SAP Fiori launchpad, the user can also directly open various analytics views of real-time data. An example is the capacity or cost related to road freight orders for the past month.

TM in SAP S/4HANA still has some UIs and screens presented in a conventional way, as the logistics industry has a high demand for dense screens with lots of information.

SAP Fiori Launchpad: Tiles, Links, and Menu Paths

In Figure 1.3 screen ❶, you can see the SAP Fiori launchpad, which allows you to configure the appearance of menu items either as tiles with or without KPIs or as links in a menu box. In this book, we'll always refer to them in functional descriptions as tiles, even if they can be set as links or are part of a standard role as link definitions.

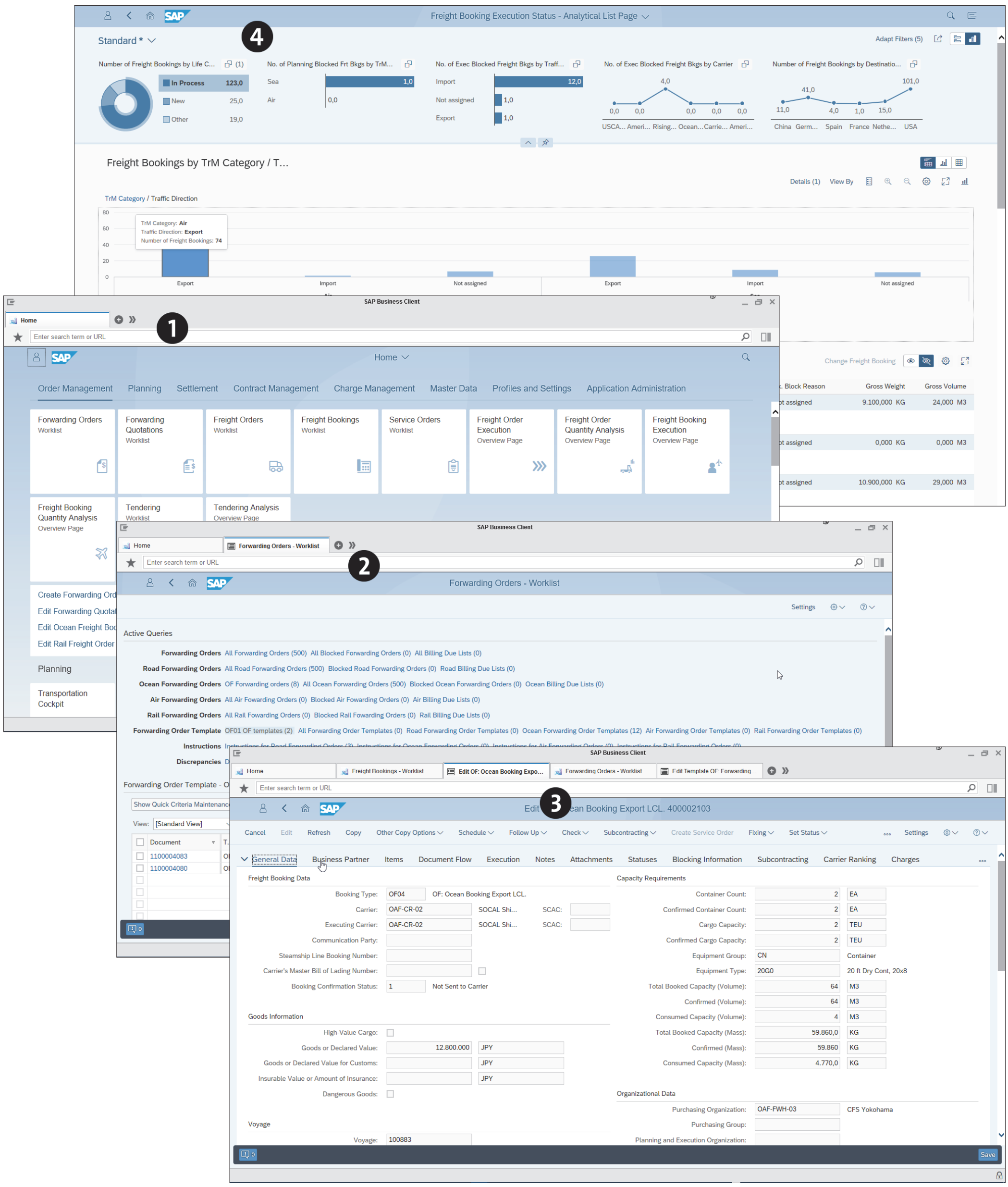


Figure 1.3 Elements of the SAP Fiori UI

1.2.2 SAP S/4HANA and Basis Support

Sitting on one of the multiple possible operating systems, SAP S/4HANA is equipped with an operating system–dependent kernel that shields the applications above from the specific behavior and requirements of the hardware and operating system. This architecture allows unified operation of the application and harmonized access to system and hardware functions, such as database and printer access. The supported database system is the SAP HANA database 2.0. Other databases can't be used for SAP S/4HANA–based systems. In this section, we'll further discuss programming, functions, and business concepts.

SAP ABAP Platform 2022

The ABAP and Java runtime systems of SAP S/4HANA are the basis of most applications that are executed in a homogenous and stable environment. ABAP is very important to SAP because most application functions are implemented in this proprietary, SAP-own programming language. From its beginnings as a COBOL-like reporting language (ABAP is an acronym for "Allgemeiner Berichts Aufbereitungs Prozessor", which would translate to "General Report Preparation Processor"), ABAP has evolved into a powerful object-oriented programming platform whose language constructs provide excellent support for building business applications. Beyond language support, ABAP is a very scalable and solid foundation for mission-critical systems, has an integrated full lifecycle management and the new ABAP RESTful application programming model, and supports a development environment in Eclipse. Embedded in the ABAP runtime environment, processes executed by a user can be shielded very well from those of other users so that problems in one executed program don't impact other running processes.

Access to SAP Program Source Code

ABAP isn't considered fancy, but SAP did develop the language to be a best-fitting, reliable, and fast platform for business applications, which is kept up to date with modern programming concepts. ABAP is, so to speak, the "workhorse" of business application programming. SAP views it as very important and fundamental. In addition, the complete source code for the business applications is visible and delivered with the system. With a little programming knowledge and the right authorization, you can start the ABAP Workbench (Transaction SE80) and look around in the coding (e.g., in TM) to find out how it works. The code availability also allows you to enhance and reuse program coding by implementing enhancement spots, for example.

SAP S/4HANA Functions to Support Business Applications

SAP S/4HANA and its included ABAP platform and Basis offer a wide range of system and support functions to all applications running on application servers. These services deal with harmonized access to the application environment (e.g., printing or communication) or with security support and are provided consistently, independent of the database and operating system. You can see an overview of many of the support functions in Figure 1.4.

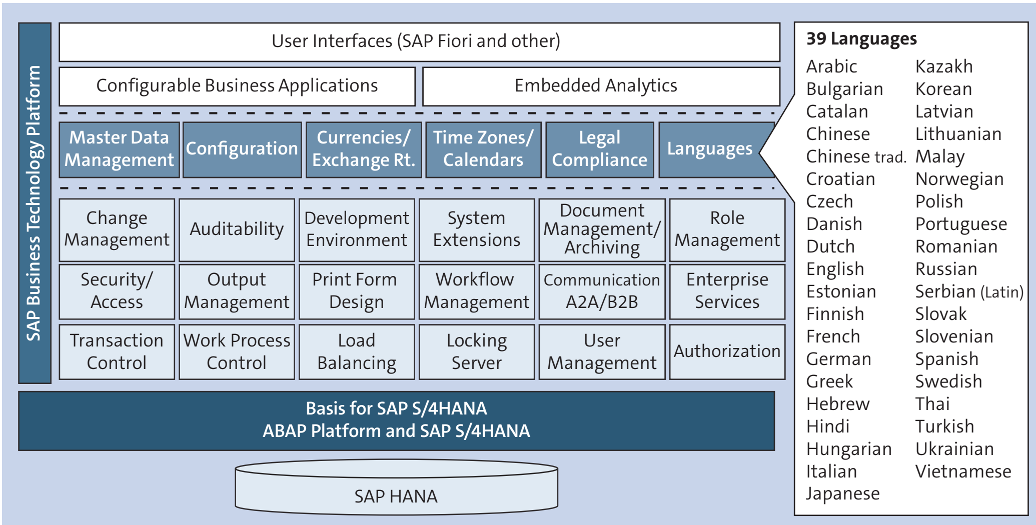


Figure 1.4 Support Functions of SAP S/4HANA, Basis, and ABAP Platform

The following support functions are the most important basic system features:

- **Transaction control**
  Transaction control implemented in SAP S/4HANA and well-designed applications guarantee consistency of related business data. If, for example, an invoice for an order is created, then transaction management ensures that the invoice is created correctly, and the invoicing status and data in the related order are updated within the same transaction. Either you accomplish everything consistently, or, in the case of a partial inconsistency, all stored data is rolled back to the state it was in when the transaction was started.
- **Work process control (work processes and load balancing)**
  By means of process control, the system balances the workload of the currently running processes and transactions so that each user gets an allocation of processing time to finalize his transaction. Newly started processes are automatically allocated to the least-loaded application server in the system environment.
- **Multilanguage support**
  Since becoming part of SAP S/4HANA, TM is delivered with all 39 languages that are available as standard for the system. Additional translations can be made as well because the tools are provided with SAP S/4HANA. All language operations are fully based on Unicode. Technically, hundreds of different languages are possible.
- **Locking server**
  The locking server ensures that only one user or transaction at a time can alter a single business object (e.g., user A tries to update order 123 by adding a new item even

as user B deletes order 123). In TM, an extended concept is implemented that works with optimistic locks, which allow multiple users to work in change mode on separate, more independent parts of the same object. Additionally, locking can be implemented at the subobject level, meaning that multiple users can concurrently work on one object, each having their own work set of object data.

- **User management and authorization**
  To manage access rights to applications, you can define user roles with a comprehensive list of authorizations. The user roles can be assigned to named users who can log on to the system. After logon, the authorizations linked to the roles assigned to the user control each activity that the user can carry out with a transaction or object. For example, a call center service agent may create new orders and create invoices but may not be allowed to correct disputed invoices. In addition to authorizations, the user roles are in an SAP S/4HANA system also related to the role-specific setup of the SAP Fiori launchpad. All these settings can be very specific to each company, so the definition and setup are usually part of the implementation phase of the SAP software.
- **Output management for printing and other channels**
  SAP S/4HANA allows you to manage all printers centrally in the system. In addition to technical integration of printing devices, printing queues and integration of printing activities into the application layer are provided. In newer installations, Adobe Document Server is often used to actively manage the document output. SAP also offers the capability to use the Adobe Forms Designer and interactive PDF forms.

  In the context of output management, the system offers options for sending created documents by fax or as email attachments instead of printing them. The output management services allow you to automatically create an archived version of the document in a document management system.
- **Communication and services**
  Communication management in SAP S/4HANA supports internal communication processes (application to application [A2A]) as well as external processes (business to business [B2B]). For all applications, there are plenty of enterprise services (web services with Web Service Definition Language [WSDL] definitions). In addition to the offerings of SAP S/4HANA, SAP BTP can be used to further enhance integration options.
- **Workflow management**
  SAP S/4HANA includes a complete workflow management system that can be integrated with all applications, the office functionality, and business process management.
- **Development workbench**
  SAP's ABAP platform contains a complete development environment for development coordination (i.e., packaging of objects), all dictionary objects (e.g., database

tables, structures, data elements, etc.), ABAP objects (e.g., programs, function modules, classes, methods, etc.), UIs (e.g., Web Dynpro, SAP Fiori, etc.), enterprise services, and other objects, such as authorizations, transactions, and message classes. The development workbench allows you to test all objects instantaneously and has very strong drilldown capabilities, such as a call-to method, referenced structures, and data elements. Figure 1.4 shows an overview of the development workbench. Alternatively, development can be accessed via an Eclipse-based environment.

- **Change and transport organizer**
  Change and transport organizer is a tool for managing centralized and decentralized ABAP Workbench development projects and Customizing projects (i.e., system and process configuration). Development objects and Customizing settings can be clustered in transport requests to achieve a structured release of consistent development and configuration content, to allow export from a development system, and to enable import into a test or production system.

Important Business Concepts in SAP S/4HANA Systems

Three essential concepts realized in SAP systems make adoption of business requirements easier and more flexible. These concepts affect SAP S/4HANA processes as well as the business applications and components built on top (except development objects such as programming code):

- **System and client concept**
  The organizational layers (system and client) of an SAP system can be used to implement an enterprise's processes with multiple companies. The client of an SAP system is a concept involving a logical separation of data and work areas within one technical system installation. Using the client, multiple independent organizations can work in a single system in completely separated work spaces with data being shielded from access by unauthorized users.
- **Financial and organizational units**
  The financial and organizational units allow you to assign users in the same enterprise to work in different areas of responsibility (e.g., company code of subsidiaries in Germany or Brazil, purchase organization in the United States, and sales organization in China). Organizational units are always related to one client in one system. In terms of multisystem usage, a master data management process must be in place to consistently allow usage of organizational structures.
- **Customizing and Implementation Guide**
  The Implementation Guide (IMG) is a tool for organizing a project implementation, that is, setting up business processes in a project or at a customer's site. You can create multiple projects, each holding Customizing tasks for specific business areas. Customizing tasks allow you to set up the configuration in the SAP system client. The configuration controls which process can be executed in what way, which consistency checks are executed, and which data determinations are done. Figure 1.5

shows part of the reference IMG and a Customizing task in a TM in SAP S/4HANA system.

Examples of typical Customizing tasks are as follows:

- Defining the countries where you do business and which currencies you use within the processes
- Defining order types and their functional details
- Defining price calculation rules and document printing rules

The IMG can also work on an overall task assignment as the Reference IMG, giving you access to all Customizing tasks in the whole system. The structure of the IMG reflects the different business areas to be configured. There are always general tasks such as country and communication settings. In addition, and depending on the installed components, you'll find application-specific tasks. In an SAP S/4HANA system instance, there are settings for procurement, finance, sales, logistics, transportation, production, and so on. In a pure TM instance, you'll find configurations for master data, forwarding order management, planning, and others.

Customizing allows you to define very detailed settings. In fact, in TM, there are more than 500 different mandatory or optional configuration tasks. You can get a system up and running with a minimum setting; however, a high level of configurable flexibility is available if you need it.

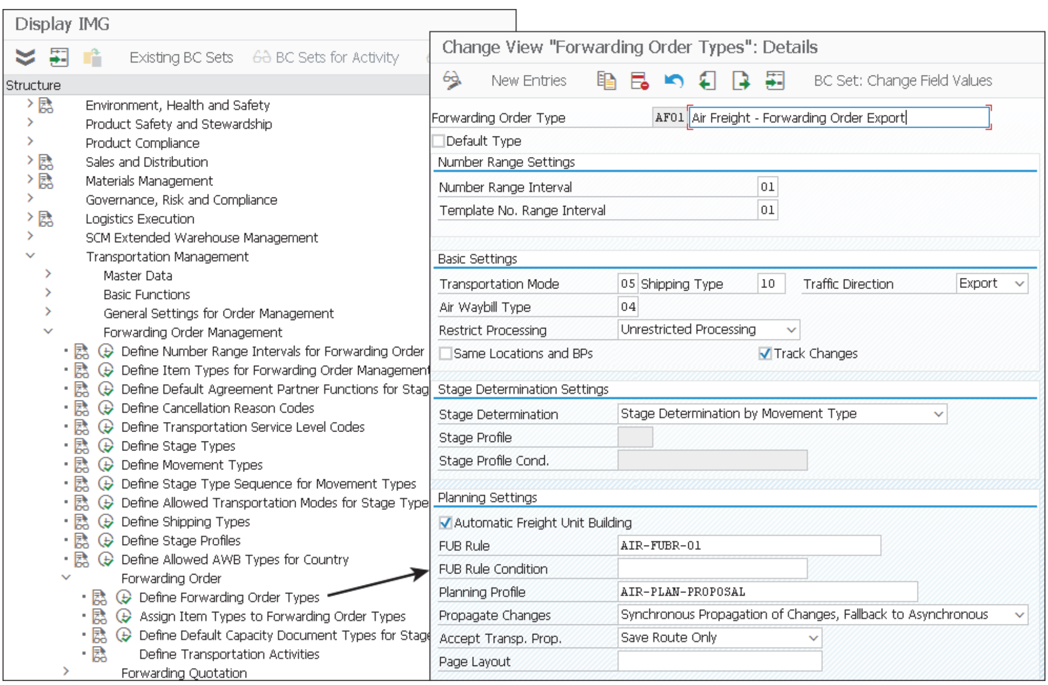


Figure 1.5 Customizing IMG and Configuration of a Forwarding Order Type for Air Freight in a TM System as Part of SAP S/4HANA

1.2.3 On-Premise and Cloud Deployment

The digital core, products, and suite components of SAP S/4HANA can basically be operated in three different deployment options:

- **On-premise deployment and application hosting (SAP S/4HANA)**
  For on-premise deployment, the system is used, operated, and maintained by the customer in the customer's own data center. When the system is operated in a data center of a hosting provider that provides the computing infrastructure, but the customer uses, maintains, and operates the system, it's application hosting.
- **Private-managed or single-tenant cloud deployment (SAP S/4HANA Cloud, private edition)**
  The infrastructure and the system are built, operated, and maintained by a cloud service provider. The customer uses the system exclusively and can make changes to it that go beyond mere configuration.
- **Public-managed or multitenant cloud deployment (SAP S/4HANA Cloud, public edition)**
  The cloud service provider provides the infrastructure and a system that operates and maintains it. The customer company can log on to the system, configure its own processes, and use them with its private data, but the company can't make any special changes to the system.

A characteristic difference between on-premise applications and their counterparts in the cloud is the method of commercialization. While on-premise applications are paid for via traditional licensing models, the subscription model is common for cloud applications. The differences are enormous in their implications and go beyond a simple cost comparison.

With the traditional licensing model, you only pay for the software and the right to use it. Hardware, operating system, database, and so on must be purchased, installed, and maintained separately, which represents a considerable additional cost factor. In most cases, a maintenance contract is also purchased, which includes further development by means of releases or enhancement packages, as well as bug fixes and service packs. Again, the customer is responsible for implementing, adapting, and commissioning the system. This is true not only for the initial implementation but also for each enhancement package and service pack.

Regarding licenses and deployments, consider the following concepts:

- **Infrastructure as a service (IaaS)**
  IaaS is the broadest cloud delivery model. While companies in the classic on-premise world set up and operate their own physical computing infrastructure, this is rented as a service in IaaS. In most cases, this rental includes storage, processing power, network infrastructure, and other resources on which the customer can install and use operating software and business applications. The virtual environments on which

customers can run their applications behave in the same way as if it were an independent, local infrastructure. Customers can therefore configure and operate the infrastructure according to their requirements. Dedicated application management, which can be obtained as a service from other providers, is necessary with IaaS.

Advantages of this delivery model are affordability of the infrastructure; scalability in case of rapid growth, easy generation of, for example, sandboxes; and demand-driven adaptation in case of load peaks and valleys.

- **Platform as a service (PaaS)**
  PaaS offers customers the opportunity to develop and operate their own applications on an infrastructure provided by the cloud provider. For this purpose, PaaS provides software frameworks, programming languages, tools, libraries, interfaces, and services. These cover the entire software lifecycle from conception through design, development, testing, deployment, and operation of the application. The customer has control over the applications created and the configuration of the hosting environment, but no access to the underlying infrastructure, such as network, operating system, server, or storage.

  PaaS services build on IaaS infrastructures and offer the same benefits, scalability, and usually a similar commercialization model. An important SAP PaaS product is SAP BTP, which gives customers the option of creating their own applications via custom code, offering added value with analytical or transactional apps, especially in differentiating process areas.

- **Software as a service (SaaS)**
  SaaS describes the use of a provider's software, which runs on its cloud infrastructure. The user pays for the use in the form of a subscription. The application can be used with the help of different devices, either through a thin client (e.g., the browser of a computer or a tablet/smartphone) or through its own program interface. Smartphone apps are to a large extent SaaS applications.

  In this scenario, the user has no access to or influence on the underlying infrastructure, such as the network, servers, operating system, or storage. There may be limited configuration options. This also includes a restriction on the customizing capability of a SaaS application. SAP SaaS solutions include SAP SuccessFactors, SAP Ariba, and SAP Concur, as well as SAP S/4HANA Cloud, public edition.

  In many applications, the user enjoys numerous advantages by using SaaS offerings. In addition to the low investment risk because they only pay for use and don't have to procure any assets (hardware, etc.), further benefits include significantly improved total cost of ownership, transparent IT costs, better scalability, greatly accelerated implementation, and easier deployment of new functionalities and innovations.

  With respect to TM, customizability and functional coverage is much lower than with on-premise or private cloud deployment, and for many scenarios, the SaaS consumption can't be seen as a real alternative.

You can see a comparison of the impact of the ownership and responsibility for the cloud and on-premise deployment models in Table 1.1.

Deployment Model	SAP S/4HANA Cloud, Public Edition	SAP S/4HANA Cloud, Private Edition	SAP S/4HANA (On-Premise)
License model	Software subscription/SaaS	Software subscription/PaaS/IaaS	Perpetual software license
Implementation	Partner/SAP/customer	Partner/SAP/customer	Partner/SAP/customer
Content ownership	Mainly SAP	Mainly partner/customer	Mainly partner/customer
Application management services	SAP	Partner/customer/SAP Enterprise Cloud Services	Partner/customer/SAP Enterprise Cloud Services
Content lifecycle management	SAP	Partner/customer/SAP Enterprise Cloud Services	Partner/customer/SAP Enterprise Cloud Services
Product support	SAP	SAP	SAP/resell partner
Technical operations	SAP	SAP	Partner/customer/SAP Enterprise Cloud Services
Infrastructure	Hyperscaler/SAP	Hyperscaler/SAP	Customer/hyperscaler/SAP/partner

Table 1.1 License, Delivery, and Operations View for the Deployment Models

Regarding the consequences for the SAP S/4HANA systems and TM, Table 1.2 shows the individual characteristics of the available deployment models, as of the time of writing.

Deployment Model	SAP S/4HANA Cloud, Public Edition	SAP S/4HANA Cloud, Private Edition	SAP S/4HANA (On-Premise)
Alias names	Essentials edition/multitenant edition (MTE)	Extended edition/single tenant edition (STE)	N/A
Implementation type	New implementation (greenfield)	Conversion, selective data transition (greenfield, brownfield)	Conversion, selective data transition (greenfield, brownfield)

Table 1.2 SAP S/4HANA Deployment Models and Their Impact/Characteristics

Deployment Model	SAP S/4HANA Cloud, Public Edition	SAP S/4HANA Cloud, Private Edition	SAP S/4HANA (On-Premise)
Infrastructure	Shared public cloud, multiple tenants	Dedicated landscape on SAP or hyperscaler cloud (Amazon Web Services [AWS], Microsoft Azure, Google)	Customer data center or hosting by hyperscaler (AWS, Microsoft Azure, Google)
License	SaaS subscription (including RISE with SAP)	PaaS or IaaS software subscription (including RISE with SAP)	Own license own hardware/hardware contract
Upgrades	Managed by SAP, fixed release schedule	Upgrade at least every two years, SAP and customer do upgrade and test	Individual decision, yearly possible by customer, maintenance required, SAP for technical support
Minimum upgrade frequency	Twice per year	Five years to stay in mainstream maintenance	Not limited (maintenance to be considered)
Scope/functionality*	Limited core ERP (not full) and some industries, 42 countries	Same SAP S/4HANA scope as on-premise, 64 countries, 39 languages, 25 industries	Same SAP S/4HANA scope as on-premise, 64 countries, 39 languages, 25 industries
Extensibility**	Within SAP S/4HANA's extensibility framework, embedded custom code, and SAP BTP	In-app key user extensibility, some classic ABAP extensibility, SAP BTP's SAP Extension Suite side-by-side, extension recommendations**	All customization, modification, and extensibility options
Modification	Not allowed	Allowed, but not recommended	Allowed, but not recommended
Configuration	Self-configuration user interfaces (SSCUIs)	Standard IMG with some restrictions	Full IMG
User interface	SAP Fiori launchpad only	SAP Fiori launchpad and other SAP S/4HANA UIs	Any suitable UI

Table 1.2 SAP S/4HANA Deployment Models and Their Impact/Characteristics (Cont.)

Deployment Model	SAP S/4HANA Cloud, Public Edition	SAP S/4HANA Cloud, Private Edition	SAP S/4HANA (On-Premise)
SAP Activate roadmap	SAP Activate methodology for SAP S/4HANA Cloud, public edition	SAP Activate methodology for SAP S/4HANA Cloud, private edition	Transition to SAP S/4HANA
SAP Best Practices	Selected cloud-specific best practices (*https://rapid.sap.com*)	SAP Best Practices (on-premise) with enterprise management layer	All best practices and model companies
SAP standard content activation service	Enterprise management layer included and optional	SAP Best Practices activation included and optional	Not included
Partner add-ons	No add-ons except whitelisted ones	Defined list of qualified add-ons	All add-ons allowed
Partner content/templates	Manual content addition by partners, public cloud templates planned	Partner templates possible	All partner templates possible
Content/project management	Implementation portal for SAP S/4HANA Cloud, public edition	SAP Solution Manager or SAP Cloud ALM	SAP Solution Manager, SAP solution builder tool, SAP standard content activation service
Suitability comment	TM functions very restricted	Good flexibility	Full flexibility, all assets
Required Basis/security support from implementer	Very low/very low	Minimal/full	Full/full
Suitability for TM projects	Very lean shipper/supply chain processes only	Good, full flexibility	Good, full flexibility and own control
* At the time of writing, TM isn't delivered in 39 languages as technically possible, but translated into 29 languages as of SAP S/4HANA 2022: AR, BG, CS, DA, DE, EL, EN, ES, FI, FR, HE, HR, HU, IT, JA, KO, NL, NO, PL, PT, RU, SH, SK, SL, SV, TR, UK, ZH, and ZF (27 languages in the S4FND software component). See SAP Note 3196048 for more information. ** See the following link for more information on what kind of extensibility is allowed and possible on the editions: *http://s-prs.co/v557501*.			

Table 1.2 SAP S/4HANA Deployment Models and Their Impact/Characteristics (Cont.)

Deployment-Related Focus of this Book

In this book, we don't explain TM options for SAP S/4HANA Cloud, public edition, as this is only available with a very limited functional footprint starting from SAP S/4HANA Cloud, public edition version 1811, which is still valid in SAP S/4HANA Cloud, public edition version 2211. Scope-wise, it can't be compared to the on-premise and private cloud versions described in this chapter. However, this may change in the coming years.

1.2.4 TM Deployment and Integration Options

As mentioned in previous sections, TM is available as part of SAP S/4HANA 2022. However, you have several options to deploy the system in an in-stack or extra-stack deployment model. The *in-stack* or *embedded* model refers to TM using the same system components as the SAP S/4HANA main ERP instance; that is, TM is an integral part of the SAP S/4HANA system. The *extra-stack* or *decentralized* model refers to an extra SAP S/4HANA instance that is operated side-by-side with the central SAP S/4HANA ERP system. It may operate TM alone, but also be home of, for example, extended warehouse management (EWM), SAP Yard Logistics, or SAP Event Management. In Figure 1.6, you can see the resulting deployment options:

❶ TM in SAP S/4HANA can run in-stack as an integral part together with other embedded components (logistics, finance) on a single instance. This option has the most benefits in terms of common master data and processes.

❷ TM in SAP S/4HANA can run extra-stack as an independent, decentralized instance connected to another SAP S/4HANA instance for logistics, sales, and finance, for example. This could be the preferred option if a business needs to have transportation up and running independent of other processes (for example, finance). Joint operation of the decentralized TM with other components (e.g., EWM) may be sensible for performance reasons.

❸ TM in SAP S/4HANA can run extra-stack as an independent, decentralized instance connected to an SAP Business Suite instance for logistics, sales, and finance, for example. This could be an option, for example, during a migration process.

If TM is deployed and used as an integral part of SAP S/4HANA, it's fully integrated with the internal components for sales, procurement, shipping, billing, inventory, product safety, and warehousing. In addition, an external integration is available to SAP Global Trade Services (SAP GTS), SAP Event Management, and cloud components such as SAP Analytics Cloud and SAP Business Network. However, integration to an external SAP S/4HANA or SAP ERP system requires the use of feature pack stack (FPS) levels for SAP S/4HANA or enhancement packs (EHPs) for SAP ERP.

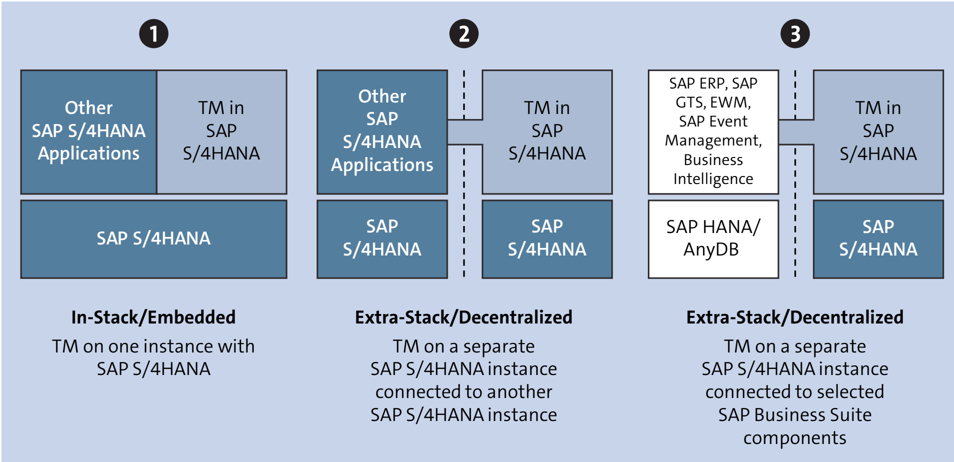


Figure 1.6 Deployment Options for the In-Stack and Extra-Stack Models of TM

The integration of TM into the SAP S/4HANA stack allows joint data to be directly processed with some fundamental business applications, such as sales, shipping, and procurement. By removing the cross-system data exchange, the workload for communication, monitoring, and data synchronization can be significantly reduced. Beyond making full use of SAP S/4HANA features, there are some architectural simplifications to consider, as a lot of process synchronizations can be omitted now:

- In settlement, no A2A messages are required because the charge calculation/settlement and billing/invoicing happens in one system.
- The billing processes now have direct access to required logistics context data.
- Replication of organizational master data is no longer required. TM uses the SAP S/4HANA business partner instead of receiving a copy of customer and vendor via the Core Interface (CIF).
- Product data is no longer replicated because TM uses the SAP S/4HANA product definitions.
- Joint master data can also be used for integration with other modules, such as dangerous goods (DG) management.
- Sales orders, purchase orders, and deliveries don't need to be replicated to TM but can be used directly for the transportation process.
- Joint use of different application areas for data retrieval is possible in core data services (CDS) for business logic, analytics, search processes, and so on.

1.3 RISE with SAP and Its Components

RISE with SAP is an offering that combines various component groups based on structure and content. For example, shortly after the release of RISE with SAP, the scope of the business process transformation component has already changed enormously due to the acquisition of Signavio (now called SAP Signavio). As of the time of writing, the RISE with SAP offering includes the following basic components:

- **SAP S/4HANA Cloud editions**
  RISE with SAP is SAP's central initiative to bring the enterprise management of its existing and new customers to the cloud. For this reason, SAP's cloud ERP is the central component of the RISE with SAP offering. The customer can decide which cloud variant (public or private) discussed in Section 1.2.3 is applied (as described, only the private cloud has a feasible TM scope). The on-premise variant isn't part of the RISE with SAP offering; that is, to use RISE with SAP, customers would have to transfer to at least the private cloud. Likewise, the RISE with SAP offering is also not available as a supplement to on-premise licenses.
- **Tools and services for technical migration**
  The RISE with SAP tools and services for migration allow a smooth transition from an existing SAP NetWeaver–based SAP system to the SAP S/4HANA world. In Chapter 13, you'll read more about system migration, especially with a focus on TM.
- **SAP Business Technology Platform (SAP BTP)**
  SAP BTP offers PaaS-based services providing enhanced integration, development capabilities, analytics, AI, and others. You can read more on SAP BTP in Section 1.3.1.
- **Business process transformation**
  SAP's business process transformation portfolio consolidates features to streamline the business processes. We'll describe more details in Section 1.3.2.
- **SAP Business Network starter pack for SAP S/4HANA**
  The SAP networks offer an integration to the networking services offered by SAP. You can find additional details in Section 1.3.3.

RISE with SAP offers a complete set of tools and services for process optimization during and after an SAP S/4HANA implementation through the following capabilities: process screening, process analysis and process mining, process modeling, workflow execution, and advanced process collaboration functions.

1.3.1 SAP Business Technology Platform

To deliver a complete cloud ERP architecture, SAP BTP offers technologies, integration, and analytics that are outside of a typical ERP scope, but still need to be well integrated. Cloud ERP initiatives have often led to unsatisfying results in the past. This was typically because the corresponding sidecar PaaS platforms weren't used for the implementation of the differentiating processes, and the cloud ERP architecture was incomplete or misaligned. Concerning SAP, the implementing customers weren't the only ones to be blamed for not using the right elements in the correct fashion due to a lack of understanding or for cost reasons; SAP sales often failed to offer SAP BTP appropriately.

SAP has now eliminated this flaw by delivering SAP BTP as standard with the RISE with SAP offering. You as customer have many advantages due to this packaging. SAP BTP contains five major technological elements that help to boost the integrative, analytical, and technology-based aspects of your business systems:

- **Application development and automation**
  The differentiation of the customer finds a suitable home here for cloud implementation. SAP BTP provides no-code, low-code, and full-stack development environments, which optimally support the creation and operation of customer-specific programming. Drag-and-drop program and business automation with prebuilt workflows are available and can be used for robotic process automation (RPA), also in conjunction with chatbots. Industry-related content enables faster process adaption.
- **Extended planning and analysis**
  SAP BTP offers extensive planning capabilities that can be utilized across lines of business. Where you have a concentration of organizations on an SAP S/4HANA instance (client), SAP BTP can consolidate information from multiple sources, simulate plans, and evaluate with a larger scope. Planning mechanisms and ability to report back into the originating systems are available for supply chain, financial, workforce, and sales planning.
- **Data and analytics**
  SAP BTP allows you to maximize the value of data and its content in order to make more educated and global decisions. With the variety of evaluation mechanisms and visualizations, you can gain extended insight into dependency and the true background of your data. The analytic solutions span SAP Analytics Cloud, SAP HANA Cloud, SAP Data Warehouse Cloud, SAP Data Intelligence, and SAP Master Data Governance to improve the quality of your data.
- **Integration**
  With more than 2,000 prebuilt integration packages and over 170 connectors into third-party systems, SAP BTP is the integration platform of SAP's cloud ERP system. It allows you to integrate to internal systems or the cloud as well as worldwide partners by using prebuilt industry specifications and getting up to speed quickly with knowledge-based mapping and integration support. The Integration Advisor helps you instantiate a successful integration based on previously gathered knowledge of any integrating party. SAP Event Mesh allows you to react to a large variety of events coming from your SAP systems or third-party solutions.
- **AI**
  SAP BTP includes ready-to-use and business-specific models, which can be used for your own business evaluations. You can either use these models with your own systems, data, and processes or build chatbots using the AI capabilities, which interact with any using parties and your internal systems. The AI tools provide a whole lifecycle management for the algorithms used within your implementation.

For SAP BTP, there are three consumption models:

- **Pay-as-you-go**
  This model allows you to consume small amounts of services and can be used for projects and percentage of completion (POC) progress without entering long-term commitments.
- **Cloud Platform Enterprise Agreements (CPEAs)**
  This model allows customers with well-planned use cases to flexibly consume the different service offerings of SAP BTP without worrying too much about usage and cost.
- **Subscription-based consumption**
  This model enables you to run particular cloud services independently of actual usage. This may be very helpful if you have an established use case and don't want to worry about any cost-related scaling.

1.3.2 Business Process Transformation

SAP bundles its process optimization portfolio under this umbrella term. This area is to be seen as a reaction to the fact that SAP S/4HANA implementations in the years up to 2020 were often carried out as pure IT projects, often neglecting improvements on the process side.

Successful business transformation requires a sound understanding of weaknesses, comprehensive process analysis, industry benchmarking, process redesign, smooth collaboration between all stakeholders, and many more steps. As the latest discipline in SAP's strategy, the company did not wait to build a complete solution suite itself, but rather completed the existing assets of SAP for the business process transformation offering through the acquisition and integration of the business process management specialist Signavio and its complete portfolio. As mentioned previously, it was included as a component in RISE with SAP.

Business process transformation with SAP Signavio is the first solution that consolidates all these components in a unified solution package. It combines in-depth process analysis with the tools needed for process reengineering or developing completely new and innovative business processes. It covers business process design, benchmarking, gap analysis, improvement, and process change management.

1.3.3 SAP Business Network Applications

The SAP Business Network starter pack for SAP S/4HANA extends business process transformation beyond your four walls. It improves integration into the processes of your business partners and helps to create dynamic, digital connections with trading partners.

The network economy, in which products and services add great value by operating within networks, is one of the major economic trends of this decade. As part of RISE with SAP, the SAP Business Network starter pack for SAP S/4HANA is designed to deliver value for SAP S/4HANA transformations by integrating the network approach and providing a jump start for entering the network economy. To this end, RISE with SAP includes limited versions of three existing SAP network solutions:

- **SAP Business Network for Procurement**
  SAP Ariba provides the digital connection between buyers and sellers within a network to enable fast, accurate, and integrated transactions. SAP Ariba is therefore the foundation for companies that want to digitize their purchasing and supply chains. The starter pack is limited to 2,000 purchase orders and invoices, as well as an ERP connection.
- **SAP Business Network for Logistics**
  SAP Business Network for Logistics is an open multicapability platform that connects different partners for inter-company logistics collaboration and insights. In close integration with SAP S/4HANA, it enables users to jointly manage logistics transactions and gain insights across the entire value chain. Here too, in addition to the basic functionalities included in RISE with SAP, there is the option of upgrading to the full scope. SAP Business Network for Logistics plays a major part in transportation, when it comes to collaboration with LSPs.
- **SAP Business Network for Asset Management**
  Like all components of the SAP Business Network starter pack for SAP S/4HANA, SAP Business Network for Asset Management is cloud-based and serves as a network for asset and machine manufacturers, customers, operators and service providers; as a global register of assets, machines, and tools; and as a collaborative platform for operation, maintenance, and lifecycle management of the assets. Restrictions within the starter pack include a limit of 200 assets, 2 member connections, and 10 portal connections.

1.4 TM as Part of SAP S/4HANA

As the main component used to coordinate both shipper-focused and LSP-focused transportation processes, TM started as a standalone SAP Business Suite application that was integrated to one or multiple separate SAP ERP systems via integration technology (CIF). In addition, other related components, such as compliance tools, could become part of the TM instance or run side by side.

With the availability of SAP S/4HANA, the market required TM as an integral part of the SAP S/4HANA products to achieve a tighter integration into the master data, logistics and financial processes, and digital core. In addition, as SAP S/4HANA is SAP's long-term strategic enterprise software, all components should be available as embedded parts of the suite or as integrated products to comply with maintenance regulations. As of the time of writing, SAP Business Suite products in logistics are guaranteed to be maintained until 2027. Afterward, only logistics products and components of SAP S/4HANA are planned to receive further release upgrades and feature packs.

Based on these strategic decisions, TM is now available on three platforms:

- **TM in SAP S/4HANA (release 2022)**
  TM was initially released as part of SAP S/4HANA release 1709 with a scope limited to shipper-related processes; that is, LSP functionalities such as customer ordering and charging weren't available. This changed with SAP S/4HANA release 1809, which achieved mostly functional parity with the SAP Business Suite–based release of SAP TM 9.6. Later, SAP S/4HANA releases extended the TM functional scope to a level that we'll describe as the main content of this book.
- **SAP TM 9.6 (SAP Business Suite and SAP NetWeaver)**
  SAP TM in SAP Business Suite/based on SAP NetWeaver has been functionally enhanced since SAP TM 8.0 and was released up to version SAP TM 9.6. It's only delivered in exceptional cases, as it's not SAP's mainstream transportation product and will run out of maintenance in 2027. Therefore, we won't describe any specific functionalities of SAP TM 9.6.
- **TM in SAP S/4HANA Cloud, public edition (release 2211)**
  As previously mentioned (refer to Table 1.2), TM is available as a public cloud application. However, it has a very limited scope compared to TM in SAP S/4HANA release 2022. The main scope of TM in the public cloud includes the creation of freight orders, planning of those orders in an external instance, and getting the planning result back into TM for further tendering, execution, and settlement. Individual processes, master data, and configuration-based process variants can't be defined in the current version. Therefore, we won't explain any details of the solution in this book.

In this section, both TM and SAP S/4HANA features are introduced. We'll also discuss relevant components from both SAP S/4HANA and SAP Business Suite that can be integrated with TM in SAP S/4HANA. We'll finally conclude with a functional overview of TM.

TM in SAP S/4HANA versus SAP TM 9.6

As we've discussed, TM can be used either as part of SAP S/4HANA or side by side with SAP Business Suite. In this book, we'll use SAP S/4HANA as our base system. However, because TM works in nearly the same way for both systems, SAP TM 9.6 users should be able to follow along as well. However, we won't highlight the functional or menu-related differences between the systems but instead concentrate on TM in SAP S/4HANA.

1.4.1 SAP Transportation Management

As a functional component, TM already has a long history within SAP logistics systems and components. Shipper-focused solutions have been provided to large, worldwide operating customers since 1987, when the mainframe system SAP R/2 was released with a module called RT, which allowed the organization of multimodal transports. Its successor on the well-established ERP system SAP R/3 was the Transportation component of Logistics Execution (LE-TRA), which was started in 1993 and released with SAP R/3 3.0 in 1995. Functionally enhanced in the following releases, it grew into a comprehensive solution for shippers to manage their transportation requirements, including cost calculation and settlement. Although still widely used in a large community of manufacturing and trading companies, LE-TRA has been overtaken in functional richness and integration capabilities by TM. Figure 1.7 displays the history of SAP's transportation software and its UIs.

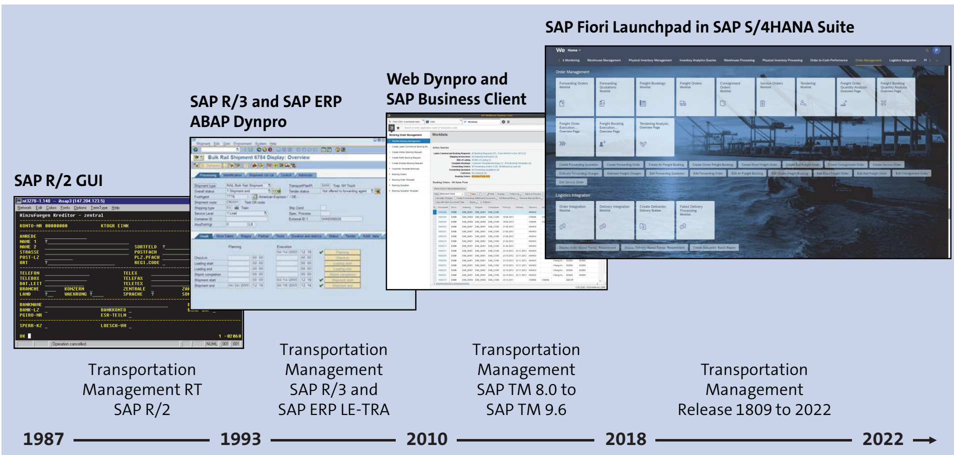


Figure 1.7 History of SAP Transportation Components

After a first start in 2007, which showed that the overall architecture of TM should be simplified, the software was relaunched in 2010 as SAP TM 8.0. It was mainly focused on shipper processes but also allowed forwarding by road transportation. In SAP TM 8.1, the functionality for ocean freight forwarding (full container load [FCL] and less than container load [LCL]) was added, opening the door into the LSP market. This was extended with SAP TM 9.0 into air freight forwarding. SAP TM 9.1 was further developed to focus on rail quote-to-cash processes, providing many railway-specific features and master data entities. With the success and availability of SAP S/4HANA, TM was integrated into this innovative platform in 2017. First, the shipper functionalities were released with SAP S/4HANA 1709, followed by the LSP-specific process features in release 1809. In parallel, SAP TM 9.5 and later 9.6 were provided as standalone releases based on SAP Business Suite. Ongoing development was then concentrated on later SAP S/4HANA releases up to 2022, which is described in this book.

Scope Overview

When it comes to transportation, cargo, and freight, TM is the main component of SAP S/4HANA. Even if it wasn't foreseen as such, it has taken over this role from the previous ERP transportation component LE-TRA. TM is set to deliver the foundation for all mainstream processes and activities in the transportation area. As outlined in the introduction chapter, TM functionalities can be used in various business situations:

- Transportation and logistics for shippers is tightly integrated to their sales, procurement, production, and logistics processes.
- Transportation management for freight forwarders enables them to process and manage end-to-end customer transportation orders and with support of multiple partners.
- Transportation management for carriers allows them to efficiently make use of their capacities and manage its use by shipper and forwarder bookings.
- Transportation management for contract LSPs, allows them to offer transportation services in close collaboration with warehousing and sales-related services.

We provide a more in-depth functional overview of TM in Section 1.4.7. As a high-level overview, you can see the functional building blocks of TM in Figure 1.8. To give you more orientation, we added the numbers of the related chapters inside the figure.

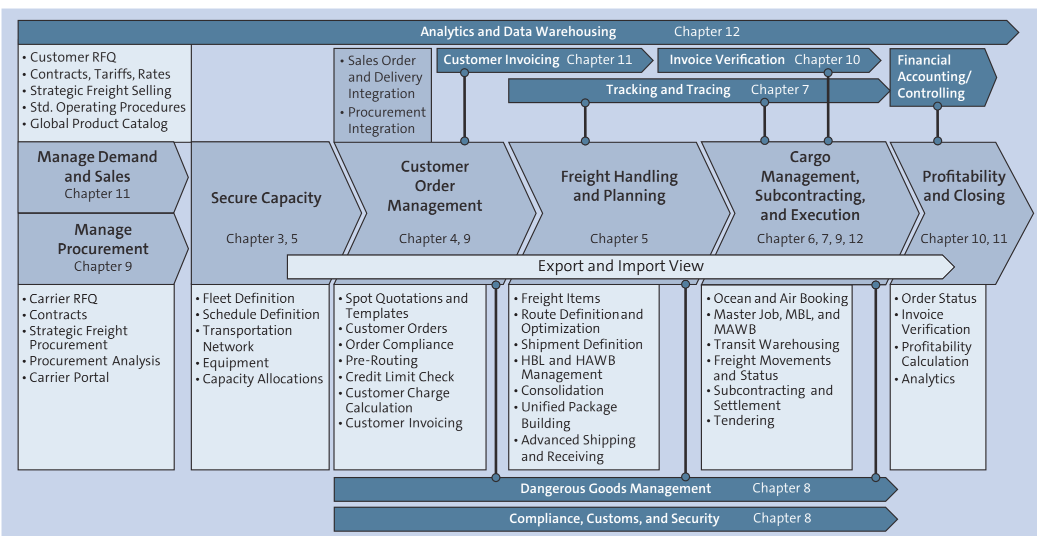


Figure 1.8 Scope Overview of TM

Following are the main functional building blocks of TM:

- Demand and sales deals are managed with the creation of customer sales prices, contracts, product catalogs, and standard operating procedures. This is mainly an LSP functional block.

- Managing procurement allows you to handle carrier contracts and price definitions.
- Securing capacity allows you to define the network and its resources/equipment, including availability and allocations.
- Customer order management is a functional block mainly used by LSP to handle transportation orders from external customers. This includes early routing decisions, compliance checks, and charge calculations for customer invoices. Customer order management is also the integration point for the ERP processes in sales and procurement, where sales orders, deliveries, purchase orders, and stock transfers are creating transportation demand.
- Freight handling and planning allows you to define units of freight that are planned to be moved through your network. They can be packaged, aligned with warehouse handling, and consolidated into logical groups (house bills).
- Cargo management, subcontracting, and execution supports handling of master jobs and master freight bills, alignment with warehousing and dock activities, subcontracting of trips, execution activities, and supplier charge calculation.
- DG management and compliance management support the integration of TM processes with various legal regulations.
- Customer invoicing and invoice verification allow you to execute settlement activities with customers and vendors.
- Tracking and tracing support automated checking of the execution status of cargo.
- Analytics and data warehousing give you information on all aspects of the transportation business.

Basic and Advanced Shipping in Transportation

As transportation functionality was moved into SAP S/4HANA, there was the need for synchronization with the scope of transportation that was provided to customers using traditional LE-TRA (the SAP ERP transportation management for shippers). The usage right for LE-TRA customers has been extended until end of 2030 (see SAP Note 2269324). However, in terms of compatibility and usage right equality, the decision was made to define a two-level scope for TM functionality:

- **Transportation management (formerly known as basic shipping)**
  The basic version of transportation management contains all semantic functions that have already been part of LE-TRA and are now available in a comparable way to be used by customers as part of TM in SAP S/4HANA. The transportation management/basic shipping scope is part of the SAP S/4HANA license and can be used by all users. However, enhanced or engine-based functions aren't part of this scope.
- **Advanced transportation management (formerly known as advanced shipping)**
  Advanced transportation management describes the full scope of TM either for an extended utilization by shippers or an end-to-end LSP operation. The advanced transportation management scope requires a specific license and isn't included in the standard SAP S/4HANA license.

Table 1.3 lists the specific features of TM with the leftmost column showing the TM functions. In the Relevance column, you find the applicability of the function for a shipper or a LSP running a transportation management system. The Availability column marks whether a function is part of the transportation management or advanced transportation management scope in SAP S/4HANA. The legend for Table 1.3 is as follows: ● function is used or available in particular TM scope, ◉ function is used and only partially available in particular TM scope. SAP Business Network for Logistics references the availability of the function as part of SAP Business Network for Logistics (see Chapter 12, Section 12.6). For exact scope definitions, refer to SAP Note 3065464, which has an attached list of the basic versus advanced scope.

	Relevance		Availability	
TM Function	**Shipper**	**LSP**	**Transportation Management**	**Advanced Transportation Management**
Organizational master data	●	●	●	●
Business partner master data (customers, vendors, carriers, etc.)	●	●	●	●
Network master data	●	●	◉	●
Resource master data		●	◉	●
Commodity master data	●	●	●	●
Service product catalog		●		●
Customer contract definition		●		●
Sales rate and tariff definition		●		●
Customer contract negotiation		●		●

Table 1.3 TMS Functions Used by Shippers/LSPs and Their Availability in TM and Advanced TM in SAP S/4HANA

	Relevance		Availability	
Carrier/vendor contract definition	●	●	●	●
Buying rate and tariff definition	●	●	●	●
Carrier/vendor contract negotiation	●	●		●
Customer quoting (forwarding quotation)		●		●
Customer orders (forwarding order)		●		●
Sales order/ purchase order integration (ERP)	●			●
Delivery integration (ERP)	●		●	●
Complex sales and distribution processes (e.g., schedule lines, rescheduling, split, goods receipt/goods issue)	●			●
Global trade integration	●	●		●
DG management integration	●	●	●	●
Customer/sales order routing	●	●	●	●

Table 1.3 TMS Functions Used by Shippers/LSPs and Their Availability in TM and Advanced TM in SAP S/4HANA (Cont.)

	Relevance		Availability	
Customer order pricing	●	●		●
Customer invoicing		●		●
Freight unit and shipment definition	●	●	●	●
Capacity and schedule definition	●	●		●
Transportation dispatching for sales orders	●	●		●
Transportation dispatching for deliveries	●	●	●	●
Transportation planning for customer orders		●		●
Unified package building	●	●		●
Advanced shipping and receiving	●	●	○	●
Consolidation of inbound and outbound load	●	●		●
Manual transportation planning	●	●	○	●
Embedded scheduling strategy	●	●	●	●

Table 1.3 TMS Functions Used by Shippers/LSPs and Their Availability in TM and Advanced TM in SAP S/4HANA (Cont.)

	Relevance		Availability	
Optimized transportation planning, scheduling, and strategies/proposals/maps/Gantt charts	●	●		●
Load planning and automated pallet building	●	●		●
Driver management		●		●
Service order management		●		●
Sea-, air-, rail-specific mode capabilities	●	●		●
Freight management for sales orders	●		●	●
Freight management for customer orders		●		●
Automatic carrier selection and ranking	●	●		●
Carrier tendering	●	●	○	●
Carrier collaboration portal/SAP Business Network Freight Collaboration	●	●	●/ SAP Business Network for Logistics	●/ SAP Business Network for Logistics

Table 1.3 TMS Functions Used by Shippers/LSPs and Their Availability in TM and Advanced TM in SAP S/4HANA (Cont.)

	Relevance		Availability	
Freight management costing for carriers	●	●	●	●
Cost distribution	●	●	●	●
Freight management invoice verification	●	●	●	●
Profitability calculation		●		●
Track and trace of shipments	●	●		●
Group logistics management	●			●
Warehouse management	●	●		●
Transit warehousing		●		●

Table 1.3 TMS Functions Used by Shippers/LSPs and Their Availability in TM and Advanced TM in SAP S/4HANA (Cont.)

1.4.2 SAP S/4HANA Enterprise Management

The enterprise management layer of SAP S/4HANA incorporates a variety of components that are directly or indirectly related to logistics and transportation processes. Note that many of these processes are also available as part of SAP ERP.

Sales

The sales components encompass a range of functions dealing with pricing and selling tangible goods and services for shippers. These components are used a lot in manufacturing and trading industries to manage the complete sales process of goods to customers. The following are typical tasks handled in the sales process:

- Managing quotations and sales orders
- Conducting availability checks for goods and materials managed in sales orders
- Creating scheduling agreements
- Managing credit limit and risk management in association with sales orders

- Determining sales price and creating invoices (billing document)
- Managing trade compliance for shippers
- Managing stock transfers within a shipper's organization (outbound aspects)
- Integrating with inventory management

The sales order is typically the source of outbound transportation demand for shippers, which is processed in TM components either at the shipper's premises (transportation department) or at an LSP. In combination with TM, you can collectively do transportation planning for sales orders, allowing you to consolidate one or multiple orders in one shipment or split an order into multiple shipments. You also can jointly plan orders from different systems or clients. Tendering, subcontracting, and executing in TM are possible based on orders prior to delivery creation. You can find further details on order integration with TM in Chapter 4, Section 4.1.

Order management is also used in combination with TM to do customer invoicing. Because TM can create draft or pro forma invoices but doesn't have an invoice settlement functionality, the SAP S/4HANA functions for billing and integration into financials are used. You can find details about this integration in Chapter 10 and Chapter 11.

Supply Chain

The supply chain in SAP S/4HANA comprises deliveries, warehousing, and basic/advanced transportation management. The transportation demand generated by these processes is already prescheduled and detailed to some extent. Supply chain functionality is typically used to handle the following tasks:

- Centralized and decentralized warehouse management that includes task and resource management, if large or more complicated warehouses are used (requires extra license and isn't included in SAP S/4HANA license)
- Stock room management, if simple or small warehouses are used (license included in the SAP S/4HANA license)
- SAP Yard Logistics to manage large or complicated external yards with rail ramps, berths, or other access mechanisms
- Delivery preparation and documentation
- Goods issue and goods receipt processing
- Transport organization and documentation
- Direct store delivery management
- Handling unit (HU) management
- Package building with a unified approach spanning EWM, TM, and the broader ERP system
- Advanced shipping and receiving (ASR) to tighten link supply chain activities between the ERP system, EWM, and TM

- Handling of inbound deliveries, including goods receipt processes
- Returns management for deliveries and orders

The former shipping and transportation functionality of SAP ERP, which was provided in the LE-TRA component, stays in SAP S/4HANA only for compatibility reasons. It's not SAP S/4HANA–enabled and will be running out of maintenance in 2027 and not used anymore from 2030. It's completely replaced by the basic transportation management scope of TM.

Materials Management

The focus of this component is procurement and inventory management of tangible goods, services, and materials for sale or for use in production processes. The following are typical processes handled with materials management:

- Purchasing requests and purchase order processing
- Inventory management of materials and products, including material evaluation for accounting and material price management
- Invoice verification for invoices related to goods and service delivery
- Self-billing process support (evaluated receipts settlement [ERS])
- Stock taking and stock correction
- Management of material master data
- Supplier returns management
- Managing stock transfers within a shipper's organization (inbound aspects)

The processes for purchasing, inbound delivery handling, and returns management provide a purchase order and inbound delivery–based integration to TM. As mentioned before, TM creates only draft invoices. For settling supplier invoices, materials management provides invoice verification and self-billing capabilities, which also integrate into the financial components. You can find details about TM supplier draft invoice integration in Section 10.1.3.

Asset Management

Asset management is used to manage master data for equipment and to plan, organize, and monitor maintenance of all equipment required to sustain a company's operations (in many cases, production machinery and equipment). For transportation, this is related to transportation equipment, such as trucks, trailers, containers, and railcars. TM provided an integration for transportation equipment in SAP TM 9.6. In SAP S/4HANA however, this connection hasn't been reestablished so far. This is one of the still open integration points, which will probably be done in a future SAP S/4HANA release.

Asset management is responsible for managing the master data and maintenance plan of the equipment, whereas TM would be responsible for its active planning and utilization within the transportation processes. When equipment needs maintenance, it should be removed from transportation plans.

Financials

Financial accounting and controlling are still a major part of each SAP S/4HANA core system and are used to integrate the monetary flow related to transportation. There are processes related to incoming vendor invoices from subcontracted service providers and carriers and, for LSPs, also customer invoices and internal invoices to be settled. An integration to profitability analysis allows you to evaluate which cost and/or revenue has been achieved for transportation-related processes (e.g., what was the cost for container demurrage on the trade lane to South America last year).

1.4.3 SAP S/4HANA Products

Besides the SAP S/4HANA Enterprise Management components mentioned previously, SAP S/4HANA offers a lot of additional functionality via SAP S/4HANA products discussed in the following sections.

Product Safety and Stewardship and Product Compliance

Regarding DG management, SAP offers two components to handle related processes in TM. Product safety and stewardship (PS&S) functionality in SAP S/4HANA can be seen as the main companion of TM. It works in SAP S/4HANA, as well as SAP ERP. You usually use it for DG activities in transportation. PS&S allows DG checks and many other processes around dangerous and hazardous goods management. We look at PS&S and its use in connection with TM in more detail in Chapter 8, Section 8.3.

SAP S/4HANA for product compliance is only available in SAP S/4HANA. It's a new software product based on SAP Fiori and has evolved to have comparable features as PS&S. However, it's not yet fully supported with TM, and it's not recommended to be used for DG management for transportation.

SAP Global Trade Services

SAP GTS is part of SAP governance, risk, and compliance (GRC) solutions. It covers a wide range of trade compliance checks and processes that must be handled in transportation. Due to increasing legal regulation and security checks, transportation has gotten more and more complex from the view of exporting from and importing into countries. Because trade compliance is mostly handled under the responsibility of local governments or groups of countries, the processes and requirements for proper export and import declarations are highly diverse. This is also one of the main reasons why SAP GTS is still mainly available in a side-by-side approach to SAP S/4HANA. Due to many changing legal requirements and related upgrades, having SAP GTS inside the core system may lead to many updates in customer landscapes. SAP GTS supports TM in the order management area, where functionality for general trade compliance and blacklist screening are provided. Furthermore, the shipment process is supported with export and import compliance as well as transit operations.

In SAP S/4HANA, you also find functionality called *SAP S/4HANA for international trade*, which offers a part of the functionality that SAP GTS provides. However, the main scope is on a legal procedure called Intrastat. We'll describe the functionality and difference in more detail in Chapter 8, Section 8.1.

Extended Warehouse Management and Stock Room Management

Warehouse management is a very common functionality for both shippers and LSPs. Many shippers operate one or more smaller or larger warehouses to store and distribute production supplies and finished goods to be reused or shipped to their customers. In the logistics service industry, warehouses can be used in various ways:

- A contract logistics warehouse to keep the inventory for a business partner for whom the LSP takes over the logistics processes
- A transit warehouse (hub) to cross-dock cargo between different vehicles or means of transport without intermediate storage
- A consolidation warehouse (e.g., container freight station [CFS]) where cargo is collected and then consolidated into a HU or larger transportation unit, which is then moved to an intermediate destination for deconsolidation

SAP Extended Warehouse Management (SAP EWM) is a warehouse management system with a rich spectrum of warehouse and material handling functionality. It's available based on SAP S/4HANA and SAP Business Suite and, in SAP S/4HANA, can be implemented in an embedded or decentralized approach. Besides pure warehouse inventory management, there is plenty of support for the following functional areas:

- Yard management (a yard as extension to a warehouse)
- Unloading and goods receipt handling
- Loading and goods issue handling
- Quality management and DG handling
- Consolidation of goods into HUs and transportation units
- Deconsolidation of transportation units and HUs
- Picking and putaway
- Shift and workforce planning
- Warehouse automation with material flow systems (MFS) or robotic picking and putaway (e.g., automated high rack storage areas)
- Value-added services and kitting

- Provisioning and loading
- Bonded storage operation

SAP EWM is fully integrated into the logistics processes of SAP S/4HANA, SAP ERP, and TM. In Chapter 12, Section 12.2, you can find more details on the integration of extended warehouse management (EWM) functionality, SAP S/4HANA, and TM.

Besides the powerful SAP EWM, which required a dedicated license to use, SAP S/4HANA also offers stockroom management as a warehousing functionality, which doesn't need separate licensing (comparable to the basic transportation management). Stockroom management provides capabilities to run small warehouses without any sophisticated processes or automation.

SAP Yard Logistics

SAP Yard Logistics, which we already mentioned in Section 1.4.2, is used to manage large or complicate external yards. Compared to the yard management included in SAP EWM, which is mainly used as an "outdoor" extension of a conventional warehouse, SAP Yard Logistics allows you to manage huge yards, which may include rail ramps, vessel berths, car manufacturers finished vehicle parking lots, bulk yards, or airport and container terminal yards. On the yard, many different resources, access paths, resource planning, and check-in/check-out support applications, as well as mobile apps, can be used. SAP Yard Logistics is directly integrated with TM. You can find more details on SAP Yard Logistics in Chapter 12, Section 12.5.

SAP Event Management

SAP Event Management is a versatile tracking and tracing tool that connects to multiple SAP Business Suite components to provide visibility of business processes and object statuses. Furthermore, SAP Event Management allows automated process control for intentional reactions to events and status messages or responses for unexpected events or missing milestone reporting.

SAP Event Management provides process tracking and control information that matches the processes in TM for shipment status tracking, consolidation status tracking, equipment tracking, and operational instruction tracking. Bidirectional integration between TM and SAP Event Management means that TM sends process and milestone information to SAP Event Management, which then tracks the process execution and compliance based on information and reporting received from inside or outside the company. Then SAP Event Management posts information back to TM to update the transportation processes. You can find details on SAP Event Management and its integration with TM in Chapter 7, Section 7.2.

SAP Billing and Revenue Innovation Management

SAP Billing and Revenue Innovation Management has been consolidated out of multiple components that were previously promoted separately:

- **SAP Convergent Charging**
  A high-speed price calculation engine that allows event-based pricing (formerly known as Highdeal software).
- **SAP Convergent Invoicing**
  An extremely flexible customer billing solution that offers billing control by multiple customer profiles (contract accounts). Billing can be driven by events. Grouping of billing items into final invoices is rule based.
- **Financial contract accounting**
  A subledger accounting system that offers very flexible accounting implementations and the ability to integrate into accounts receivable as a general ledger.
- **Financial customer care**
  Scenario that allows you to dispute parts of invoices. It also helps you manage your receivables and collections and perform cashiering (in logistics businesses, many orders still must be prepaid in cash before the cargo is moved).

SAP Billing and Revenue Innovation Management has been integrated with TM based on custom development projects. We explain SAP Billing and Revenue Innovation Management in more detail in Chapter 11, Section 11.4.

1.4.4 SAP Business Network Global Track and Trace

As logistics was expanding into cloud-based offerings, SAP picked the easy win areas to offer public cloud-based logistics technology to its customers on a SaaS or PaaS basis. SAP Business Network Global Track and Trace was one of the first transportation-related services. Released in 2018 as a new tool for collaborative process tracking, it was designed for parties engaging in visibility for a joint logistics process in the public cloud. The first releases were limited to scenarios driven out of SAP S/4HANA, but this was extended with every quarterly released upgrade.

SAP Business Network Global Track and Trace allows joint access and scenario usage. The event processing, visualization, and process handling capabilities are provided for all related and registered parties. The implemented scenarios don't just represent the view of one company anymore (i.e., the process owner) but a common view on a scenario where all relevant companies can view and contribute.

1.4.5 SAP Business Network for Logistics

SAP developed SAP Business Network for Logistics as a public cloud offering and as an alternative to the TM collaboration portal. It encompasses much of the functionality of the TM integrated collaboration portal, as well as integration into other supply chain planning and tracking and tracing features. SAP Business Network for Logistics is an overarching application that helps end-to-end supply chain processes with many players in controlling their integrated supply chain processes.

1.4.6 Components for SAP Business Suite

As SAP Business Suite is kind of a predecessor of SAP S/4HANA, many components linked to TM are also available within this system. TM can be operated side by side with components and subcomponents of SAP Business Suite. For a comprehensive installation, TM is typically connected to the following components:

- SAP ERP with Financial Accounting and Controlling (FI-CO), Logistics General (LO), Sales and Distribution (SD), Logistics Execution (LE), Materials Management (MM), and Plant Maintenance (PM)
- SAP Environment, Health, and Safety (EHS) Management as an integral part of the SAP Supply Chain Management (SAP SCM) Basis layer
- SAP GTS as part of the SAP GRC solutions
- SAP EWM
- SAP Event Management

Due to the installation requirements—sales and logistics processes on one side and transportation processes on the other—process steps always happen in one of two different environments, which leads to additional master and transactional data exchange. Based on SAP ERP sales orders or purchase orders and delivery data, a corresponding transportation demand will be represented in TM (for details, see Chapter 4, Section 4.1).

Drawback of Former SAP ERP Transportation Solutions (LE-TRA)

Of the multiple (older) transportation solutions in SAP Business Suite, the shipment component in LE was created as an integral part of a shipper's outbound or inbound process and has been used intensively by thousands of SAP ERP customers for more than 20 years. Although it offers comprehensive functionality, the following limitations make it too inflexible to address general transportation needs or to be the foundation of a complete transportation suite and platform:

- Shipped goods are dependent on material master data, which you need to create deliveries (an LSP usually doesn't have this master data of shipped goods).
- No joint inbound and outbound moves can be handled (either outbound delivery shipment or inbound pickup shipments).
- Shipment demands from multiple SAP ERP systems or clients can't be managed in a centralized way based on LE-TRA because reference documents (e.g., deliveries) are required, and they aren't available from other systems.
- There is no order management to support selling and billing of transportation services (i.e., LE-TRA isn't easily usable for LSPs).

1.4.7 Functional Overview of TM

We now want to take a closer look at TM's overall mode of operation, without going into too much detail yet. In a first step, we introduce the main business objects of TM, as their name will appear throughout all following descriptions. Table 1.4 lists the business object naming, commonly used abbreviations, and definitions.

Business Object	Abbreviation	Definition/Description
Order-based transportation requirement	OTR	An order object representing the transportation demand from sales orders, purchase orders, returns or stock transfer orders in SAP S/4HANA.
Sales order, purchase order, stock transfer order	SO, PO, STO	SAP S/4HANA order objects representing sales, procurement or transfer of goods and the related transportation demand. These objects are usually used in shipper scenarios only.
Delivery-based transportation requirement	DTR	An order object representing the transportation demand from an inbound or outbound delivery in SAP S/4HANA.
Inbound delivery, outbound delivery	IDL, ODL	SAP S/4HANA objects representing inbound or outbound deliveries and the related transportation demand predominantly in shipper scenarios.
Forwarding quotation	FWQ	An offer from a carrier or LSP to an ordering party for the transportation of goods, which contains information about the price and other conditions related to the offered transportation services.
Forwarding order	FWO	An order from an ordering party to a carrier or LSP to transport goods from a shipper to a consignee in accordance with agreed terms and conditions.
Freight unit	FU	A set of goods that are transported together across the entire transportation chain. A freight unit can include constraints for transportation planning, should stay intact for the whole transportation cycle, but may be also split with consequences to an existing plan.

Table 1.4 Main Business Objects of TM

Business Object	Abbreviation	Definition/Description
Package unit	PU	A package unit is a consolidation of multiple freight units into a larger unit or containment (e.g., a pallet or a roll cage) with the purpose of using a rule-based creation (package building rule) and moving the package unit as a unit on multiple segments of the transportation chain.
Transportation unit, trailer unit, railcar unit	TU	A set of goods with an assigned resource that is transported as a unit across a part of the transportation chain. A transportation unit can have an individual appearance based on its assigned transportation mode and characteristics (e.g., a transportation unit can be a railcar or a trailer).
Consignment order	CO	A logical consolidation of multiple freight units to represent a unit more oriented to organizational business purposes than logistics operations. The consignment order corresponds to a shipment in typical logistics processes; that is, you can use it to handle customs or bills of lading.
Container unit	CU	A set of goods with an assigned container resource that is transported as a unit together across a part of the transportation chain.
Transportation resource	RES	A machine, means of transportation, or other asset with a limited capacity that fulfills a function in the supply chain (e.g., truck, container, crane, forklift, trailer, vessel).
Schedule	SCHED	A sequence of stops with related recurring departure and arrival times that is valid for a specified period. Cargo associated with the schedule may move along the sequence or any part of it.
Freight booking	FB	An order providing transportation capacity whose execution is planned by a carrier, for example, a ship owner or airline. The freight booking contains the plan for the logistical processing (e.g., fixed departure times of the ship or plane).

Table 1.4 Main Business Objects of TM (Cont.)

Business Object	Abbreviation	Definition/Description
Freight order	FO	An order whose execution is planned by a carrier or the shipper. The order contains the plan for the logistical processing (e.g., when and onto which vehicle freight units are to be loaded and planned departure times for the vehicle) and execution data. freight orders are typically used for road, rail, and express transportation.
Forwarding agreement quotation	FWAQ	A quotation object representing a customer request for quotation (RFQ) or a response to such request. Forwarding agreements can be created from the forwarding agreement quotation.
Forwarding agreement	FWA	A long-term contract that represents the contractual relationship with a customer to whom you're selling transportation services.
Freight agreement quotation/request for quotation	FAQ/RFQ	An individual business document a shipper or LSP sends to a carrier asking the carrier to bid for the provision of future transportation services in a trade lane for a defined period.
Freight agreement	FA	A long-term contract that represents the contractual relationship with a carrier from whom you're buying transportation services.
Forwarding settlement document	FWSD	A document that is sent to SAP S/4HANA to request the creation of an invoice for logistic services to be sent to a customer.
Freight settlement document	FSD	A document that is sent to SAP S/4HANA requesting the verification of an invoice for logistic services received from a supplier or carrier.

Table 1.4 Main Business Objects of TM (Cont.)

The business objects described in Table 1.4 are used in combination with various processing tools and engines to run transportation management operations. Figure 1.9 shows the data flow and the interaction of objects, engines, and master data in a TM system.

The following descriptions and numbering refer to Figure 1.9. The requirements management component comprises all functions involving TM integration with the shipper's logistics processes (i.e., sales orders, purchase orders, stock transfer orders, and deliveries). It's frequently used in shipper transportation management, where a company needs to manage transportation for its own distribution and procurement tasks but may also be applied in a tight collaboration in contract logistics.

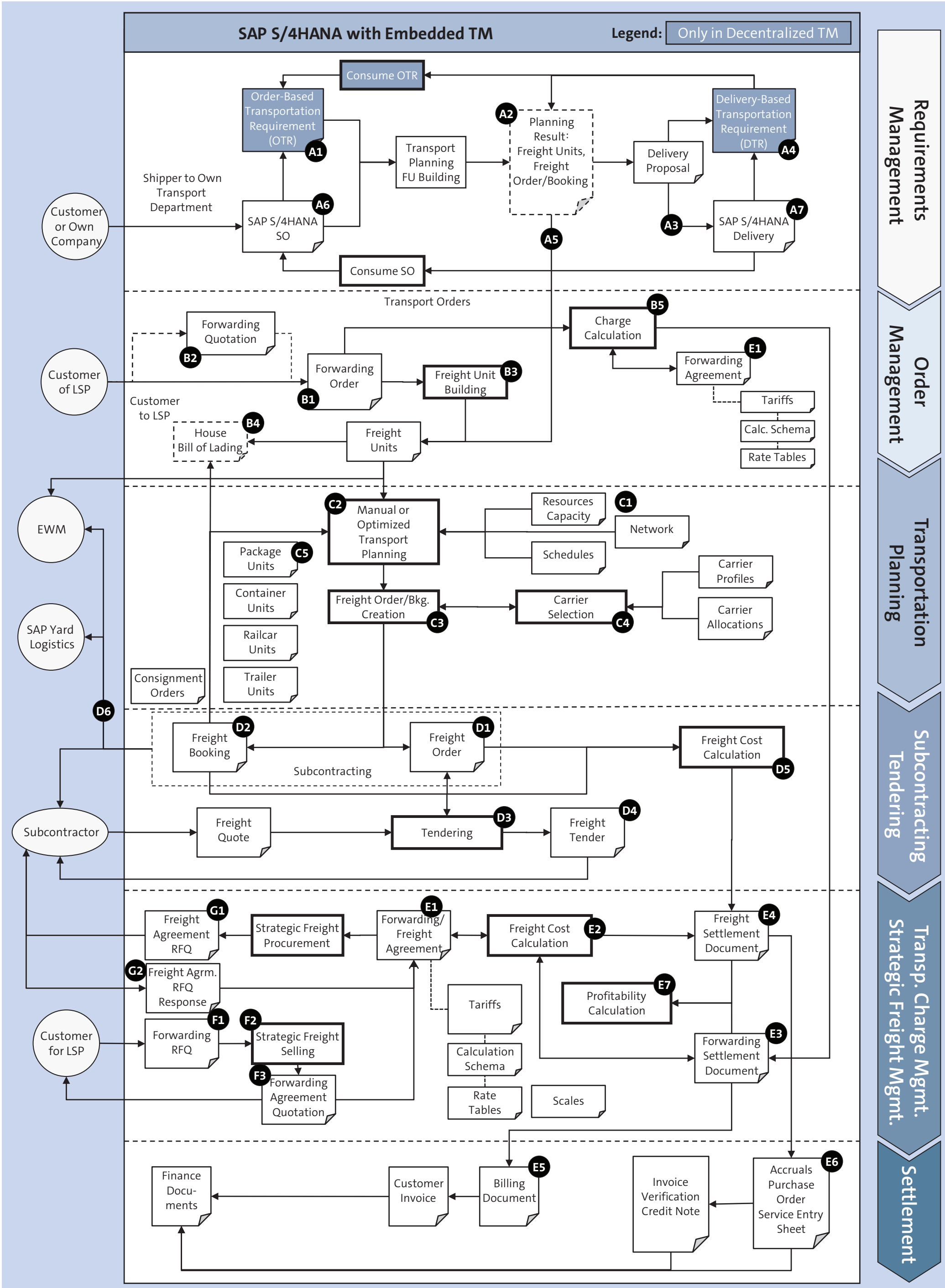


Figure 1.9 Usage and Flow of TM Business Objects

There are two different ways of handling requirements from shipper systems in TM (refer to Section 1.2, Figure 1.6):

- Sales order and delivery processes as well as transportation management are handled inside the same SAP S/4HANA instance (see bullets A6 and A7 of Figure 1.9).
- Sales order and delivery processes are handled in one SAP S/4HANA ERP system, and TM is a decentralized operation in a separate instance (TM in SAP S/4HANA). This refers to the light gray boxes and bullets A1 and A4.

Requirements Management

In the first case in Figure 1.9, the sales and logistics process is handled on the same SAP S/4HANA instance as TM, and the interaction is simplified. The SAP S/4HANA sales orders, purchase orders, or stock transfer orders A6 are directly linked to transport planning A2 and freight unit building, which creates an SAP S/4HANA delivery A7 and manages sales order consumption. Cross-system communication for building deliveries is avoided.

In the decentralized TM case, OTRs A1 are created in TM from SAP ERP sales orders, purchase orders, or stock transfer orders A6 in the ERP component. By means of the transportation planning component A2 (see description later in this section), freight units and freight orders are created A5, which are used to create delivery proposals that are sent back to ERP to create deliveries according to the transportation plan A3. The deliveries may be altered in ERP and, once released, are transferred to TM, resulting in the creation of DTRs A4 that consume the planning result based on the previously used OTRs. In this way, the initial planning result is reused and adjusted without starting from scratch.

Order Management

Order management is the main component for LSPs, where they start the sales processes for their customers. Transportation demand from customers is received as a customer order that creates a forwarding order in TM (B1 in Figure 1.9). Even if the name of the object is closely related to freight forwarding, the same object is also used for carriers to handle intermodal customer orders (e.g., *booking* for air and ocean cargo or a *waybill* for rail cargo). In the context of forwarding orders, a variety of processing and check functionality can be used:

- Transportation proposals to get routing options
- Credit limit checks for the order against credit management
- Blacklist and denied party screening against SAP GTS compliance management
- DG check against mode- and country-specific rules defined in SAP S/4HANA for product compliance

A forwarding order can be based on a previously created forwarding quotation, which is a spot quote for a transportation service given to a customer B2.

Forwarding orders are used to create freight units from the items of the order B3. Freight unit building is a planning service used to break large orders down into pieces that can be physically handled separately (e.g., on pallets or in truckloads) and that also can go different ways based on logistical or regulatory considerations. At a later stage, house bills of lading (HBL) are generated B4, for example, based on the freight units and assigned freight bookings to comply with legal documentation regulations.

Forwarding orders integrate with transportation charge management in TM where they use services such as charge calculation to determine the price components of a customer order B5. The charge calculation uses the same calculation structures and framework as explained later E1.

Transportation Planning

Transportation planning provides manual and optimizer-supported planning capabilities to TM C2 and allows multimodal end-to-end planning with consideration of real and virtual transportation costs. It can be used to create a release-ready transportation plan and to determine a list of transportation proposals for possible routings of an order. Transportation planning involves owning or making use of a variety of network and resource master data (used to define the network), resources with their capacity, and schedules for recurring multistop connections C1.

Operational planning is done in the transportation cockpit as a UI that allows manually performing activities such as assigning freight units to a means of transport and running a parameterized optimization over the whole or a selected subset of the transportation demand and capacity offering. For this activity, the freight units, network, capacity, resources, and schedules—as well as existing and new freight orders and freight bookings—are considered C2. Based on the planning result, freight orders are created or freight units are assigned to freight bookings C3. During or after this step, carrier selection can be executed, which allows the assignment of one or multiple carriers to a freight order according to carrier profiles, allocation rules, and selection rules C4.

In addition to handling freight units, freight orders, and freight bookings, additional consolidation levels for cargo can be created or used. This would be package units, container units, trailer units, or railcar units in case of physical consolidation, or consolidation orders for logical consolidations (shipment) C5.

Subcontracting and Tendering

The subcontracting component provides order objects representing the relation to service vendors or carriers. Freight orders can be created manually or based on a planning run (D1 in Figure 1.9). They provide an individually planned definition of a consolidated or unconsolidated freight move to be executed with a means of transport (e.g., a milk run in a city or an FTL move across a country). Freight bookings are used to represent a capacity allocation prebooked on a means of transport, which is often run on an air or ocean schedule and operated by a carrier within his network D2. Examples are air freight capacity reservations for a master air waybill (MAWB) or booked container capacity on a container vessel. For freight bookings, TM offers comprehensive capacity management that allows you to plan and allocate the capacity required to execute transportation services as a forwarder or carrier (e.g., maintenance of master flight plans and four-week flight plans).

Freight bookings usually have an assigned carrier (airline, ocean liner). For freight orders, individual tendering can be done based on a list of preferred vendors D3. Tendering can be executed as peer-to-peer, broadcast, or open tender. The partners may be integrated either via B2B messaging or through access by a vendor portal. Freight tender and freight quote objects make it possible to keep track of the process and provide the decision basis for carrier selection D4. The same way order management is integrated into transportation charge management in TM, subcontracting uses this component to determine the costs of a move, including apportionment to the single freight units of a consolidated shipment D5.

The freight order and freight booking business objects used in subcontracting are also the foundation of the execution process and cargo management. TM tools support a variety of processes for these two objects:

- Loading and unloading of consolidated transportation units and loose cargo
- Discrepancy handling in hubs and stations
- Consolidation of cargo to and deconsolidation from transportation units (e.g., containers and pallets)
- Status management for cargo and shipments
- Creation of legal, regulatory, and operational documentation, such as manifests and bills of lading
- Integration to EWM and SAP Yard Logistics D6

Transportation Charge Management

When it comes to cost, revenue, and profitability in transportation, transportation charge management in TM is the component of choice. It integrates into order and subcontracting processes and provides structured contract, tariff, and rate data for all calculations.

In TM, agreements are the main contract objects that can be used as forwarding agreements to represent a customer contract as well as freight agreements to embody a supplier contract (E1 in Figure 1.9). From a structural perspective, these contract types are similar because they contain tariffs referring to calculation schemas that hold a list of charge elements, which are applicable for charge calculation either as prices for a customer or costs for a supplier. Each charge element typifies a certain kind of rate, fee, or surcharge (e.g., basic sea freight or wait time surcharge). To efficiently negotiate a supplier contract or close a customer contract, TM comes with a component called *strategic freight management*, which allows the creation of contract quotes to suppliers and has analytical tools to analyze and compare bids. From a selected bid, a freight agreement can be assigned to the corresponding supplier.

The freight cost calculation engine analyzes the charge elements of a calculation sheet and calculates the correct amounts in the correct currencies and with the appropriate exchange rates E2. The calculation results are stored in the charge substructures of the forwarding order (customer invoice) or the freight order and freight booking (supplier invoice).

Settlement

From the forwarding order, freight order, and freight booking business objects, you can create draft invoices E3 E4 for settlement integration to the SAP S/4HANA ERP system. To create customer invoices, one or more forwarding settlement documents E3 are created from the forwarding order and then are sent to ERP to create billing documents E5. For supplier invoice settlement, freight settlement documents E4 are created from the freight order or freight booking; then they are transferred to ERP to create accruals and later to create a purchase order and service entry sheet (SES) for invoice verification or self-billing E6. Based on the two installation options as described earlier, TM either has a cross-system integration between TM and ERP, or both components are run within the same SAP S/4HANA instance.

Based on the charges calculated on the cost and revenue side, TM produces a profitability calculation for either standard or real costs E7.

Strategic Freight Management

As proper contract negotiations with customers and subcontractors are a very important prerequisite to profitable operations, the area of strategic freight management provides tools to work out and implement commercial agreements. For freight procurement, freight agreement RFQs G1 can be created from existing vendor contracts using analytical and simulation tools in strategic freight procurement. The responses from the subcontractors G2 can subsequently be evaluated, and assignments of business shares can be worked out and finally manifested in freight agreements E1.

For example, in terms of selling freight services, customers send out RFQs for the freight they intend to ship within the next quarter, lining out volumes on origin-destination-commodity-equipment combinations of their shipments. These RFQs may be received as Microsoft Excel sheets and are converted and stored as forwarding agreement quotations or RFQs F1. Using strategic freight selling F2, offers can be worked out in a distributed way (e.g., per trade lane) based on existing tariffs and contracts or from scratch. The resulting forwarding agreement quotation F3 is then converted back into the customer's format and sent back to the customer. Upon customer request, the forwarding agreement quotations can be converted into forwarding agreements.

1.4.8 TM Operations Example

The organizational capabilities and functional abundance of TM enable its use for a variety of shipper- and LSP-related transportation and logistics processes. It includes, but isn't restricted to, direct, multistop and multistage, full truckload (FTL), and less than truckload (LTL) transportation. In terms of ocean transport, TM supports typical use cases such as ocean carriage door-to-door or port-to-port for FCL or LCL. Consolidated air freight scenarios, rail carriage, and intermodal processes are supported as well. Beyond that, a variety of other implementations are possible.

Air Freight Example

To give you an example of a typical logistics process, Figure 1.10 shows a door-to-door air freight scenario from Bremen, Germany, to Bangkok, Thailand, that uses local processes:

- Pickup in Bremen, Germany
- Consolidated long-haul truck moves for pre-carriage
- Evaluation of different flight options to find the most cost-efficient way
- Capacity reservation and schedule-based movements for the air freight main leg from Frankfurt to Bangkok
- Airline de-feed in Thailand from airport to local freight gateway
- Delivery in Bangkok, Thailand
- Compliance with customer service-level agreements (SLAs)

Looking at an example like the air freight scenario, you can imagine how the geographical and mode-specific aspects imply that the operational and transactional execution must be handled by different people in different roles. Various LSP employees, such as customer service representatives, local station operators, documentation teams, gateway teams, and long-haul dispatchers, are actively involved in various tasks. This "handshake" is organized in TM, where, with appropriate authorization, each participating person or group gets access to role-specific functionality and the related business objects.

Figure 1.11 breaks the air freight process down into example transactional tasks required for an air freight transport with the involvement of six groups and the corresponding task assignments.

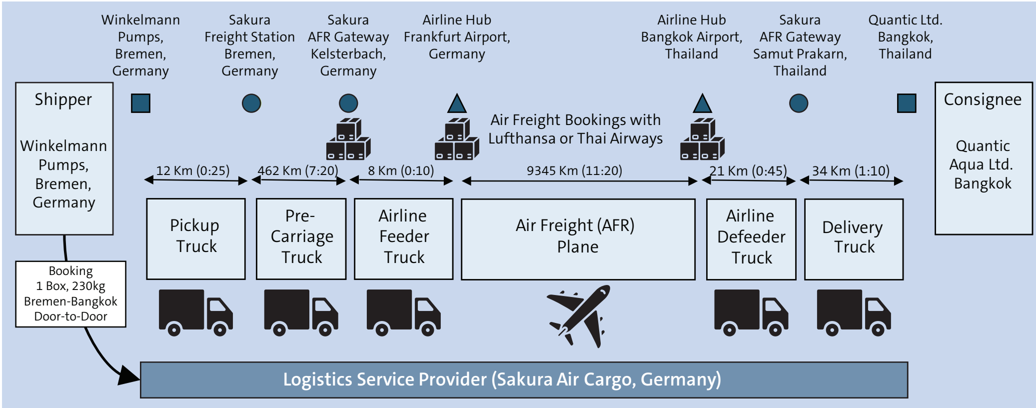


Figure 1.10 Example of a Door-to-Door Air Freight Scenario

Customer service	Export station	Export gateway	Import gateway	Import station	Settlement
• Create customer order • Propose E2E routing • Create work order • Provide visibility • Tracking and tracing • Manage customer exceptions • Manage claims • Basic compliance check • Service catalog • Standard operating procedures	• HAWB/MAWB worklists • Prebook airline capacity • Manage pickups, feeding • Create, manage, close, and print MAWB • Change bookings and routing • Consolidate HAWB to MAWB • Warehouse communication	• Work order and HAWB worklists • Book/manage air cargo capacity, four week flight plan • Create MAWB • Track and trace • Create truck manifests • Manage customs and documents • Consolidation • Compliance checks • MAWB stocks	• Import management • MAWB/HAWB worklists • Break bulk handling • Customs clearance • Plan and manage direct deliveries • Plan and manage defeeding/line haul • Create truck manifest • Customs management	• HAWB worklists • Customs clearance • Transit handling • Break bulk handling • Plan and manage deliveries • Create truck manifest • Create consignee invoice	• Vendor settlement • Carrier invoice creation • Carrier invoice settlement • CASS integration

Figure 1.11 Air Freight Process Tasks in Different Organizations

Connection Capabilities

TM provides powerful workflow and connection capabilities that easily allow assigning and controlling the flow of information and tasks within and between areas of responsibility in a company. Beyond that, TM can integrate processes between several TM instances (e.g., a shipper using TM as its local transportation planning system in combination with SAP S/4HANA ERP, an LSP managing its customer orders with TM, or a carrier managing cargo with TM).

The shipper, the LSP, and the carrier can all be running their own TM instances. For the shipper, TM in SAP S/4HANA is used to arrange transportation. For the LSP and the carrier, TM is used to handle their core business, that is, selling, arranging, buying, and executing freight and cargo moves for their customers. The process flow across the systems, as shown in Figure 1.12, goes through the following steps:

1. The shipper receives an order for goods from the end customer and starts a sales and delivery process in the SAP S/4HANA system.

2. To arrange transportation, the shipper uses TM to plan shipments based on sales orders and deliveries.
3. The planned transportation orders for subcontracting are now communicated as multimodal door-to-door service orders to the LSP, who receives them as forwarding orders for transportation services.
4. The LSP uses planning tools in its own TM instance to create a multimodal route with several freight orders that might be subcontracted to one or more external carriers (e.g., an ocean carrier) or that the LSP might execute itself (road or rail legs).
5. In subcontracting, the external carrier receives the freight orders from the LSP as forwarding orders in its own TM system and executes them.
6. As the middleman, the LSP now needs to settle customer receivables and external vendor payables.
7. The customer receives an invoice from the LSP for the services ordered.
8. The external carrier receives a payment for the services executed for the LSP.
9. Cost for the internal BUs are transferred internally in the LSP.

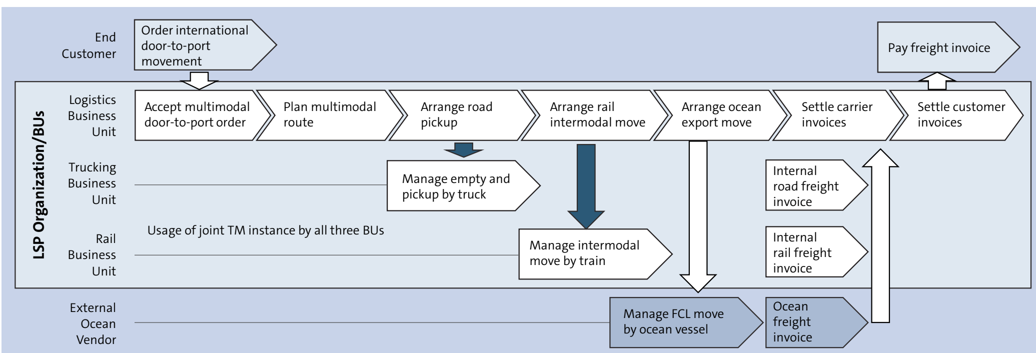


Figure 1.12 TM Instances Utilization, When Integrating Different Usage Levels

In Figure 1.12, you also can see that TM also is an efficient platform to drive the collaboration between multiple BUs of an enterprise that have the focus on transportation but view the challenge from their specific domain. LSPs often tend to grow their business into multiple areas of logistics that are distinct operations but, in the end, can be a part of an end-to-end process. You can find examples of companies that originally were, for example, a railway or a container shipping line, but decided at certain stages to create a forwarding BU or a trucking BU that operate as independent entities. Although they can take their own external orders, the idea is to gain more share of the operation by using them as part of the end-to-end business.

In the traditional IT world, the BUs act independently in determining their best-of-breed TMS. With higher pressure from the market, companies noticed that running independent TMSs leads to difficulty in identifying synergies in the shared end-to-end processes and executing according to that information. Therefore, the tendency of today's companies is to move their BUs to a joint platform for transportation, which allows them to run the end-to-end order and plan, as well as the detailed parts to be managed and executed by the BUs.

The LSP organization, which originally was a railway, founded a logistics unit (forwarder) and a trucking unit. All three units are running clearly separated parts of a joint platform, which allows them to operate independently but share important data and aspects to achieve synergies. For relevant parts of the end-to-end process (truck leg, rail leg), information is shared that allows each unit to achieve better results as if they were operating on distinct systems.

1.5 Summary

In this chapter, we provided you with an overview of SAP S/4HANA as a business foundation, its deployment options, SAP S/4HANA's functional scope, and SAP software provided for transportation management. We discussed the basic TM business objects and processes that we'll further examine throughout the book, and we discussed a TM operations example.

In the next chapter, we'll introduce the TM solution architecture, technical concepts, frameworks, and integration technologies, which can give you a deeper understanding of TM functional principles.

Chapter 2
Solution Architecture and Technological Concepts

When you get started with transportation management (TM) in SAP S/4HANA, you'll quickly notice two important technological concepts that are different from the traditional SAP ERP or even SAP S/4HANA technology: the user interface (UI) uses current web technology, which enables the user to customize the UI easily, and data is modeled in an object-oriented way.

As you read this book, you'll notice that we rarely use transaction codes and ABAP programs. The reason for this is that TM doesn't use the SAP GUI; it uses web UIs instead, even before SAP Fiori was invented.

This means TM's web-based UI can be used without the user having to install any frontend software on his computer. This is especially helpful for users who don't use the application frequently or only execute one business transaction in the system. This chapter will give consultants and technical experts insight into how to customize the UI to adjust the terminology and screen layout to customers' needs.

In SAP S/4HANA, we'll see a different setup of systems compared to what we've known in the SAP ERP era. SAP S/4HANA consists of two systems: a *backend system* and a *frontend system*. You'll be familiar with the backend system from having already dealt with SAP ERP or previous editions of TM. This is where the business logic resides and where the UIs are built. The frontend system is used to display the UI to the user, and the SAP Fiori launchpad is run on this server. The separation of backend and frontend systems is done to separate hardware capacity between running business logic and rendering the UI. Furthermore, multiple backend systems can be accessed via the same frontend system. This resembles the architecture from approximately a decade ago when SAP Portal consolidated multiple systems in one UI.

Like other SAP applications developed after the year 2000, TM has moved away from the traditional framework of retrieving both master data and transactional data directly from database tables. The new framework, called the Business Object Processing Framework (BOPF), encompasses both data storage and data processing. It's the framework of choice not only in TM but also in other functionalities within SAP S/4HANA as well as other SAP applications, such as SAP Business ByDesign. We delve deeper into the contents of data storage and data processing in Section 2.1.

Don't Get Confused about Names!

As part of refactoring many SAP ERP modules in the course of migrating them to SAP S/4HANA, the business object model was also used to model the functionality in other functional areas. However, the tools and frameworks we describe in this section will concentrate on the TM functionality. As the SAP Transportation Management (SAP TM) application was developed previously as a standalone product and moved into SAP S/4HANA, the technological concepts used in previous versions of SAP TM are taken over into SAP S/4HANA. Therefore, the frameworks and tools used to build object-oriented data modeling for other functional areas in SAP S/4HANA can be different from the ones described in this chapter.

In addition to how data is stored and processed, TM uses a different UI technology, which we examine in Section 2.2 in combination with delving into how TM screens are now displayed in the SAP Fiori launchpad. Furthermore, as we discuss in Section 2.3, TM uses various tools and frameworks that allow a consultant or even the user to customize and personalize the application without having to consult a programmer. These features come in very handy because they reduce the number of modifications—which is a big advantage when it comes to support and troubleshooting. The coding itself is still standard, and customizing of the system is done in a different layer. If UI customizing has a negative effect on system behavior, you can undo it; removing the customizing layer quickly resets the functionality to standard. No programming is involved in this process. How to monitor the different frameworks will be covered in Chapter 13, Section 13.3.

Finally, we explore the various integration technologies that TM uses to communicate with other applications in Section 2.4.

2.1 Technological Foundation of TM

If you've ever dealt with software architecture, you've probably heard the term *service-oriented architecture* (SOA) countless times. SOA is not only an architecture for exchanging data between different business partners or systems but also a new way of data modeling within a system itself.

The BOPF is the central technological foundation of TM and incorporates the idea of modeling data in a SOA-compliant way. As a consultant or application expert, you won't find a way around eventually dealing with this framework.

The BOPF models the storage of data in an object-oriented way but also merges the processing of data into the same framework. Therefore, data storage and data processing are closely linked.

If you've already dealt with the traditional technological concepts of SAP applications, the BOPF may seem cumbersome at first glance. However, many developers agree that this framework simplifies how you design a process in a program. In this section, you'll learn that the link between different pieces of information is much closer than with the traditional framework; getting information and understanding how information is related is more tangible because the different pieces of information now follow a hierarchical structure that can also be illustrated by technical drawings.

Although this section isn't designed to make you a development expert who knows all the tricks and terms of the BOPF, we do want to give you a basic understanding of how you can interact with the BOPF so you understand where to find data and where to get started if you're looking for the root cause of a problem.

When you access Transaction /BOBF/CONF_UI or Transaction BOBF, you'll find an overview of all business objects used in TM. Figure 2.1 shows how these business objects are grouped into different types. From a technological point of view, these objects are all alike, but from a business point of view, this grouping makes sense.

Let's look at these types. *Business process objects* store transactional data such as customers' transportation requests or transportation orders. Quite similar, the *dependent objects* also store transactional data but this data is reused by several *business process objects*, for example, attachment folders or charges. Dependent objects can't be created without another object. They are dependent on business process objects. As the name suggests, you can find master data stored in *master data objects*, such as vehicle resources or locations.

Especially when you're performing transportation planning in TM, you'll enter various profiles and settings that are used for optimizer planning, carrier selection, and so on. This data is stored in *metadata objects*.

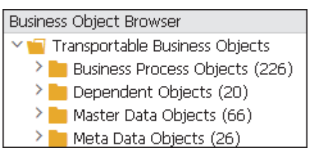


Figure 2.1 Business Object Types

2.1.1 Storing Data in the Business Object Processing Framework

Because the BOPF stores data in an object-oriented way, each document or master data item is stored as an object instance in the database. Throughout this chapter, we use a freight order (the order of a transportation service) as an example to illustrate how data is stored.

The freight order has some unique header data such as the order number and the assigned carrier. The special characteristic of this information is that it can occur only once per freight order—with good reason. A freight order with two numbers doesn't make sense.

However, the freight order also has information that can have a different cardinality in any order. If you look at the items in the order, you'll see that some freight orders carry only one item, while others have multiple items. All items, however, are always linked to unique information, such as the order number. We could say that the item information is assigned to the header information.

The BOPF reflects the information structure in its business object structure. When you access Transaction /BOBF/CONF_UI or BOBF, take a look at the freight order's technical setup by double-clicking the business process object **/SCMTMS/TOR**. A business object consists of different nodes, each with its own purpose. All business objects have one characteristic in common: the superordinate *root node*, which contains the header information we just introduced. The subordinate nodes contain information assigned to the header information, such as the items. Subordinate nodes can have multiple instances within one instance of a business object.

Instances

The model of an object is defined during design time and contains the structural and functional concept of the business object type.

During runtime "instances" of that document type are created, the structural model is populated with the information linked to the real-world documents.

As you see in Figure 2.2, the item information (**Items of the Transportation Order**) is stored in node **ITEM_TR**, while other information (optional for a freight order) is stored in other nodes.

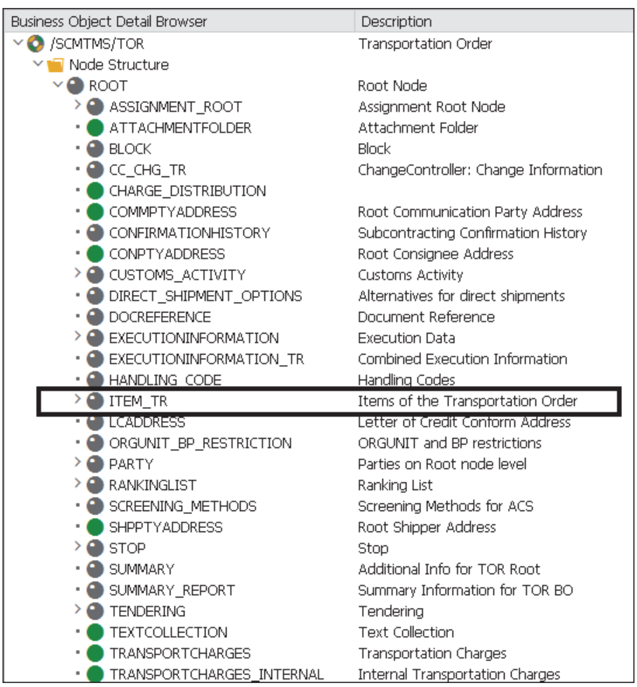


Figure 2.2 Nodes of the Business Object /SCMTMS/TOR

All information is stored in the nodes in a structured way. If you double-click on a business object node, you can navigate to a detailed view of the data structure of the particular BOPF model node element.

As you can see on the right side of Figure 2.3, a simple Data Dictionary (DDIC) structure is assigned to each node, in this case, the root node. This *data structure* contains all fields that can be filled with information, such as the freight order number, carrier, and so on. Double-clicking the data structure takes you to the DDIC (Transaction SE11) so you can see the structure.

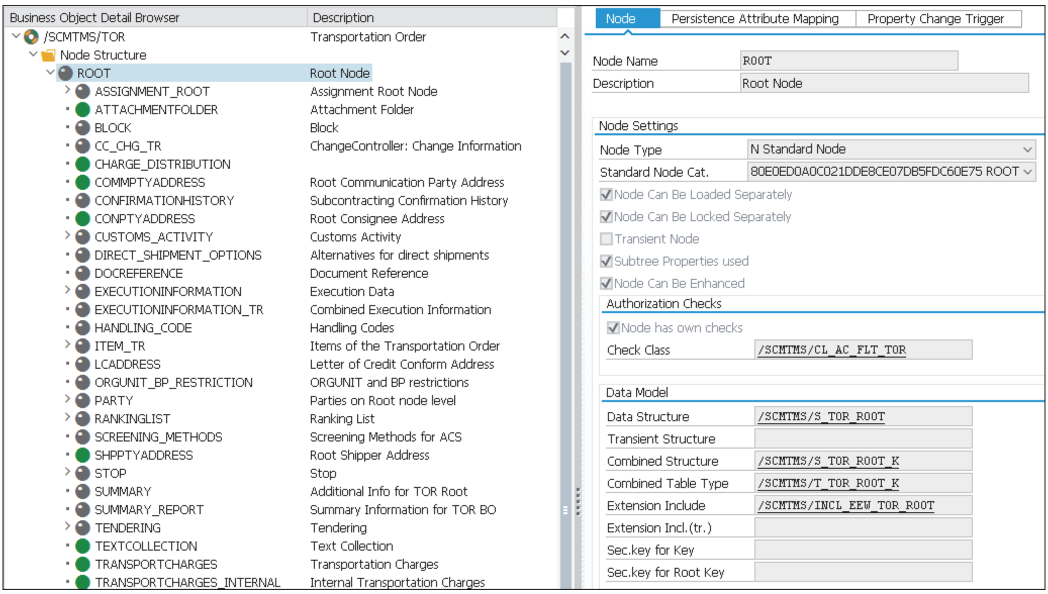


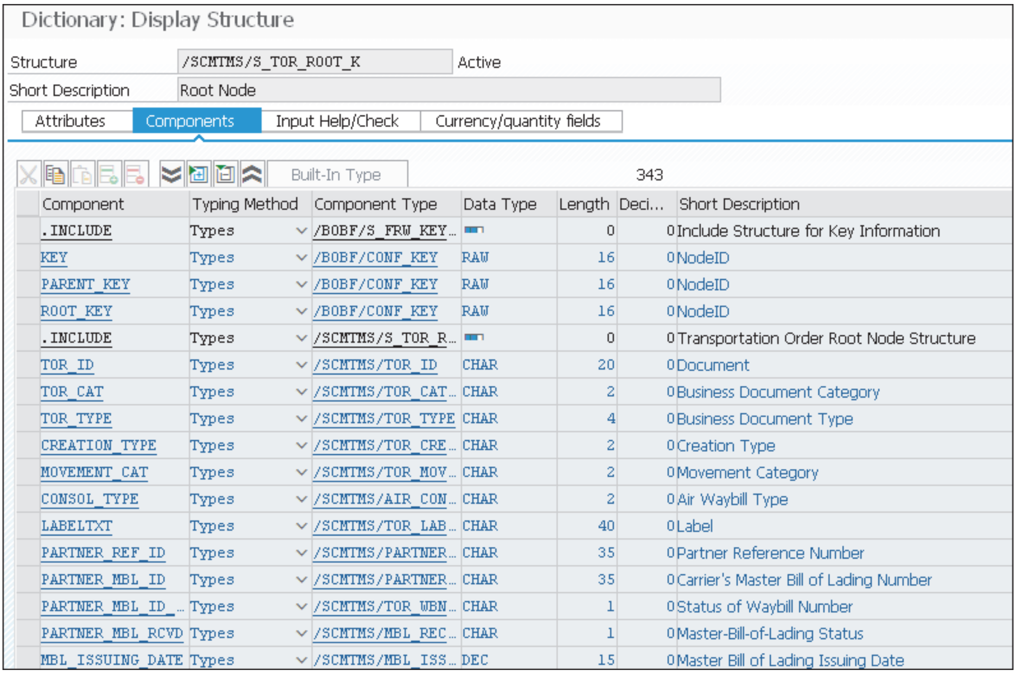
Figure 2.3 Details of a Business Object Node

Figure 2.3 also shows that a combined structure (shown in Figure 2.4) is assigned in addition to a data structure. The combined structure looks exactly like the data structure except that it has three additional BOPF-specific fields to model the hierarchy of the object nodes:

- **KEY**
  Each node instance can be identified in the database with a unique, 32-digit hexadecimal key, such as 005056AC01921ED1BEE25DC2FC88401C.
- **PARENT_KEY**
  In order not to lose the link to its direct superordinate node, each node carries the parent key of its superordinate node.
- **ROOT_KEY**
  The root key field contains the key of the superordinate node instance that this node instance is part of.

The "Family" in Object-Oriented Modeling

In object-oriented modeling, "family" terms are used instead of the lengthy terms *superordinate* or *subordinate* (IT people tend to find short terms if abbreviations don't do the trick.). Therefore, the terms *parent node* and *child node* are more often used here.



Dictionary: Display Structure

Structure: /SCMTMS/S_TOR_ROOT_K — Active
Short Description: Root Node

Attributes | Components | Input Help/Check | Currency/quantity fields

Built-In Type — 343

Component	Typing Method	Component Type	Data Type	Length	Deci...	Short Description
.INCLUDE	Types	/BOBF/S_FRW_KEY...		0	0	Include Structure for Key Information
KEY	Types	/BOBF/CONF_KEY	RAW	16	0	NodeID
PARENT_KEY	Types	/BOBF/CONF_KEY	RAW	16	0	NodeID
ROOT_KEY	Types	/BOBF/CONF_KEY	RAW	16	0	NodeID
.INCLUDE	Types	/SCMTMS/S_TOR_R...		0	0	Transportation Order Root Node Structure
TOR_ID	Types	/SCMTMS/TOR_ID	CHAR	20	0	Document
TOR_CAT	Types	/SCMTMS/TOR_CAT...	CHAR	2	0	Business Document Category
TOR_TYPE	Types	/SCMTMS/TOR_TYPE	CHAR	4	0	Business Document Type
CREATION_TYPE	Types	/SCMTMS/TOR_CRE...	CHAR	2	0	Creation Type
MOVEMENT_CAT	Types	/SCMTMS/TOR_MOV...	CHAR	2	0	Movement Category
CONSOL_TYPE	Types	/SCMTMS/AIR_CON...	CHAR	2	0	Air Waybill Type
LABELTXT	Types	/SCMTMS/TOR_LAB...	CHAR	40	0	Label
PARTNER_REF_ID	Types	/SCMTMS/PARTNER...	CHAR	35	0	Partner Reference Number
PARTNER_MBL_ID	Types	/SCMTMS/PARTNER...	CHAR	35	0	Carrier's Master Bill of Lading Number
PARTNER_MBL_ID_...	Types	/SCMTMS/TOR_WBN...	CHAR	1	0	Status of Waybill Number
PARTNER_MBL_RCVD	Types	/SCMTMS/MBL_REC...	CHAR	1	0	Master-Bill-of-Lading Status
MBL_ISSUING_DATE	Types	/SCMTMS/MBL_ISS...	DEC	15	0	Master Bill of Lading Issuing Date

Figure 2.4 Combined Structure of the Root Node of a Business Object

We've talked about *how* data is stored, but we've not yet talked about *where* data is stored. And even though we're introducing new ways to model data in nodes and objects, at the end of the day, we're back in the world of database tables.

The BOPF introduces new means only for data *modeling*; data *storage* is done with database table technology that you already know about from SAP products such as SAP ERP. However, the database tables contain the 32-digit keys of the node instances with which you can easily find node instances on the database tables. The details of a node like the one shown earlier in Figure 2.3 provides the information regarding where data is stored. The structure of the database table is defined with a DDIC table type that can also be found in the node information. The table type is the *combined table type* that you can also see in Figure 2.5, just below the entry for the combined data structure. It usually has the combined structure type as line type.

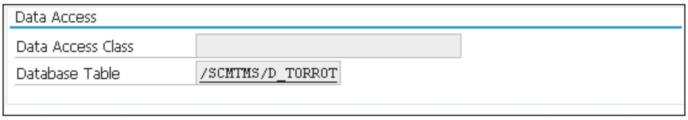


Figure 2.5 Database Table Assigned to a Business Object Node

Maybe you'll recognize that not every node has a database table assigned. TM also often works with transient data, which is only used during runtime and not stored in the database table. Figure 2.6 shows the **SUMMARY** node, as an example, which is marked as a **Transient Node**.

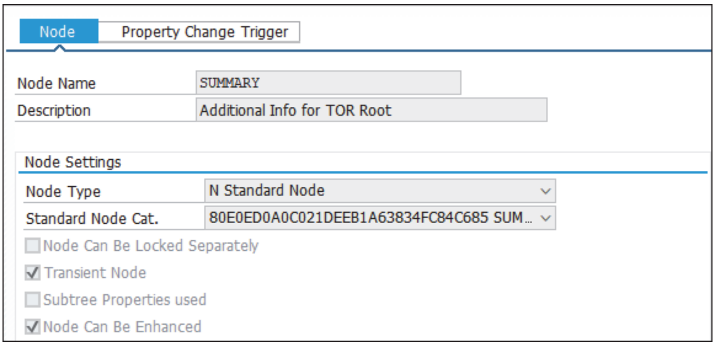


Figure 2.6 Details of Transient Node SUMMARY

Node Associations

One of the goals of the BOPF is for users and developers not to need to connect directly to database tables anymore. Therefore, the link between nodes should be established with more than the parent keys and root keys that we've talked about in the previous section—that would be too technical. Another more general way needs to be established.

Nodes are connected with a special element, called an *association*, provided by the BOPF. An association is a logical link between two node instances. In Figure 2.7, there are associations from the root node to other nodes (**/SCMTMS/TOR • Node Elements • Root • Associations**). When you're retrieving data from a business object instance, follow the path from node to node using the association as a kind of bridge to get required information. For example, if we have only the number of a special freight order and want to know what items are on it, we start at the root node and then use the association between the root node and the item node to get to the information in the item node. After we're on the item node instance, we can look for the field in the DDIC structure assigned to the node.

To take a closer look at an association's setup, you can use Transaction /BOBF/CONF_UI or BOBF to access the business object; however, instead of opening the node structure, open the node elements and expand any node. There, you'll find a folder called **Associations**, as shown in Figure 2.7.

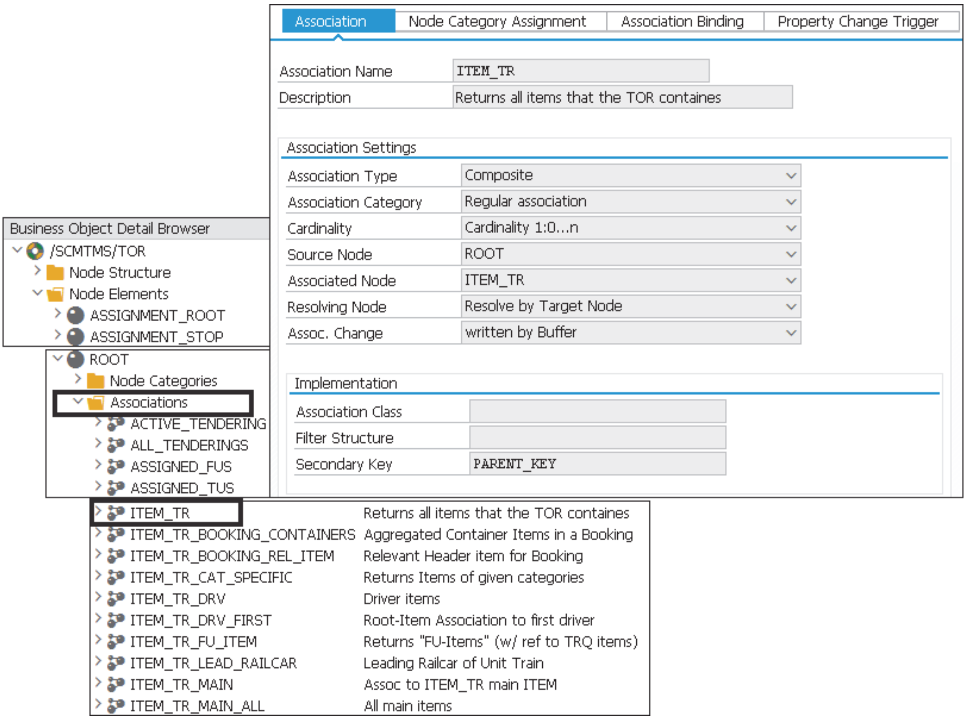


Figure 2.7 Associations of a Business Object Node

When reviewing the different association of, for example, the **ROOT** node of the object **/SCMTMS/TOR**, it can be recognized that some associations contain an association class and some don't.

In some scenarios, a more complex business logic is required to resolve the target node instances. This could be the case, for example, when navigating from the **ROOT** node of the **/SCMTMS/TOR** object to the linked **ROOT** node of the **/SCMTMS/TRQ** object. As the TRQ object isn't part of the hierarchical model of the **/SCMTMS/TOR** instance, this relationship can't be modeled using the parent-child fields in the data structure of the **TOR** object. The corresponding business logic to resolve the relationship is stored in an implementing ABAP class, which utilizes specific BOPF interfaces to integrate with the BOPF model.

For more simple relationships, which can be modeled using the parent-child keys in the particular data structures, BOPF provides generic methods to resolve the relationship. An example could be the relation between the **ROOT** node and the **ITEM_TR** node of the object **/SCMTMS/TOR**, as shown in Figure 2.7.

Recall that a freight order can contain several items and therefore several instances of the item node. The association defines whether several nodes can be assigned or only one. As you can see in the **Cardinality** field on the right side of Figure 2.7, several item nodes can be assigned to the root node because the cardinality of the association is 1:0…n.

Keep It Nice and Tidy

When you browse through the associations, you'll find some associations from the root node to another node with the cardinality 1:1. You might be wondering why, in this case, another node is needed at all and why the information from the associated node isn't put into the root node.

From a technical point of view, there's really no reason to do this. But from a logical point of view, there *is* a good reason: to keep the model nice and tidy.

Let's consider an example from real life. Your kitchen has a drawer for cutlery, a drawer for pans, and a drawer for herbs and spices. (Hopefully you have more than three drawers in your kitchen, but for this example, three is enough.) Now, instead of using separate drawers, you *could* put everything onto a big shelf, but you would probably have a problem finding anything easily and quickly.

The same applies to the business object model. The more fields a node contains, the bigger the database table will be. A business object node can, in this example, be compared with a drawer; the fields can be compared with the items in your kitchen.

The performance of database accesses depends on the number of fields in one line. Therefore, the number of fields in one line should be kept slim. For this reason, there are some node associations with the cardinality 1:1; the information of the associated node is stored in a different database to improve database reading performance.

Displaying Data Stored in a Database

Let's return to the goal of preventing users and developers from having to connect to databases. This also applies to consultants and technical experts. When working with TM, you should no longer use Transaction SE16 to display data in the background. Instead, stick to the business object model and display data in the object-oriented way.

To do this, you can use Transaction BOBT. Enter the business object in the corresponding field, and then select a query, as shown in Figure 2.8. Note that Transaction BOBT is only intended for development systems, not for a production system, as the transaction requires development authorization.

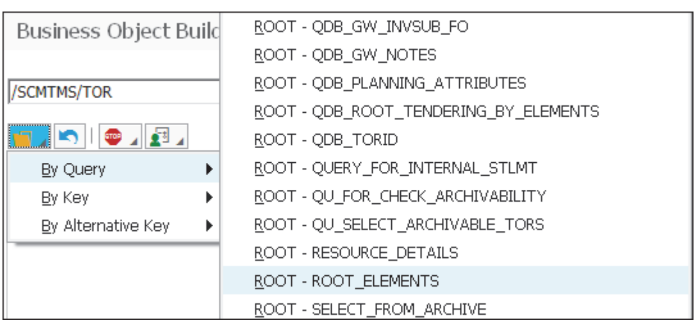


Figure 2.8 Query on the Root Node

Query

A *query* is a predefined search for business object node instances. Developers use queries to find node instances that carry certain information. Although we don't delve deeper into queries in this chapter, you should know that you can use queries in Transaction BOBT to find node instances. You can even create your own custom queries.

The node instances are displayed in a table view. In the example in which you want to get information about an item in a freight order but you only know the number, you can use a query to display the root node first. Then, you can use the association to the items to get to the item information, as shown in Figure 2.9.

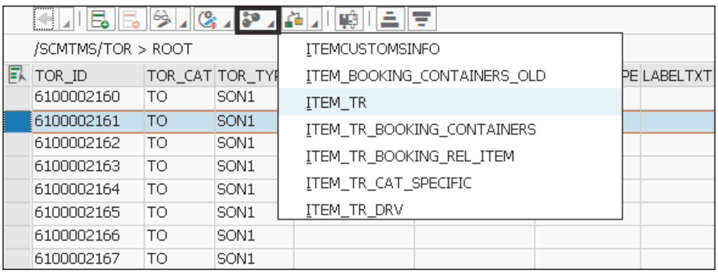


Figure 2.9 Executing an Association in the BOPF Test Workbench

2.1.2 Data Processing with the Business Object Processing Framework

As already mentioned, the BOPF is not only a way of modeling the storage of data but also of handling data processing. If you used Transactions /BOBF/CONF_UI or BOBF and browsed through the different node elements, you probably noticed that many node elements are assigned to a node:

- Node categories
- Associations
- Determinations
- Validations
- Actions
- Queries
- Alternative keys
- Status variables
- Status derivators
- Status schemas
- Attribute value sets
- Authorization objects
- Authorization field mapping

Don't worry—we won't go through all the node elements in this chapter. However, it's worth taking the time to look at the most important node elements. Associations help to establish a link between two business object nodes and, therefore, mainly support the consistent modeling of data storage; however, the node elements we want to deal with now are used for the data processing part of the BOPF methodology.

The three node elements responsible for built-in data processing are determinations, actions, and validations. You can browse through these elements the same way you browsed through the associations earlier.

Determinations

If you know a little bit about how SAP ERP was coded, you know that even when performing the most elementary changes to data, you need to establish the links to all follow-up activities in the coding. If a user wanted to add some custom logic to the follow-up activities, then the coding needed to be enhanced. In other words, to add custom logic, a developer had to know exactly where in the code certain things happen. With the BOPF, this problem has been solved with determinations. The framework automatically triggers the execution of *determinations* after one of the *create*, *read*, *update*, or *delete* (CRUD) data methods is called. The trigger conditions are defined using the checkboxes for the operations **Create**, **Update**, **Delete**, **Load**, and **Determine**. Each of the operations on one of the node instances will trigger the execution of the determination. The determinations can be executed at different timepoints in the transactional BOPF cycle, for example, after making modifications, before saving, and so on.

Let's take a look at an example involving the determination for number drawing for our freight order. As you can imagine, the logic of number drawing needs to be executed only upon creation of the freight order.

When you look at the details of the determination **DET_DRAW_NUMBER** shown in Figure 2.10 (or when you double-click the determination and then go to the **Request, Read & Write Nodes** tab), the following is defined: that the coding to draw a number for the freight order is only called when the root node instance is created. This is defined with the request node depicted in Figure 2.10.

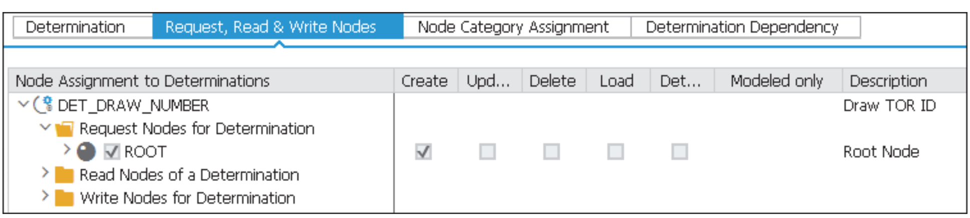


Figure 2.10 Triggering a Determination

Now that we know *when* the determination is called, we can take a look at *how* it's called and how the coding to be processed is found.

When you go back to the **Determination** tab, which is shown in Figure 2.11, you'll find that a class is assigned to the determination. This class is called whenever the determination has to be executed.

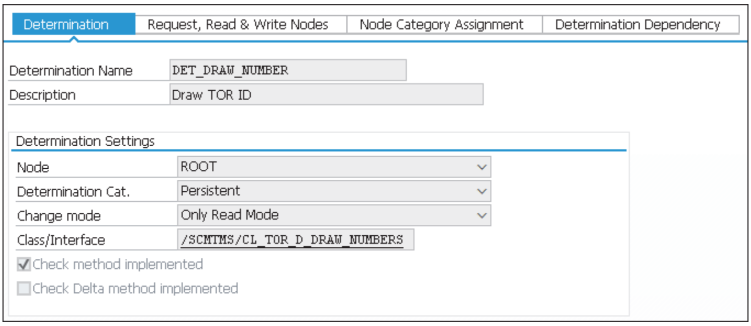


Figure 2.11 Details of the Determination

Naming Conventions

Whenever you find a class with the name /SCMTMS/CL_TOR_D_*, you can assume that it's a class designed for a determination of the business object TOR.

The naming convention is that after the namespace /SCMTMS/ and the usual identifier CL, there is an abbreviation of the business object that is being dealt with and one letter to determine whether the class is for a determination (D), action (A), validation (V), or query (Q).

Each class assigned to node elements uses an interface that provides three methods, as you can see in Figure 2.12. When a determination is executed, the framework calls the EXECUTE method of the interface. Further methods can be added to the class, but they won't be considered by the framework; instead, they need to be called by the EXECUTE method.

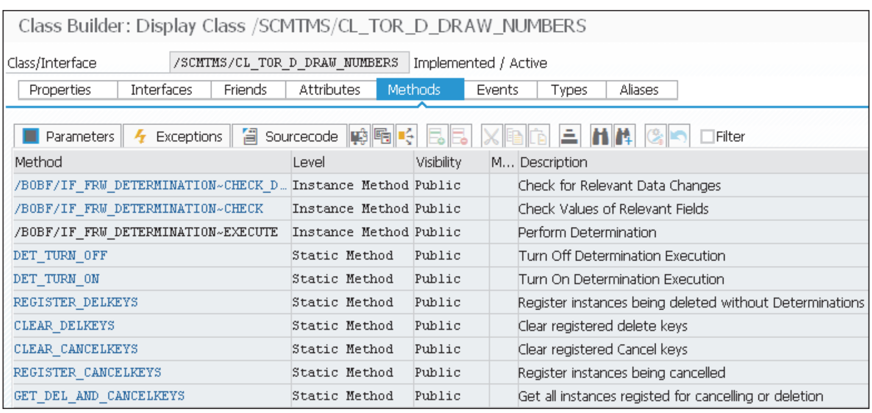


Figure 2.12 Class of a Determination

In addition to the EXECUTE method, there are also two more methods provided by the framework: CHECK and CHECK_DELTA. Both methods are optional to be implemented and will serve as a precondition regarding whether the logic of this determination should be executed, that is, whether the EXECUTE method should actually be called.

Actions

Actions provide methods to model business logic for a certain business object. Each action has an implementing ABAP class that utilizes BOPF-specific interfaces to integrate with the BOPF model. Within the ABAP class, the business logic for a particular process step is implemented. Often actions with the prefix "set" change status values, but all other kind of business logic can be modeled using actions.

Actions could be triggered in the interaction with the UI, but also out of determinations, reports, or interfaces. Say, for example, we've put together a full truckload of various cargo items. We want to check whether the combination of goods on the truck is feasible or whether some goods can't be transported together. To execute this incompatibility check on the freight order, we use the corresponding button on the freight order UI.

Incompatibility

This section discusses only what happens to the data. We cover how to set up an incompatibility check in Section 2.3.2.

The UI action is linked to an action of the business object node, and the corresponding program logic is processed. Each action, like the action of the incompatibility check in Figure 2.13, has a class assigned to it that contains an interface with an EXECUTE method that is called by the framework. As you can see, the BOPF uses exactly the same approach for linking program logic with the BOPF entities as with determinations.

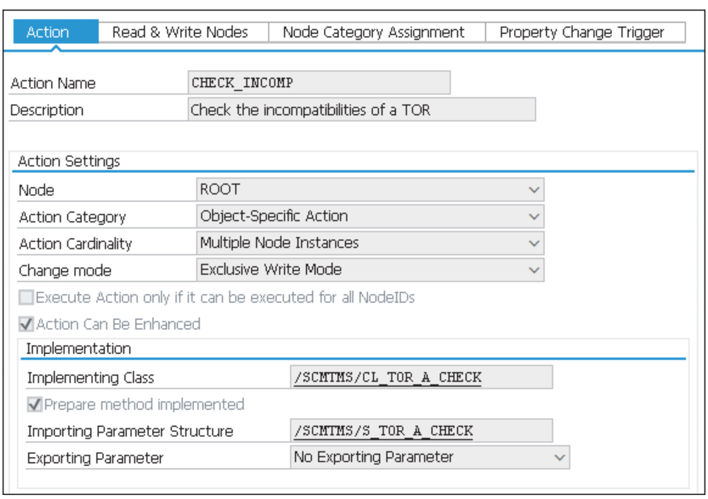


Figure 2.13 Details of an Action in BOPF

Validations

As with determinations and actions, a *validation* is also a piece of coding called and executed by the BOPF. The BOPF offers two different types of validations:

- **Action validations**
  These validations are associated with an action of the business object node and are called *before* the action is called. The action validation checks whether the action may be executed. For example, if we call the action that sends a transportation order to a carrier, an action validation checks beforehand whether a carrier is already assigned to the transportation order. If not, the action validation fails, and the action won't be executed.
- **Consistency validations**
  These validations are called after a change has been made to a business object node. Consistency validations, therefore, aren't directly linked to an action but monitor the change of a node instance, just like the determinations. However, while determinations may change some data on the node instance, the validations don't change anything on the node instance. Instead, they validate the consistency and prevent saving of the data or create warning or error messages to notify the user. In fact, validations don't lock the node instance while the validation is performed. Therefore, validations can't change any data on the node.

For example, when you create a freight order, you save the freight order. A consistency validation is always called when saving the freight order to check whether the locations and dates of the freight order are in a logical order, the vehicle resource isn't used on any other transport at the same time, and so on. If, for example, the vehicle resource used on this freight order is already assigned to another transport at the same time, the validation generates an error message to be shown on the UI. It doesn't, however, remove the vehicle resource from the freight order because that would be a change of the freight order document, which a validation isn't able to do.

Enhancement of BOPF Model

As mentioned earlier, without built-in program logic, the developer has to know exactly where the custom enhancement must be inserted. With the BOPF, this is often no longer necessary. Now the developer can simply add program logic using guided procedures that are provided when a business object is enhanced. Standard and custom logic are then displayed next to each other, making it look like one final product in the end (which, in fact, it is).

You can find the guided procedures that can be used for custom development in the enhancement guide of TM at *http://s-prs.co/v557502*. This guide is based on SAP TM 9.x but is still relevant for SAP S/4HANA as the BOPF model is still used.

2.1.3 Business Add-Ins

Rest assured, supporters of the "good old" SAP techniques—there are still some relics from the SAP applications we all know, such as the business add-ins (BAdIs). BAdIs are enhancements to the standard program logic without any modifications. SAP provides *enhancement spots*, which are specific places in ABAP coding where you can insert special program logic and alter data that needs to be processed.

A very popular example of an enhancement in TM is the BAdI for optimizer preprocessing. Before handing over data to the optimizer, the user can add or change information that was previously gathered by the SAP TM functionality. You find a list of all available BAdIs in the Customizing under **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management**, including available BAdIs for master data, basic functions, forwarding order management, freight order management, planning, settlement, and integration.

To create a BAdI, you can either use Customizing or go to Transaction SE18, as shown in Figure 2.14, and enter the name of the BAdI or enhancement spot. The TM-specific BAdIs start with /SCMTMS/, following the naming convention. When you do an F4 search on the BAdIs, you'll see that TM offers more than 100 BAdIs.

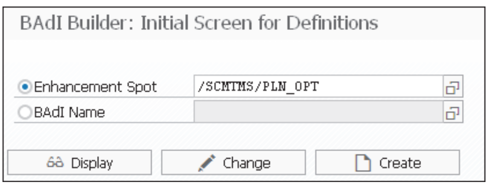


Figure 2.14 Choosing an Enhancement Spot to Enhance Standard Business Logic

In an enhancement spot, there is usually a sample implementation to help the developer get started with the custom enhancements. You can forward-navigate to the enhancement implementation (like the one shown in Figure 2.15) and to the enhancement's implementing class. The implementing class uses an interface that provides the developer with a data structure that is passed on from the standard coding and, after execution of the custom logic, back to the standard program flow again.

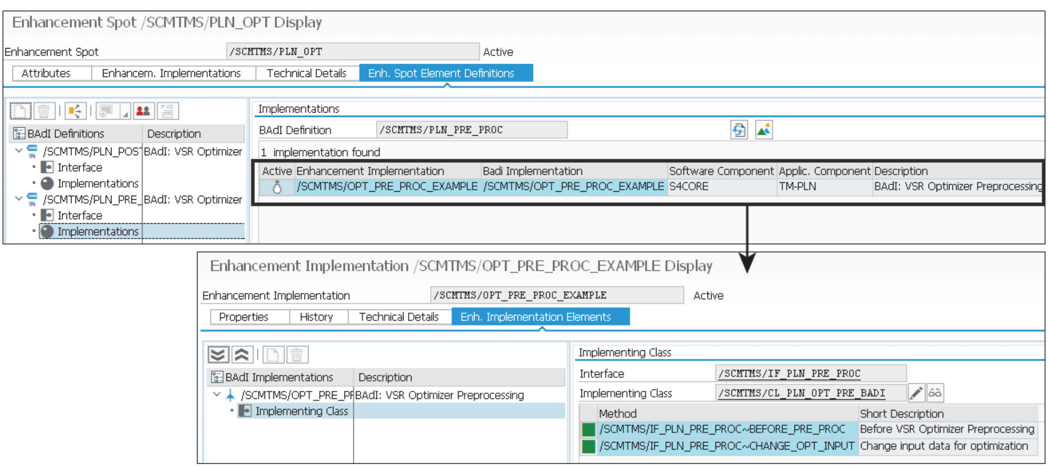


Figure 2.15 Enhancement Implementations

ABAP Development

Because this book aims to provide insight about what you can do with TM as a technical expert, we won't delve deeper into how to implement BAdIs or any ABAP coding at this stage.

2.2 User Interface Technologies

As mentioned in the introduction to this chapter, SAP S/4HANA requires two systems to display a UI to the user. In this section, we'll first look at how UIs are built and then delve into how they make their way onto the business user's screen.

In addition to the new way of storing and processing data, TM uses a new UI technology. Where former SAP applications relied on SAP GUIs, the new applications use web UI technology. The shift to web UI technology is accomplished by implementing UIs with Web Dynpro for ABAP, that is, using ABAP coding designed to be transformed into markup language that can be rendered by browsers. While new UIs that were exclusively developed for SAP S/4HANA already use an SAP Fiori technology, most of the TM UIs still use the Web Dynpro for ABAP technology, which is then rendered in a way that looks similar to the native SAP Fiori UIs.

TM can't exist *completely* without SAP GUI transactions, but the border between the usage of SAP GUI and web UI technology is clearly marked. While technical experts and consultants can continue to use SAP GUI for customizing and system monitoring, business users rely on the SAP Fiori launchpad from which they can perform all business transactions.

2.2.1 SAP Fiori Launchpad

The SAP Fiori launchpad is the one-stop shop to open all your SAP systems in one window. It's more of a UI technology than a client application. The tiles depicted on the SAP Fiori launchpad will redirect you to the application chosen and the UI technology within that. It works in a similar way as SAP Enterprise Portal and can also be opened in a browser when opening it from the desktop directly (shown in Figure 2.16).

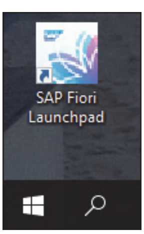


Figure 2.16 SAP Fiori Launchpad on a Windows Desktop

The SAP Fiori launchpad works with tiles that are clustered in different tabs. How the tiles and tabs are configured will be explained in more detail when talking about user roles in Section 2.2.3. There is a maximum number of tiles per tab. As you can see in Figure 2.17, all other tiles will be displayed as a text menu below the tile section. Because the SAP Fiori launchpad doesn't offer hierarchical structuring, apps such as **Create Container Unit** and **Edit Container Unit** need to be displayed as two separate tiles on the SAP Fiori launchpad.

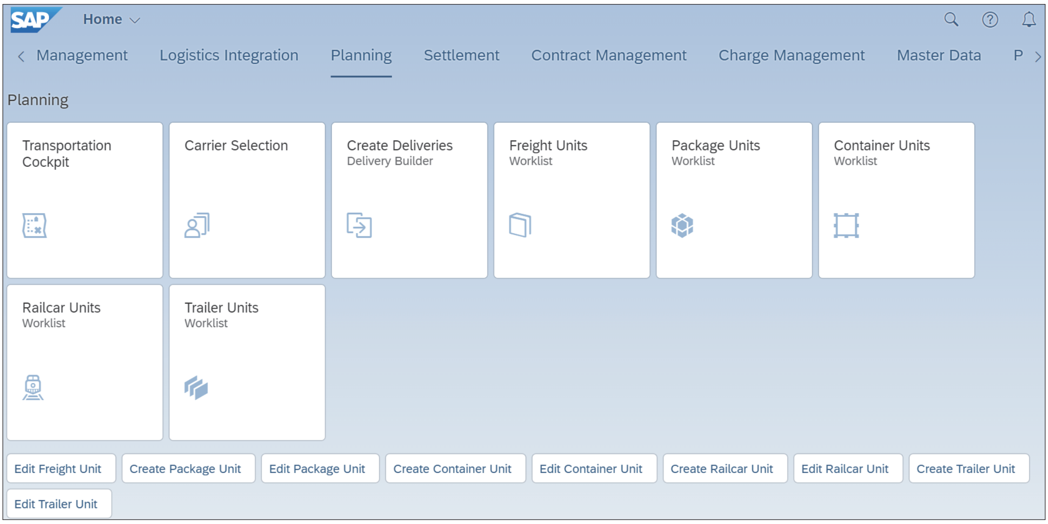


Figure 2.17 SAP Fiori Launchpad: TM Menu

2.2.2 Floorplan Manager and Floorplan Manager BOPF Integration

We've talked about the BOPF already in Section 2.1 as the first major technological pillar of TM. We'll now talk about the UI technology, which is the second major technological pillar of TM. The UI technology is supported by the Floorplan Manager (FPM) framework. The FPM is a tool that helps the developer build UIs with different building blocks. As already mentioned, TM mainly uses the Web Dynpro UI via FPM, but some of the latest UIs, mainly in analytics, are also created using the SAP Fiori design principles. Nevertheless, the focus of this chapter is FPM as the main UI technology of TM.

Each UI consists of an FPM application that defines one use case in the TM system. The forwarding order, for example, is one FPM application. As you'll see in Chapter 4, several FPM *application configurations* are designed for the forwarding order, each for different use cases (e.g., ocean forwarding order, air forwarding order, etc.).

Apart from the FPM application, the developer can now use different *UI building blocks* (UIBBs) to build a UI. The FPM framework provides predefined components called *generic UI building blocks* (GUIBBs) for this. For TM, we use the following components:

- **Overview page**
  The overview page defines the general layout of the screen. It provides a global toolbar at the top of the screen and can embed several other components.
- **Form**
  The form GUIBB gives you the opportunity to assemble several text and display fields of a flat structure (e.g., the root node) on the screen. The **General Data** tab on any business document is a typical example of a form GUIBB.
- **List**
  The list GUIBB displays the content of a table. For example, the table in the **Execution** tab of the forwarding order is made of a list GUIBB.
- **Tree**
  Hierarchical relations can be shown in a tree GUIBB. Very common examples of tree GUIBBs are the items in the forwarding order.
- **Tab**
  As you've seen in most UIs, in TM, the information in a document is divided into different tabs. These tabs are also built on a provided GUIBB.
- **FBI view**
  The Floorplan Manager BOPF Integration (FBI) view defines the link between the UIBB and the data in the BOPF. We'll talk about the FBI view later in this section. The FBI view is also a GUIBB in FPM.

Each FPM application configuration must have an overview page to provide the global toolbar. On the overview page, you can assign several UIBBs that can be built based on the listed GUIBBs. This assignment is depicted in Figure 2.18.

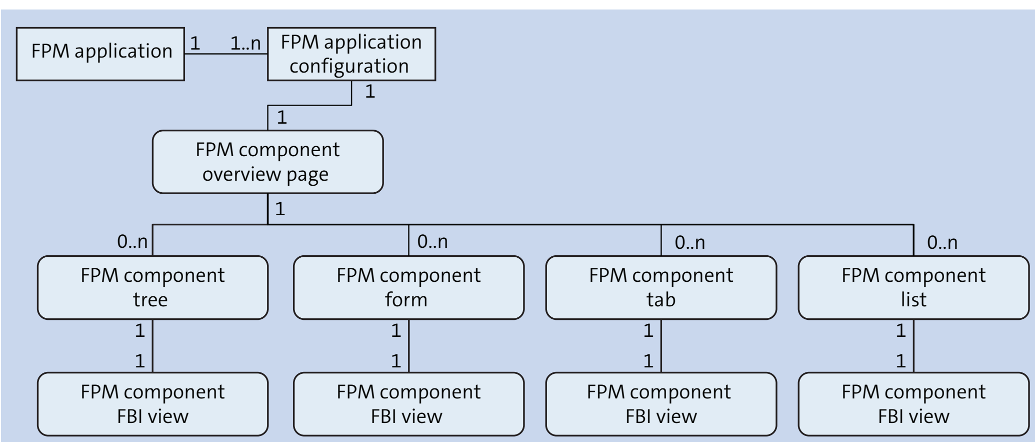


Figure 2.18 Assignment Hierarchy of Components in FPM

As you can see by the shape of the boxes, the overview page and assigned UIBBs are all FPM components, only of different types. The type of FPM component (meaning GUIBB) is described in the second line of the corresponding boxes.

So far, we've defined only the general look of the UI, but we haven't done anything about the link between the data in the system and how it can be put onto the screen. This link is established in the FPM framework using *feeder classes*, which provide the UIBBs with both data and a field catalog. The *field catalog* provides metadata about the data (e.g., which columns are available in a list). In the TM system, the feeder classes are also where the FBI framework comes into play.

The FBI framework provides generic feeder classes that developers can reuse and assign to the UIBBs they have chosen on the overview page. FBI provides one feeder class per GUIBB; this is necessary because every GUIBB requires its own feeder class that delivers information specific to and specifically structured for the GUIBB.

Apart from the feeder class, the FBI also provides an FBI-specific GUIBB, which is the *FBI view*. The FBI view establishes the link between the BOPF node and the UIBB. Each UIBB has one FBI view. You can see this assignment in the component configuration or component Customizing. As you can see in Figure 2.19, especially in the lower screen, the FBI view contains the business object and business object node of the data that should be displayed in this UIBB. Furthermore, the FBI view contains a UI structure that consists of all fields that should be available on the UI.

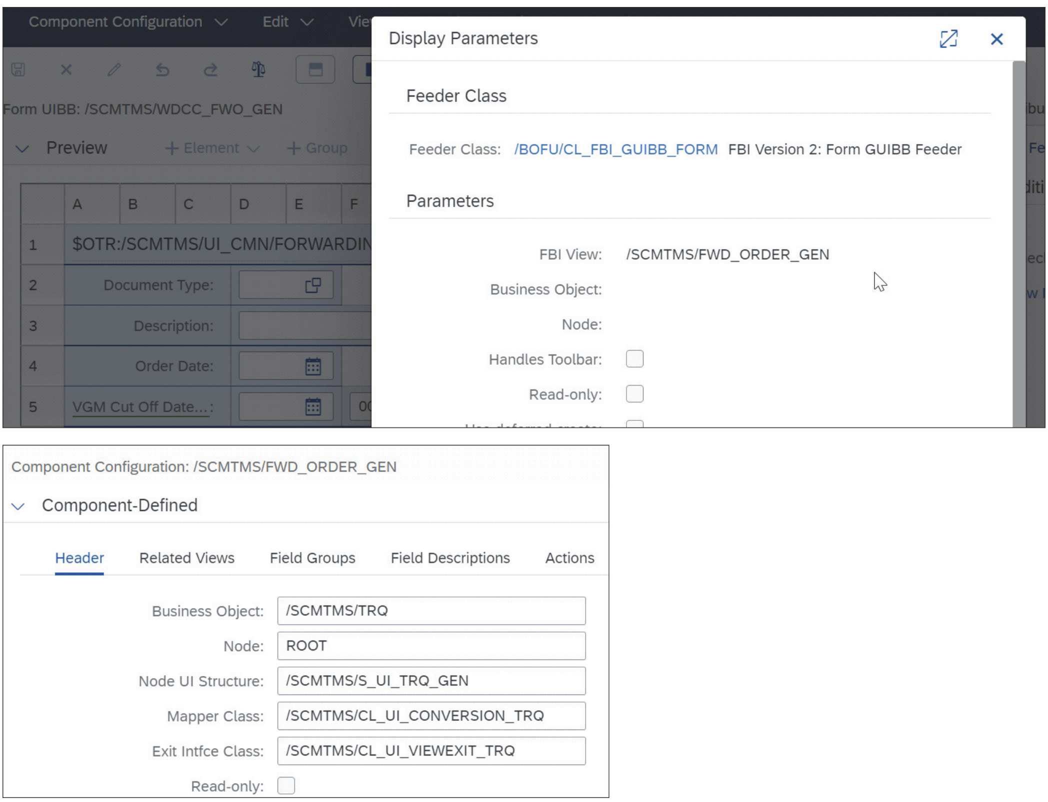


Figure 2.19 FBI View

Node Structure versus UI Structure

The actual node structure can't be used as the structure providing fields to the UI because the concept of the UI structure differentiates between data stored on the database and data to be read by a user. For example, the creation date of a document is stored as a time stamp in one field of the node structure, but this time stamp isn't readable to any user. Therefore, the UI structure contains three fields for the creation date: date, time, and time zone.

If the UI structure contains fields that aren't part of the UI structure, the *mapper class*, also depicted in Figure 2.19, is responsible for passing the data from the BOPF to the UI structure.

At runtime, the FBI view fills the fields of the UI structure and passes it to the feeder class that passes the data on to the FPM-based UI. All communication between the BOPF and FPM is therefore channeled through the FBI-specific feeder class and the FBI view.

Transient UI – BOPF Integration (TBI)

You'll notice that a few UIs, the more complex ones that contain information from several nodes, follow a different approach than the normal FBI. These UIs are using a TM-specific concept, the Transient UI – BOPF Integration (TBI). TBI can handle complex logic that can't be achieved with the standard capabilities of FBI; for example, it can show in one UI information from a forwarding order, freight unit, and freight document at the same time. This concept was invented to improve the performance for complex UIs and support the needs for these UIs.

2.2.3 Defining User-Specific Roles, Catalogs, and Menus

Recall that the SAP Fiori launchpad displays tiles grouped in tabs. The user role will eventually define what tiles and tabs the user is able to see. SAP has predefined some roles according to the tasks different users may have in their daily business.

For the SAP Fiori launchpad, all tiles are collected in *catalogs* that are configured on the frontend system. We differentiate between *technical catalogs* and *business catalogs*. Technical catalogs are a collection of tiles that technically are related. As you can see in Figure 2.20, the TM functionality provides two technical catalogs: one technical catalog is generated out of the replication of the Web Dynpro applications that were designed in the backend system. The second catalog is the one containing new SAP Fiori apps that were explicitly designed for SAP S/4HANA. However, the technical catalogs aren't used to display tiles on the SAP Fiori launchpad when a business user logs on. Instead, business catalogs subdivide the applications into logical groups. These groups should reflect the different divisions within a company.

It's only the SAP Fiori launchpad group that eventually defines which applications are represented as tiles and which ones as text links. As you can see in Figure 2.21, the tiles are put into a layout that will be reflected on the SAP Fiori launchpad when a business user logs on. The tiles in the group, however, will have to reference tiles from the business catalogs.

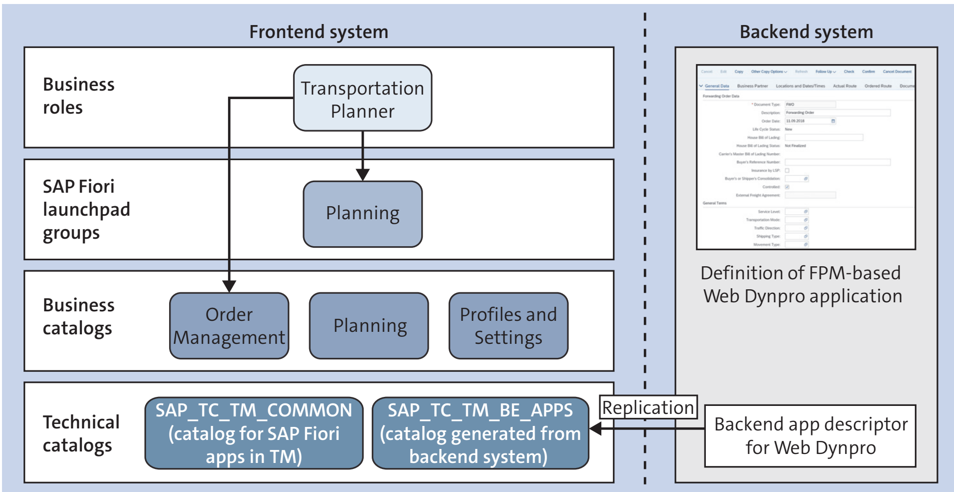


Figure 2.20 Technical Structure of the SAP Fiori Launchpad

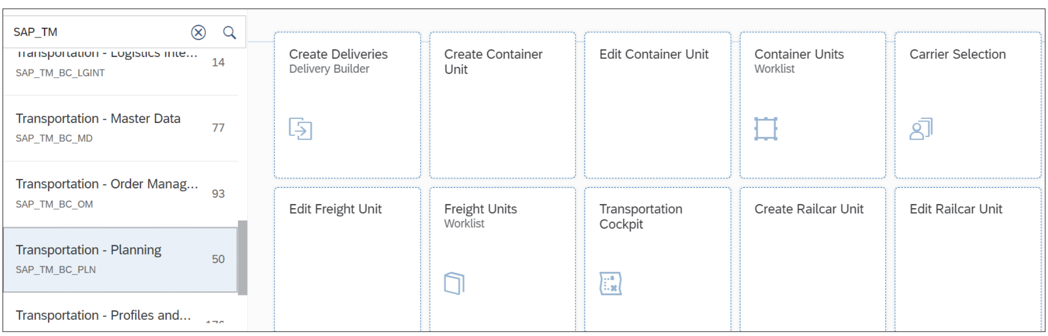


Figure 2.21 Definition of SAP Fiori Launchpad Groups

To define which user role will be able to access which apps, the SAP Fiori launchpad groups need to be assigned to a user role in Transaction PFCG of the frontend system. When defining the role, both the SAP Fiori launchpad group (defines how the tiles and text links should be displayed) and the corresponding business catalogs (define what Web Dynpro applications to access) are assigned to the role. If a user is assigned numerous roles, all the tiles and links defined in the respective roles are displayed in the SAP Fiori launchpad.

2.2.4 Customizing Screen Areas

Compared to SAP GUI transactions, one big advantage of Web Dynpro for ABAP applications is the ability to customize screens. Technical expert or consultants can now perform changes to the UI in Customizing mode without touching any lines of code or making modifications to the system.

When browsing through a business transaction, you might come across some fields that you either don't need or that you want to rename. With Web Dynpro ABAP, you can change the UI in Customizing mode. From the business transaction, right-click on the screen area you want to customize, and choose **Technical Help**, as shown in Figure 2.22. A new popup opens, and you can navigate to the UI Customizing by clicking on the link of the component Customizing of the current view.

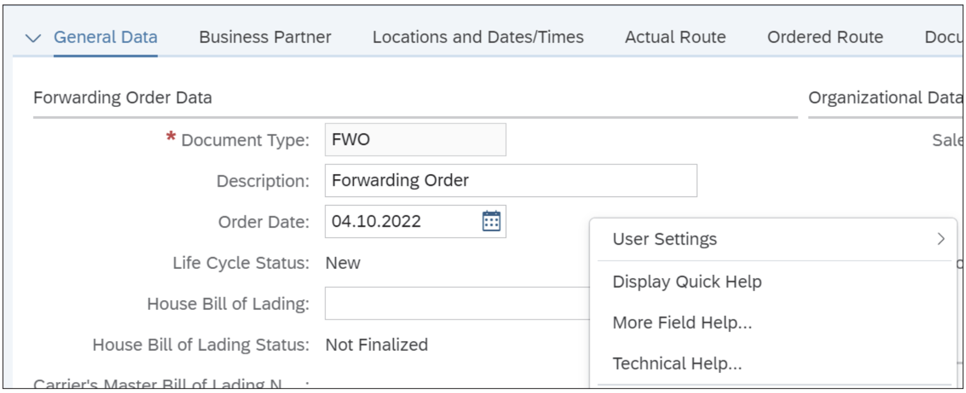


Figure 2.22 Opening Technical Help for a Web Dynpro Application

Creating a Customizing for a UIBB

In a new TM system, you won't see the link for the component Customizing in the technical view popup. If this is the case, choose the link for the component configuration.

In the component configuration (which is SAP standard and should therefore not be changed), you can choose **Other Functions • Create Customizing**.

Note that both the component configuration as well as the component Customizing are located in the backend system.

In the UI Customizing, you can add and remove fields, change labels, and change the way fields are displayed, as shown in Figure 2.23. Changes can be seen directly in the preview screen of the Customizing application.

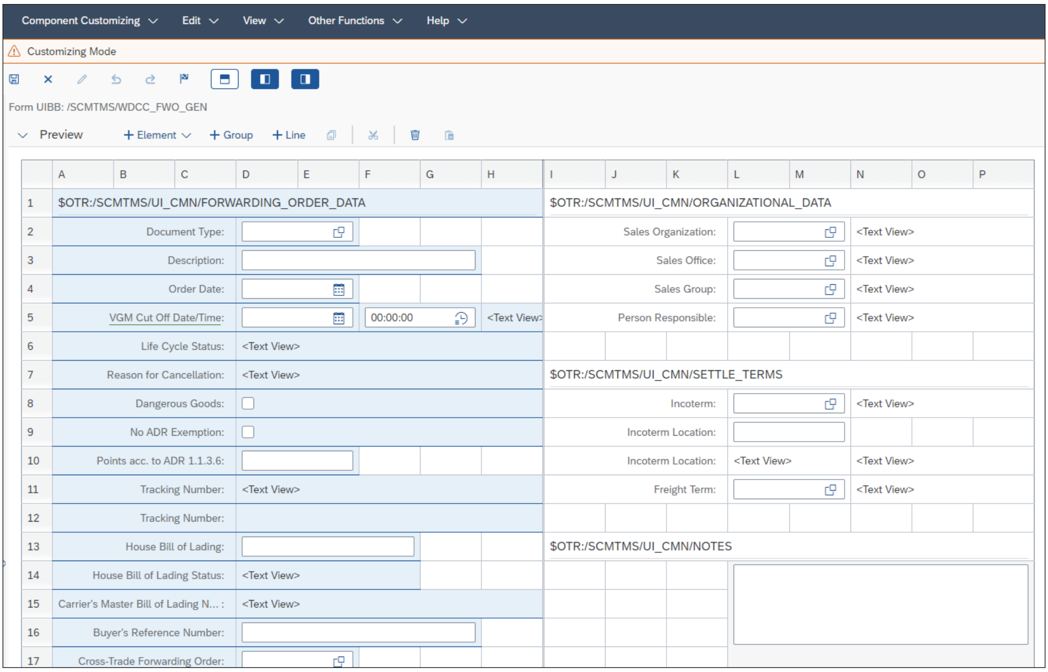


Figure 2.23 Customizing a Web Dynpro Application

2.3 Frameworks and Tools Used throughout TM

Business process execution in TM is based not only on new TM-specific developments but also on various tools that enhance TM functionality and support business process execution:

- Business Rules Framework plus (BRFplus)
- Incompatibilities
- Post Processing Framework (PPF)
- Document creation and adaption
- Optimizer server
- Process Controller Framework
- Background remote function call (bgRFC) trigger

Some of these are third-party tools that require a license independent of the SAP license for SAP S/4HANA. If you've worked with other SAP applications before, you've probably come across some of these tools already. In general, the purpose of using these tools is to enable the user to configure the system in more detail with less modifications or coding changes.

Monitoring of TM, including Frameworks

In Chapter 13, you'll get an overview of the most important areas that need to be monitored in TM. Additionally, we'll talk about tips and tricks for using TM.

2.3.1 Condition Framework Using the Business Rules Framework

The most prominent framework you'll come across when using TM is *Business Rules Framework plus* (BRFplus), which provides conditions to aid in automatic decision-making in TM business process execution.

Conditions are tools that determine an input value based on master data or transactional data and derive an output value from the determined input value. Their use is widespread throughout the TM functionality; you'll find possible action areas for them in all process areas.

The following are the most common functions:

- Determination of document types
- Determination of organizational units
- Determination of the applicant rate tables in transportation charge management
- Determination of incompatibilities
- Determination of loading/unloading time of a freight unit
- Determination of delivery time windows for a freight unit

Take the determination of the organizational units of a freight order as an example. In this case, the condition is processed upon creation of the freight order.

The condition type used for this process step is `/SCMTMS/TOR_ORGUNIT`. In Customizing, you can see this condition type by following the IMG path **Transportation Management • Basic Functions • Conditions • Define Condition Types**. The definition of the condition type includes three important details that you might need for your condition creation, as shown in the boxes in Figure 2.24:

- The top box displays information about a singleton condition.
- The middle box displays the result type definition.
- The bottom box displays the business object node as a starting point for input value determination.

The first checkbox indicates whether more than one instance of this condition type is allowed in the system. Some condition types, called *singleton conditions*, may have only one condition defined in a system. Note that their trigger point can't be influenced by Customizing. For example, when sending a sales order to a standalone TM system, there is one condition type in the TM system that determines the document type of the document created by the transferred SAP S/4HANA sales order. In Customizing, there is no means of determining which one of these condition types should be called.

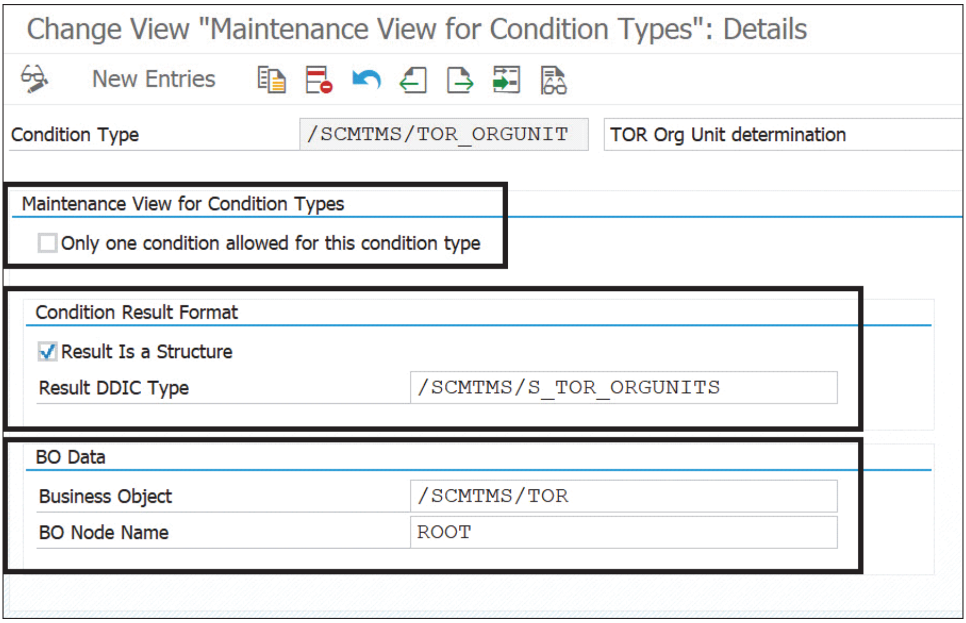


Figure 2.24 Definition of a Condition Type

If there can be more than one condition of a condition type, as in our example, then there is a field where this condition has to be entered to be processed, for example, in Customizing for the freight order type.

The second crucial piece of information is the DDIC type of the result. In Customizing, you can enter a data element, structure, or table type that is used as the output of the condition. If a structure is used, the corresponding flag in Customizing must be set.

If you're building more complex infrastructures, then the last piece of information in Figure 2.24 is the most important. In the **BO Data** section, you can see where the condition starts searching for an input value. The business object and business object node are displayed here.

You'll create a lot of conditions to automate business decisions when you're setting up your TM functionality. As an example, a condition can be used to determine the planning and execution organization within a freight order. The condition uses the information of the source and the destination location to derive the corresponding organizational information. The formula is pretty easy: If the source location of the freight order is Istanbul, and the destination location of the freight order is Berlin, then the planning and execution organization is Turkey. If the freight order goes the other way around, the planning and execution organization is Germany.

We start creating our condition by choosing the Create Condition app in the **Profiles and Settings** tab of the SAP Fiori launchpad. We choose the corresponding condition type (i.e., **/SCMTMS/TOR_ORGUNIT**) and specify that we want to create a condition based on a *decision table*, which is also the example in Figure 2.25.

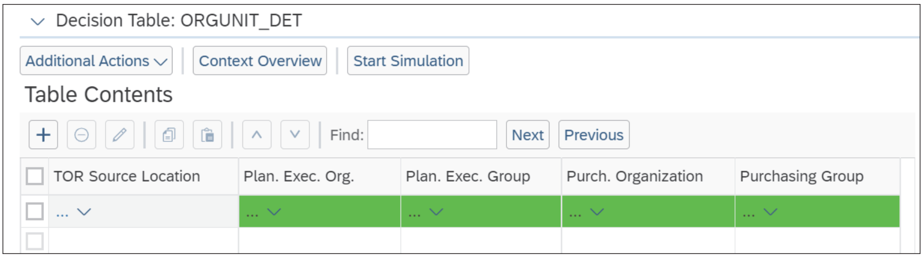


Figure 2.25 Decision Table of a Condition

This is the most commonly used type of condition. With the decision table, you can map a combination of input data to explicit output data, as you'll see later.

In some cases, it might be more convenient to use a condition with direct business object access. This condition determines the input data, which, in this case, is also the output data. Direct business object access is commonly used when defining incompatibilities, which we deal with in Section 2.3.2.

When we define the condition, we see a decision table. Input columns have a gray background, and output columns have a green background. You can see that, by default, the source location of the freight order is taken as an input value. You can change the input data by clicking the **Data Access Definition** button at the top of the screen.

Figure 2.26 shows that the condition type predefined the data access definition: the source location of the freight order. You can add more input values by adding a line to the table. With F4 help, you can see what data access definitions are offered for this condition type. If you know that your input value can be found on the root node of the business object **/SCMTMS/TOR**, which represents the freight order, you can leave the **Data Access Definition** field empty and enter the business object, business object node, and field directly in the corresponding fields.

Note that you can enter only the business object and node that were defined as the starting point in Customizing or a node that is directly associated with this node. For example, we want to add the destination location of the freight order as a second input value. Because this data access definition isn't predefined, and the information isn't stored on the root node of the `TOR` business object, a custom data access definition needs to be created.

Because the information we want to retrieve isn't stored on the root node, we need to use a *data crawler* to use associations to navigate to the node where our field is. To do so, we need to define or find a data crawler profile via the Customizing menu path **Transportation Management • Basic Functions • Conditions • Define Data-Crawler Profile**.

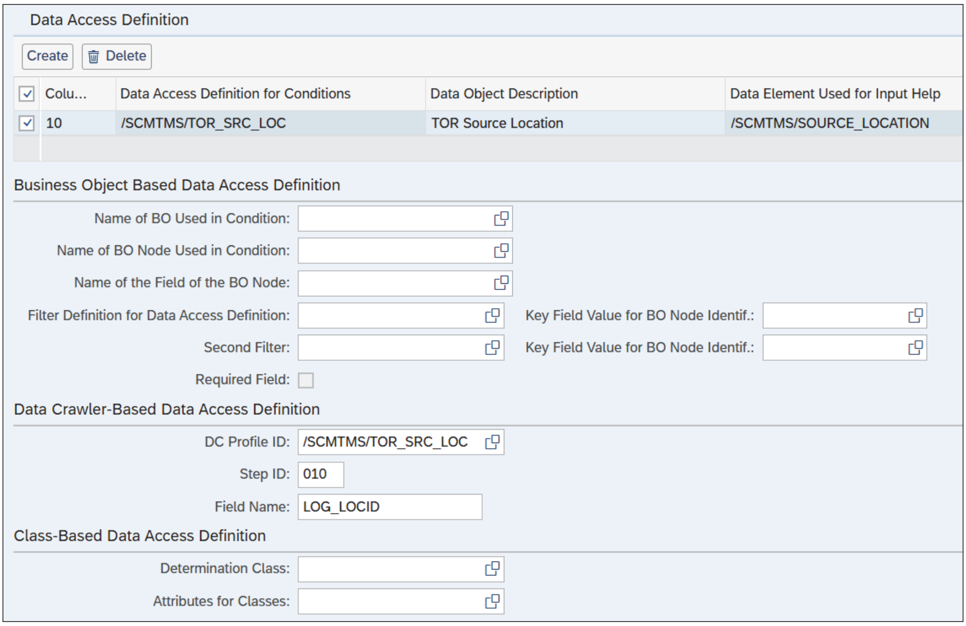


Figure 2.26 Data Access Definition of a Condition

In this Customizing activity, we want to look at an already-existing data crawler profile that provides the last location of a freight order (**/SCMTMS/TOR_LAST_LOC**). On the first screen, it's defined where the data crawler should start "crawling" the data on the business object. The data crawler has to start at the starting point of the condition; in this case, the business object **/SCMTMS/TOR** and the node **ROOT** (refer to Figure 2.24). Figure 2.27 shows the Customizing settings defining the starting point.

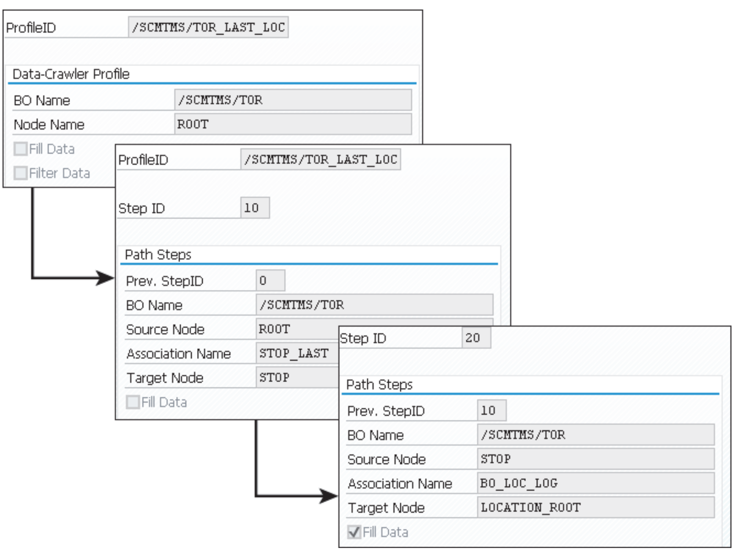


Figure 2.27 Data Crawler

The next step is to define the target of the data crawler. To do this, we define a step for the data crawler, which we do using the **Path Steps** in the dialog structure. The lower two screens of Figure 2.27 show how these path steps are maintained.

The data crawler step represents our use of an association. When we enter a step number and press Enter, the starting point of this step is automatically updated. The only thing we have to maintain is the association we want to use. Fortunately, the business object /SCMTMS/TOR offers an association that not only returns data of the STOP node (where all stops of the freight order are stored) but also offers an association that filters out all stops except the destination location.

Therefore, we use the association STOP_LAST. To retrieve the location ID and further details of this location, however, we decide to add another step by moving to the root node of the business object representing the location (refer to **Step ID 20** in Figure 2.27). Because we've now reached the point where we want to be with our data crawler to retrieve data, we select the **Fill Data** checkbox shown at the bottom of Figure 2.27.

Notice in the lower area of Figure 2.26 that the data crawler profile (**DC Profile ID**) can directly be entered on the screen where the data access definitions of the conditions are defined. To provide the data crawler as a predefined element of the data access definition, the data crawler is assigned to a new data access definition in the Customizing settings. The data access definition can then be used in the Customizing settings of the condition type.

To do so, we create a new data access definition in Customizing, following the menu path **Transportation Management • Basic Functions • Conditions • Data Access Definition**. Here, we create a new data access definition and assign the data crawler profile, define the step in which we want to retrieve data, and enter the field we want to read. The field is the component name of the DDIC structure assigned to the node that we've navigated to with our data crawler.

To help the users enter the right input data, the data type of the field in **Data Element for F4 Helps** has to be maintained. If the data type of your input field isn't known, it can be identified using the DDIC structure of the business object node.

Because condition types can start at different business object nodes, not all data access definitions created in Customizing may be used in a condition of a certain type. Therefore, data access definitions are assigned to condition types in Customizing. Following the Customizing path **Transportation Management • Basic Functions • Conditions • Assign Condition Type to Data Access Definition**, you can maintain a corresponding entry to assign the data access definition we just created to the condition type /SCMTMS/TOR_ORGUNIT. If you set the **Dflt DAD** field to **Data Access Definition is Default for Condition Type (X)**, your data access definition is displayed in every new condition of this type.

The data access definition can be maintained in the corresponding field of the new condition. The information concerning the data crawler profile and input help is entered automatically.

If you click **Back**, you go back to the decision table and maintain values by clicking the link. We can now enter the data in the decision table, as shown in Figure 2.28.

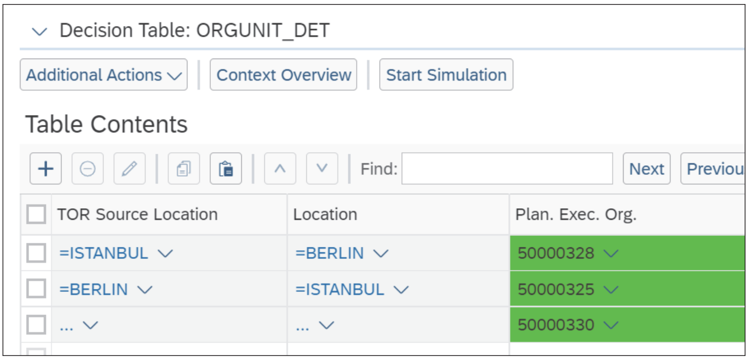


Figure 2.28 Decision Table

When maintaining more complex decision tables, note that the system always reads decision tables from top to bottom. If a corresponding combination of input values is found, the system stops looking through the table and continues the business process with the output values found.

In our example, we now have a third planning and execution organization: Europe. This organizational unit is responsible for all other freight orders except for the ones between Istanbul and Berlin. We therefore enter a third line in the decision table, leaving the input values empty (which acts as a wildcard) and enter the planning and execution organization. In this case, it's very important to enter this line as the last line in the decision table because if it's the first, all freight orders get the planning and execution organization Europe.

Organizational Units in Decision Tables

Organizational units have an ID and organizational unit number. In decision tables, only the number is displayed. Therefore, you don't see the IDs **Germany**, **Turkey**, and **Europe**, which we've used in our example in Figure 2.28, but only the organizational unit numbers.

After saving the condition, you can assign your condition to a freight order type, as shown in Figure 2.29. The planning and execution organization is always determined using the condition when a freight order of this type is created.

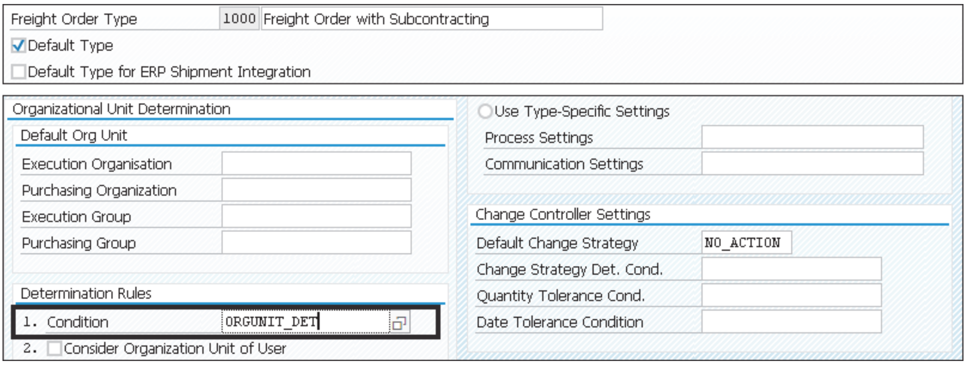


Figure 2.29 Organizational Unit Determination in Freight Order Type Customizing

Transporting Conditions

If you set up the system so that Customizing can be transported when you enter a condition in edit mode, you're asked to record your changes to the condition in a software Customizing transport request.

Conditions can be transported to other systems. Be aware that this makes sense in some circumstances but not all; in our example, using organizational unit numbers doesn't make sense because the organizational unit numbers would be different in another system. However, conditions can also be created and edited in systems where normal Customizing in Transaction SPRO isn't permitted.

2.3.2 Incompatibilities

Incompatibilities are used to implement planning, loading, and routing constraints. Loading constraints identify goods as incompatible with other goods, vehicles, or compartments. Routing constraints identify goods or vehicles as incompatible with locations.

Incompatibilities

This section about incompatibilities aims to provide an overview of the functionality that incompatibilities provide and how they work. We take a more detailed look at the use of incompatibilities in the corresponding sections of this book, especially in Chapter 5.

You can create incompatibilities by choosing the Create Incompatibility app in the **Profiles and Settings** tab of the SAP Fiori launchpad.

An incompatibility has two main settings: incompatibility area and incompatibility type. Both can be found at the top-right corner of Figure 2.30. The **Incompatibility Area** field defines where this incompatibility can be used—that is, in the entire optimizer run, only in carrier selection, and so on.

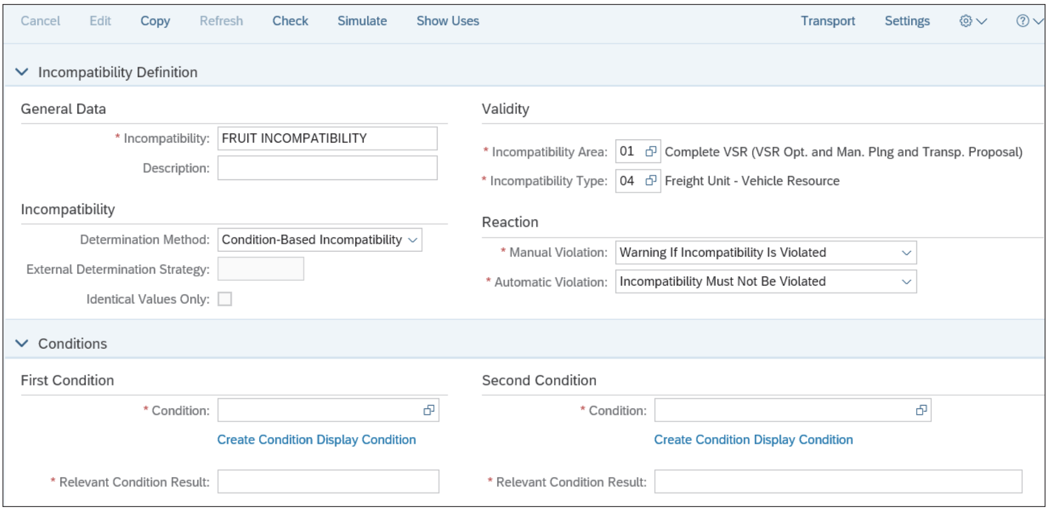


Figure 2.30 Incompatibility Definition

The **Incompatibility Type** field defines what should be made incompatible with what. Incompatibilities contain a condition that needs to be checked for each of the involved documents. The result values of the condition are compared with a check value, which is defined in the incompatibility. The incompatibility check is passed only if the condition results meet the defined expected results. Depending on the incompatibility type you've chosen, the condition type of both conditions is predefined.

For example, say we want to define that a certain truck can't carry fruit and vegetables, so we choose the incompatibility type **Freight Unit – Vehicle Resource**. Incompatibilities make use of conditions to determine values that are then validated based on whether they are incompatible to each other. The condition types of the two conditions being compared are now predefined. By clicking **Create Condition**, you can create a new condition from the **Incompatibility Definition** screen.

In Figure 2.31, we create the first condition: **FRUIT INCOMPATIBILITY**. Because the freight unit itself doesn't carry any unique information that identifies it as a fruit or vegetable, we need to fine-tune the condition.

We know that the products **APPLE**, **PEAR**, and **ORANGE** are fruits. Therefore, we define the decision table in such a way that if the input (the data access definition looks at the product ID of the freight unit's product item) is one of these, then the output is **FRUIT**, as illustrated in Figure 2.31 .

The first condition is automatically entered into the corresponding field in the **Incompatibility Definition** screen when you save it. We now enter the value "FRUIT" in the **Condition Result** field.

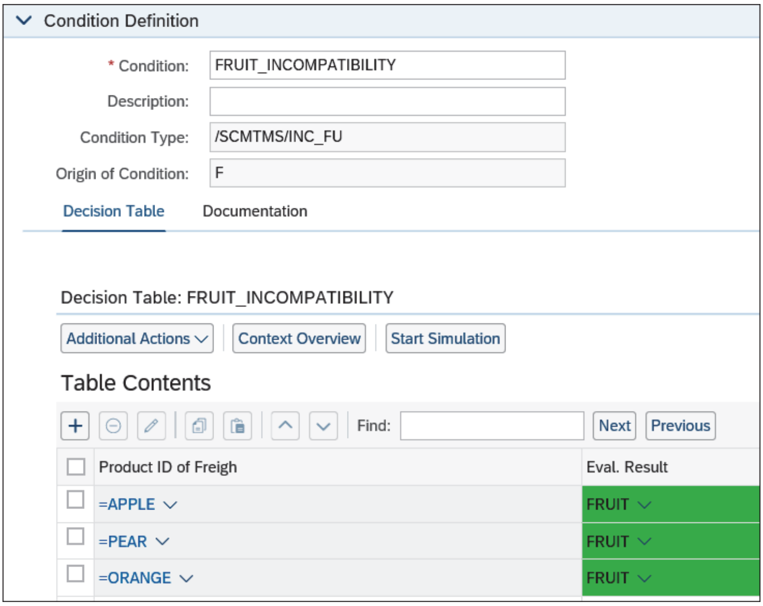


Figure 2.31 Grouping Multiple Input Options to One Value for Incompatibilities

Now we need to create the second condition: the condition determining the resource name. In this condition, we can use the direct business object access condition because we only need the name of the truck. Set the condition access type to direct business object access, and define a corresponding data access definition.

In the incompatibility definition screen, we now set the condition result of the second condition to **TRUCK1**. Now the truck is incompatible with all freight units that are defined as **FRUIT** in the first condition.

Grouping Products for Transportation Purposes

This example doesn't have any grouping information on the transportation quality of the freight unit. In general, it's recommended to store that information in the product's *transportation group*.

After we've saved our incompatibility definition, we can group it together with others in *incompatibility settings*, which are shown in Figure 2.32. In these incompatibility settings, we can define whether we want equal behavior in manual and optimizer planning.

We delve deeper into the use of the different incompatibility types when we talk about planning with the TM functionality later on.

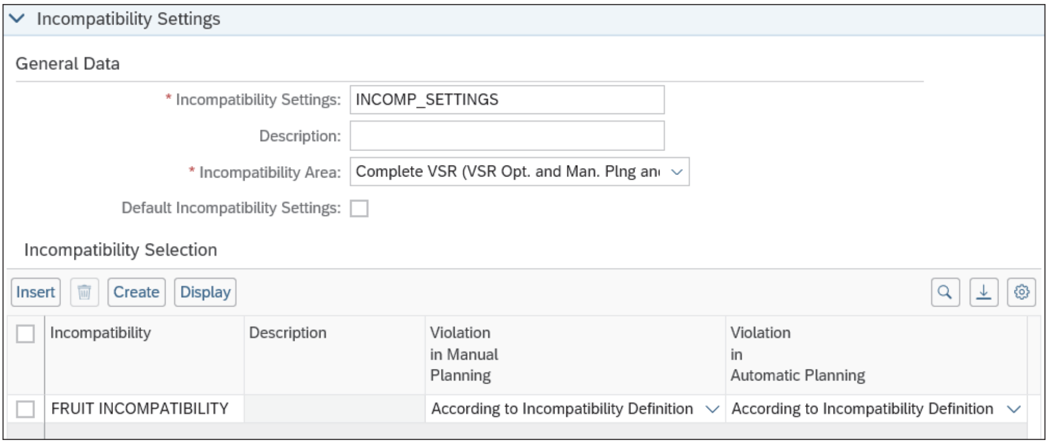


Figure 2.32 Incompatibility Settings

2.3.3 Post Processing Framework

While in the classic SAP ERP applications such as Sales and Distribution (SD) and Logistics Execution (LE), the “Nachrichtensteurerung” (NAST) was used as the output management system, TM uses the Post Processing Framework (PPF) for output management. The PPF can be used to execute certain follow-up activities to a business process step.

The PPF is used for the following tasks, or *actions* (to name a few):

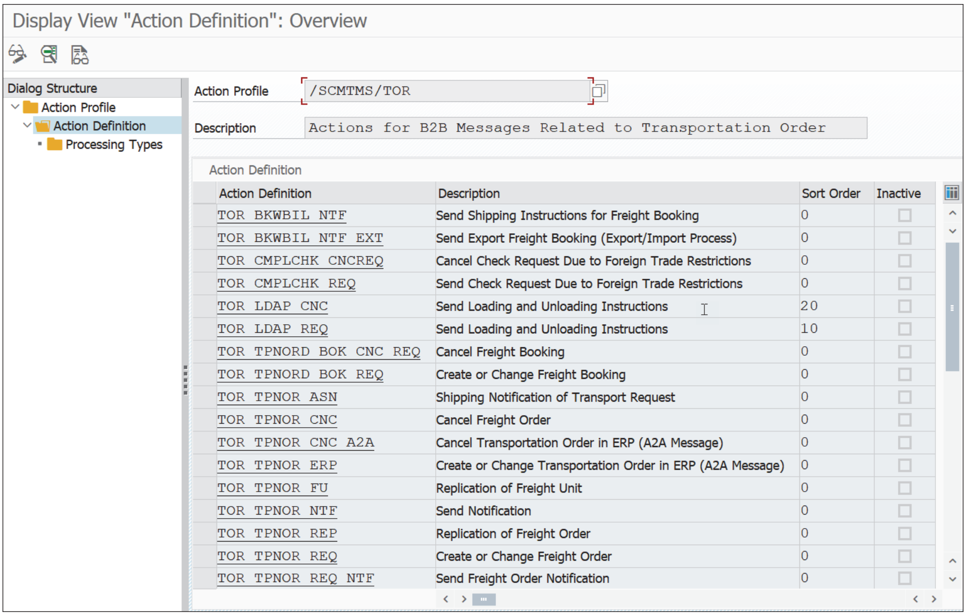
- Document printing
- Sending messages, such as email, fax, or Electronic Data Interchange (EDI)
- Using workflow triggers

All actions are defined in the PPF with a *schedule condition* that defines whether the action needs to be executed and a *processing time* that defines when to execute the action.

In general, it’s important to note that PPF actions can only process information that is already saved to the database. This prevents you from accidentally sending preliminary transportation orders to a carrier, for example.

The transaction for configuring the PPF isn’t part of any TM role. Instead, you must enter Transaction SPPFCADM in the backend system. On the initial screen of this transaction, you can see various PPF applications. Select **/SCMTMS/TRANSPORTATION**, and choose **Define Actions Profiles and Actions**.

An action profile like the one shown in Figure 2.33 bundles all actions concerning a specific business process area (e.g., the action profile **/SCMTMS/TOR** bundles all actions important for the business to business [B2B] communication of a freight order).



Action Definition	Description	Sort Order	Inactive
TOR_BKWBIL_NTF	Send Shipping Instructions for Freight Booking	0	
TOR_BKWBIL_NTF_EXT	Send Export Freight Booking (Export/Import Process)	0	
TOR_CMPLCHK_CNCREQ	Cancel Check Request Due to Foreign Trade Restrictions	0	
TOR_CMPLCHK_REQ	Send Check Request Due to Foreign Trade Restrictions	0	
TOR_LDAP_CNC	Send Loading and Unloading Instructions	20	
TOR_LDAP_REQ	Send Loading and Unloading Instructions	10	
TOR_TPNORD_BOK_CNC_REQ	Cancel Freight Booking	0	
TOR_TPNORD_BOK_REQ	Create or Change Freight Booking	0	
TOR_TPNOR_ASN	Shipping Notification of Transport Request	0	
TOR_TPNOR_CNC	Cancel Freight Order	0	
TOR_TPNOR_CNC_A2A	Cancel Transportation Order in ERP (A2A Message)	0	
TOR_TPNOR_ERP	Create or Change Transportation Order in ERP (A2A Message)	0	
TOR_TPNOR_FU	Replication of Freight Unit	0	
TOR_TPNOR_NTF	Send Notification	0	
TOR_TPNOR_REP	Replication of Freight Order	0	
TOR_TPNOR_REQ	Create or Change Freight Order	0	
TOR_TPNOR_REQ_NTF	Send Freight Order Notification	0	

Figure 2.33 Action Profiles Containing Action Definitions

Let's briefly consider the most important settings of the PPF. In Figure 2.34, you can see in the **Action Settings** area, where we can define the processing time of the action and whether the action should be scheduled automatically or by a batch job.

The processing type of the action can be one of the following:

- Trigger alert
- Method call
- Workflow
- Smart Forms actions
- External communication

The type you choose determines the required information for the detailed processing. Schedule conditions define whether an action should be processed at all. The most common way of defining a schedule condition is to implement BAdI `EVAL_STARTCOND_PPF`. You can also define start and scheduling conditions in Transaction SPPFCADM by choosing the application **/SCMTMS/TRANSPORTATION** and selecting **Condition Configuration (Transportable Conditions)**.

The usage of an action profile is defined in the type Customizing of certain business documents such as freight order, as shown in Figure 2.35. Here, you can assign two action profiles: one for uncritical actions such as printing, which can be executed after save asynchronously (e.g., **/SCMTMS/TOR_PRINT_ROAD**) and one for critical actions such as B2B communication, which needs to be executed before save synchronously (e.g., **/SCMTMS/TOR**).

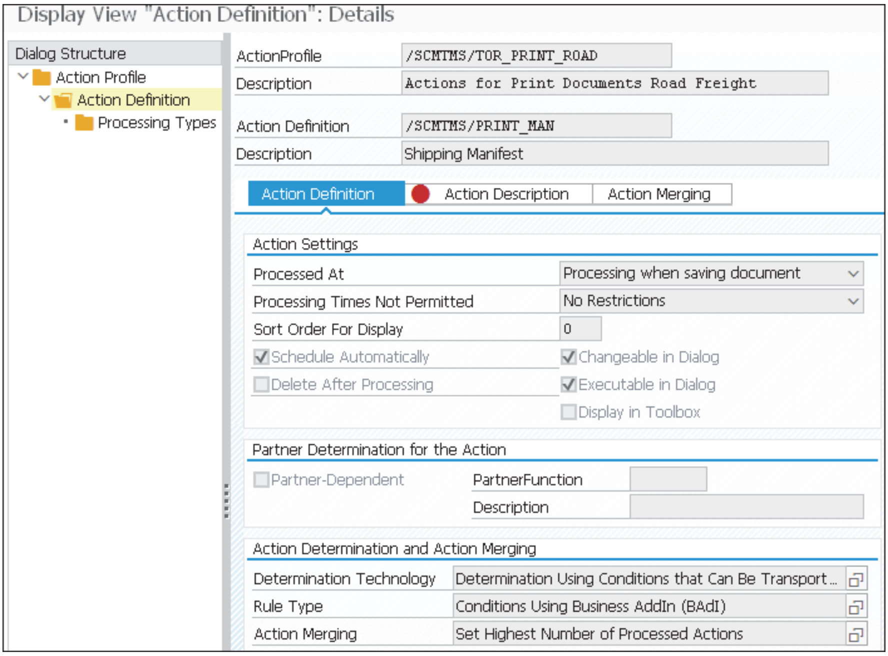


Figure 2.34 Action Definition

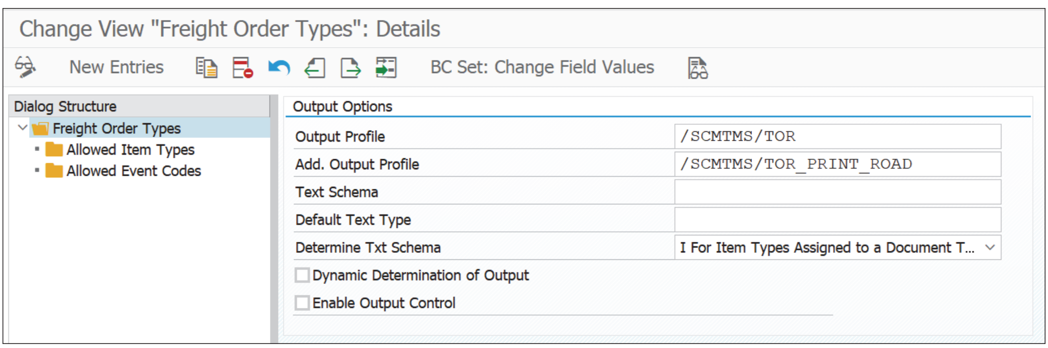


Figure 2.35 Action Profile Assignment to Business Document

Dynamic Action Profiles

There is also the option to determine the action profiles dynamically based on the **Output Management Adapter Settings**, which you can access via **Cross-Application Components • Reusable Objects and Functions for BOPF Environment • PPF Adapter for Output Management • Maintain Output Management Adapter Settings**. In this setup, the TM system determines during the runtime of a business object all active output management agents for the related technical object and node such as /SCMTMS/TOR node ROOT and executes the activated action profiles.

2.3.4 Document Creation

The previous section mentions that you can accomplish document printing with PPF. However, TM is also capable of designing print forms to a certain extent. TM integrates with Adobe Document Server, a tool that can be run within SAP GUI in the backend system.

Start Transaction SFP, and choose the print form you want to alter. Then add new fields to the print form or alter the layout on the **Layout** tab, as illustrated in Figure 2.36.

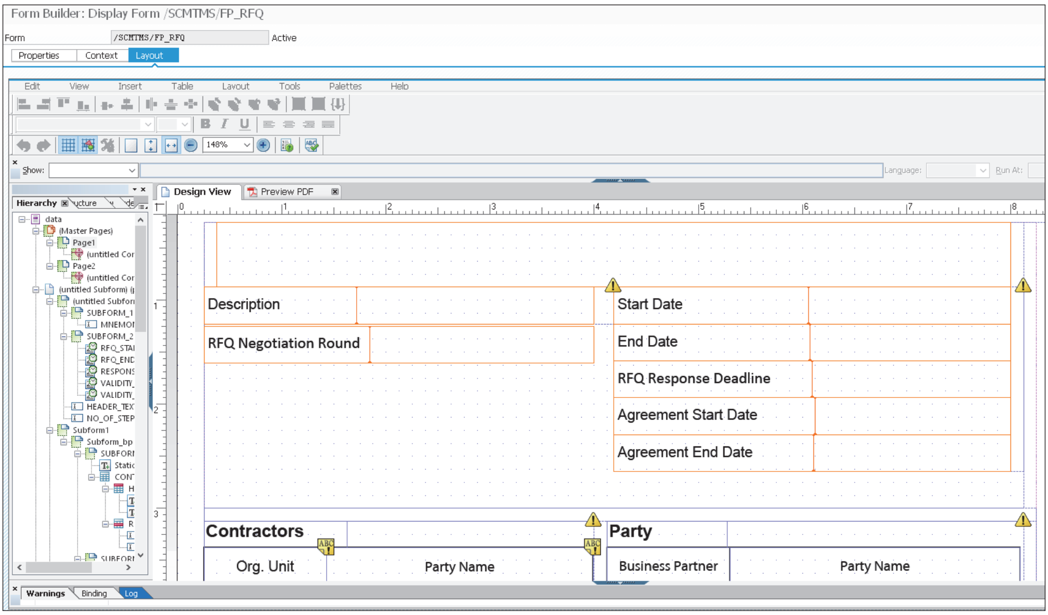


Figure 2.36 Configuring a Print Form

> **Adobe Document Server**
>
> Adobe Document Server requires its own license and its own plug-in for you to use it within SAP GUI.
>
> We won't go deeper into altering print forms in this chapter. For more information, consult resources that cover the Adobe Document Server.

2.3.5 Optimizer

SAP has already used optimization programs in various supply chain management applications, such as SAP Advanced Planning and Optimization (SAP APO)-Transportation Planning/Vehicle Scheduling (TP/VS), a predecessor of TM. The optimizer is a C++-based application designed to solve transportation problems in a mathematical way. Bear in mind that transportation problems might not be solved completely but can be handled with a best approach. This applies to the optimizer too.

The optimizer can be run on hardware different from the application servers running TM. In fact, it's recommended because the system requirements of TM and the optimizer differ.

Optimization runs can be performed in parallel. To provide enough optimizer resources, either the optimizer should provide a sufficient number of slots, or you should connect several optimizer engines to the backend system running the TM functionality, as shown in Figure 2.37.

RCCF: Destinations for Engines

Dest. ID	Appl.	Short Text	Status	M...	P...	Comm. Type	Communication Connection
TSFM01	TSFM	Strategic Freight Management Optimizer	Active	10	1	RFC	OPTSERVER_TSFM01
TSPS01	TSPS	Transportation Service Provider	Active	10	1	RFC	OPTSERVER_TSPS01
TVRG01	TVRG	Transportation Proposal	Active	10	1	RFC	OPTSERVER_TVRG01
TVS001	TVSO	Load Optimization	Active	10	1	RFC	OPTSERVER_TVS001
TVSR01	TVSR	Vehicle Scheduling and Routing engine	Active	10	1	RFC	OPTSERVER_TVSR01
TVSS01	TVSS	Vehicle Scheduling engine	Active	10	1	RFC	OPTSERVER_TVSS01

Figure 2.37 Optimizer Connections

The optimizer connections can be monitored in Transaction RCC_CUST. Figure 2.37 provides an overview on the six applications the optimizer provides:

- **TSFM** for strategic freight management
- **TSPS** for carrier selection
- **TVRG** for transportation proposals
- **TVSO** for load optimization
- **TVSR** for optimizer routing and scheduling
- **TVSS** for scheduling of existing freight orders

It's important to know that these six applications are only executable files on the optimizer server. No master data or transactional data is stored on the optimizer engine except for log files.

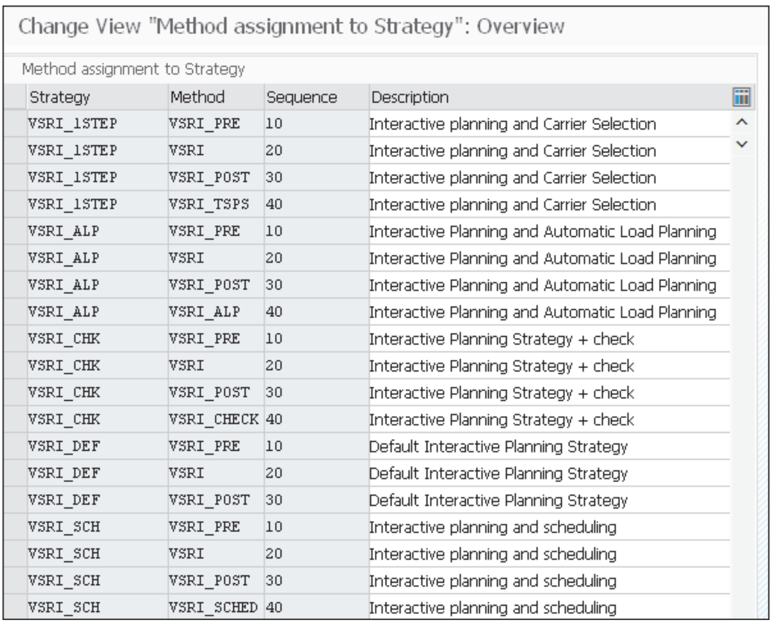
If you want to update your optimizer program, simply download the newest version of the executable files for the SAP Supply Chain Management (SAP SCM) optimizer from the SAP Software Center (*https://launchpad.support.sap.com/#/softwarecenter*), and replace the existing files on the server with the new ones.

2.3.6 Process Controller Framework

Another tool in TM that simplifies enhancements of the standard logic is the Process Controller Framework. In many functional areas of TM, strategies provided by the Process Controller Framework are performed. A *strategy* is a sequence of methods being performed one after another. Because all methods included in a strategy contain the same signature, it's very easy for developers to add their own methods to a strategy. For example, you can define the strategy for performing manual planning in the planning profile. As you can see in Figure 2.38, there are several strategies to choose from.

If you compare these strategies in Customizing (follow the IMG path **Transportation Management • Basic Functions • Process Controller • Assign Methods to a Strategy**), you can see that they all have common methods (e.g., **VSRI_PRE** or **VSRI**), but some strategies also offer additional methods (e.g., **VSRI_SCHED**). If you want to enhance the logic of manual planning, create a completely new strategy, or copy a standard strategy and add your own custom logic.

Services define which strategies may be used in which context. In TM, a service is linked strictly to a use case. A strategy containing several methods can then be assigned to a service. This establishes the hierarchy shown in Figure 2.39.


Change View "Method assignment to Strategy": Overview

Method assignment to Strategy

Strategy	Method	Sequence	Description
VSRI_1STEP	VSRI_PRE	10	Interactive planning and Carrier Selection
VSRI_1STEP	VSRI	20	Interactive planning and Carrier Selection
VSRI_1STEP	VSRI_POST	30	Interactive planning and Carrier Selection
VSRI_1STEP	VSRI_TSPS	40	Interactive planning and Carrier Selection
VSRI_ALP	VSRI_PRE	10	Interactive Planning and Automatic Load Planning
VSRI_ALP	VSRI	20	Interactive Planning and Automatic Load Planning
VSRI_ALP	VSRI_POST	30	Interactive Planning and Automatic Load Planning
VSRI_ALP	VSRI_ALP	40	Interactive Planning and Automatic Load Planning
VSRI_CHK	VSRI_PRE	10	Interactive Planning Strategy + check
VSRI_CHK	VSRI	20	Interactive Planning Strategy + check
VSRI_CHK	VSRI_POST	30	Interactive Planning Strategy + check
VSRI_CHK	VSRI_CHECK	40	Interactive Planning Strategy + check
VSRI_DEF	VSRI_PRE	10	Default Interactive Planning Strategy
VSRI_DEF	VSRI	20	Default Interactive Planning Strategy
VSRI_DEF	VSRI_POST	30	Default Interactive Planning Strategy
VSRI_SCH	VSRI_PRE	10	Interactive planning and scheduling
VSRI_SCH	VSRI	20	Interactive planning and scheduling
VSRI_SCH	VSRI_POST	30	Interactive planning and scheduling
VSRI_SCH	VSRI_SCHED	40	Interactive planning and scheduling

Figure 2.38 Method Assignment to Strategies

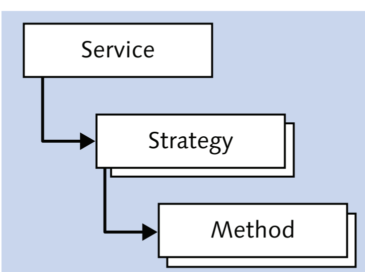


Figure 2.39 Process Controller Hierarchy

2.3.7 bgRFC Trigger

Did you ever wonder why sometimes updates to documents need time and aren't done directly? The reason for this is the concept of a *background remote function call (bgRFC) trigger* in TM. Triggers are set when the asynchronous processing of an action, such as the data propagation from freight order to freight unit after planning, fails due to a locking issue. Note that many updates are done asynchronously in TM to avoid long waiting times for the business user. If such an update fails due to a locking issue, the business user won't notify it, so triggers are used to remember the missing update.

Technically, triggers use the bgRFC framework to restart and manage everything. The creation of a trigger is implemented with the help of technical business object `/SCMTMS/TRIGGER_COLLECTOR` and a direct output agent (same concept as the SAP Event Management integration, which we'll discuss in Chapter 7, Section 7.2).

Let's take a closer look at one example. In Figure 2.40, you can see the creation of one trigger during freight unit building. Imagine the following scenario: A freight unit is created based on a sales order that should be delivered in two weeks. Currently, a planner wants to plan the freight unit in the transportation cockpit and locks the document. At the same time, the sales agent gets a call from the customer. The customer wants the goods one week earlier.

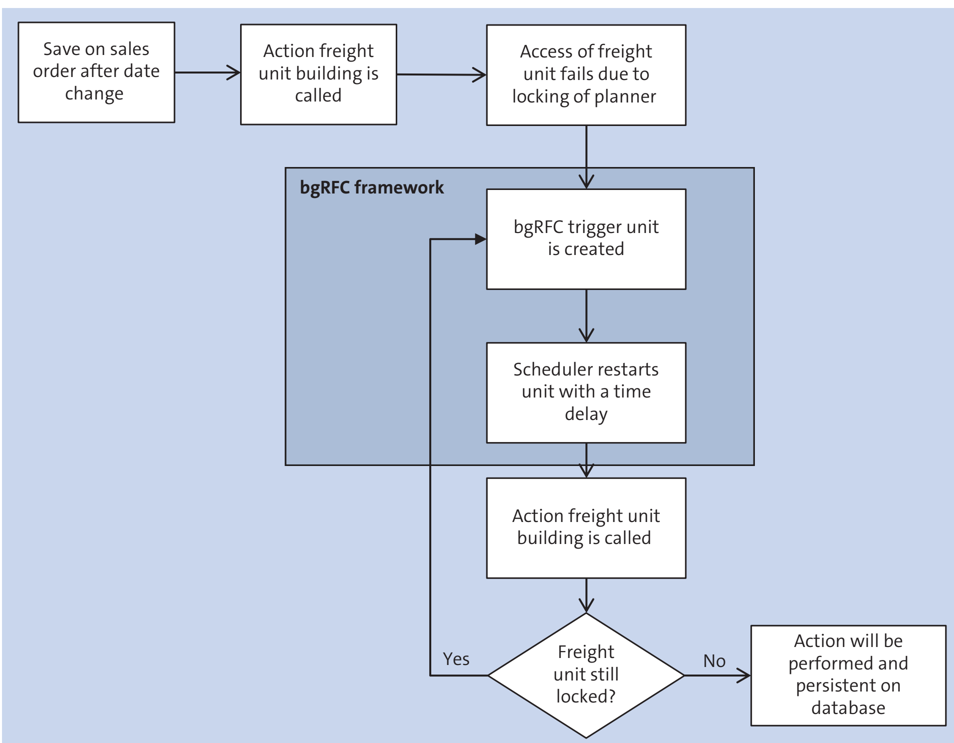


Figure 2.40 bgRFC Trigger Concept

The sales agent changes the sales order with the new date and saves. The save is processed successfully, but the update to the freight unit fails due to the locking of the planner. Now, TM creates a bgRFC trigger unit to remember the missing update. At this point, there is an inconsistency between the sales order date and the freight unit date. Therefore, monitoring of the triggers is quite important.

The bgRFC scheduler will restart the unit after some time and execute the action again. From a technical point, the trigger unit doesn't know what the action should do. It only knows which actions should be performed on which document. The actions in TM are implemented stateless, which is the prerequisite of this concept. After restarting the action, TM will collect the latest information, which is needed for the activity. Overtakes and duplicates are not issues in this case.

If the action is successfully performed, the unit will be deleted, and the changes are stored on the database. If the document is still locked, a new trigger unit is created and handed over to the bgRFC scheduler again. Failed units due to program errors needs to be handled manually. To monitor the triggers, execute Transaction SBGRFCMON (see Figure 2.41).

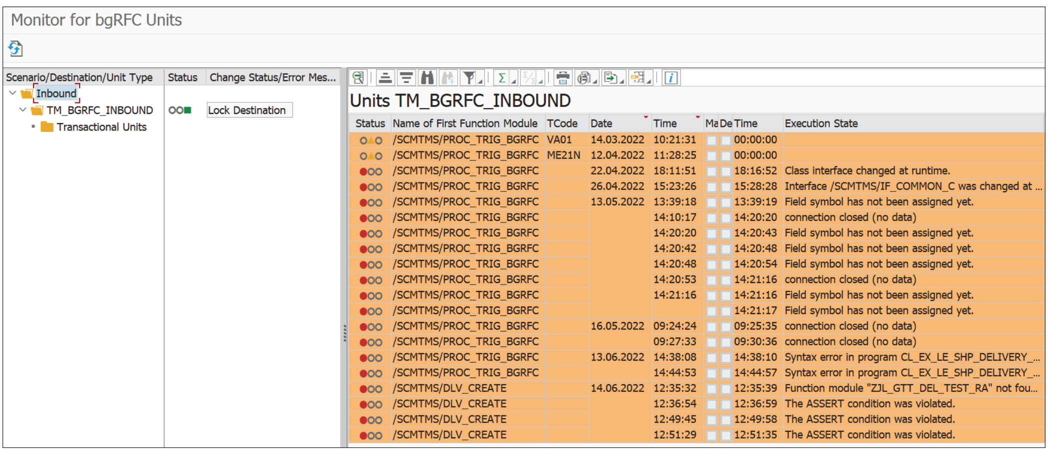


Figure 2.41 bgRFC Triggers in the TM System

The bgRFC frameworks needs to be configured during the initial setup of a TM system for TM to work properly. The minimum configuration consists of two steps: defining the supervisor destination and defining the inbound destination for the bgRFC framework.

The supervisor destination is mandatory for the general usage of the bgRFC framework and isn't TM specific. It manages the bgRFC scheduler and is relevant for the general work of the framework. You can maintain the destination in Transaction SBGRFCCONF (typically done by the Basis team as an administration activity in an implementation project).

The inbound destination is required to successfully execute the bgRFC. It acts like a queue and should be created for each SAP S/4HANA application. The TM-relevant destination is **TM_BGRFC_INBOUND**. The destination can be created via report /SCMTMS/TRIGGER_SETUP_BGRFC, which can be executed in Transaction SE38. After executing the report, you can check the setting in Transaction SBGRFCCONF in the **Define Inbound Dest.** tab (see Figure 2.42).

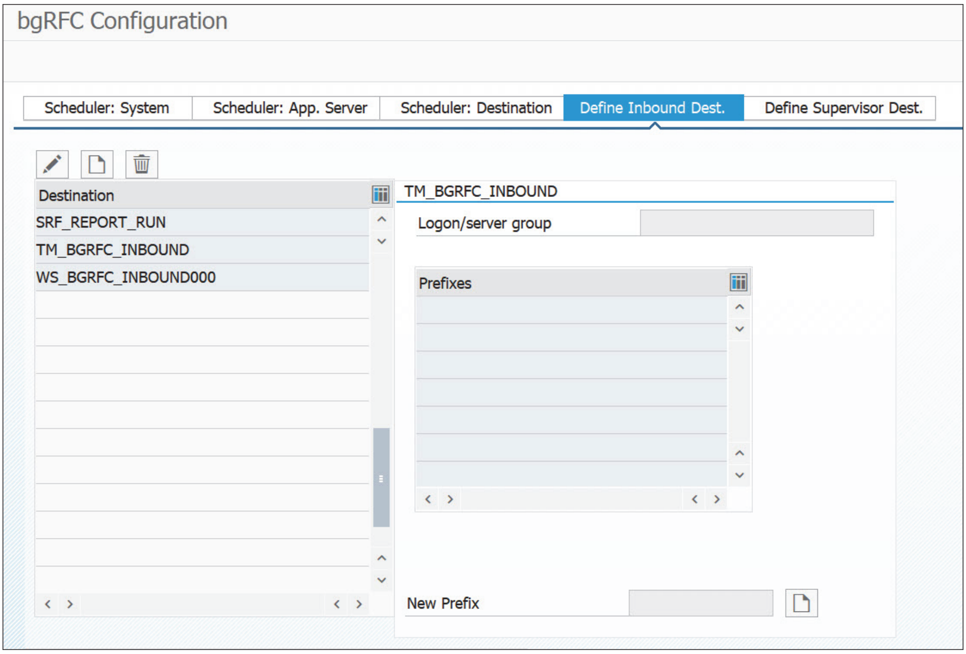


Figure 2.42 Inbound Destination for the bgRFC trigger

Enhancement of Trigger Concept

If you create your own actions based on custom logic, it sometimes also requires a custom trigger to support locking issues. In this case, you can enhance the standard triggers with a custom trigger. It's important that the action is implemented stateless and that the object/action is in charge of its own state. Otherwise, the concept of the trigger would not work anymore. A trigger only restarts a certain action for a business object; but doesn't contain any information. Therefore, the action needs to capture all important information before execution.

2.4 Integration Technology with TM

So far we've talked about the technologies that enable business logic within TM. In Chapter 1, we saw that the TM functionality is embedded in SAP S/4HANA, but it can also be run as standalone TM based on an SAP S/4HANA stack. If we run a TM system that isn't embedded in an SAP S/4HANA system, or whenever we communicate with internal or external systems outside of the system the TM functionality runs in, technologies that enable business logic *within* TM aren't sufficient without integration with other SAP or non-SAP applications.

Figure 2.43 shows that TM uses various integration technologies to communicate with other applications. We'll take a look at these integration technologies in this section.

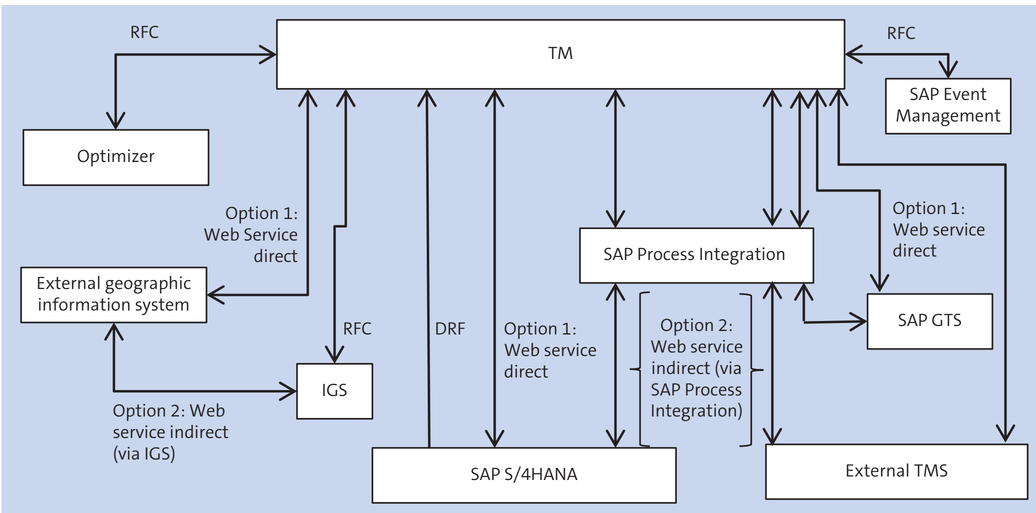


Figure 2.43 Overview of TM Integration When Not Embedded in SAP S/4HANA

2.4.1 SOA-Based Integration with SAP Process Integration

When you look at the early stage of SAP R/3, you can see that the entire business logic was meant to run on one system. All the data gathered in business transactions was supposed to be stored on a central database from which it could be retrieved by different application modules.

Nowadays, with the big increase in data volume and the high level of interconnectivity of business partners (both internally and externally), system landscapes have become heterogeneous. Not only is data spread throughout different systems, but business logic is also run in several applications. With the introduction of SAP S/4HANA, SAP has taken a step toward reversing this trend and reintegrating functionality that has grown in a heterogeneous solution landscape into one centralized system. However, we still see a large number of enterprises running on a heterogeneous system landscape, which is why we want to spend some time discussing how TM can work in such environments.

To orchestrate both the supply of data and the business logic for the entire system landscape, you need to establish a central instance that is aware of all systems in the system landscape and knows where data can be provided. In the SAP system landscape, this central instance is SAP Process Integration.

SAP Process Integration provides a platform that allows different interfaces to communicate with each other. The communication is established using a uniform technology: web services. SAP Process Integration not only acts as a directory for systems and applications in a landscape but also supports and monitors communication among systems.

The concept of SOA was established after it became clear that the entire business logic of an enterprise could not be executed in one system alone. SOA is supposed to enable interaction between systems regardless of their respective system architectures or programming languages.

Web services are essential helpers of SOA that implement the concept of the interaction of systems. Web services contain a data structure, usually in XML format, that shows what data can be passed from or to a system in the system landscape. In the respective applications, *proxies* interpret the web service and execute business logic in the application.

The system applications offer their web services to a service broker (in our case, SAP Process Integration). The service broker acts as a web service directory; you could also say the service broker is like a dating agency for business systems. All systems in the system landscape can now access the directory of web services in SAP Process Integration and download the web services descriptions into their applications. At that point, they can start implementing business logic that either fills the XML data structure to send data to other systems (this system is the *service consumer*) or implements logic to interpret the XML to use the data (this system is the *service provider*). After it executes the business logic, the service provider can respond with another XML file to the service consumer.

We could look at more theory to understand the integration of systems with SOA and web services, but it might be best to examine it using a concrete example. Let's look at the solution architecture for the integration of an SAP S/4HANA sales and distribution sales order into TM.

Let's assume that the system landscape we have is a TM application that wants to interact with a separate SAP S/4HANA. The first step is to register both TM and SAP S/4HANA in the System Landscape Directory (SLD) of SAP Process Integration so that it's aware of both systems and their application purposes. (The content of SAP Process Integration is constantly updated, which means it knows what a TM application is for.)

After the systems are registered in the SLD, the web services can be published to the respective systems. A web service consists of two service interfaces—one interface for each application. The service interface can be loaded into the application system.

Let's look at the service interface on the TM side. The service interface for SAP S/4HANA order integration is called `IntracompanyTransportationRequestRequest_In`, and you can find it in the TM system using Transaction SPROXY. If you pay close attention, you'll see that after you've confirmed the transaction code, there is a notification in the message area that the Enterprise Services Repository (ESR) is started. Because the ESR is situated in the SAP Process Integration system, the information we see in Transaction SPROXY is actually loaded from the connected SAP Process Integration system.

SAP S/4HANA versus SAP ERP

Although we're referring to SAP S/4HANA as our base system here, all integration steps through the next four sections apply to SAP ERP as well.

If you're still using an SAP ERP system, SOA-based communication between SAP ERP and TM for order integration works only if an SAP ERP 6.0 EhP 7 and EhP 8 system or higher is in place. Older versions of SAP ERP don't offer the business functions and service interfaces needed to use the predefined content for communication as explained in this chapter.

To integrate SAP ERP without predefined SAP Process Integration content, you have to establish IDoc communication out of SAP ERP that is sent to SAP Process Integration, where the IDoc needs to be mapped to the predefined service interface for order-based transportation requirements (OTR) and delivery-based transportation requirements (DTR) creation. Furthermore, direct communication between SAP ERP and TM that bypasses SAP Process Integration is no longer possible.

Figure 2.44 shows the numerous service interfaces available for TM. The service interfaces enable not only communication between SAP systems within a company (application to application [A2A] communication) but also the communication between SAP systems and legacy systems or systems of external business partners (B2B communication).

There are a few important things to consider about how the web service works when you're selecting the service interface for integrating SAP S/4HANA orders into TM. On the detailed view of the service interface, you can see a number of different tabs. Get familiar with the data structure that is passed to the TM system. If you go to the **External View** tab and expand one node after another, as depicted in Figure 2.45, you'll see that the XML message's data structure consists of two parts: the message header and the transportation request itself. The message header contains metadata about the message, especially stating from which system this message was sent and which system was supposed to be the recipient.

The important information for us is in the transportation request, which indicates what data can be passed to the TM system. Notice that the data structure is somewhat similar to the data structure of the business object `/SCMTMS/TRQ`, of which an instance will be created with this web service.

Figure 2.44 Service Interfaces in Transaction SPROXY

When data is exchanged between two systems, both systems need to be able to interpret the data that is passed. Therefore, if the service consumer sends a date to the service provider, the service provider needs to know that the field will be no longer than eight digits. This can't be taken for granted because the SAP S/4HANA system has its own data types that aren't communicated to TM. *Global data types* are used for this reason.

Global data types are defined in SAP Process Integration. Here, we can create a global data type for a delivery date. Although global data types are based on core data types, such as string, integer, and so on, you can also encounter aggregated data types, meaning a structure containing several global data types. These global data types within an aggregated data type are again based on core data types.

The entire XML message format consists of fields using global data types. After the service interface is loaded into the application system, the proxy generation performs the necessary next steps.

So far, we've only looked at the data structure of the service interface's message. Remember, however, that the TM system can't yet work with the data types contained in the message, so we need to perform a proxy generation. A proxy is an application system–owned interpreter of the web service's service interface; it converts the global data types of the message into data types that the TM system can work with. Let's look at what the proxy generation achieved with the city name of the shipper party.

The city name was based on a global data type (upper box), but as you can see in Figure 2.45, the proxy has generated its own data element in the TM system (lower box).

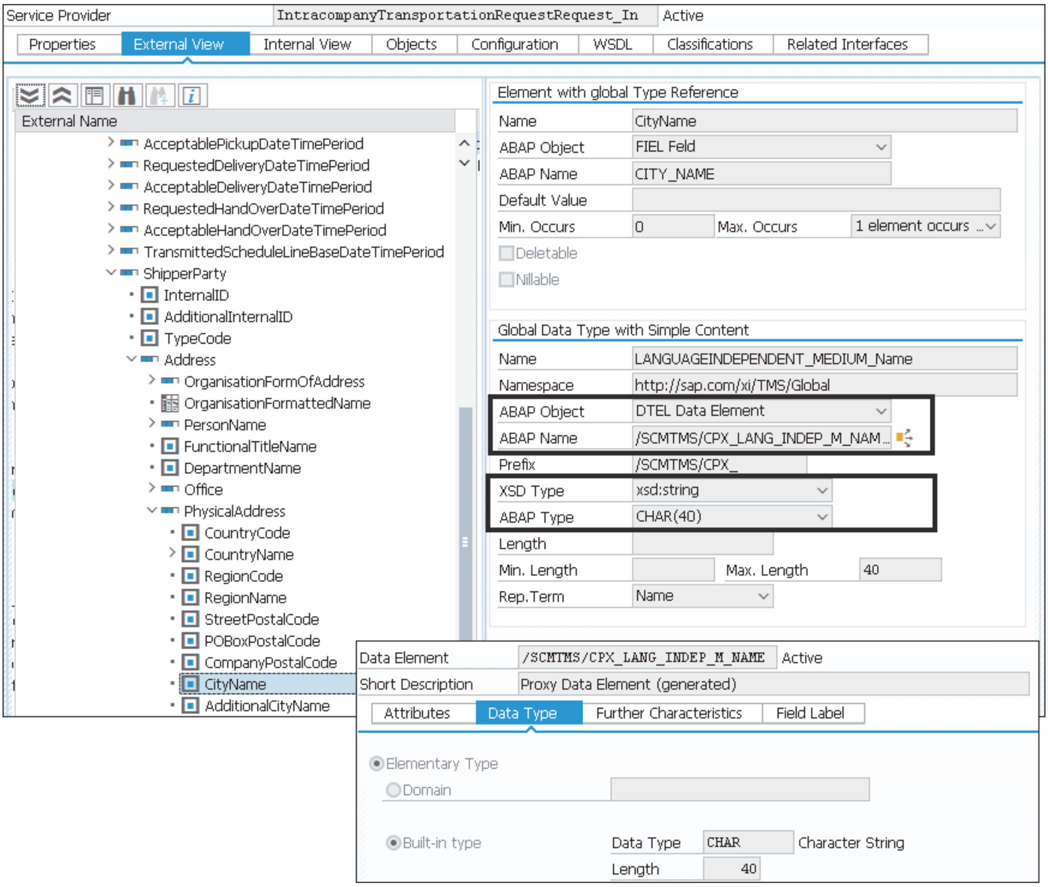


Figure 2.45 Data Element Generated by Proxy

The global data type defined that the city name should be based on the core data type string and should not be longer than 40 characters. If you look at the generated data type in Transaction SE11, you can see that this setup has been taken over in the new data element in TM.

If aggregated global data types are used, the proxy generates a structure type. So far, we've only looked at the data structure of the service interface in TM. However, the OTR or DTR won't be created unless some business logic is executed. As we've said, a web service consists of a common data structure and business logic on the service consumer's side as well as on the service provider's side. In communication between the service consumer and the service provider, neither knows exactly what is happening on the other side of the communication channel. The business logic of the communication partner is supposed to be a black box. This makes sense especially if communication via web services has been established between two systems with different programming languages. The proxy not only generates the data elements in the system but also creates a *provider class* (Figure 2.46).

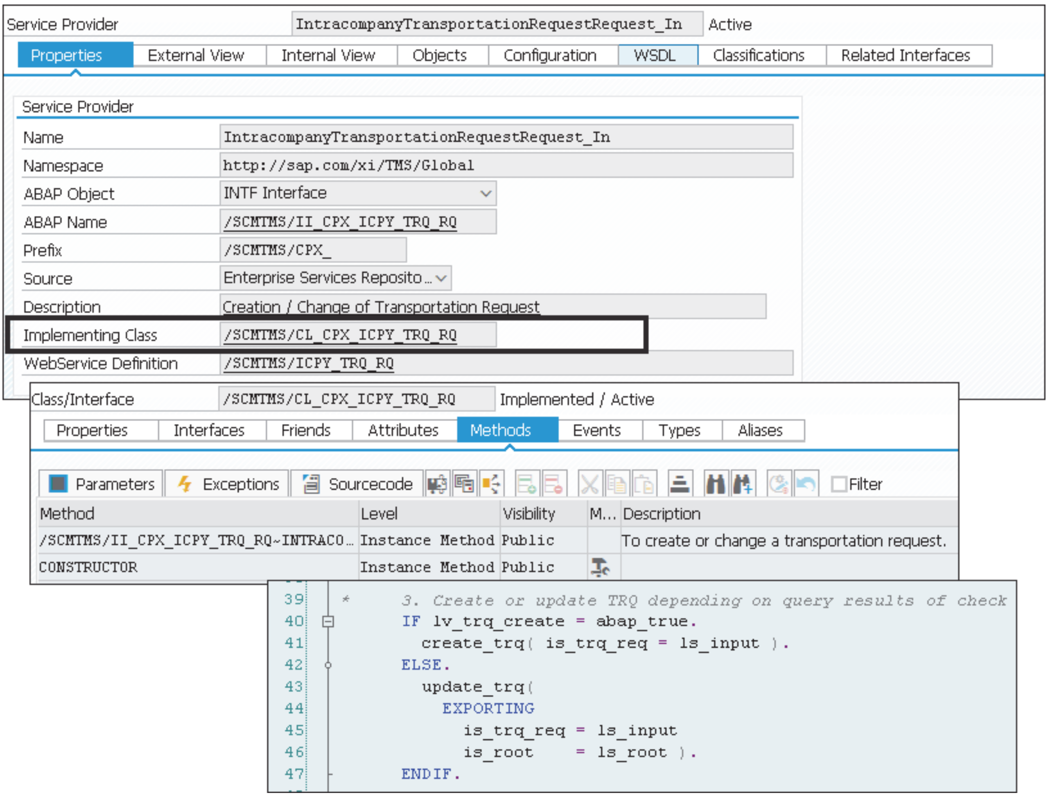


Figure 2.46 Proxy Provider Class

Use of the provider classes is comparable to the use of the classes assigned to actions, validations, and determinations that we discussed earlier. The provider class consists of a constructor and an executing method that is called after a message of this service interface is received in the system.

When you display the service interface in Transaction SPROXY, go to the **Properties** tab shown in Figure 2.46. Here, you'll find the provider class that was also generated by the proxy (lower part of the upper screen). When delving deeper into the implementation of this class (the middle screen shows methods provided by the class), you'll see that, in our example, the instance of the business object TRQ will be created. The lower screen shows an excerpt from the actual coding implemented in the method.

This Isn't the Entire SOA Story

Communication between two SAP systems using SOA is a very complex topic for which many resources are available. This section provides just a quick glimpse at how the integration of transactional data between SAP S/4HANA and TM works.

Recall from Figure 2.43 that you have two options for transferring an SAP S/4HANA order from SAP S/4HANA to TM: either using SAP Process Integration as middleware or using a direct web service–based communication channel. Both options have advantages and disadvantages, and the choice is yours.

The web services for the standard integration are delivered with the TM-specific content for SAP Process Integration. In both application systems, you need to activate some business functions to use the service interfaces. We describe these in further detail in Chapter 4.

We've now looked at the service interface for receiving information from an SAP S/4HANA document to create a corresponding document in TM. The same settings can be observed in the SAP S/4HANA system, where the service interfaces for the service consumer's side are present. You can get a detailed look at the SAP S/4HANA service interfaces in Transaction SPROXY in the SAP S/4HANA system.

As outlined in Table 2.1, TM offers several web services for A2A communication that can be clustered into different functional areas of TM.

Service	Service Consumer	Service Provider
Transportation Requirements (OTRs and DTRs)		
Create transportation requirements	SAP S/4HANA	TM
Cancel transportation requirements	SAP S/4HANA	TM
Provide document flow	SAP S/4HANA	TM
Freight Settlement		
Transfer freight settlement document to SAP S/4HANA	TM	SAP S/4HANA
Cancel freight settlement document	TM	SAP S/4HANA
Delivery Proposals		
Propose inbound delivery creation	TM	SAP S/4HANA
Propose outbound delivery creation	TM	SAP S/4HANA

Table 2.1 Overview of A2A Services in TM

Service	Service Consumer	Service Provider
Customs Integration		
Request compliance check	TM	SAP GTS
Request export/import declaration	TM	SAP GTS
Warehouse Integration		
Send load plan to warehouse	TM	EWM
Receive notification about final load plan	EWM	TM

Table 2.1 Overview of A2A Services in TM (Cont.)

Update of Transferred Documents

In most cases, the web services that create documents in the other system are also used for updates. The proxy provider class evaluates whether a document has already been created and updates the corresponding document. Therefore, no duplicate documents are created in the service provider's system.

Integrating master data from SAP S/4HANA to the TM functionality that resides within another SAP S/4HANA system is done using technology provided by the master data governance framework: the Data Replication Framework (DRF). We'll discuss DRF integration in Chapter 3, Section 3.1.5.

2.4.2 Integration with SAP Process Integration without Predefined Content

If you take a closer look at the capabilities of SAP Process Integration, you'll see that this middleware application is used not only as a service broker and SLD but also for supporting message mapping in B2B communication. B2B communication takes place when two companies exchange data with their respective systems.

Let's walk through another example. We're a carrier, and our customer (a fashion company) wants to order transportation services. The fashion manufacturer uses a TM system and has implemented various shipper scenarios. After the fashion manufacturer has finished transportation planning, an order for transportation execution is placed. To do this, the shipper sends out a request for quotation (RFQ) to us, the carrier. As a carrier, we're also using a TM system. As you'll see in more detail in the next chapters, the document flow is as follows: the shipper has created a freight order and now sends us an RFQ. Because we're a carrier, and the shipper's freight order is a transportation request, we then create a forwarding quotation or forwarding order for the shipper's freight order (depending on the exact process).

This B2B communication can be established using SAP Process Integration. After the shipper's RFQ has arrived in our system landscape, SAP Process Integration determines which inbound service interface needs to be triggered to which recipient based on the sender's system information and the message type. If the data structures of the RFQ and the forwarding order's service interface don't match, SAP Process Integration can also perform field mapping. The service interface on our TM side then automatically creates a forwarding quotation or forwarding order.

Table 2.2 lists all available B2B service interfaces that TM provides.

Service	Service Consumer	Service Provider
Transportation Requirements (Forwarding Order and Forwarding Quotation)		
Create transportation requirements	External	TM
Cancel transportation requirements	External	TM
Confirm transportation requirements	TM	External
Tendering		
Send transportation order	TM	External
Cancel transportation order	TM	External
Send RFQ	TM	External
Receive RFQ response	External	TM
Freight Booking		
Send freight booking	TM	External
Cancel freight booking	TM	External
Confirm freight booking	External	TM
Send transportation waybill	TM	External
TOR Objects (Freight Order, Consignment Order, Freight Unit)		
Replicate TOR object	TM	External
Receive TOR object	External	TM

Table 2.2 Overview of B2B Services in TM

Using TM and Other Systems

In this example, we assumed that both business partners use TM applications. Unfortunately, this can't be taken for granted.

Note, however, that the mapping of messages in SAP Process Integration can be much more sophisticated than in this example. SAP Process Integration can also map incoming IDocs to service interfaces.

Synchronous or Asynchronous?

Web services can be performed synchronously or asynchronously. All A2A and B2B web services in TM are performed asynchronously. This makes sense because, in most cases, a user has to validate information that was entered using a service interface. For example, if a freight booking is sent to a carrier, the carrier needs to evaluate whether the requested space is still available. In the case of a synchronous communication, the shipper can't work until the carrier has responded with at least a technical confirmation of the message receipt.

2.4.3 TOR Generic Interface

One interface that's important in TM is `TransportationOrderGenericRequest_In/Out` (see Figure 2.47). This interface supports all /SCMTMS/TOR-based business documents across all `TOR` categories (therefore the name "TOR Generic"). There are still some open points in the standard such as missing fields or unsupported scenarios (e.g., external planning with freight bookings). Therefore, it's necessary to check the interface in detail during an implementation project. Still, the way forward to integrate or duplicate freight units or freight orders in a multi-instance landscape, even with non-SAP applications, is using the TOR Generic interface.

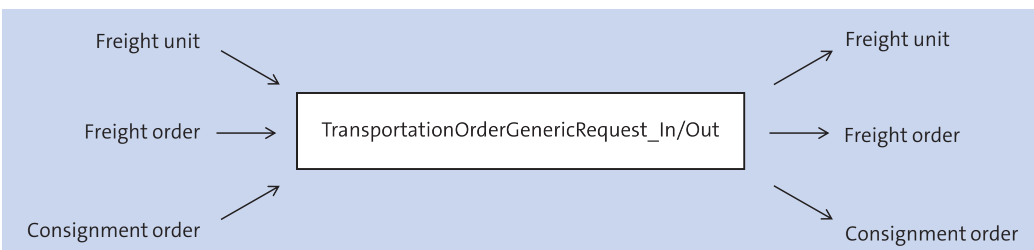


Figure 2.47 Interface TransportationGenericRequest_In/Out

The interface contains all information to duplicate freight units, freight orders, or consignment orders in other applications to support external planning scenarios, shipping notifications, carrier collaboration, or any other communications based on the `TOR` documents.

SAP ERP versus SAP S/4HANA: Shipment IDoc

If you're currently in a project to convert your SAP ERP system using the LE-TRA module to SAP S/4HANA using TM, the TOR Generic interface is the replacement of the famous shipment IDoc 05. During your project, you have to adapt to the new SOA interface of TM.

2.4.4 RFC-Based Communication

Recall Figure 2.43, which showed that TM not only uses web services via SAP Process Integration but also uses RFCs as the integration of TM and SAP Event Management. SAP Event Management can be installed on the same system as TM. However, you need to use Transaction SM59 to define an RFC connection to the SAP Event Management system, even if it's installed on the same system as TM. The same applies for the connection to the SAP SCM optimizer engine. We cover the setup of SAP Event Management integration in Chapter 7, Section 7.2.

2.5 Summary

This chapter introduced you to the technological foundation of TM, showing its two major technological pillars: the BOPF, which takes over the tasks of data modeling, storage, and processing, and the UI technology built on the FPM framework. We also covered how the data stored in the BOPF is transferred to the UI technology using FBI.

While talking about UI technologies, we explored how the SAP Fiori launchpad interacts with the user and how catalogs decide what tiles are shown to the user in the SAP Fiori launchpad. TM screens can be customized without any coding or modifications.

Furthermore, we looked at other tools and frameworks used in TM, such as BRFplus, PPF, and Process Controller Framework. These tools facilitate Customizing and adapting TM to the business use case.

The final part of this chapter covered the technical integration of a TM standalone system with other business applications. In general, we've differentiated between A2A communication using predefined content on both application systems and B2B communication, where only predefined content in SAP Process Integration is available for TM. This technical information about TM is meant to build a foundation for the TM business processes described in Chapter 3 through Chapter 12.

The information for a basic understanding of the technical foundation of the TM system has been provided. In the next section, the TM-specific master data will be explained before deep diving into the processes run with the TM functionality.

Chapter 3
Master Data

Master data serves as a cornerstone for any business process. All central business objects and procedures, such as order management, planning, subcontracting, and charge management, are based on master data. In addition, master data represents the internal organization and business partners and their relationships, and it's essential for specifying the transportation network and available equipment types and resources.

In the previous chapter, we gave you an overview of the solution architecture and technological concepts of transportation management (TM). Before we take a closer look at transportation requirements, planning, and execution, we dedicate this chapter to explaining the mandatory and optional master data, while making you familiar with the most important terminology and configurations.

Master data is an integral part of any planning system and the foundation of any business process. All central business objects and processes that are key to transportation management are based on logistical master data. This data, apart from general master data such as organizational structures and business partners, typically includes the transportation network and resources, which together describe how transportation orders can be executed. Therefore, independent of the TM release or deployment option, master data is important because it supports both planning and execution activities.

One of the key features of TM is that it allows logistical processes to be executed independently of master data relating to business partners and transported goods. For third-party logistics providers (3PLs) who mainly provide transportation services, it's essential that the transaction data can be created with minimal existing master data.

In this chapter, we explain general master data, logistics master data representing the transportation network, and the resources used to execute the transportation of goods. All other master data and transportation mode–specific settings are explained in the relevant context. To support end-to-end transportation scenarios for shippers and logistics service providers (LSPs) and to ensure consistency with the execution process, a set of general master data is required, for example, to model your organizational structure and avoid the recurring maintenance of addresses or material attributes. We look at this general master data in Section 3.1. For scenarios that use TM in a side-by-side deployment, we explain master data integration that can be based on the Data Replication Framework (DRF). DRF is also required for master data integration if a central master data repository is in use. By seamlessly integrating with SAP ERP or SAP S/4HANA and avoiding master data maintenance, TM can use and reuse existing customer and material master data.

Several master data elements are needed to support proper transportation planning and execution. In Section 3.2, we explain how these elements are created and combined to form a transportation network.

For transportation execution and to represent the capacity needed to perform the transportation activity, equipment types and resource master data such as vehicles and trailers are used. To reflect availability and operating times and to handle transportation orders, you can set up calendar and handling resources. The configuration and maintenance of equipment types and resources is explained in Section 3.3.

Let's begin by exploring the use of general master data in TM.

3.1 General Master Data

All corporate departments use general master data. As it represents the internal organization, business partners, and their relationships, all business processes rely on general master data. Clearly defined master data is of central importance for well-regulated financial processing in particular. In this section, starting with the definition of the organizational structure, we present a thorough overview of the most important general master data, its significance for transportation processes, and its integration and distribution, if applicable.

3.1.1 Organizational Structure

The individual elements of an organizational structure are used to map an enterprise in an SAP system. These organizational structures determine the operational framework in which all sequences and functions of logistics and financial processes occur. They also reflect the legal and organizational structure of a company. Organizational master data allows you to create organizational models, which are the legal, geographic, or organizational boundaries for the organizations that take part in the transportation process. By representing the structure of a company and being used to determine responsibilities, the organizational units build a framework in which all relevant business processes occur.

In this section, we'll dive into the internal organizational structure, its creation, and how to merge organizational hierarchies originating from different source systems, which may be relevant in a side-by-side deployment.

Internal Organizational Structure

An organizational structure can be set up as a combination of organizational elements. The simplest structure may consist of a single employee who is responsible for various tasks. However, in a larger enterprise, or in the case of an LSP, the structure may be divided into various organizational areas. Figure 3.1 shows the structure, cardinality, and relationships between the organizational elements in the enterprise resource planning (ERP) system (SAP ERP or SAP S/4HANA) and TM.

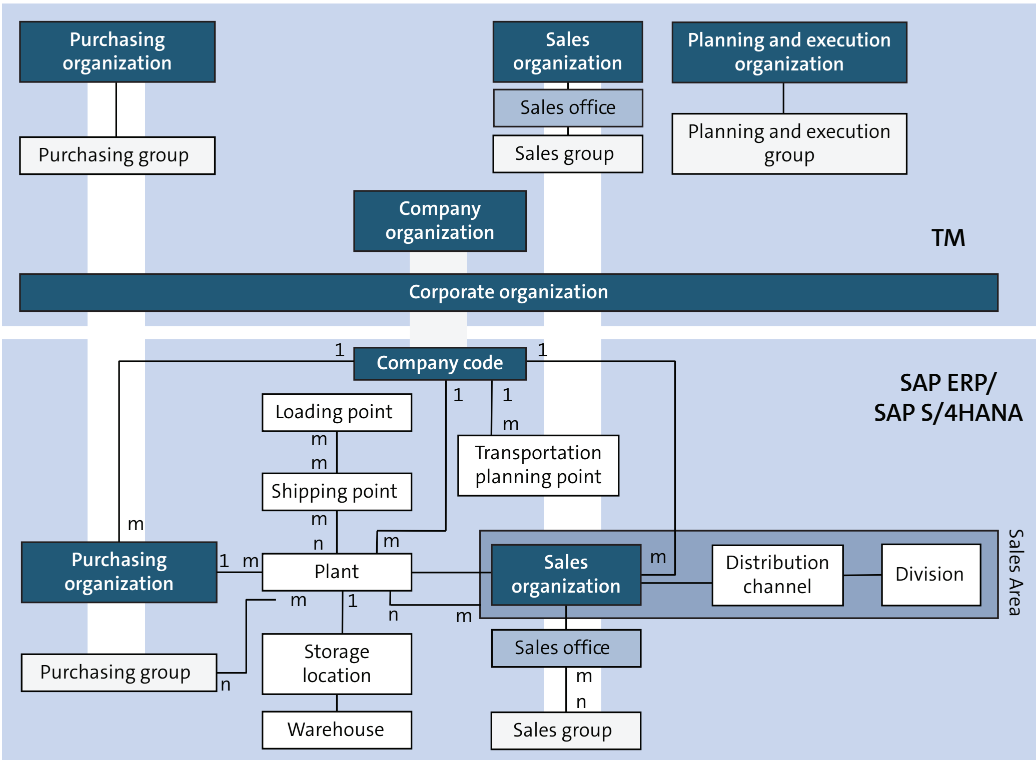


Figure 3.1 Organizational Structures in SAP ERP or SAP S/4HANA and TM

In TM, organizational units can be modeled independently from the SAP ERP or SAP S/4HANA organizational structure. They are categorized in three basic types:

- Sales (sales organization)
- Purchasing (purchasing organization)
- Planning and execution

These organizations can be further divided into groups and offices; employees acting on different roles are typically assigned to organizational groups.

The optional corporate organization usually serves as the highest node and entry point in the organizational structure. The corporate organization can consist of one or more company organizations.

The company organization corresponds to the company code. Like the company code, the company organization defines the local currency and usually represents the legal entity of the company. In TM documents, we'll distinguish between the procuring company code and the paying company code. The *procuring company code* represents the company that is responsible for the procurement of transportation services. It's typically retrieved from the purchasing organization responsible for a freight document. The accruals for the freight costs are booked in financial accounting to this company code. The *paying company code* is the one responsible for paying the transportation requirement. It's retrieved from the predecessor document (e.g., sales order).

The sales organization organizes and structures the sale of logistics services and executes these services. You can assign multiple sales organizations to a company organization (e.g., for each country), and divide each sales organization further into sales offices (e.g., East Coast, West Coast, etc.), and these further into sales groups (e.g., air freight, sea freight, etc.).

In SAP ERP and SAP S/4HANA, the sales organization is combined with two additional organizational elements to define sales areas. These two elements, the division and distribution channel, don't exist in TM. Because certain master data in SAP S/4HANA builds on these two organizational elements, they can be defaulted in Customizing (**Transportation Management • Basic Functions • General Settings • Define General Settings for TM**), which is shown in Figure 3.2.

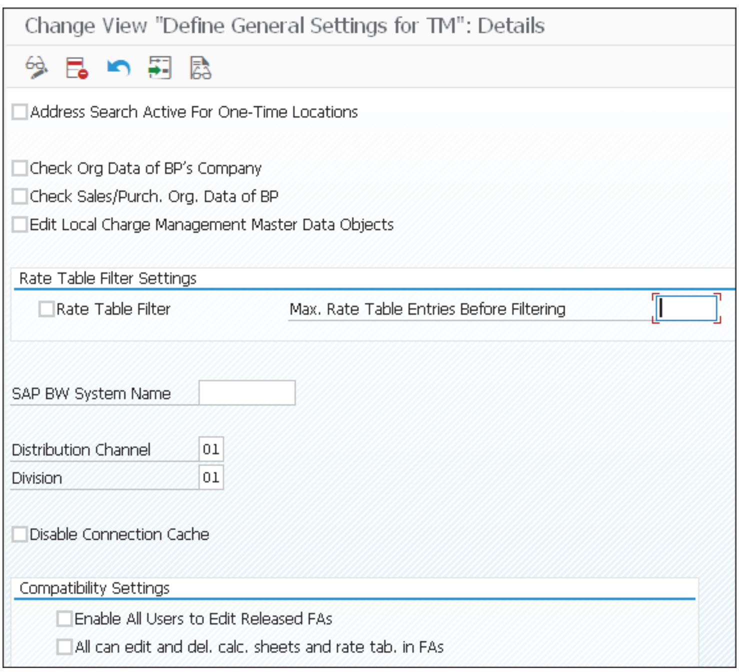


Figure 3.2 General Settings for TM

These default values are used to access business partner master data stored on the sales area level by adding these as defaults.

The sales organization is relevant in the following documents:

- Forwarding quotation
- Forwarding order
- Forwarding agreement
- Forwarding settlement document
- Forwarding agreement quotation

The next basic type of organizational unit is the purchasing organization. The actual procurement of materials and services always takes place in relation to a purchasing organization. You need purchasing organizations and purchasing groups for subcontracting. The purchasing organization arranges and executes all purchasing transactions relating to the logistics services provided by carriers and freight forwarders.

Several purchasing organizations can be defined, for example, one for each country or each transportation mode. Several purchasing groups (e.g., for each shipment type, region, etc.) can be assigned to each purchasing organization. The following types of documents are generally associated with the purchasing organization:

- Freight unit
- Freight order
- Freight booking
- Consignment order
- Service order
- Freight agreement
- Freight settlement document
- Freight agreement RFQ master

For transportation planning and execution, which is the final organizational unit type, you can define planning and execution organizations. These represent the different organizational units that are responsible for freight by land, sea, and air in different geographical regions. In this context, the planning and execution organization organizes the dispatching of accepted transportation orders and planning of loads to be shipped, and then either executes the activities required or oversees their execution if they are outsourced.

Similar to purchasing organizations, planning and execution organizations can be subdivided into several planning and execution groups. They are used in the following documents and objects:

- Freight unit
- Package unit
- Transportation unit
- Freight order

- Freight booking
- Resource

While sales organizations, purchasing organizations, and planning and execution organizations are limited to their specific tasks according to their definition, in some LSP scenarios, it's required that the same organizational unit performs several tasks, such as selling transportation services to a customer and purchasing transportation services from a vendor. For this purpose, you can define a generic organizational unit of type forwarding house. A *forwarding house* is an organizational unit that can perform sales activities, purchasing activities, and planning and execution activities, so it can be assigned to any of the mentioned documents and objects.

Creating the Organizational Structure

Because a direct relationship with financial grouping objects (e.g., company codes, accounts, internal orders, etc.) is deliberately *not* established in TM, the organizational data needs to be mapped to SAP ERP, SAP S/4HANA, or the connected external billing system for settlement and used there for financial assignment.

The organizational structure in TM can be defined independently, or the same organizational structures can be used in TM and SAP ERP or SAP S/4HANA to enable a meaningful assignment of the sales and purchasing processes to the subsequent settlement processes. An example of this kind of structure was provided earlier in Figure 3.1, which compares organizational structures in TM with the ones in SAP ERP or SAP S/4HANA.

In this context, the company organization corresponds to the SAP ERP or SAP S/4HANA company code and is used by transportation charge management for invoicing and charging. When we create organizational units and staff assignments, we can distinguish between two elements:

- Organizational units
- Positions

An organizational unit is an object that is used to map the corporate structure of a company in an organizational model in an SAP system via various organizational elements and attributes. When you create the organizational element, you assign two things to it:

- **Organizational unit function**
  The organizational unit function describes the purpose of an organizational unit. Functions include purchasing, sales, planning and execution, company, corporate, and forwarding house.
- **Organizational unit role**
  The organizational unit role defines the organizational element's level within the hierarchy. The following roles can be selected: organization, office, and group.

The hierarchical relationship of organizational elements, based on the roles and functions, is fixed. For organizational units with a sales function, you can only assign organizational elements with unit role group to the organizational elements with unit role office. The element with the office unit role can only be assigned to an organizational unit with an organization unit role. For organizational units with a purchasing or planning and execution unit function, you can only assign organizational units with a group unit role to organizational units with an organization unit role. You can also assign employees to the organizational unit, which you need to do to use the workflow capabilities.

Organizational structures are created in Customizing by following menu path **Transportation Management • Master Data • Organizational Management • Organizational Model • Create Organizational Model** or using Transaction PPOCE. Changes to these structures are made in Customizing by following menu path **Transportation Management • Master Data • Organizational Management • Organizational Model • Change Organizational Model**. Alternatively, you can use Transaction PPOME (see Figure 3.3).

At this stage, you also define the mapping to, for example, company codes for financial accounting, sales organizations in sales and distribution, and purchasing organizations in materials management. The corresponding four-digit code is maintained as **BSG Org. Unit** in Figure 3.3. If the **Business System Group** represents the same logical system as the current system client, the mapping is to the corresponding internal component, whereas a different **Business System Group** points to external integration (to the system the organizational unit originates from).

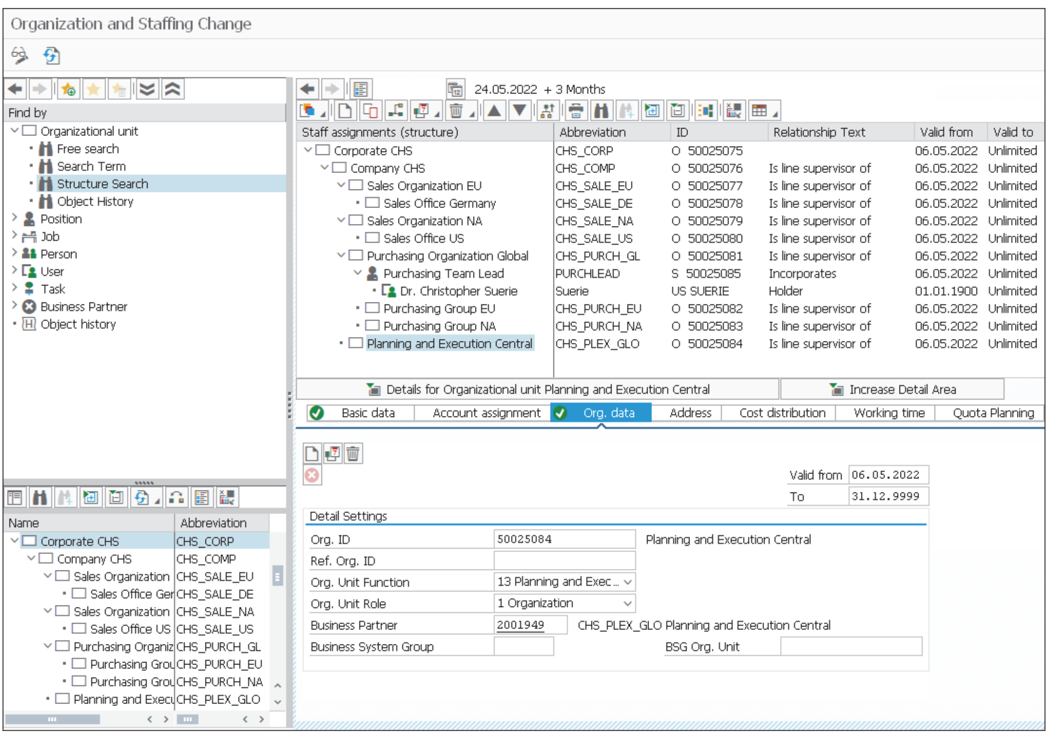


Figure 3.3 Organizational Hierarchy of an LSP

Business Partners

When an organizational unit is created, the system automatically creates a business partner in the background. This business partner is used in transactional documents to represent the assigned organizational unit. For that purpose, you need to configure the internal number assignment in Customizing by following menu path **Cross-Application Components • SAP Business Partner • Business Partner • Basic Settings • Number Ranges and Groupings**.

The *position* (e.g., purchasing team lead in Figure 3.3) organizational unit is used mainly to cascade and represent a hierarchy for workflow processing. If a process requires the involvement of several users in a specific sequence, and users should respond to errors and exceptions or approve a business document (e.g., to check whether a freight agreement meets specific commercial conditions), workflows are used.

In this context, you can define the organization's hierarchical structure and assign employees with specific tasks to individual organizational elements. Consider the following employees:

- **Tendering manager**
  Responsible for freight tendering in a purchasing organization.
- **Sales manager**
  Responsible for credit limit checks in a sales organization and is the recipient of the relevant workflow tasks.
- **Purchasing agent**
  Responsible for invoice verification.
- **Transportation planners, truck drivers, loading clerks, and warehouse personnel**
  Assigned to an organizational element categorized as planning and execution.

Creating and Merging the Organizational Hierarchy

While organizational structures can be created as just described, you can also upload definitions of organizational hierarchies from SAP ERP, SAP Supply Chain Management (SAP SCM), an internal SAP S/4HANA component, or an external SAP S/4HANA system using a report shown in Figure 3.4. You can find this report in Customizing by following menu path **Transportation Management • Master Data • Organizational Management • Organizational Model • Create and Merge Organizational Hierarchy** or launching report /SCMTMS/TRANS_ORG_MODEL directly.

The report reads the existing structure in the source system, displays the organizational hierarchy, and then creates and saves the corresponding elements in the TM organizational model.

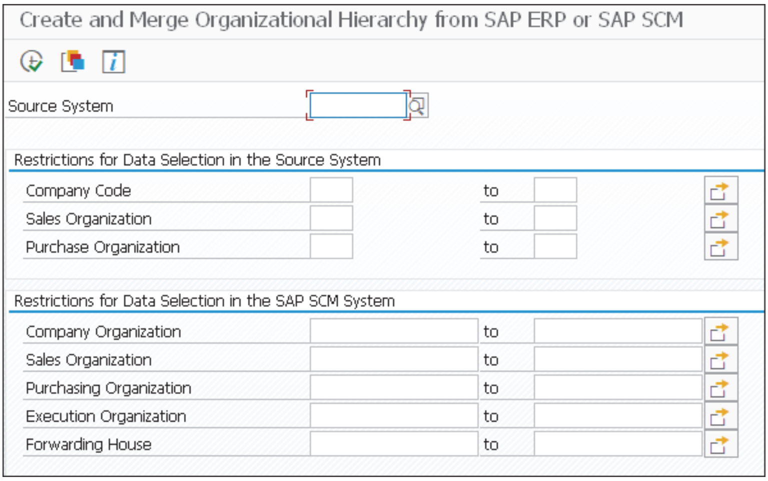


Figure 3.4 Report to Create and Merge the Organizational Hierarchy

To refine the selection of existing definitions of organizational hierarchies from the source system, you can enter the relevant company code, sales organization, and purchasing organization. To transfer the selected elements to the TM system, you can either drag the selection to the TM organizational hierarchy or use the buttons. You can remove the transferred elements before the organizational hierarchy has been saved. After the data has been saved, though, you have to make adjustments in the organizational model itself.

3.1.2 Business Partner

Business partners are typically persons or organizations in which a company has a business interest. Whether it's a single entity or a group of business partners, this master data object is used for a variety of business transactions. In general, *business partners* are all legal entities or individuals with whom a company maintains business contacts. SAP systems usually differentiate between *customers* and *vendors*. From an accounting point of view, all customers with whom a company is in contact are *debtors*. Suppliers (or vendors) who provide deliveries or services are called *creditors*. A business partner can be a debtor and a creditor at the same time and therefore have different business partner roles.

Business partners, as well as the roles they assume for your company, are managed centrally. According to this *role concept*, the business partner is defined as a general business partner first, and then its business partner roles are assigned. Each role might contain specific data that is relevant for the role. This way, there is no need to store redundant data because the general business partner data is independent of a business partner's function- or application-specific extensions. Therefore, when a business partner is first created in an SAP system, the general business partner role is automatically assigned and populated with general data such as name, search terms, and so on.

Business partners are all organizations, enterprises, and individuals with a fixed or loose working relationship or order-based relationship with a shipper or LSP. This relationship may be defined by long-term contracts that are negotiated between the parties involved or by ad hoc activities (e.g., quotations and orders). On the other hand, business partners may also be employees of the company, such as drivers. In the context of TM, the following business partner roles are relevant:

- Business partner (general) (000000)
- Customer (FLCU01)
- FI customer (FLCU00)
- Vendor (FLVN01)
- FI vendor (FLVN00)
- Carrier (CRM010)
- Global trade services: Customs office (SLLCOF)
- Driver (TM0001)
- Organizational unit (BUP004)
- Contact person (BUP001)
- Prospect (BUP002)
- Employee (BUP003)
- Internet user (BUP005)

The role carrier (CRM010) contains the role vendor (FLVN01). Both roles allow maintenance of data on the level of a purchasing organization. Roles FI customer (FLCU00) and FI vendor (FLVN00) allow maintenance of data on the company code level.

As mentioned at the beginning of this chapter, TM allows logistics processes to be executed largely without the existence of business partner master data. However, a business partner master record is virtually indispensable when it comes to settlement and billing.

In the following sections, we'll unpack business partner master data further.

Defining Business Partners

As mentioned before, business partners can be centrally maintained and defined using the SAP role concept. You find the relevant maintenance transaction in **Master Data • Define Business Partner**, by launching Transaction BP, or by using specific SAP Fiori apps Manage Customer Master Data for customers or Manage Supplier Master Data for vendors or carriers. In the Define Business Partner app, you can create new business partners or assign additional roles to existing business partners. Figure 3.5 shows the definition of a carrier created in the roles of business partner (general), financial services business partner, and carrier. You can maintain the following information for all general business partners using the provided tabs:

- **Address**
  The business partner's main address.
- **Address Overview**
  Additional addresses with a note on usage (e.g., mailing address or delivery address).
- **Identification**
  Additional ID numbers to identify the business partner for communication (e.g., the International Air Transport Association [IATA] agent code of an air freight service provider, Standard Carrier Alpha Code [SCAC], or commercial register number).
- **Control**
  Business hours and texts.
- **Payment Transactions**
  Details for payment transactions, including bank details and payment card details.
- **Status**
  Status information and lock flags.

Additional texts from the **Additional Texts** tab (e.g., addresses or signatures) can be used for printing addresses or signatures on documents such as air waybills. To support printing in several languages, define the language of the texts and enter additional texts for one text type in different languages for one business partner instance.

Depending on the business partner role, additional information or special tab pages are available. For business partners with the role carrier, the **Transport Data** tab shows transportation-relevant information, such as the **SCAC** assigned to the (road) carrier, in Figure 3.5.

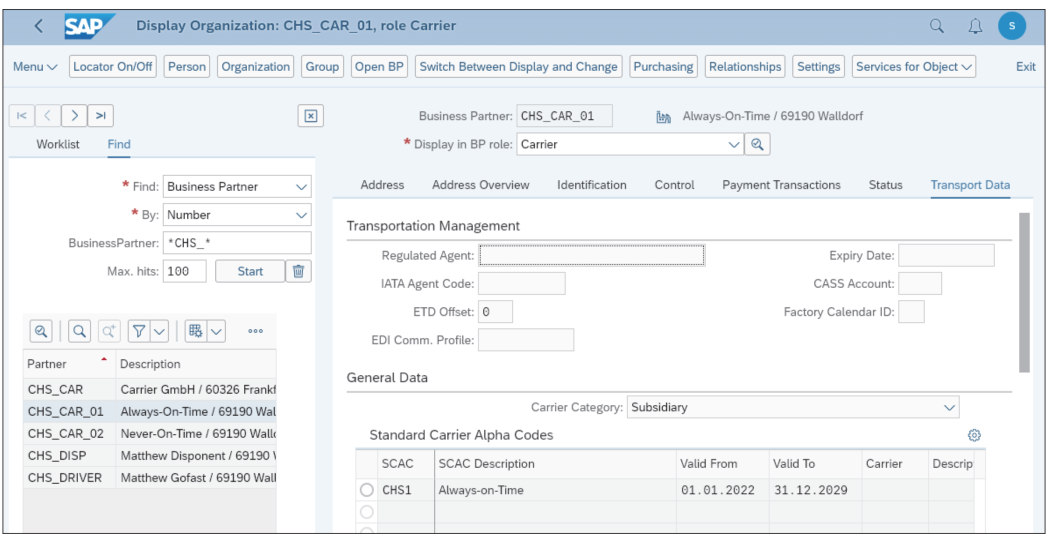


Figure 3.5 Business Partner Master Record for a Carrier

Carrier Profile

Additional carrier-specific information is stored in the carrier profile, which can be created for business partners with role carrier in Transaction /SCMTMS/TSPP or on the classic user interface (UI) from menu path **Logistics • Transportation Management • Master Data • Transportation Network • Define Carrier Profile**.

The carrier profile is used to define carrier-specific and transportation lane–specific parameters and attributes to define the service provider's range of responsibilities, transportation capabilities, and service level. These parameters typically include the following:

- Routes operated in the transportation network, as shown in Figure 3.6
- Freight codes, product freight groups, and transportation groups
- Transport equipment used or available (Section 3.1.3)
- Fixed and dimension-based transportation costs for carrier selection

These profiles are used in subcontracting processes such as carrier selection to determine the carrier. In this context, carrier determination can take into account internal costs, as well as parameters specific to the transportation lane, such as whether transportation allocations or business shares should be used or whether the carrier is eligible for continuous moves. More details about carrier selection will be provided in Chapter 6, Section 6.5.

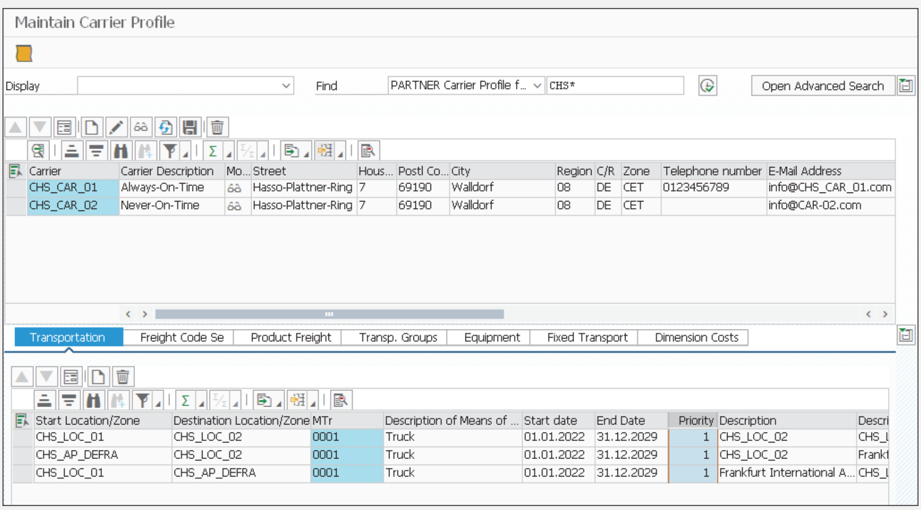


Figure 3.6 Carrier Profile

Employees and Internal Organizational Units

When you define the organization of an enterprise, business partners are automatically created for the individual organizational units (Section 3.1.1). These are created with the organizational unit role and can be used directly to map business transactions *within* the enterprise.

It's also possible to define a business partner's employees as business partners themselves if they occupy a dedicated role in your business partner's enterprise (e.g., the carrier's dispatcher who is personally responsible for your enterprise). These employees are defined in the role of employee (see Figure 3.7). Because of the option to create hierarchies and relationships between business partners, you can then assign the employee as a subordinate business partner of the carrier and assign a relevant function description to the employee to clarify his role. Figure 3.7 shows the definition of a business partner employee and the relationship between this employee and the main business partner (carrier).

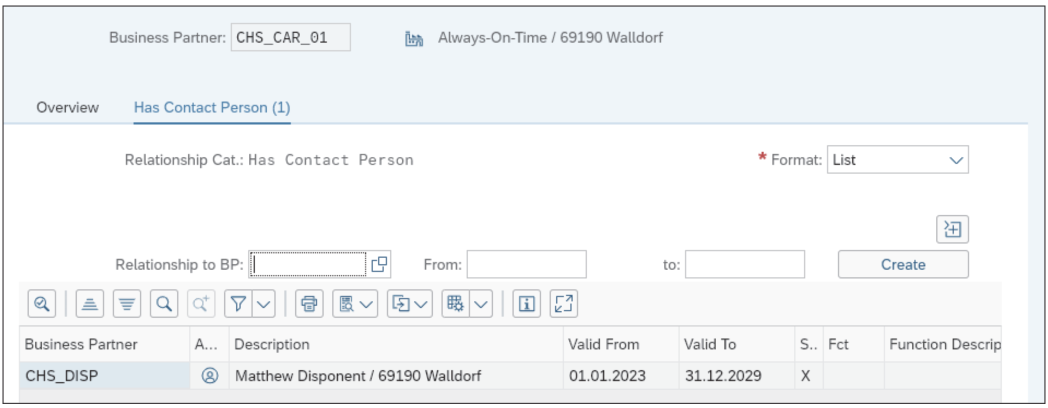


Figure 3.7 Business Partner and Relationship Definition for Employees

For transportation execution, a driver is a person who can operate vehicles (see also Section 3.3) and perform transportation-related tasks. Drivers are defined as business partners with the role driver.

Figure 3.8 illustrates that this role not only provides additional parameters such as qualifications but also allows you to specify the driver's availability and create shift sequences and absences, similar to the resource availability mentioned in Section 3.3.5. Although the system doesn't check the consistency of required or offered qualifications (e.g., to handle dangerous goods [DG] or operate a specific vehicle), these qualifications held by the driver typically include licenses or certain permissions. The configuration of qualifications can be found in Customizing via menu path **Transportation Management • Master Data • Resources • Resource Attributes • Define Settings for Qualifications**. Drivers are assigned to freight orders on the **Driver** tab or in the transportation cockpit.

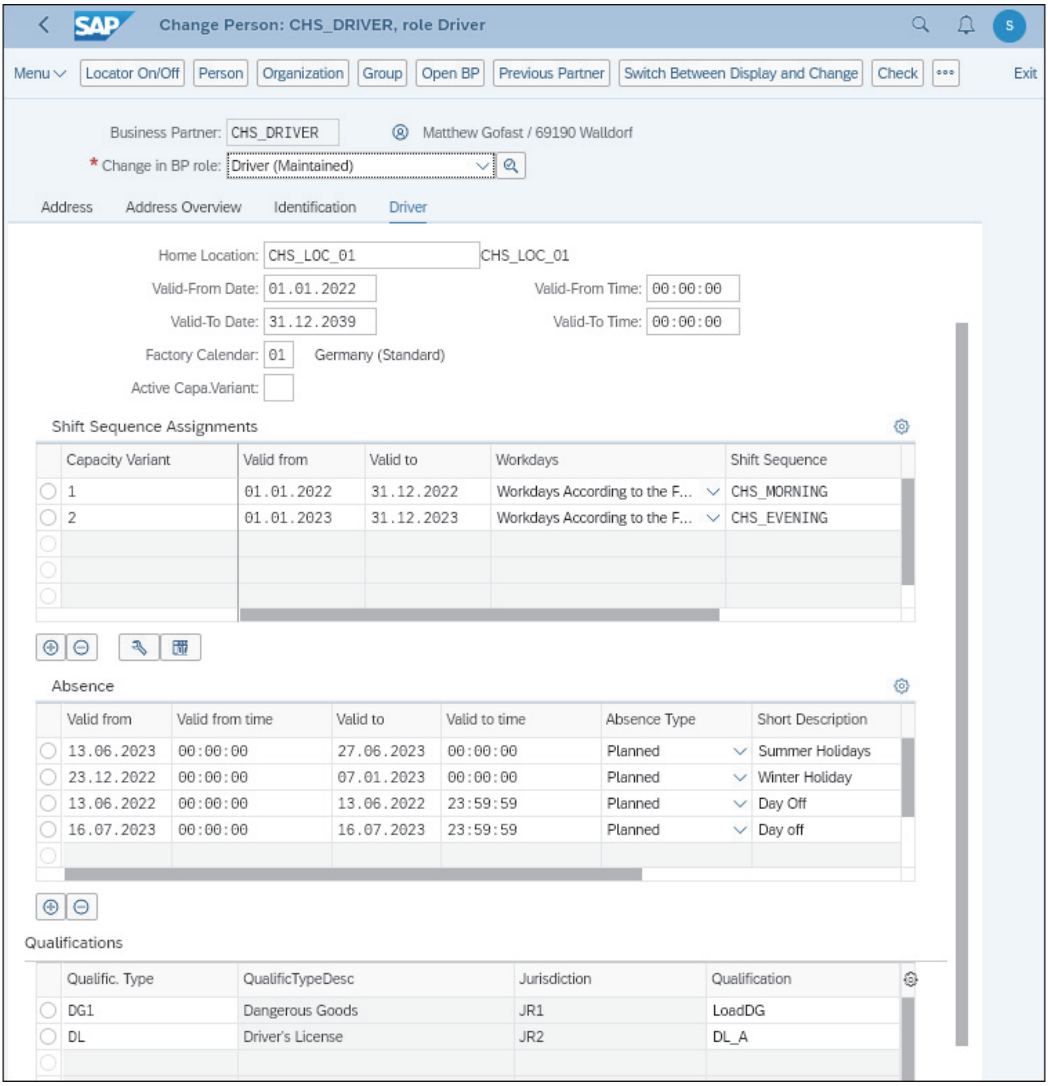


Figure 3.8 Business Partner with a Driver Role

Business Partner Determination

Business partners are assigned to transactional documents, such as forwarding orders, freight orders, or freight bookings, either manually or automatically. During the assignment to a transactional document, it's checked that an appropriate business partner role has been defined for the assigned business partner, The automatic assignment of the business partner is controlled by a business partner determination profile, which can be assigned to the corresponding document type in Customizing (e.g., **Transportation Management • Freight Order Management • Freight Order • Define Freight Order Types**). If business partner determination is not only dependent on the document type but also dependent on the Incoterm used in the business document, you can assign the business partner determination profile based on these two criteria in Customizing via menu path **Transportation Management • Master Data • Business Partner • Assign Partner Determination Profile Based on Incoterms**.

The business partner determination profile in Figure 3.9 is defined in Customizing via menu path **Transportation Management • Master Data • Business Partner • Define Partner Determination Profiles**. You can specify relationships between partner functions and how these relationships are used to automatically determine business partners for partner functions. The following relationships are available to determine a business partner:

- **Partner function and source partner function**
  The business partner associated with the source partner function is copied to the partner function.
- **Business add-in (BAdI)**
  A customer-specific logic can be implemented in a BAdI to determine the business partner.
- **Fixed business partner**
  A business partner is fixed and assigned to a partner function in Customizing.
- **Relationship category**
  The corresponding business partner for a partner function is determined based on the partner relationship specified in the business partner master data (business partner relationships).
- **Partner function and source partner function in business partner master data**
  The business partner is determined based on the relationship between organizations and business partners in the business partner master data (**Customer/Vendor Partner Determination** tab).

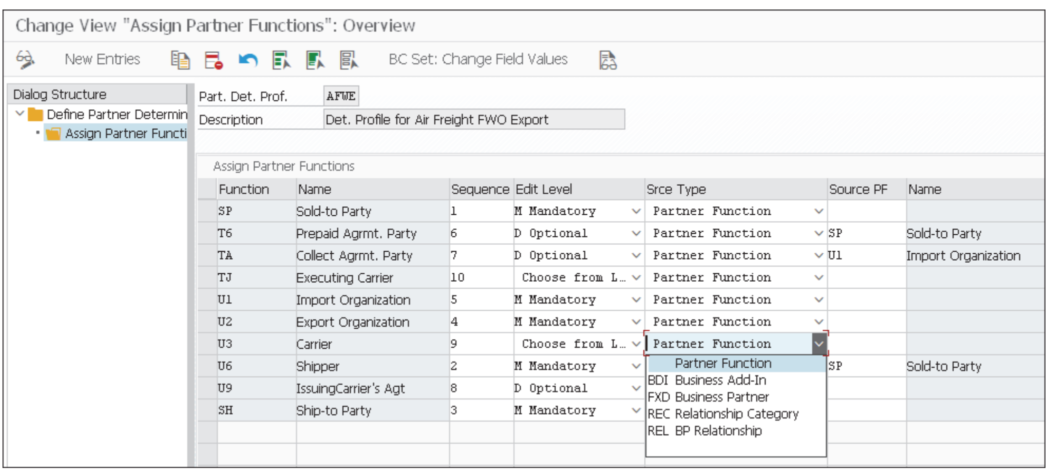


Figure 3.9 Business Partner Determination Profile

In addition to the pure determination, the business partner determination profile defines the set of partner functions available in a document, the sequence in which the business partner functions are displayed on the **Business Partner** tab of the transactional document, and the level of control a user is granted in inserting, editing, and deleting partner functions.

3.1.3 Materials

Material master data (or product master data, which is the term used from the transportation perspective and will be used interchangeably in this section) doesn't have a definitive set of semantics in transportation logistics. Instead, it may differ radically depending on the role and perspective of the user. By definition, material master data classifies, identifies, and characterizes materials, articles, and services that are purchased, sold, manufactured, or provided as a service and remain essentially unchanged over a long period.

From the shipper's point of view, the material master data includes the deliverable, producible, and sellable goods. Materials can be maintained with their attributes and various quantities and can then be allocated to organizations. In addition, you can define various types of transport materials and equipment in the material master (e.g., pallets, pallet cages, and cardboard boxes), which can also represent transport demand through their use in packaging one or more other materials. Materials that share similar attributes can be grouped together and assigned to a material type. Standard material types are **ROH** for raw materials, **HALB** for semifinished products, and **FERT** for finished products. Packaging materials are typically assigned to material type **VERP**.

In addition to the obligatory definition of material number and description, you must define the base unit of measure (e.g., count, box, or kilogram). Via the base unit, you can define additional quantity units with the conversion factors. The indication of the gross and net weights and volume is especially important for logistics processing because these values are taken into account for the capacity calculation of combined shipments. Volume refers to the volume occupied by a material during transport, not the net contents of a unit of material. In the material master, there is a sales view (**Sales: General/ Plant**) in which you can define the transportation group (**Trans. Grp**) and material freight group (**Material freight grp**) as transport-relevant attributes (see Figure 3.10).

The transportation group is a categorization criterion that allows you to categorize materials that have the same defined processing conditions. Examples of values in the transportation group include palletized goods, refrigerated goods, and dairy products. If the material is classified as DG, you need to create a DG master record for transportation processing. Product safety and stewardship (PS&S) lets you save the necessary identifications and definitions for the various norms and carriers. Here, you can store DG classes and codes, material characteristics, rules for loading materials together, paper print definitions, and other details for DG definition. Each material classified as a

DG requires its own separate DG master record. As an alternative to DG processing with PS&S, you can choose DG processing based on product compliance.

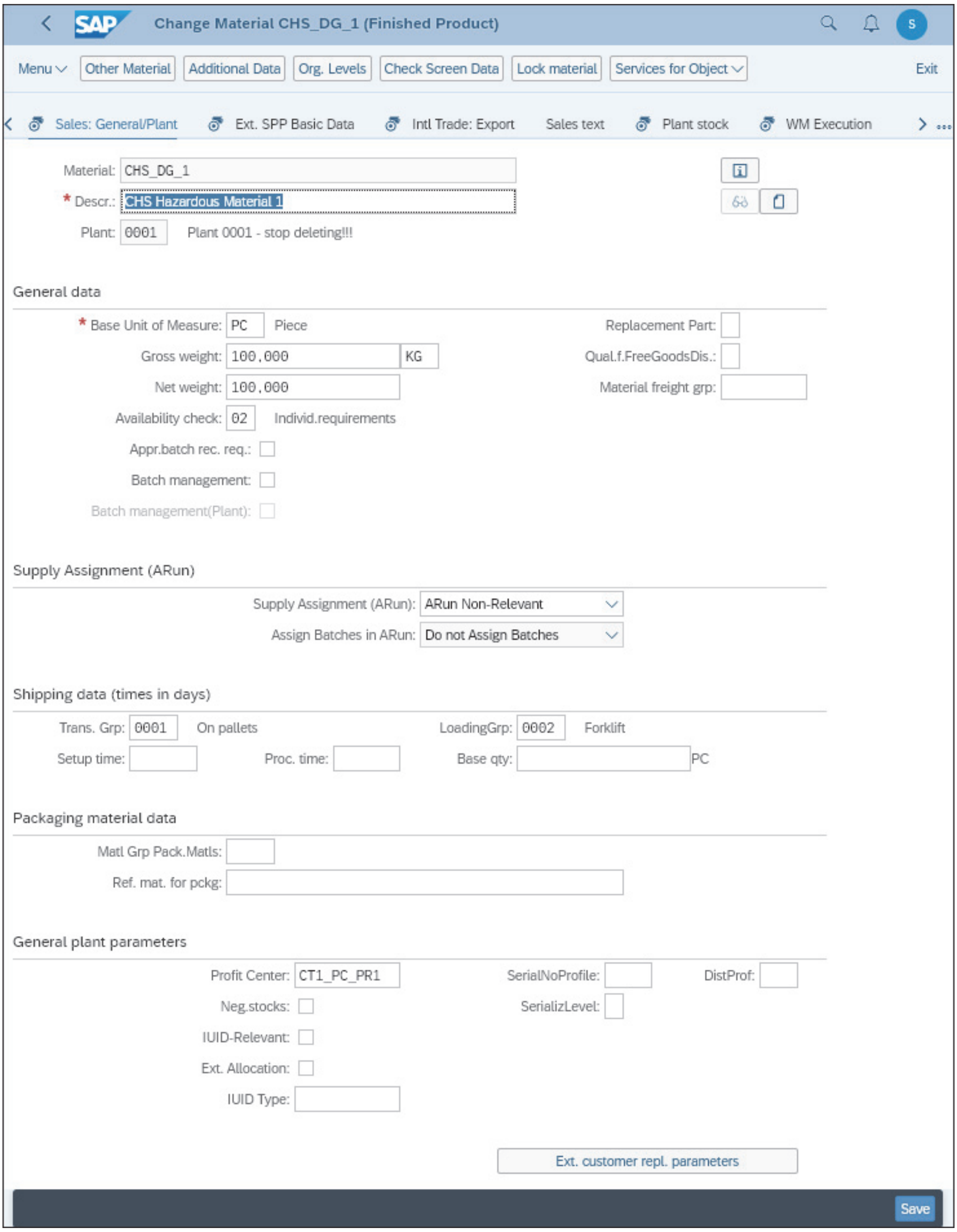


Figure 3.10 Material Master

Transportation services offered by an LSP are often commissioned with reference to standard material types or material groups as product master records. Such grouping can be done in the necessary granularity (with three to eight digits), using elements such as the commodity or harmonized system (HS) code, UN hazardous materials number, or other standards.

In transport processes in which full loads are frequently requested and transported (e.g., in container line operations or railway operations with full railcars), the material master records are usually defined based on transport equipment. These cases often involve the transportation of large numbers of the same or similar containers or railcars, the contents of which need to be defined only in general terms and, in many instances, can't even be specified when the order is initially created. However, the transport equipment must be defined (e.g., a 20-foot refrigerated container or a 67-foot flatcar). Only the required number of transport equipment products is defined as the load, and more precise details about the goods to be transported are added later.

Therefore, the range of ways in which LSPs can view the product master is much more diverse. In this case, the material master can be used in the following ways:

- Precisely defined products in 3PLs
- Standardized freight codes and material groups
- Roughly defined product categories
- Categories of transport equipment in which products represent only the outer packaging of the materials being transported
- Service products

Standardized or custom freight codes or material groups (e.g., statistical goods numbers) are used to ensure appropriate grouping and classification of products. Other details (e.g., gross weight) can be represented only in a generalized way and must be entered individually in the transportation order. Standardized freight codes and material groups are frequently used in rail logistics, for example, where they are used directly to calculate freight charges.

Material master data is important for packaging and the definition of packaging hierarchies. The relevant material master data for this process will be explained in detail together with its use in Chapter 5, Section 5.3.3.

In TM, an LSP's product represents the services operated by that provider and therefore doesn't refer to the material goods that are transported (as in the case of express service providers). You can create service product catalogs in master data. We describe service products in Chapter 11, Section 11.1.3.

When TM is operated without product-related master data, all goods to be transported are entered only as text in the transportation order. In this case, all load-specific and transportation-relevant details are directly maintained in the order itself.

3.1.4 Dangerous Goods

The handling of dangerous materials is regulated by numerous laws and regulations. Essential master data must be managed and maintained with the most up-to-date security regulations. Goods receiving and goods issue processing, warehouse operations, labeling, and printouts must be adapted to meet the requirements for handling dangerous materials and goods. The DG functions enable you to ensure the safe transportation of DG in compliance with international regulations.

Since SAP S/4HANA release 2021, you can choose between DG processing based on PS&S and DG processing based on product compliance. Because both solutions are incompatible with each other, you can activate only one. DG management based on product compliance is limited to road freight as of the time of writing. We'll discuss both options in the following sections.

Dangerous Goods Processing Based on Product Safety and Stewardship

If a material has been classified as dangerous, you need to create a DG master record to check this material during transportation processing. The transportation business documents that contain the material are then checked for the relevant regulations and to ensure that all necessary information is included and parameterized in the business document. When you perform DG checks for your business documents, the system bases the checks on the relevant DG data. This is typically done in a shipper scenario.

In a nonshipper scenario, if an LSP is supposed to handle DG, the LSP usually doesn't have DG master data in its system. Therefore, DG checks can also be done without DG master data, using document-based DG records instead. LSPs can directly maintain DG-related data in the forwarding order if a DG profile has been assigned to the corresponding forwarding order type. The document-based DG records can also be created automatically when a forwarding order based on data sent by the business partner (e.g., the shipper) is created.

DG Content Loader

You can use a content loader to import PS&S regulatory content, downloaded from the SAP Support Portal, directly into the DG master data tables in TM. This functionality is especially useful for LSPs that don't have the DG master data in their system and usually receive data from their shippers, either in written or electronic form. It helps them to minimize the effort required to maintain and enter relevant data in a forwarding order and can be used as a template for document-based DG records. The content itself comprises dangerous goods regulations (DGR), the necessary texts (e.g., substance names and phrases), and the required Customizing data.

In this section, we describe both the master data and classification of the DG master record, as well as the relevant settings and parameters to maintain phrases and text outputs. This master data is typically provided by the shipper, while document-based DG checks are based on the data in the relevant business documents and the basic configuration of PS&S services in TM. This configuration is part of transportation compliance and is therefore explained in Chapter 8.

Dangerous Goods Master

When you check DG, you're checking the product you want to transport against the rules you've defined in Customizing. This can be a check of certain aspects of the DG master data or the combination of the goods you want to transport. The check reflects the national and international regulations regarding the transportation of DG. The regulations depend on the transportation mode and the countries crossed while transporting the goods, and the check is triggered by material master attributes.

Figure 3.11 shows a material and the relevant settings to define whether hazardous substance data exists for this product and how to perform a DG check. These attributes can be found in the material master in the **Basic data 2** tab. Here, you can specify whether the material is a hazardous substance or environmentally relevant. The actual execution of the check, as well as the output of DG documents, is controlled by a **DG indicator profile**. The profile itself contains a combination of indicators that are maintained in the DG check settings of the PS&S services; in Figure 3.11, this is **GPP** (DG, relevant for document output and checks). You can find these settings in Customizing by following menu path **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PS&S • PS&S Services • Dangerous Goods Management • Dangerous Goods Checks and Dangerous Goods Documents • Common Settings • Specify Indicator Profiles for the Material Master**.

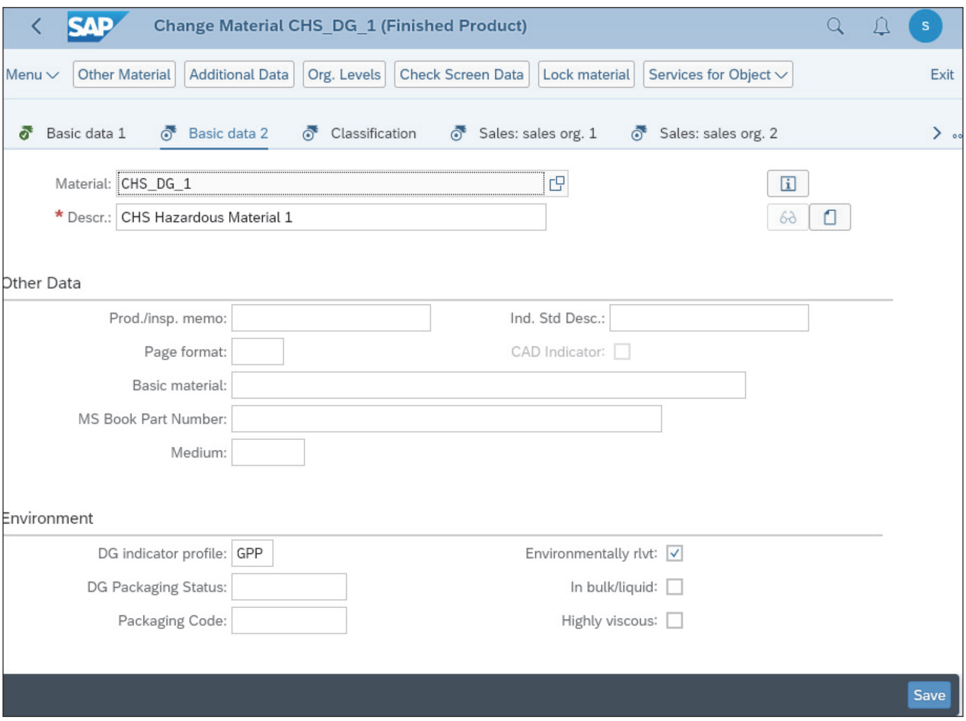


Figure 3.11 DG Indicator Profile in Material Master

The system can perform checks automatically; in addition, you can trigger the checks manually. Due to different risks in transporting DG, the system carries out checks in different ways and at different process steps to ensure safety during transportation. For example, the system can perform checks during freight unit building and vehicle scheduling and routing (VSR) optimization. This ensures the compliance of the resulting freight unit and freight orders. In addition, you can perform checks on all relevant business documents. If there are DG errors, you can correct them and perform the check again.

The DG master contains the data required to perform DG checks and generate DG documents and papers according to the applicable DGR and laws. To create a DG master record, you assign a DGR to an existing product and add other data. After you've created a DG master record, it becomes available for DG checks and for creating DG documents. To create a new DG master record or display or edit an existing one, you use the transactions in the classical UI via **Logistics • Transportation Management • PS&S Services • Dangerous Goods Management • Dangerous Goods Master**. Figure 3.12 shows the DG master of the material master from Figure 3.10. To meet national and international regulations for this material, this master record has been created with reference to specific regulations (**Regulation**), a validity area (**Val. Area**), and a mode of transport category (**DG Mode**).

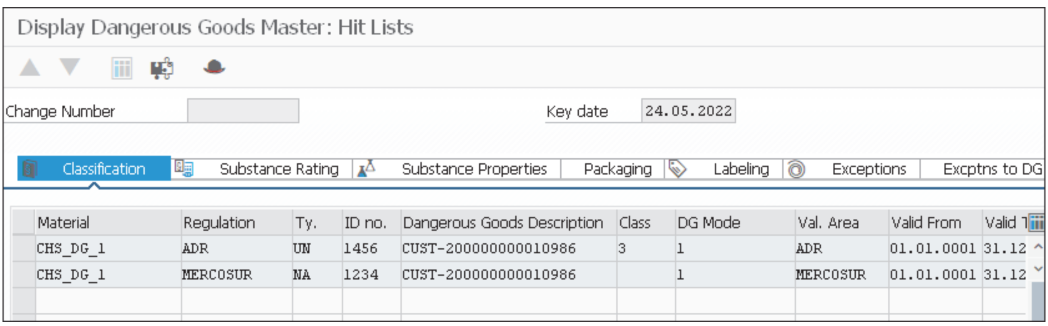


Figure 3.12 DG Master

Legal regulations are relevant for the transportation of DG. You classify the master data by assigning a validity area and mode of transport category to the DGR. The classification assigns classes and codes and therefore specifies how the transportation is restricted or should be executed. The validity areas for DG data records are defined according to the applicable DGR and specify the countries, regions, jurisdictions, or organizational units in which the parameters of the DG master are valid. To carry out DG checks and generate DG papers, you must ensure that the validity areas for the DG master records don't overlap. In addition, the mode of transport category specifies the type of transport to which the rule applies—for example, road, rail, inland waterway, sea, or air (cargo and passenger).

Figure 3.13 shows the underlying structure and relationship of some of the most important parameters of the DG master record and the "handshake" with the PS&S configuration. (To learn more about PS&S service configuration and compliance checks, see Chapter 8.)

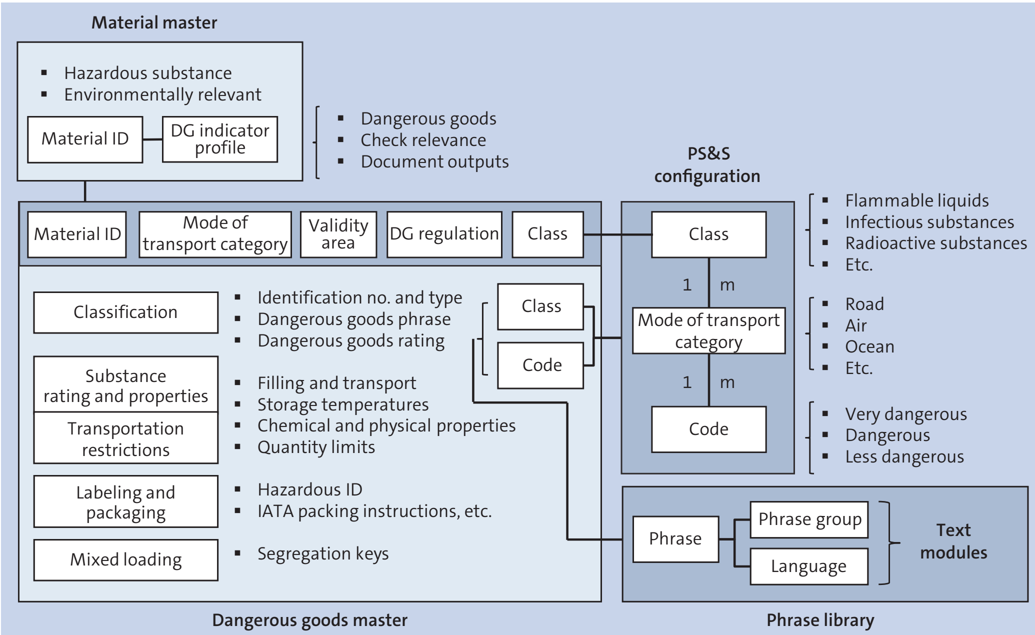


Figure 3.13 Structure of DG Parameters

In addition to the classification data, the DG master contains information about the dangerous substances themselves (see Figure 3.13). To help you be compliant with legal regulations, hazardous materials are accompanied by detailed information about how they are supposed to be filled and transported, their storage conditions, and what to do in the event of an accident.

The classification of the products and substances that present a danger during transport is based on classes and codes, which are assigned to the DGR specified in the DG master. The assignment of classification codes to DG classes and DGRs is part of the PS&S configuration shown in Figure 3.14, which you can find in Customizing via **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PS&S • PS&S Services • Dangerous Goods Management • Dangerous Goods Master**.

Labels on tanks, trucks, and containers indicate the type of risk of the hazardous or dangerous substance and clearly identify the DG. For example, toxic substances carry a danger label consisting of a black skull and crossbones on a square white background. The declaration—usually warning placards and alphanumeric keys in the top half of the label—follows internationally agreed-upon symbols and code systems. It provides information about required extinguishing media, required personal protection measures, and possible reactions of the substance.

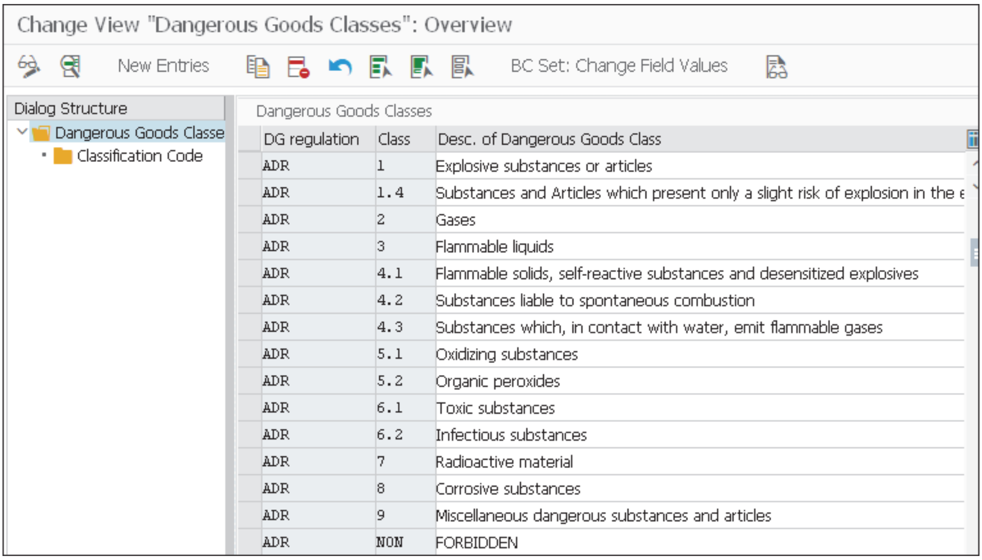


Figure 3.14 Assignment of Classification Codes to Classes

Phrase Management

Whether the physical execution of a transport occurs by sea, land, or air, it often crosses borders and is handled by people speaking different languages. Therefore, warnings and instructions regarding how to handle DG can be language dependent. These texts are usually printed on specifications and first aid measures; they are typically used for document creation, DG texts on DG documents, and reporting.

A central tool to manage these texts is available. The language-dependent text modules are called *phrases* and are part of the master data for DG handling. Phrases are managed in phrase libraries and grouped together in phrase groups. Figure 3.15 shows the **Phrase Library CUST** and **Phrase N03.00700810**, which belongs to **Phrase Group 03.00**.

The *phrase library* defines the phrase assignment and origin. Using the import functionality provided by PS&S, you can upload purchased or company-specific phrase libraries and merge them with your existing phrase library. You can also update active phrases after importing a new version of the passive library by creating phrase references from the passive phrases to phrases in the active phrase library.

For each library, a *phrase group* is used to classify phrases. Each phrase belongs to a single phrase group and might have different assigned phrase codes. These codes are optional, language-dependent abbreviations for individual phrases.

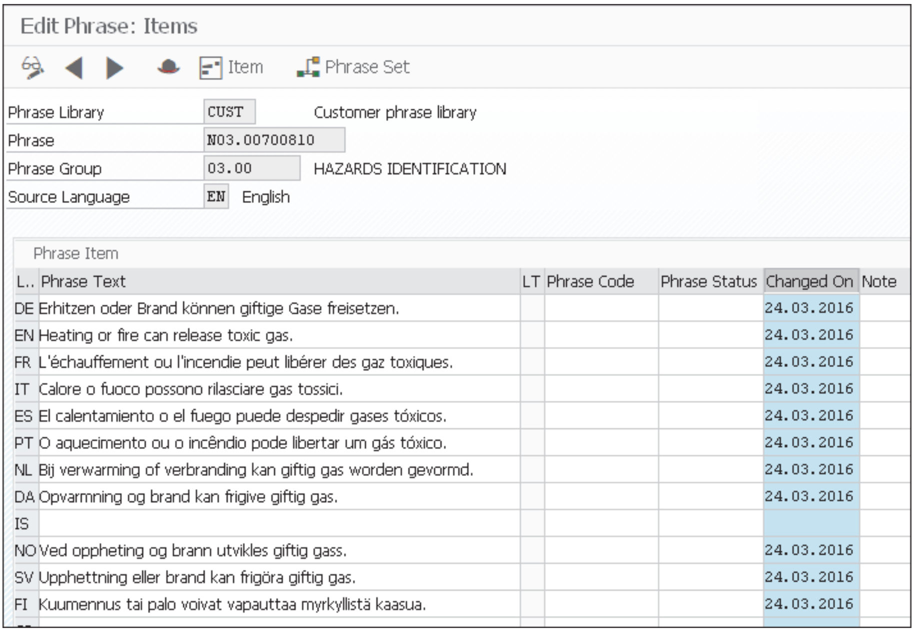


Figure 3.15 Editing DG Phrases

Dangerous Goods Processing Based on Product Compliance

Dangerous goods processing based on product compliance allows you to transport hazardous materials in compliance with international regulations by road. You have to activate the usage of product compliance in Customizing via **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PC • Activate Product Compliance** and activate the business features you want to use at **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PC • Activate Business Features for Product Compliance**. Figure 3.16 shows the available business features for product compliance. The relevant business feature for DG processing in TM is **Dangerous Goods Integration into Value Chain**.

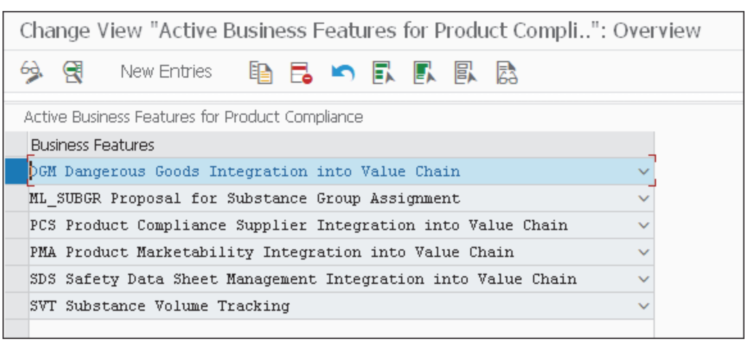


Figure 3.16 Activating Business Features for Product Compliance

If product compliance is activated, the business feature **Dangerous Goods Integration into Value Chain** is activated, and the compliance-relevant indicator in the product master is selected, then the system checks whether transportation of a compliance-relevant product is allowed, forbidden, or restricted during the creation of documents (freight units, freight orders). Depending on the check result, individual items or the complete document can be blocked or warnings can be raised. If an item has been classified as a hazardous good, the system also checks the availability of the DG data.

The data model for DG in product compliance distinguishes between the unpackaged product (i.e., the product which is produced) and the packaged product (i.e., the product which is sold). Only the packaged product is being transported. In the **Compliance View** of the product master data, you have to define the basic DG classification for the unpackaged product and the enclosure-specific DG classification for the packaged product. The basic DG classification includes the UN number and packing group (if applicable) as well as the basic DG description. This is the basis for the enclosure-specific DG classification, which includes packaging information and the enclosure-specific DG description. The DG information for the packaged product includes descriptions for documents, marking text for packages, labels for packages, and placards for containers, tanks, or vehicles.

3.1.5 Master Data Creation and Integration

Depending on the deployment option used for TM, the relevant master data is created based on different strategies and interfaces. If you're using embedded TM, no integration is required, as shown in Figure 3.17. Material master data and business partner master data are readily available, and location master data is created on the fly or via a report when needed. This is a major difference compared to the side-by-side deployment, which integrates TM with an SAP system (classic SAP ERP or SAP S/4HANA).

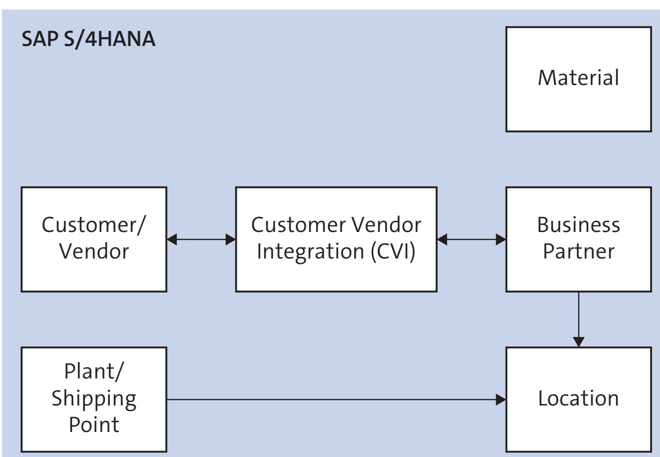


Figure 3.17 Master Data for TM in SAP S/4HANA

A side-by-side approach has to be used if you want to link TM with multiple SAP ERP or SAP S/4HANA instances as sources of transportation requirements. These deployment options are shown in Figure 3.18. For these two deployment options, TM is deployed side by side, while the transportation requirements originate either from SAP ERP or from SAP S/4HANA. Consequently, the master data (material, business partner, location) needs to be transferred from the source system (SAP ERP, SAP S/4HANA) to TM. In these deployment scenarios, the DRF is used as an interface technology.

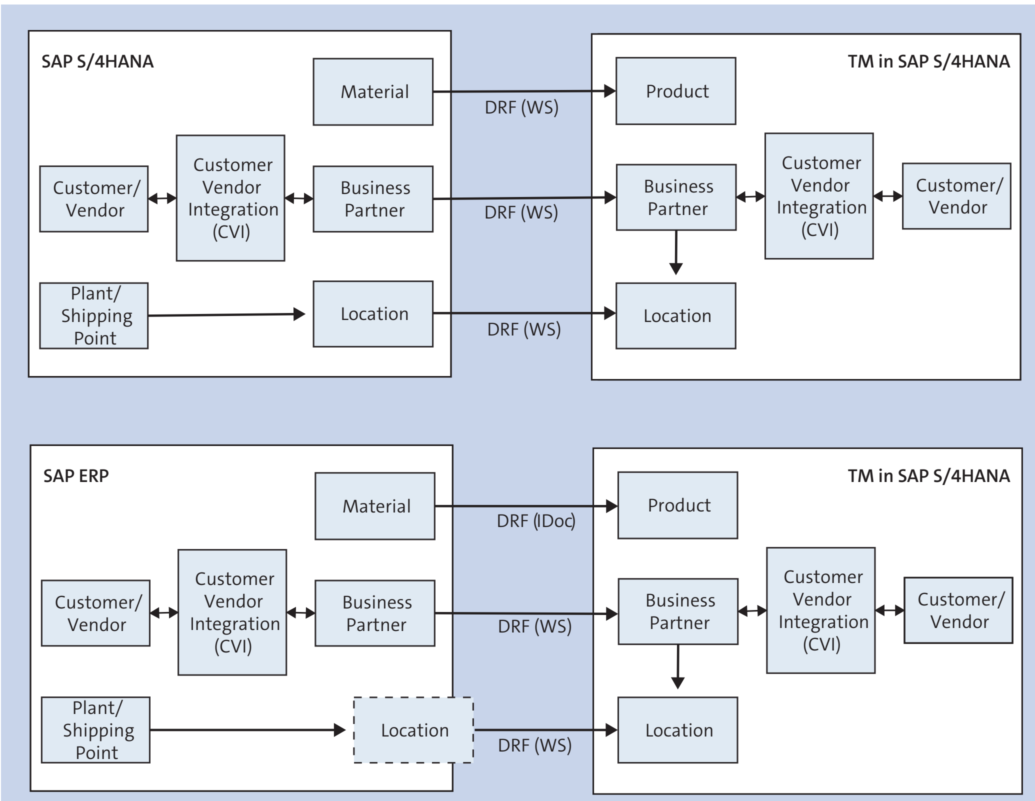


Figure 3.18 Side-by-Side Deployment Options

Another option with reference to master data governance is the use of a central master data repository (SAP Master Data Governance [SAP MDG]). Here, all master data is maintained in a central system and replicated to all systems that require master data. This setup can be used both for an embedded TM deployment as well as for a side-by-side deployment. In this case, master data is also replicated from the source system to all target systems (SAP S/4HANA, TM) via DRF.

Thus, we have to look at three elements of master data creation/integration in the remainder of this section: customer-vendor integration (CVI) to synchronize customer/

vendor master data with business partners, DRF to integrate master data from an external source into TM, and the automatic creation of location master data in TM.

Customer-Vendor Integration

In SAP S/4HANA, the business partner is the central object to store partner data. You can use CVI to create customer master data or vendor master data based on a business partner and vice versa. In other words, CVI is bidirectional, and you can both propagate customer/vendor master data to business partners as well as populate data from the business partner to the customer/vendor. One customer and one vendor can be assigned to a business partner simultaneously in a corresponding business partner role so that a business partner is always available for holding customer and/or vendor data.

In general, master data synchronization synchronizes master data objects in an SAP system that are similar from a business point of view but not from a technical point of view; in this way, you can integrate different SAP applications (e.g., sales and distribution or materials management with TM) seamlessly in your business processes. The synchronization of customer and business partner master data allows you to integrate SAP applications that make technical use of the business partner in its UI and use the customer master as a technical basis in subsequent business processes.

It's important to note that master data synchronization can neither synchronize master data objects across systems nor transfer master data objects from external or legacy systems. It only synchronizes objects within one system (SAP S/4HANA).

Technically, there are two synchronization options available:

- **Synchronization using the synchronization cockpit**
  The synchronization cockpit is used to prepare, perform, and check the initial synchronization of master data objects.
- **Synchronization from the master data maintenance**
  When master data is saved, the synchronization process is carried out for those objects for which it has been activated. This process can be used to create or change existing objects.

CVI takes place in the background while the master data is processed. Customer integration and vendor integration can be used independently from each other, but both may be required in a TM scenario. You can find the relevant activities to control master data synchronization in Customizing with path **Cross-Application Components • Master Data Synchronization • Synchronization Control**. The specific settings for CVI are done in Customizing via path **Cross-Application Components • Master Data Synchronization • Customer/Vendor Integration**. Finally, the synchronization cockpit shown in Figure 3.19 can be executed from Customizing via **Cross-Application Components • Master Data Synchronization • Synchronization of Mass Data • Execute Synchronization Cockpit**.

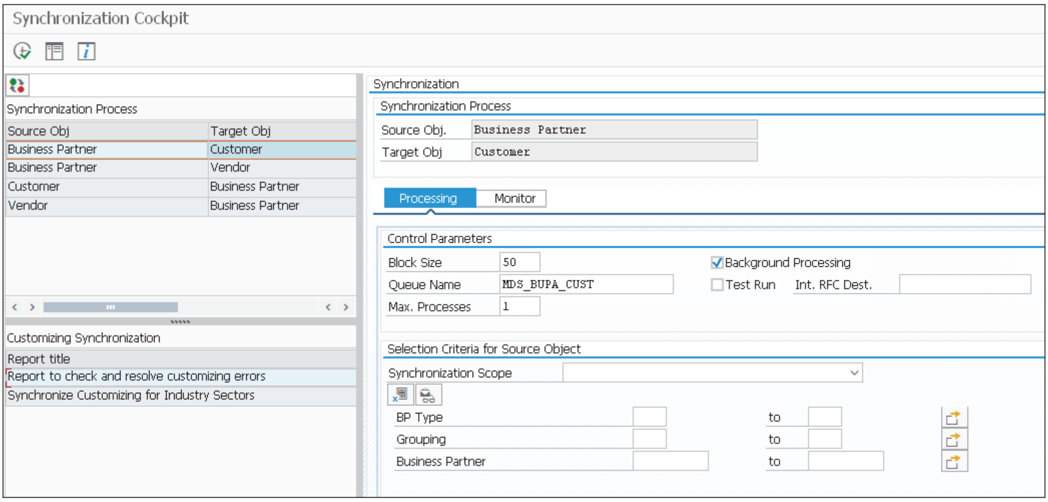


Figure 3.19 Synchronization Cockpit

Data Replication Framework

The DRF is used to replicate master data such as business partners, products, and locations between source systems (e.g., SAP ERP or SAP S/4HANA) and target systems (SAP S/4HANA), as shown previously in Figure 3.18. You can use this function to replicate master data to TM or any other SAP S/4HANA target system. The DRF uses key mapping to map the IDs of the corresponding objects in the source and the target system to determine the IDs of local master data entities based on the IDs of the master data objects in the source system. Therefore, a replication can be made, even if the object IDs in the two systems aren't identical. This is essential if a target system receives data from several source systems that may contain the same objects with different IDs or where the same key may be used for different entities in different source systems.

DRF uses a push mechanism, which means the source system decides which data is sent and when it sends the data. From a technical perspective, DRF supports web services, Application Link Enabling (ALE), remote function calls (RFCs), and file transfer. The configuration of DRF is done in Customizing via **Cross-Application Components • Processes and Tools for Enterprise Applications • Master Data Governance • Central Governance • General Settings • Data Replication**. The customizing is divided into two parts:

- **Define Custom Settings for Data Replication**
  The first part deals with customer/system-specific settings such as the definition of the system landscape, replication models (i.e., which data to send where), and business object–specific settings (e.g., use of ALE, change pointer).
- **Enhance Default Settings for Outbound Implementations**
  The second part contains SAP-delivered settings (e.g., filter objects, outbound implementations) that need to be configured if it's required to replicate custom business objects or enhance existing outbound implementations.

The DRF offers to replicate master data by using an object selection or by defining a replication model. The Customizing for the replication model shown in Figure 3.20 is defined in **Cross-Application Components • Processes and Tools for Enterprise Applications • Master Data Governance • Central Governance • General Settings • Data Replication • Define Custom Settings for Data Replication • Define Replication Models**.

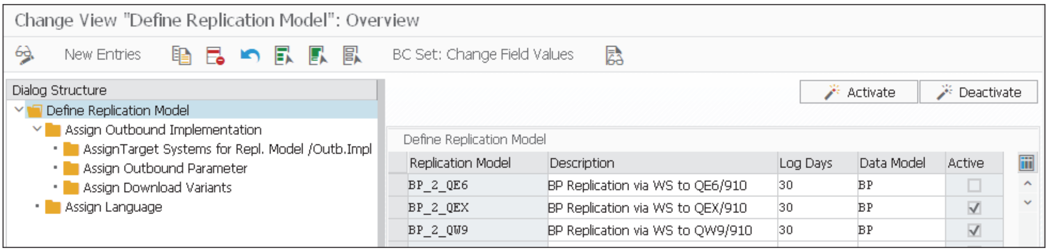


Figure 3.20 Replication Model

The definition of the replication model is the second step in the configuration of DRF, after the technical settings related to the system landscape have been done. In the replication model, you can assign several outbound implementations. The outbound implementation defines which data is transferred and which communication channel is used for the transfer. Table 3.1 lists the outbound implementations that are relevant in the context of a TM implementation.

Outbound Implementation	Business Object	Business Object Type	Communication Channel
986_3	Business Partner	986	Web services
194_1	Material	194	IDoc
194_3	Material	194	Web services
189	Location	189	Web services
DRF_0045_L	Shipping Point	DRF_0045	Web services
464_L	Plant Location	464	Web services

Table 3.1 DRF Outbound Implementations Relevant to TM

For business partners (business object 986 – Business Partner), the outbound implementation `986_3 – Outbound Impl. for BP/REL Services` is used to initiate a web service to create a replication request message, which is answered by a confirmation message upon successful creation of the business partner in the target system. Key mapping can be based on the `Business Partner ID` or on the `Business Partner UUID`. Note that locations aren't automatically created from the DRF with the replication of the business partner but have to be created locally in the target system based on business partner master data. The following business partner roles are transferred with the DRF:

- Business partner (general) (000000)
- Organizational unit (BUP004)
- Carrier (CRM010)
- Customs office (SLLCOF)
- Driver (TM0001)
- Supplier (FLVN01)
- FI supplier (FLVN00)
- Customer (FLCU01)
- FI customer (FLCU00)

For products (business object 194 – Material), you can use outbound implementation `194_3 – Outbound Impl. for Product via Services`, if the source system is SAP S/4HANA or outbound implementation `194_1 - Material through IDoc`, if the source system is SAP ERP. Using the DRF allows you to transfer product master data, which doesn't depend on organizational levels such as plant, storage location, or sales organization. The master data replicated to TM includes client-dependent data, language-dependent material descriptions, and conversion factors for units of measure. For products, key mapping supports both the `Material ID Internal Format` and `Material ID External Format`.

As mentioned before, locations are typically created locally from business partner master data in TM. However, plants and shipping point Customizing data exists in SAP S/4HANA and SAP ERP, which needs to be represented as location master data in TM processes. Therefore, DRF can also be used to create location master data in the source system based on plant and shipping point information and to replicate this location master data to the target system. If the source system is SAP ERP, this option isn't viable because no location object exists there. Therefore, the plant and shipping point Customizing settings are directly replicated to TM where the locations can then be created in this case.

For locations (business object 189 – Location), you can use outbound implementation `189_1`, if the source system is SAP S/4HANA. If the source system is SAP ERP, you can use outbound implementation `464_L` for plants and outbound implementation `DRF_0045_L` for shipping points/receiving points. The key mapping for locations supports the `Location Number` and the `Location UUID`.

After you've assigned the outbound implementations to your data replication model, you need to assign the target system to your replication model/outbound implementation. You can also assign multiple target systems, for example, if you use SAP MDG and want to replicate master data to SAP S/4HANA for sales and distribution processes and TM in a side-by-side deployment. The assignment of the target system(s) to the replication model shown in Figure 3.21 is defined in **Cross-Application Components • Processes and Tools for Enterprise Applications • Master Data Governance • Central Governance • General Settings • Data Replication • Define Custom Settings for Data Replication • Define Replication Models**.

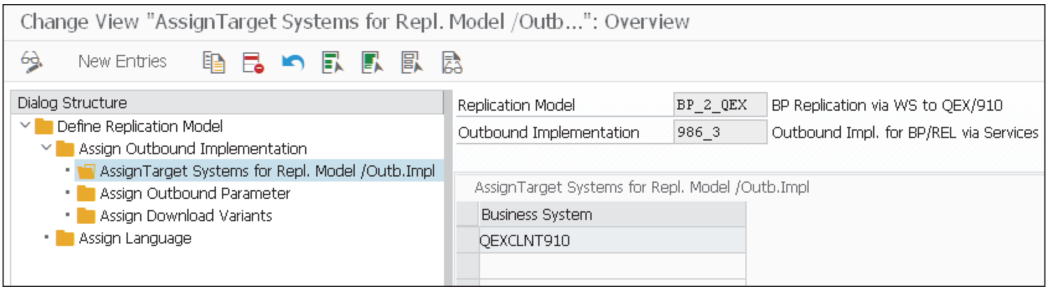


Figure 3.21 DRF: Assign Target Systems

Often, master data objects contain more information than is required in your transportation process and TM system. Business partners may contain business partner roles that aren't relevant to TM, and materials may have defined plant- or storage-related information that isn't relevant for transportation. To avoid subsequent problems based on incomplete or inaccurate master data, you can exclude the nonrelevant data from the replication using filters. These filters can be defined either using web application DRFF or by assigning manual replication filter criteria in Transaction DRFOUT. Figure 3.22 shows how to exclude data specific to **Plant** and **Storage Location** from the transfer of material master data by assigning an *.

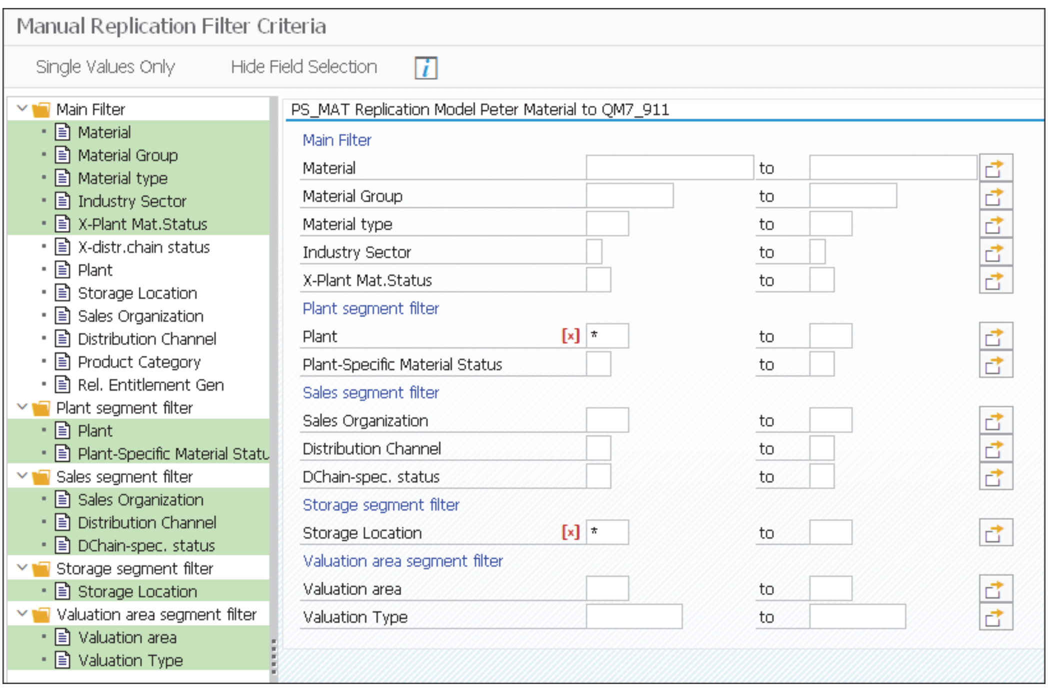


Figure 3.22 Manual Replication Filter Criteria

Finally, the replication is executed via Transaction DRFOUT. The transaction supports three modes:

- **Initialization**
  All data of the selected replication model and outbound implementation is processed.
- **Changes**
  The system analyzes all changes between the current date and the last initialization or change. Optionally, a specific date/time range can be defined.
- **Manual**
  Individual data as defined in the manual replication filter criteria is processed.

Figure 3.23 shows how to execute the data replication for the previously created replication model. In the example, only changes from January 2023 are to be replicated.

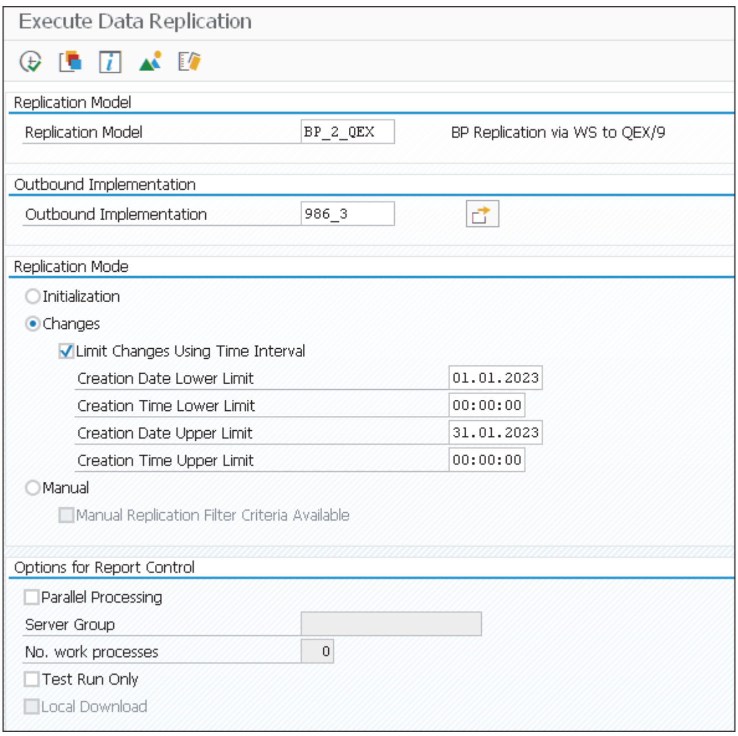


Figure 3.23 Execute Data Replication

If the data replication doesn't work as expected, you can analyze the logs that have been created from the execution of the replication. Figure 3.24 shows the options offered by the log accessed through Transaction DRFLOG. You can limit the analysis by replication model and outbound implementation as well as by the replication mode (initialization, change, manual) that has been used to trigger the replication. That way, you're able to focus the analysis on the relevant/failed replication.

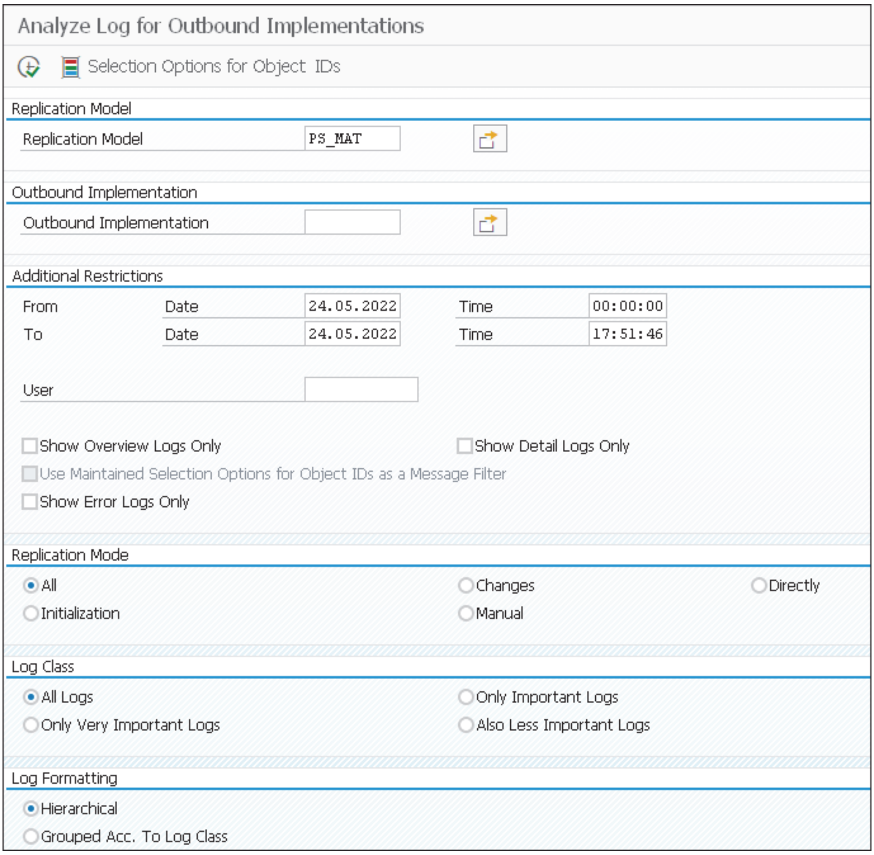


Figure 3.24 Analyze Log of Data Replication

Location Creation

Locations are the elementary nodes in the transportation network as will be described in Section 3.2.1. While some locations may have been transferred to TM via DRF, some locations may need to be created internally in TM. There are three ways of creating locations internally:

- Based on business documents
- Based on business partner master data
- Based on a report

The creation of locations based on business documents guarantees that for each source and destination of a transportation requirement, the corresponding location exists prior to the creation of the freight unit. Whenever a document that is relevant for TM is created or updated, it's checked whether all necessary locations to represent plants, shipping points, or business partners exist to identify pickup and delivery addresses for transportation. If a location is missing, it will be created immediately. This logic applies to the following document categories:

- Sales and distribution documents: Sales order, sales scheduling agreement
- Materials management documents: Purchase order, stock transfer order, purchase scheduling agreement
- Deliveries: Outbound delivery, inbound delivery

The creation of locations based on business partner master data can be activated using an implementation of BAdI `/SAPAPO/LOC_CREATE`. The BAdI implementation allows a location to be created after the creation of a business partner. Subsequent updates of the business partner address are also triggered.

Finally, locations can also be created based on report /SAPAPO/CREATE_LOCATION. This report, shown in Figure 3.25, is used to create locations for plants, shipping points, and business partners. Locations are created for those objects within the selection for which no location already exists. To update locations representing plants and shipping points, you can use report /SAPAPO/UPD_LOC_SP_PL. This report updates the addresses and geocoordinates of locations and should be triggered on demand or periodically.

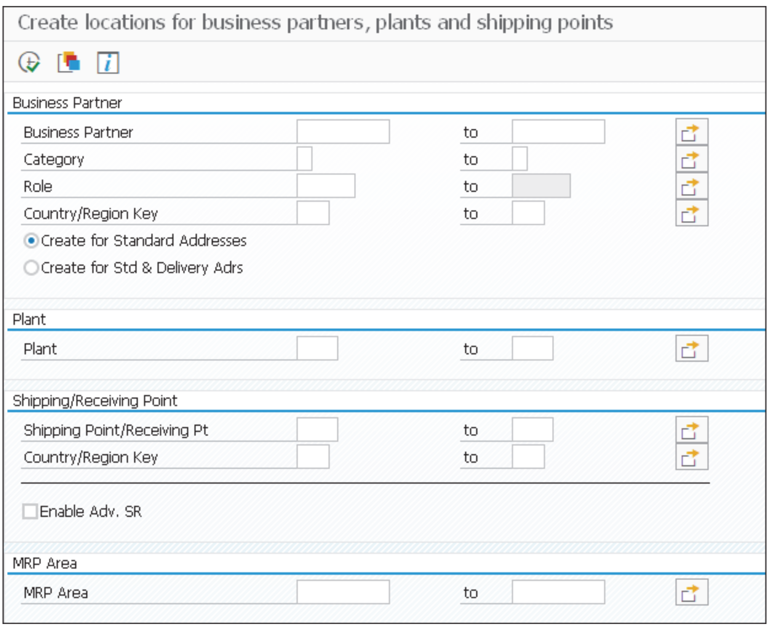


Figure 3.25 Creation of Locations by Report

By default, the location details and descriptions are taken from the original entities. In addition, the location names correspond to the names of the original entities (e.g., business partner name), except for shipping points, which are prefixed with *SP_*. If a location with the defaulted name already exists, suffixes (_01, _02, etc.) are appended to the name. The location details, names, and descriptions can be adapted by implementing BAdI `/SAPAPO/LOC_DETAILS`.

This section introduced the general master data, the main characteristics of the organizational structure, the business partners and materials, and the creation and integration of these objects. Before we explain the resources, let's continue with the logistics master data that is used to define and specify the transportation network.

3.2 Transportation Network

The transportation network defines direct reachability between your locations and transshipment locations, which together define how freight can be transported between your locations. Direct reachability between location A and location B means that B can be directly reached from A by a transportation option, such as a vehicle type, vehicle resource, or schedule. Transshipment locations allow reloading from one transportation option to another. The network definition is essential for automatic planning, which determines the best path through the network and assigns the most suitable carriers for given transportation demands and for charge calculation considering freight and forwarding agreements that contain rates defined on trade lanes as the geographical basis.

The following sections introduce locations and all other concepts for modeling your transportation network from reachability, transshipment locations, and business partner relation perspectives:

- Locations (Section 3.2.1) form the nodes in the network at which goods are loaded or unloaded. Locations represent the most basic network concept because they define the source and destination of any transportation.
- Transportation zones (Section 3.2.2) allow you to group locations and thereby define reachability and transshipment options in an aggregated fashion.
- Transportation lanes (Section 3.2.3) define reachability between locations and zones on a means of transport and carrier level.
- Schedules (Section 3.2.4) express recurring reachability at fixed dates and times along a predefined location sequence for a given mode or means of transport, as described in Section 3.3.1.
- Transshipment locations (Section 3.2.5) are required for intermodal transportation or any scenario involving consolidation and deconsolidation.
- Default routes (Section 3.2.6) define paths from source to destination through a sequence of transshipment locations. They implicitly define transshipment locations to be used from source to destination and can also predefine schedules or carriers to be used for the stages from source to destination.
- Trade lanes (Section 3.2.7) offer an additional perspective on the network. These are used to define business relationships to your customers (i.e., forwarding agreements) and carriers (i.e., allocations, business shares, and freight agreements).

- The transportation network cockpit (Section 3.2.8) is a powerful tool to visualize all objects of the transportation network on a map, search for specific objects, and maintain objects on the map. Its text-based cousin, the transportation network personal object worklist (POWL), is presented as well.
- The integration of geographical services (Section 3.2.9) is essential to determine the geographical coordinates of locations, ascertain the distances and durations between locations, and provide the geographical map data for a graphical visualization of a map.

3.2.1 Locations

A *location* represents a logical and/or physical location where goods are delivered, picked up, or transshipped, or where trucks and trailers get coupled or uncoupled. To define a location, choose the Define Location app. Enter the name and location type, which you can select from a list of more than 15 standard location types. These include, for example, production plant (1001), distribution center (1002), customer (1010), port (1100), and airport (1110). You can maintain additional data in the following tabs (see Figure 3.26):

- **General**
  In the **General** tab, you can maintain identifiers such as the **UN/LOCODE** and the **IATA Code**, which are commonly used in ocean freight and air freight businesses, respectively; the **Geographical Data** specifying **Longitude**, **Latitude**, and **Altitude**; the **Precision** representing whether the geographical coordinates have been obtained, for example, on the street, city, or region level; the **Match (%)** indicating how well the determined geographical coordinates match the given address, where 100% represents a perfect match, and lower percentages indicate typos; and the **Validity End** defining how long the coordinate can be stored and accessed (Section 3.2.9). You can lock the geographical data, which then won't be affected if the address data is changed. In addition to the time zone and assigned business partner, the tab contains the priority, which can be used to define location-dependent nondelivery costs or earliness and lateness costs to be considered in automatic planning.
- **Address**
  The **Address** tab contains the default address, PO box address, and other contact details. The geographical coordinates are determined automatically as soon as you maintain the country code (Section 3.2.9). By following path **Logistics • Transportation Management • Master Data • Transportation Network • Geocoding • Mass Geocoding** in the SAP menu, you can determine geographical coordinates for many locations in one step.
- **Alt. Identifiers**
  Alternative identifiers for the location can be maintained in a dedicated tab. You can predefine the possible types of alternative location identifiers by selecting IMG menu path **Transportation Management • Master Data • Transportation Network • Location • Configuration for Alternative Location Identifiers**.

- **TM**
  The **TM** tab allows you to maintain the minimum and maximum goods wait times, which are described in more detail in Section 3.2.5. In addition, you can define the trailer handling capability that can enable trailer swap, recoupling, or recoupling for pickup and delivery only. You can also specify air cargo security information; classify the location as unknown shipper, known shipper, account shipper or regulated agent; and set the handover party code and its expiry date. It's also possible to link the location to an SAP S/4HANA extended warehouse management (EWM) target system and specify the EWM warehouse number. You can also define the location loading profile and the attached equipment profile, which impose constraints on the vehicle resource and vehicle type that can be loaded and unloaded at this location (see Chapter 5, Section 5.8.7).
- **Resources**
  You can assign calendar and handling resources in the **Resources** tab. These are described in more detail shortly.

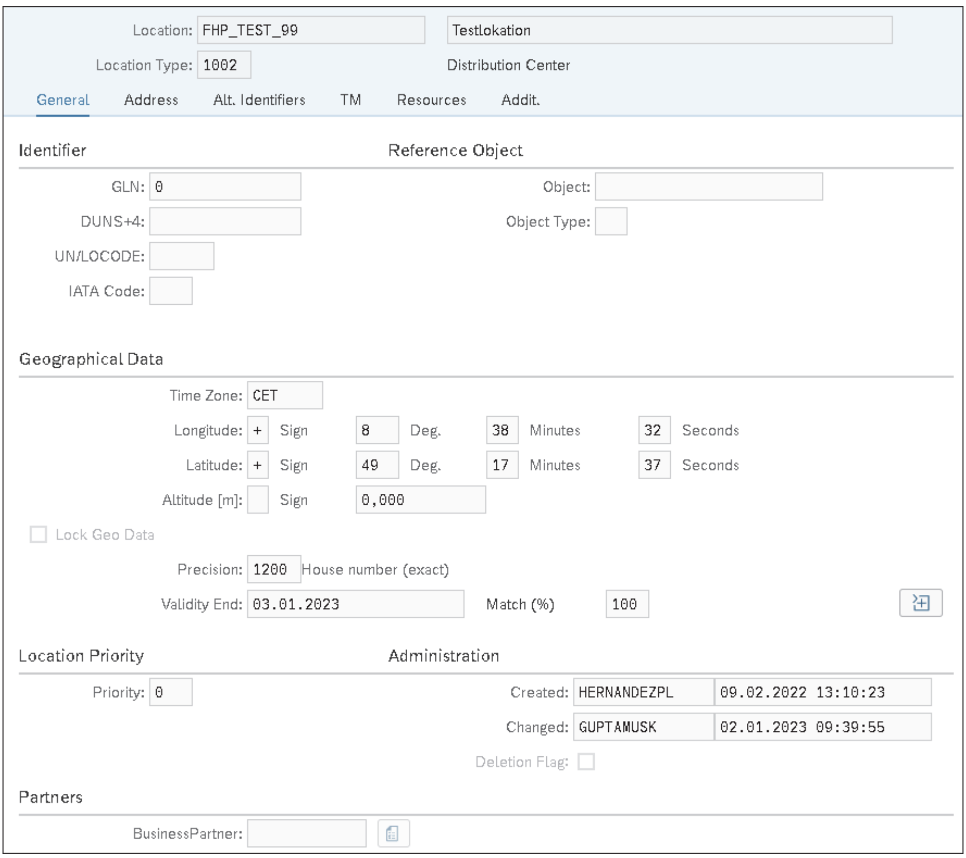


Figure 3.26 Maintaining a Location

You can assign handling or calendar resources (operating times) for inbound and outbound transportation in the **Resources** tab. A calendar resource defines during which time intervals loading and unloading can take place at the location. In addition to this, a handling resource can restrict the number of loading and unloading activities that can be handled in parallel at the location. Thus, both calendar resources and handling resources affect the scheduling of unloading and loading activities at the location. You also have the option of not assigning a calendar or handling resource. In this case, loading activities at the location aren't subject to any time restrictions. See Section 3.3.5 for an introduction to handling resources and calendar resources.

Figure 3.27 shows the maintenance of the inbound and outbound resources for a location in the **Resources** tab. By entering the values for consumption, you can define how much of the capacity offered by the relevant handling resource is consumed by a loading or unloading activity. You can define the same handling resource for inbound and outbound activities.

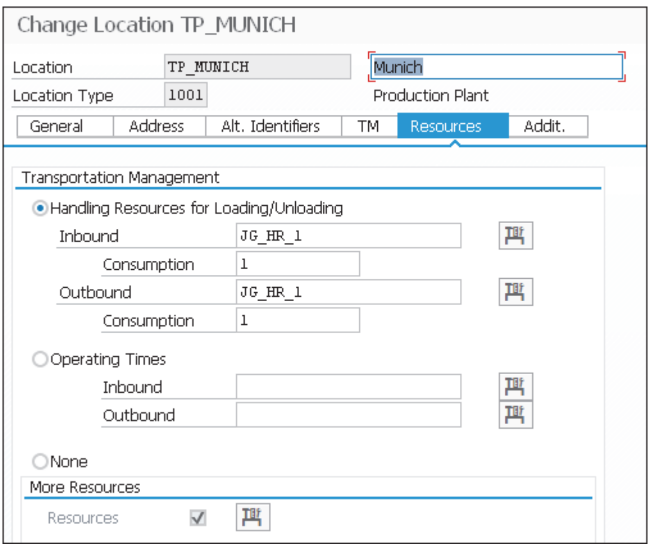


Figure 3.27 Defining Inbound and Outbound Resources for a Location

You can also click the button next to the **More Resources** field to define handling resources or calendar resources that depend on the means of transport. This enables the use of several handling resources at the same location (e.g., different loading ramps for truck and rail transportation). If a vehicle type isn't used in the vehicle type-dependent settings for a location, the general inbound and outbound resources for the vehicle type apply.

In the example shown in Figure 3.28, unloading activities at location **TP_MUNICH** are scheduled in accordance with calendar resource **TB_CAL** if the means of transport **HH_EU_M** is used, while neither calendar nor handling resource is used for means of transport **HH_EU_S**. Loading activities are scheduled according to handling resources **JG_HR_1** and **JG_HR_2** for means of transports **HH_EU_M** and **HH_EU_S**, respectively. The **Valid** column allows you to determine whether to use the calendar resource (value **1**), the handling resource (value **2**), or neither resource (value **0**) for scheduling for each means of transport.

Central versus Decentral Location-Specific Definition of Calendar and Handling Resources

While you can still use the preceding definition of calendar and handling resources used at a certain location, we recommend using the scheduling settings to define calendar resources and handling resources per location for various reasons. First, you can centrally define these constraints for all locations, which is much easier compared to maintaining them separately in each single location. Second, you can create alternative scheduling settings, enabling easy switching between them for simulation purposes, which would be nearly impossible to achieve when defining directly in each location. Third, you can easily upload and download scheduling settings.

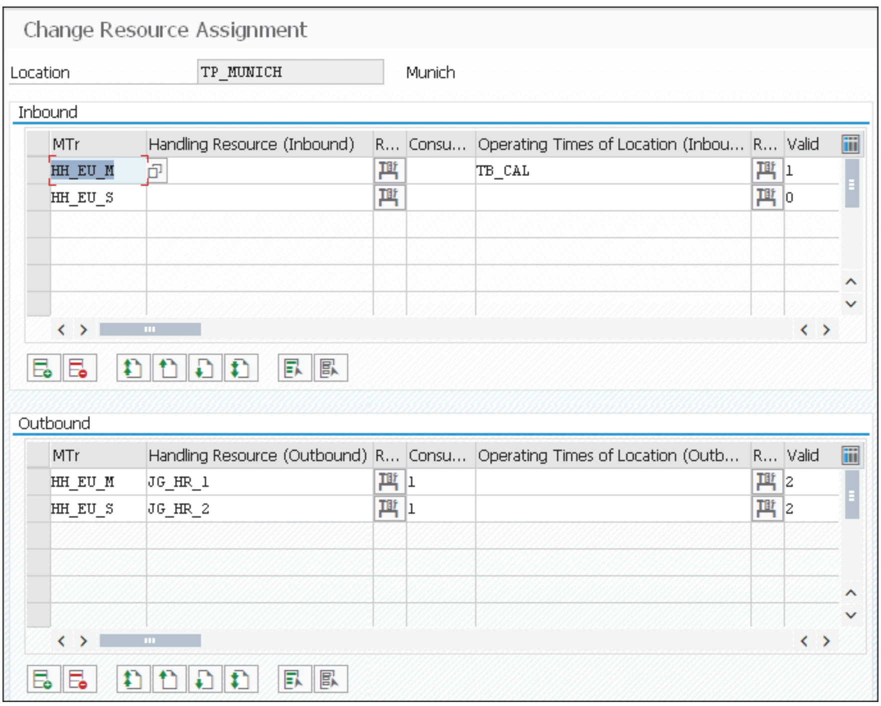


Figure 3.28 Defining Means of Transport-Dependent Inbound and Outbound Resources for a Location

Using a Resource for Inbound and Outbound Transport or for Several Locations

A calendar resource or handling resource can be used for inbound and outbound transportation at a single location. One calendar resource could even be used for many different locations, which reduces your maintenance efforts as you define it only once and use it multiple times.

You can store any locations that you don't want to store permanently in the system as master data as one-time locations. These are used whenever it's necessary to enter location data, such as address details, but a reference to the master data record isn't possible or desirable. A one-time location is defined by the name of the organization, the address or communication data, or a combination of these details. One-time locations are typically used when you create forwarding orders from new ordering parties, and the locations of these parties aren't defined in the master data.

3.2.2 Transportation Zones

A transportation network usually contains a large number of locations. Defining relationships such as transportation lanes or trade lanes between pairs of locations is possible, but it's a time-consuming and error-prone task. A definition on the location-to-location trade lane level for agreements, allocations, and business shares isn't required in many transportation businesses. Instead, these need to be maintained on a more aggregated level.

A *transportation zone* is a group of locations; it allows the transportation network to be represented and maintained in an aggregated form. Relationships such as transportation lanes or trade lanes can be defined on the zone level, which is much more compact, manageable, and less error prone.

To define a transportation zone, choose the Define Transportation Zone app, and click the button for creating a transportation zone. When you enter the name and description of the transportation zone, the screen for maintaining the transportation zone appears. You can also search for existing zones and edit one of them (see Figure 3.29).

In the **Zone - Location** tab, you can explicitly assign locations to the zone and exclude locations from the zone. The **Zone - Postal Code** tab allows you to assign a set of valid postal code ranges of a specific country to the zone, and in the **Zone - Region** tab, you can include a set of countries and regions. The last two tabs result in an implicit assignment of those locations to the zone, which match the postal code ranges, countries, or regions defined for the zone. This implicit assignment is very useful because of its robustness: new locations entering the transportation business are automatically included in the respective zones. If you want to know the locations included in a zone, just select the zone, and click the **Display Included Locations** button, or choose **Logistics • Transportation Management • Master Data • Transportation Network • Transportation Zone • Determine Locations within Transportation Zone** in the SAP menu.

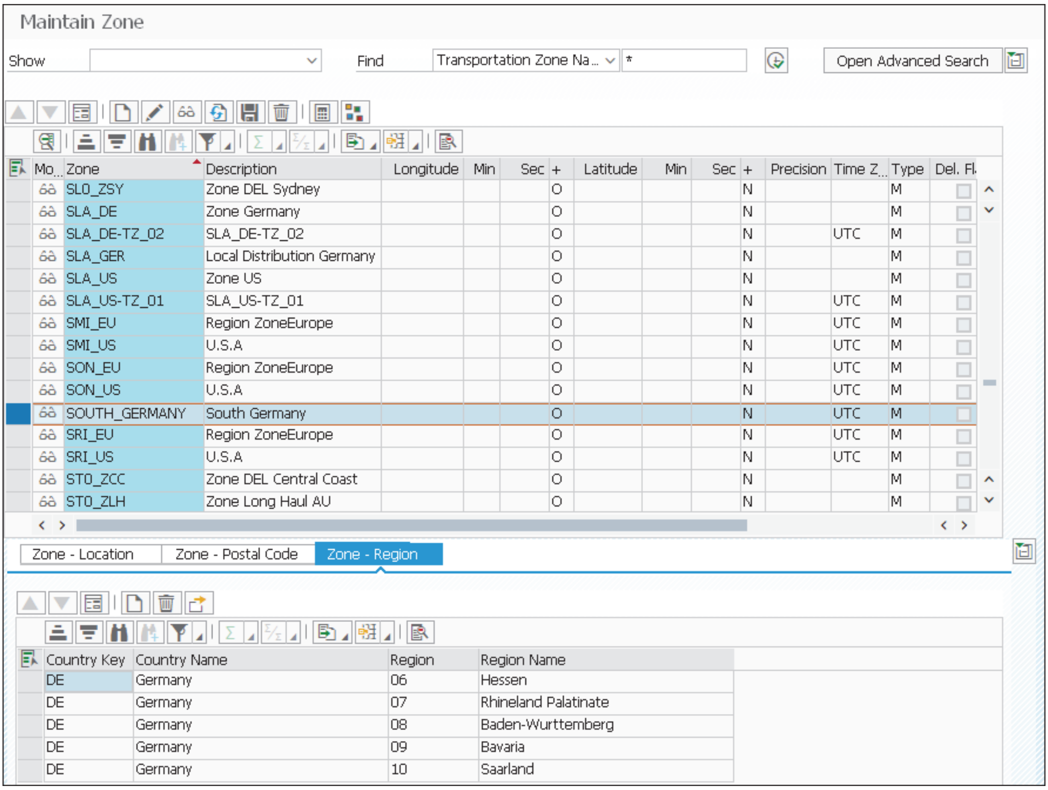


Figure 3.29 Maintaining a Transportation Zone

The zone type is determined automatically and indicates whether the zone contains only direct location assignments (direct zone), only postal code assignments (postal code zone), only region and country assignments (region zone), or a combination of these (mixed zone).

You can define the geographical coordinates of a zone, which are used to display the zone in the transportation network cockpit. Alternatively, you can use the **Calculate Coordinates** button or determine the geographical coordinates for many zones in a single step by selecting **Logistics • Transportation Management • Master Data • Transportation Network • Transportation Zone • Calculate Transportation Zone Coordinates** in the SAP menu.

If you need many zones—say, one per country or one per region—you can select the menu button in the top-left corner of the zone maintenance and follow menu path **Extras • Create Zones** to create all the required zones in a single step by choosing the countries and regions relevant for your business.

The transportation network can be structured to a greater degree using the transportation zone hierarchy, in which zones can be assigned to other, higher-level zones. All locations within a transportation zone automatically also belong to its higher-level transportation zone. The transportation zone hierarchy is used when determining the distance and duration between locations and has a far-reaching impact on many business processes, such as charge calculation, transshipment scenarios, VSR optimization, and carrier selection.

To maintain the transportation zone hierarchy, follow path **Logistics • Transportation Management • Master Data • Transportation Network • Hierarchy • Maintain Hierarchy** in the SAP menu. As shown in Figure 3.30, use the name **RELH_ZONE** for the transportation zone hierarchy and the name **RELHS_ZONE** for the hierarchy structure, and select **Create** or **Change**. The **RELHS_ZONE** hierarchy is delivered as standard. The customer-specific transportation zone hierarchy must be maintained in the **RELH_ZONE** hierarchy.

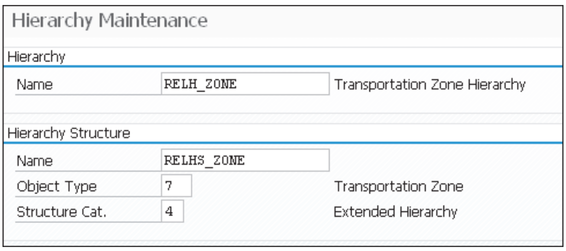


Figure 3.30 Choosing the Transportation Zone Hierarchy

Maintenance of the transportation zone hierarchy is shown in Figure 3.31.

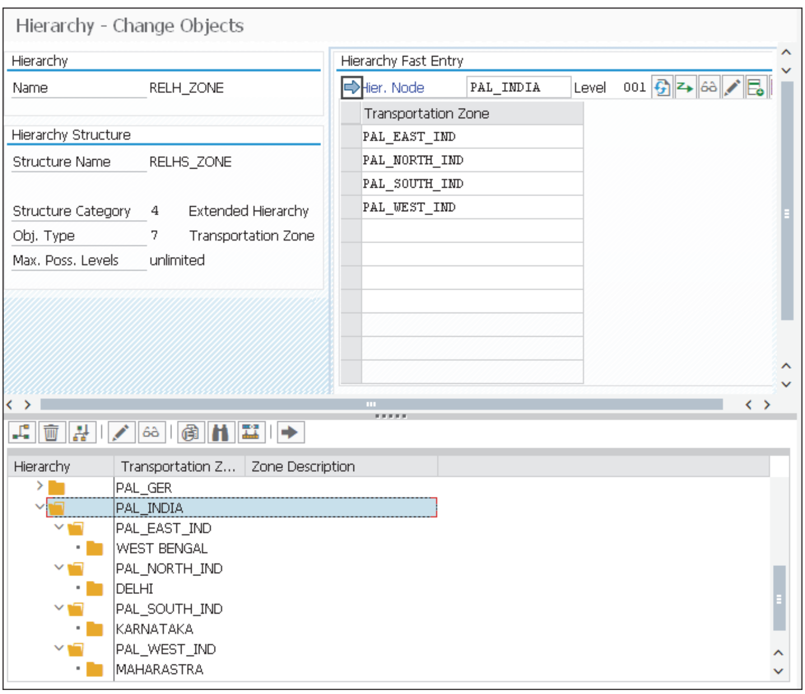


Figure 3.31 Maintaining the Transportation Zone Hierarchy

The maintenance screen is structured around an overview of the existing transportation zone hierarchy displayed as a tree structure and the **Hierarchy Fast Entry** area, where you can enter new hierarchy nodes. The **RELH_ZONE** hierarchy element is the root node in the hierarchy, which means that all other zones are directly or indirectly subordinate to this element. You can double-click to select a parent node in the tree display, enter one or more zones in the **Hierarchy Fast Entry** screen area, and click the **Copy** icon to add these to the hierarchy. To delete zones from the hierarchy, select a hierarchy element in the tree display, and click the **Delete Objects from Hierarchy** button. This deletes all *subordinate* elements from the hierarchy. To remove all objects from the hierarchy, delete the root (note, however, that the **RELH_ZONE** element is retained to allow you to add new elements to the hierarchy later).

Careful Modeling of Transportation Zones and Zone Hierarchy

Use the transportation zones and transportation zone hierarchies to model your transportation network as compactly as possible and avoid redundancies when defining transportation zones and in the transportation zone hierarchy.

Remember that the same location can be contained in several transportation zones and that transportation zones can overlap in this way. When you're creating a new zone, the system informs you by a message if it overlaps with an existing zone.

Two transportation zones are considered to be overlapping if they have at least one location in common and are considered equivalent if they contain the same set of locations. Equivalent transportation zones are always overlapping, but overlapping transportation zones aren't necessarily equivalent.

We recommend that you avoid defining equivalent zones because a very large number of implicit combination options may arise for automatic planning (transportation proposals and VSR optimization), both during automatic determination of transportation lanes, distance, and duration (Section 3.2.3) between locations and when determining transshipment locations. This may lead to long runtimes in certain cases.

If you've maintained equivalent zones, you should delete all but one of these. In addition, check overlapping transportation zones to determine whether the overlaps are useful from a business perspective or whether they could be eliminated.

Keep your transportation zone hierarchy as flat as possible.

3.2.3 Transportation Lanes

Transportation lanes describe the reachability of locations within the transportation network. They are defined by three elements:

- A start, which may be a location or a transportation zone
- A destination, which also may be a location or a transportation zone
- A means of transport

A transportation lane indicates that the destination can be directly reached from the source by truck types and truck resources of the means of transport. When you maintain the start or destination, a transportation zone always represents all the locations it contains. If a transportation lane is defined between two transportation zones, this means that the means of transport can directly reach all locations in the destination transportation zone from all locations in the source transportation zone. A transportation lane from a start location to a destination transportation zone indicates that the means of transport can reach all locations in the destination transportation zone from the source location. An intra-zone lane (a transportation lane where the start and destination transportation zones are the same) indicates that the means of transport operates between any two locations within this zone. A location transportation lane (a transportation lane where the start and destination location are the same) has no influence on reachability between locations but can be used for the initialization of allocations.

Compact Maintenance of Transportation Lanes

Check whether the reachability of locations in your transportation network can be modeled by transportation lanes with transportation zones as the start and/or destination. In most cases, fewer transportation lanes are required if you define them using transportation zones rather than using locations directly.

Reachability Definition without Transportation Lanes

If you have a very simple transportation network, in which every location is reachable from every location in your planning scenario, you can even declare full reachability for a means of transport by a dedicated parameter in the corresponding Customizing (Section 3.3.1), without having to define a transportation lane at all. However, more sophisticated networks are usually defined with transportation zones and transportation lanes.

To maintain a transportation lane, choose the Define Transportation Lane app. You can maintain transportation lanes in the following tabs:

- **Tr. Lane**
  To create or change individual transportation lanes, enter the start and destination, and select **Create** or **Change**.
- **Intra-Zone Lane/Loc. Transp. Lane**
  Enter a location or transportation zone. You can then create or change a transportation lane from the location to the same location (location transportation lane) or from the transportation zone to the same transportation zone (intra-zone lane).
- **Mass Maint. (Create)**
  Use an existing transportation lane as a template for generating new transportation lanes. You can overwrite existing transportation lanes, leave them unchanged, or

enhance them with additional information (see Figure 3.32). You can also specify whether the duration and distance are to be copied from the template or recalculated.

- **Mass Maint. (Display/Change)**
  You can define selection criteria for transportation lanes (start, destination, start location type, destination type, etc.) and then display or change the selected transportation lanes based on these criteria.

The screen for maintaining an individual transportation lane and the mass maintenance screen have similar structures. The mass maintenance screen is shown in Figure 3.32. Here, you can create several transportation lanes at the same time, assign both a means of transport and a carrier to each, and maintain all the transportation lane parameters.

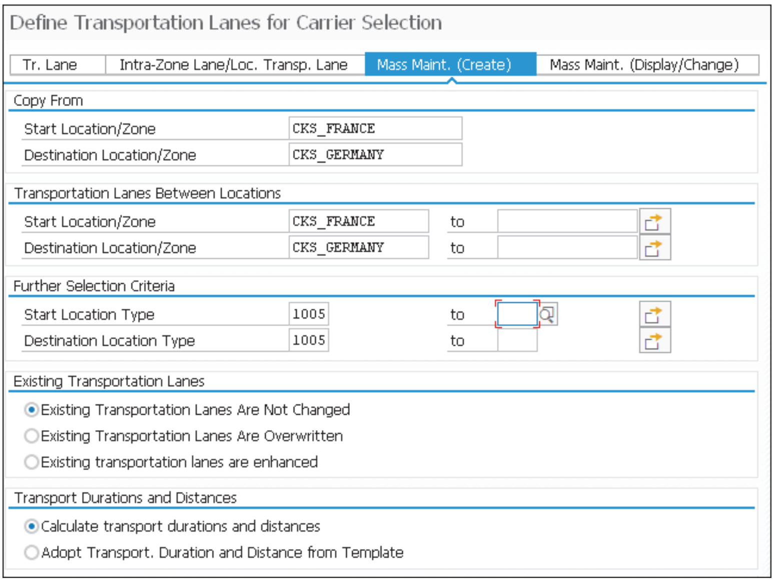


Figure 3.32 Mass Creation of Transportation Lanes

The left side of Figure 3.33 shows the transportation lanes. The means of transport for the transportation lanes are displayed in the **Means of Transport** screen area, with one row representing each means of transport in a transportation lane. You can double-click on a row to select the corresponding means of transport for a transportation lane and maintain the following parameters:

- The validity dates for the means of transport on the transportation lane.
- The distance between the start and destination and the amount of time it will take the means of transport to travel that distance (i.e., the duration). You can generate a proposal using the button provided.
- Two control indicators that indicate whether the specified duration and distance are to be overwritten by an automatic distance and duration determination.

- The **Precision** field that indicates whether the distance was calculated automatically based on the straight-line distance (value: **0000**), with *geographical information system* (GIS) precision (**0100**), or entered manually (**1000**).
- The quantity, distance, and minimum costs, of which the last is only relevant for destination-based distance costs (the use of these costs is controlled in the constraints and costs settings, which are discussed in Chapter 5, Section 5.8.4).

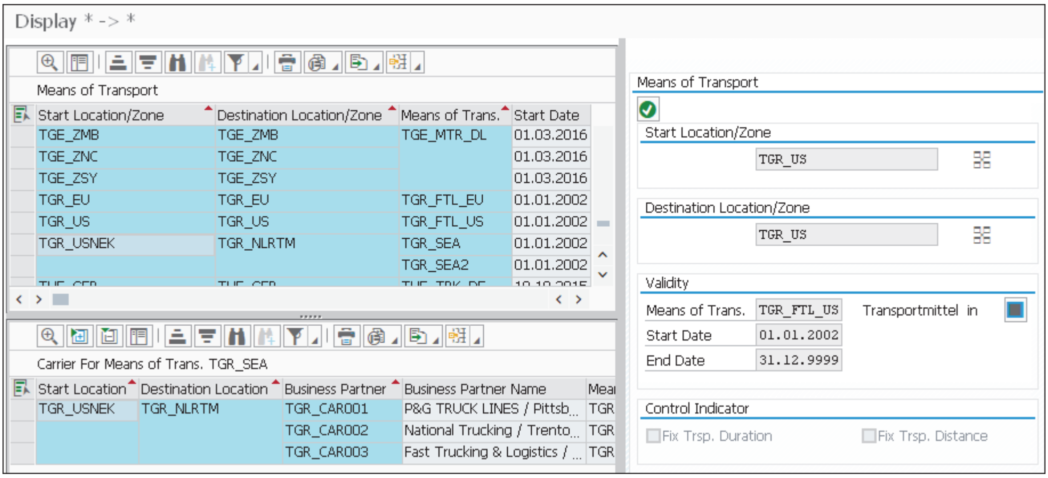


Figure 3.33 Displaying Transportation Lanes

Additional parameters allow you to control the carrier selection (see also Chapter 6, Section 6.5.4):

- You can specify whether business shares are to be taken into account in the carrier selection, which tolerances apply when an excess or shortfall occurs, and which penalty costs are to be used in cases that fall short of or exceed the business share.
- You can define a strategy for carrier selection by selecting the **Relevant for Carrier Selection** field and specifying whether costs and/or priorities are to be used, which costs are to be used (e.g., internal costs or costs from TM charge calculation), and whether or which continuous moves are permitted.
- You can decide whether the planning period or the minimum and maximum capacities defined for the carriers are to be used for the initialization of allocations (see Chapter 6, Section 6.4.4).
- You can also define several means of transport for a transportation lane. To do this, click the **Create** button for a new entry in the **Means of Transport** screen area.

For each means of transport, you have the option of assigning carriers in the **Carrier** area (in the same way you assign a means of transport) and maintaining additional details for each carrier that is relevant for carrier selection:

- Internal costs
- Priority

- Arrival and departure windows for continuous moves
- Maximum distance for continuous moves
- Discounts for continuous moves
- Desired business share for the carrier
- Minimum and maximum capacity for initializing the allocation of the carrier (see Chapter 6, Section 6.4.4)

You can also define whether the carrier is to be considered for peer-to-peer tendering and broadcast tendering and then define its priority for each tendering mode (see Chapter 6, Section 6.6).

You can control the effects of the parameters maintained for the transportation lane on carrier selection in the carrier selection settings (see Chapter 6, Section 6.5.4). Note that direct shipment option (DSO) determination (see Chapter 5, Section 5.2.2) uses carrier selection to choose the best option, and thus the carriers on the transportation lane represent the only alternatives considered.

The automatic transportation lane, distance, and duration determination selects the appropriate transportation lane for a means of transport and a specified start and destination location and determines the corresponding distance and duration between the start and destination. This automatic determination is used, for example, by automated planning procedures and VSR optimization or transportation proposals; it enables the integration of geographical services to spare users the laborious task of manually maintaining distances and durations between locations (Section 3.2.9).

The selection of a transportation lane for a start and destination location is necessary because the hierarchies of transportation zones (Section 3.2.2) and means of transport (Section 3.3.1) may give rise to several transportation lanes, which subsume the means of transport, start, and destination location.

You can make settings in Customizing to specify the sequence in which the three hierarchies (start, destination, and means of transport) are to be taken into account when determining the transportation lane. To do this, select IMG path **Transportation Management • Master Data • Transportation Network • General Settings for Transportation Network Determination**. The **Consider Hierarchical Relationships between Means of Transport First** and **Consider Source Hierarchy First** parameters allow you to select one of the following four access sequences:

- (1) Means of transport, (2) Start, (3) Destination
- (1) Means of transport, (2) Destination, (3) Start
- (1) Start, (2) Destination, (3) Means of transport
- (1) Destination, (2) Start, (3) Means of transport

The access sequence determines which hierarchy is taken into account first when a transportation lane is determined.

Let's consider an example that is based on a scenario with a means of transport T1, a higher-level means of transport T2, locations A and B, zone ZA (which contains location A), and zone ZB (contains location B).

When a transportation lane from A to B is requested, the transportation lane determination function goes through the possible combinations in this sequence, following the access sequence: (1) Means of transport, (2) Destination, (3) Start:

1. Means of transport T1, Start A, Destination B
2. Means of transport T2, Start A, Destination B
3. Means of transport T1, Start A, Destination ZB
4. Means of transport T2, Start A, Destination ZB
5. Means of transport T1, Start ZA, Destination B
6. Means of transport T2, Start ZA, Destination B
7. Means of transport T1, Start ZA, Destination ZB
8. Means of transport T2, Start ZA, Destination ZB

The first combination in this sequence for which a transportation lane exists returns the transportation lane as a result. The underlying principle here is to select more specific transportation lanes first, which allows you to maintain general transportation lanes and refine exceptions with more specific transportation lanes.

The automatic distance and duration determination determines the distance Di(S,De) and duration Du(S,De) for the given start location S, destination location De, and means of transport T. Depending on the configuration, the distance from the transportation lane can be used, or, alternatively, it can be calculated on the basis of a straight-line distance or a geographical service, which takes account of the existing road network, and so on.

When a specific request is submitted for (T,S,De), the system first checks whether a transportation lane exists for (T,S,De). If it finds one, the distance and duration values maintained for the transportation lane (T,S,De) are returned directly as the result for Di(S,De) and Du(S,De).

If a transportation lane (T,S,De) doesn't exist, a transportation lane (T´,S´,De´) is determined in accordance with the configured access sequence. This transportation lane (T´,S´,De´) is a "superior" (higher-level) transportation lane in at least one of the hierarchies (i.e., means of transport, start, or destination). If the GIS quality parameter is set for means for transport T´ (for information about maintaining a means of transport, see Section 3.3.1), the GIS calculates the distance Didyn(S´,De´). If GIS quality isn't selected for T´, then Didyn(S´,De´) is calculated as the product of the straight-line distance between S´ and De´ and the distance factor for means of transport T´.

The distance Didyn(S,De) is then determined the same way for means of transport T on the basis of the GIS quality parameter of T. The requested distance Di(S,De) is then calculated as follows: Di(S,De) = Didyn(S,De) × Di(S´,De´)/Didyn(S´,De´). The relationship between the distance Di(S´,De´) maintained for the transportation lane (T´,S´,De´), and the result of the dynamic distance calculation Didyn(S´,De’) is thus also used to determine the specific distance requested. All distance calculations are based on the geographical coordinates of S and De (or S´ and De´).

If the distance of transportation lane (T,S,De) or (T´,S´,De´) isn’t maintained, then Di(S,De) = Didyn(S,De), and Di(S´,De´) = Didyn(S´,De´), respectively.

The duration calculation for Du(S,De) is essentially the same as the calculation of Di(S,De). Either the duration is returned by the GIS or it’s calculated using the straight-line distance and the average speed of the means of transport. If the duration of transportation lane (T,S,De) or (T´,S´,De´) isn’t maintained, then Du(S,De) = Dudyn(S,De), and Du(S´,De´) = Dudyn(S´,De´), respectively.

3.2.4 Schedules

A schedule represents a recurring transportation that follows a predefined location sequence. It can be used to model regular ship, air, road, or rail transportation and is valid for a specific period. The schedule contains a set of departure rules defining the pattern of days on which the transportation is possible, the times of departure and arrival among the location sequence, and cutoff and availability times needed for transshipment scenarios. A departure represents one instance of transportation along the whole location sequence, with all arrival times and departure times being determined by the departure time at the first location of the sequence. The departures of a schedule can be generated based on a departure rule of the schedule or maintained manually. A departure defines that goods can be transported along the location sequence, or a subsequence of it, respecting the predetermined departure and arrival times for the locations. Thus, a schedule defines reachability in the transportation network, according to a predefined location sequence and given the departure and arrival times of the stops.

Figure 3.34 shows an example of a carrier flight schedule with location sequence Frankfurt, Chicago, and Los Angeles, and two departure rules, which can be used to generate the departures (called *flights* for the air mode of transport), as shown in Figure 3.35.

Schedules can be consumed by creating a freight document based on a schedule’s departure, either by manual (ad hoc) creation (see Chapter 6, Section 6.1.1 and Section 6.2), capacity management (see Chapter 6, Section 6.4), or transportation planning (see Chapter 5, Section 5.7 and Section 5.8). The schedule-based freight document inherits schedule data from the location sequence; the relevant times for departure, arrival, cutoff, and availability; and any available capacities. Capacity management allows the systematic creation of freight documents for a set of schedules and all their departures in a predefined time period (e.g., for the next months). Transportation planning chooses the best departures for a given set of freight units, either by creating new freight documents for the chosen schedule departures or by consuming already existing schedule-based freight documents, which may stem from capacity management or a previous planning step.

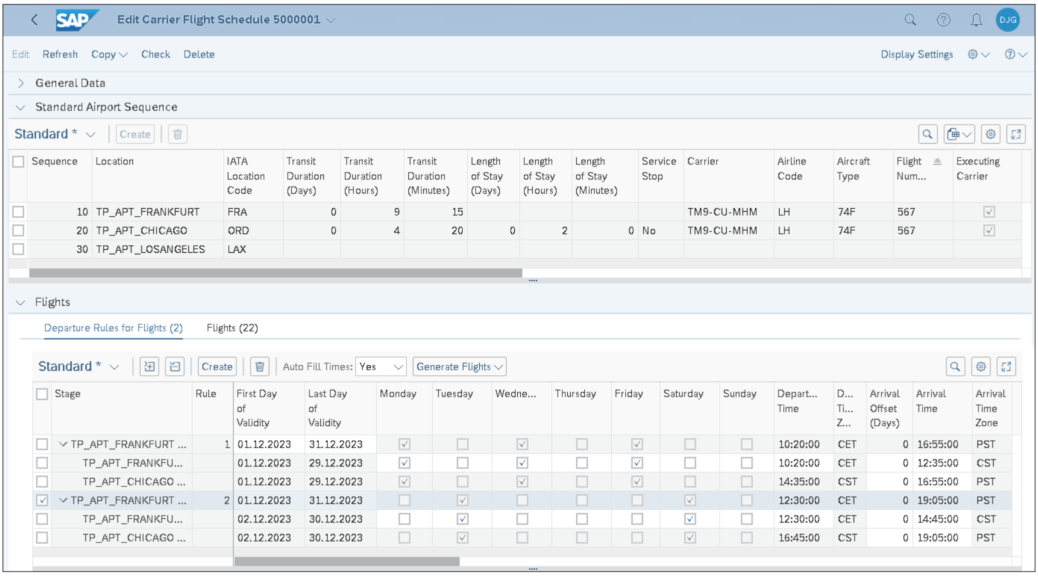


Figure 3.34 Carrier Flight Schedule with Location Sequence and Two Departure Rules

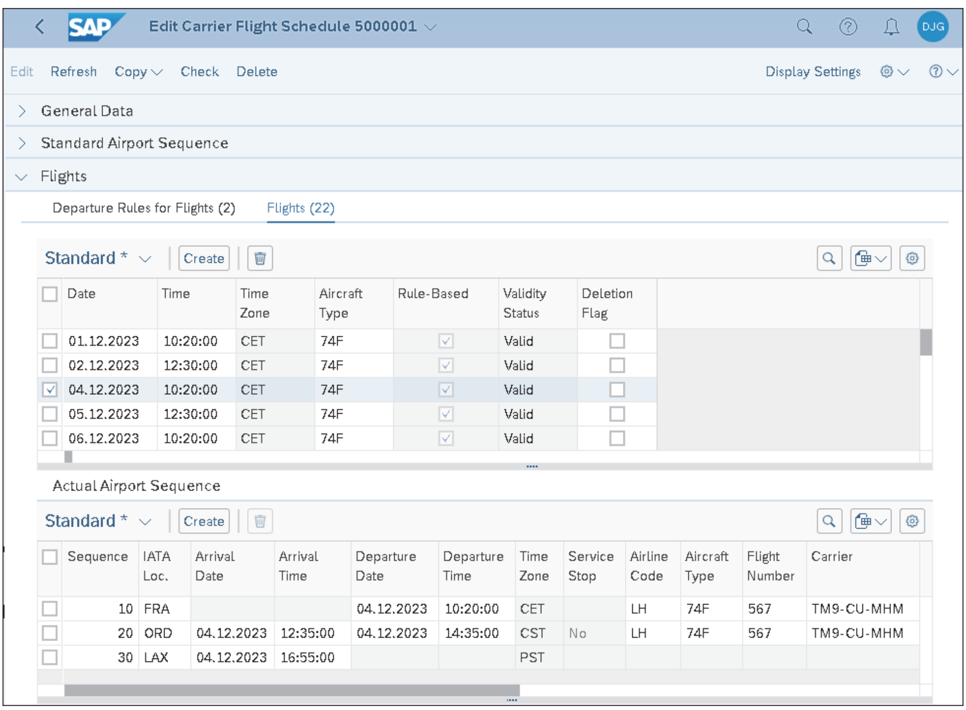


Figure 3.35 Carrier Flight Schedule with Departures (Flights)

Each schedule has a type chosen from the types maintained in IMG menu path **Transportation Management • Master Data • Transportation Network • Schedule • Define Schedule Types**. The schedule type defines how schedules of this type can be used. You can define the following, as shown in Figure 3.36:

- **Default Type**
  One of all schedule types can be marked as default. If you create a new schedule and don't specify a schedule type, this default type is chosen.
- **Transportation Mode**
  You can choose one of the modes of transport defined in the system (Section 3.3.1), such as road, rail, sea, or air.
- **Gateway**
  This specifies whether the schedule is a gateway schedule or a carrier schedule. The schedule can have a source gateway and a destination gateway, and using the additional parameters **No Source GW** and **No Destination GW**, you can even omit one gateway. Thus, you can model three kinds of gateway schedules, containing both source and destination gateway, only source gateway, and only destination gateway.
- **Direct**
  For a gateway schedule, you can define whether the two gateways are directly connected or whether other locations, such as ports or airports, are used in between, which is the most common use case. The corresponding schedules are called direct gateway schedules and indirect gateway schedules, respectively.
- **Reference**
  If you've chosen an indirect gateway schedule type, you can define whether it refers to a carrier schedule or is maintained without reference to any carrier schedule.
- **Document Type**
  This specifies the freight document type that is used for creating freight documents out of the schedule.
- **Allocation Type**
  If you maintain an allocation type, you can create allocations of this type out of the schedule (see Chapter 6, Section 6.4.4). Otherwise, you can't create allocations out of the schedule.
- **Template**
  This defines the schedule to be used as a template only; that is, the freight documents can be changed manually regarding location sequence and departure and arrival times. If the schedule isn't used as a template, the location sequence and times can't be changed manually, and the freight document keeps a reference to the schedule. Independent of this parameter, automatic planning never changes the location sequence or departure or arrival times.
- **CC Strategy**
  The change controller strategy is called after the schedule has been changed. For example, you can define a change controller strategy for automatic propagation of

the schedule changes into the already created freight documents. Note that the standard doesn't propagate any schedule changes into referencing freight documents, allocations, or schedules. However, the reference data status of a referencing instance is updated to allow the user to identify the need for manual adjustments according to the schedule changes.

- **Deletion Strategy**
  The deletion strategy is called after the schedule has been manually deleted by the user or automatically deleted per report. It allows you to insert your own logic to be processed after schedule deletion.
- **Offset Time Type**
  You can choose between two alternatives for defining cutoff and availability times in the schedule. On the one hand, with the **Relative** option, your cutoff and availability entries in the schedule are interpreted relatively. A cutoff of 1 day and 12 hours means that the cutoff time for a departure at 8 a.m. is mapped into a cutoff time of 8 p.m. two days before. Similarly, an availability of 20 hours for an arrival at 5 p.m. is mapped into an availability time of 1 p.m. on the next day.

  On the other hand, with the **Absolute** option, the time is interpreted absolutely, and the date is determined relatively by a minimum offset. A cutoff is defined by an absolute time and an offset in days. For example, a departure at 10:00 a.m. and a cutoff defined by an offset of one day and a time of 11:30 a.m. results in a cutoff time 11:30 a.m. two days before. For a departure at 11:45 a.m. and the same cutoff values, the cutoff time would be 11:30 a.m. one day before.
- **Auto-Fill Times Mode**
  Using this parameter, you can configure whether the automatic filling of dates and times works based on times or durations.
- **One Freight Document**
  If this parameter is active, only one freight document can be created per schedule departure, and this freight document covers the complete location sequence of the schedule. Thus, all freight units to be transported by this departure are consolidated into the same freight document. The schedule gets locked during planning to ensure that another planning session can't create another freight document. Deactivating this parameter, you can create multiple freight documents for one departure by either manual or automatic planning.
- **Use Transportation Costs**
  This parameter allows you to define internal planning costs for the schedule, such as fixed costs for using a departure and quantity costs.
- **Use Capacities**
  You can use this flag to maintain schedules with capacities. If capacities are used, you can define default units of measure for weight, volume, quantity, alternative quantity, and normalized quantity.

- **Do Not Propagate Carrier**
  You can specify whether the carrier defined on the schedule header is propagated to referencing schedules or freight bookings when assigning the schedule.

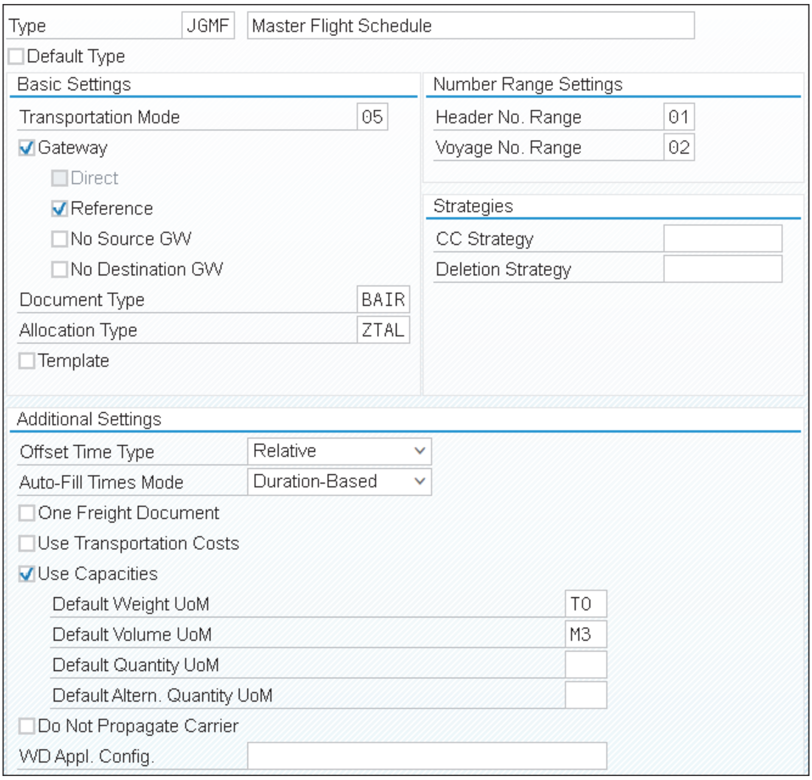


Figure 3.36 Schedule Type

A carrier schedule contains a location sequence along which goods can be transported by a carrier with the given mode of transport. Each intermediate location in the sequence can be used to load and unload goods, whereas the first and last locations allow only loading and unloading, respectively. The following carrier schedule types are delivered as standard: ocean carrier schedule (type 1000), carrier flight schedule (1100), road carrier schedule (1200), and rail carrier schedule (1300). Ocean carrier schedules connect ports, carrier flight schedules connect airports, and the other two types connect locations via road and rail, respectively. The location sequence can model ocean carrier schedules with 20 or more ports, as well as direct flights between two airports and multistop flights along a sequence of airports. Carrier schedules are used mostly to represent transportation capabilities offered by external carriers, such as ocean carriers and road carriers. However, it's not mandatory to assign a carrier. This makes it possible to model a schedule for your own fleet or for an air freight scenario in which an airline offers its schedule but is represented by regional subsidiaries that can all receive air freight bookings for the schedule.

A gateway schedule allows transportation from a source gateway (for consolidation) to a destination gateway (for deconsolidation), or from a source gateway to a destination port, or from a source port to a destination gateway. Gateways usually serve as transshipment locations (Section 3.2.5); for ocean transport of containers, they are commonly called container freight stations (CFSs). The following gateway schedule types are delivered as standard: sailing schedule (type 2000), sailing schedule with reference (2100), master flight schedule (2500), master flight schedule with reference (2600), and road gateway schedule (2200). Indirect gateway schedules, such as sailing schedules and master flight schedules, connect the source gateway to the destination gateway via a source (air-) port and a destination (air-) port. Indirect gateway schedules are used to model scenarios in which the transportation between the (air-) ports is mainly organized by consolidation at the source gateway, and deconsolidation is organized at the destination gateway.

The gateway-to-gateway connection wraps the port-to-port connection details. This allows the users to focus on cutoff times at the source gateway and availability times at the destination gateway, which implicitly consider the cutoff times at the source port and the availability time at the destination port, respectively. The departure rules and departures between the (air-) ports can be defined implicitly by reference to an underlying ocean carrier schedule or carrier flight schedule, respectively, or explicitly without any reference to a carrier schedule.

For an ocean carrier schedule with the port sequence PT_DEHAM (Hamburg), PT_USPNJ (Newark), and PT_USCHS (Charleston)—with these ports having CFSs CFS_DEHAM, CFS_USPNJ, and CFS_USCHS, respectively—you can define three sailing schedules covering the following locations:

- CFS_DEHAM → PT_DEHAM → PT_USPNJ → CFS_USPNJ
- CFS_DEHAM → PT_DEHAM → PT_USCHS → CFS_USCHS
- CFS_USPNJ → PT_USPNJ → PT_USCHS → CFS_USCHS

While the first and third sailing schedules use a direct port connection out of the underlying ocean carrier schedule, the second sailing schedule uses an indirect port connection with port PT_USPNJ as the intermediate port between the ports PT_DEHAM and PT_USCHS.

Gateway schedules that refer to two or more carrier schedules are called *connection gateway schedules* and can be used by transportation planning and capacity management like any other gateway schedule. A significant portion of air freight forwarding worldwide is handled by connection flights that combine multiple flights offered by one or multiple airlines. If certain connection flights are used frequently in your business, you can create a connection master flight schedule with departure rules that combine departure rules of multiple carrier flight schedules. Figure 3.37 gives an example of a gateway in Frankfurt to an airport in Frankfurt to an airport in Chicago to an airport in Denver to a gateway in Denver. The departure and arrival times for the airport-airport stages stem from two referenced carrier flight schedules.

In ocean freight forwarding, the analogous concept of connection voyages can also be used to combine multiple voyages offered by one or multiple ocean carriers.

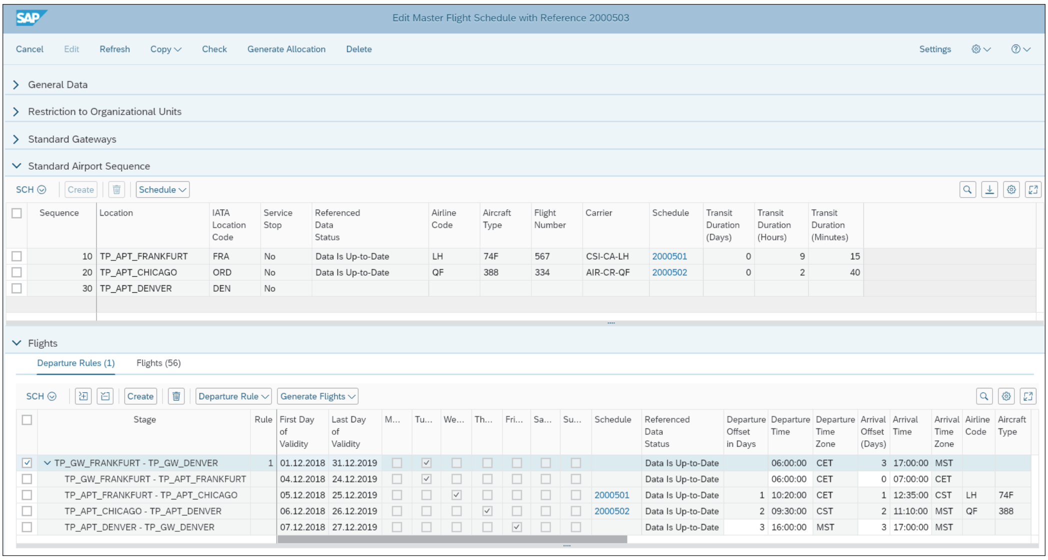


Figure 3.37 Departure Rule for a Connection Master Flight Schedule

Modeling Main Vessels, Feeders, and De-Feeders by Gateway Schedules

Frequently, ocean transportation involves a main vessel that covers big ports, feeder vessels that bring goods from smaller ports to one of the main vessel's ports, and de-feeder vessels transporting goods from the main vessel's ports to smaller ports. Figure 3.38 shows an example with a main vessel visiting the ports Ⓐ, Ⓑ, and Ⓒ. The first feeder connects ports ❶ and ❷ with main port Ⓐ, the second feeder connects ports ❸ and ❹ with main port Ⓑ, the first de-feeder connects main port Ⓑ with ports ❺ and ❻, and the second de-feeder connects main port Ⓒ with ports ❼ and ❽. Usually, the main vessel is the bottleneck as it covers much larger distances.

If you want to transport goods between all small ports, you could model this by bringing detailed feeder and de-feeder schedules into the system, and create sailing schedules, one for each pair of source and destination port. Each sailing schedule would combine a feeder schedule, the main vessel schedule, and a de-feeder schedule. In many cases, you don't need that precision level on the feeder and de-feeder level. For example, let's assume that port ❶ serves Ⓐ within two days and port ❼ gets served from Ⓒ within five days. Then, you could define a sailing schedule with source gateway ❶, first port Ⓐ, last port Ⓒ, destination gateway ❼. While the main ports get connected by an ocean carrier schedule for the main vessel, the feeding and de-feeding durations can be maintained as pickup transit duration and delivery transit duration for the two gateways, respectively.

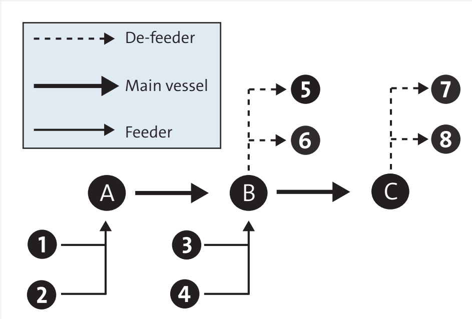
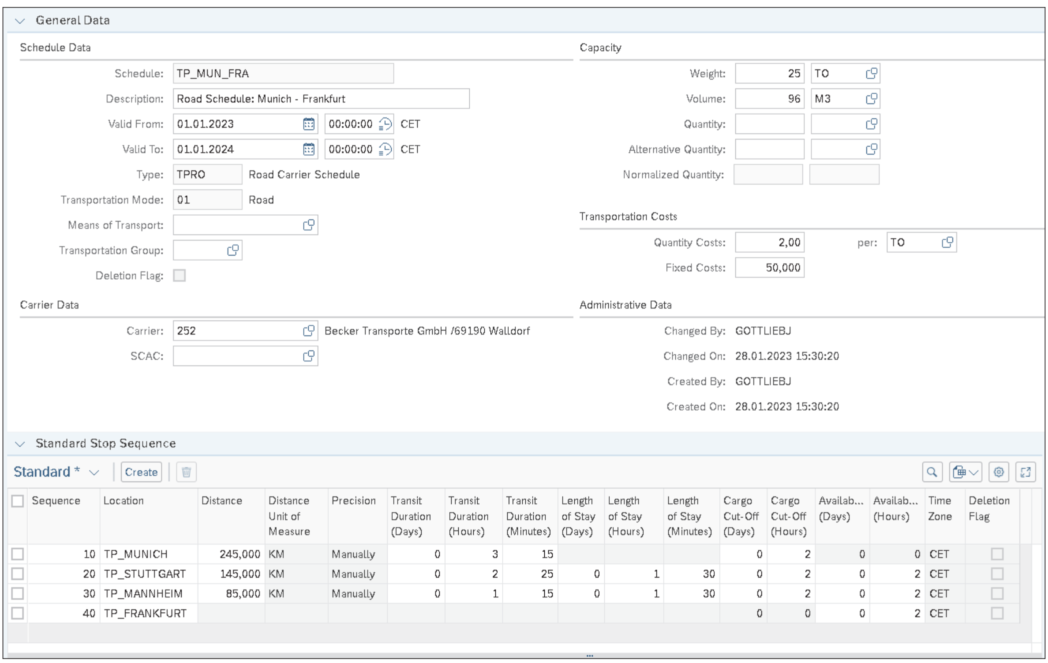


Figure 3.38 Main Vessel with Feeders and De-Feeders

If you need de-feeders but no feeders at all, you could use a sailing schedule without source gateway; that is, it starts with the main vessel port but with a destination gateway to cover the small port served by a de-feeder.

Create a new schedule by choosing the Create Schedule app and the schedule type. When creating a carrier schedule, you first define the **General Data** and the **Standard Stop Sequence**, as shown in Figure 3.39 for a road carrier schedule.



Sequence	Location	Distance	Distance Unit of Measure	Precision	Transit Duration (Days)	Transit Duration (Hours)	Transit Duration (Minutes)	Length of Stay (Days)	Length of Stay (Hours)	Length of Stay (Minutes)	Cargo Cut-Off (Days)	Cargo Cut-Off (Hours)	Availab... (Days)	Availab... (Hours)	Time Zone	Deletion Flag
10	TP_MUNICH	245,000	KM	Manually	0	3	15				0	2	0	0	CET	
20	TP_STUTTGART	145,000	KM	Manually	0	2	25	0	1	30	0	2	0	2	CET	
30	TP_MANNHEIM	85,000	KM	Manually	0	1	15	0	1	30	0	2	0	2	CET	
40	TP_FRANKFURT										0	0	0	2	CET	

Figure 3.39 Road Carrier Schedule: General Data and Location Sequence

Maintain the validity and the stop sequence by iteratively adding the locations. Optionally, you can define the description, means of transport, and carrier, either explicitly or implicitly, by entering its **SCAC**, which is commonly used in the US transportation industry. Additionally, you can maintain the following general data:

- **Transportation Group**
  The transportation group can be used to determine which freight units can be assigned to the schedule at hand.
- **Capacity**
  You can define capacity restrictions for weight, volume, quantity, alternative quantity, and normalized quantity (not shown in the screenshot). These serve as templates for the capacities that are maintainable for departure rules, which themselves also serve as templates for the capacities maintained per departure generated for the departure rule. Note that the capacities can be maintained only if this functionality is activated in the schedule type.
- **Transportation Costs**
  You can define quantity costs and fixed costs, which are considered by automatic planning and apply per schedule departure. In the optimizer cost settings, you can specify whether the quantity costs are multiplied by the distance traveled (see Chapter 5, Section 5.8.3). Like the capacity definition, these costs serve as templates for the departure rules that also serve as templates for the generated departures. This functionality can be used only if it's activated in the schedule type.
- **Mode-specific fields**
  For ocean carrier schedules, you can define the loop to group-related schedules along the same rotation. For carrier flight schedules, you can define the airline code, flight number, and aircraft type code, as well as whether the carrier is executing the flight itself, to identify code-shared flights.

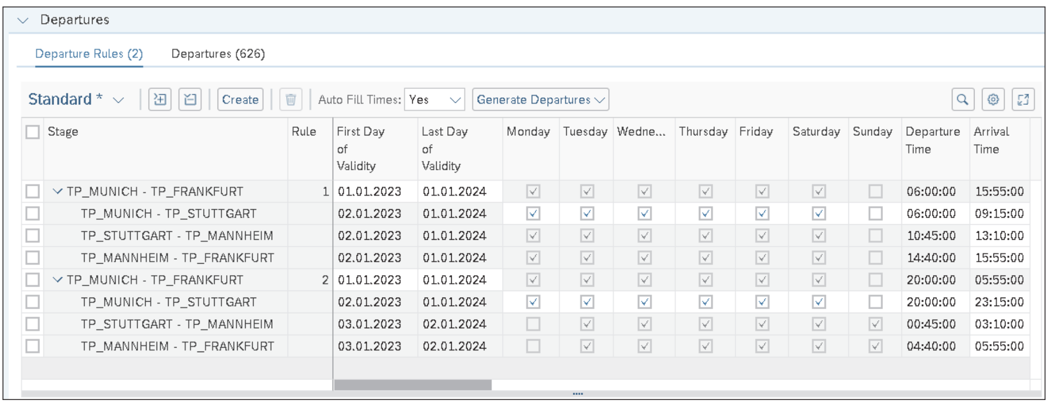
The stop sequence serves as a template for the departure rules and allows you to maintain the following data:

- **Transit Duration**
  This represents the transit duration from a stop to its successor.
- **Distance**
  The system automatically determines the distance between two consecutive stops based on the geographical coordinates of the locations. You can manually change the proposed distance.
- **Length of Stay**
  This represents the length of stay at an intermediate stop.
- **Cargo Cut-Off**
  You can define the cutoff time that is considered by automatic planning. This value specifies when freight units must be delivered to the location at hand so that they can be transported by the schedule from this location. Depending on the schedule type, you can define it relatively or absolutely, as described previously. It's also possible to define document cutoff and DG cutoff times.

- **Availability**
  You maintain the availability time considered by automatic planning, which defines when freight units delivered by the schedule to the location at hand can be picked up for further transportation departing from the location.

By clicking the **Create** button in the **Departure Rules** tab, you can maintain multiple departure rules following the location sequence. Figure 3.40 shows an example of two departure rules defined for the road carrier schedule depicted earlier in Figure 3.39. You can define the validity of the rule, which can be a subperiod of the schedule's validity; the pattern of days; the times of departure, arrival, cargo cutoff, document cutoff, DG cutoff, and availability; and the durations for transit and length of stay.

With the **Auto Fill Times** option, you can change one departure or arrival time and let the system propagate this to the other times. Defining a factory calendar allows you to suppress the generation of departures on public holidays according to the calendar.



Stage	Rule	First Day of Validity	Last Day of Validity	Monday	Tuesday	Wedne...	Thursday	Friday	Saturday	Sunday	Departure Time	Arrival Time
TP_MUNICH - TP_FRANKFURT	1	01.01.2023	01.01.2024	✓	✓	✓	✓	✓	✓		06:00:00	15:55:00
TP_MUNICH - TP_STUTTGART		02.01.2023	01.01.2024	✓	✓	✓	✓	✓	✓		06:00:00	09:15:00
TP_STUTTGART - TP_MANNHEIM		02.01.2023	01.01.2024	✓	✓	✓	✓	✓	✓		10:45:00	13:10:00
TP_MANNHEIM - TP_FRANKFURT		02.01.2023	01.01.2024	✓	✓	✓	✓	✓	✓		14:40:00	15:55:00
TP_MUNICH - TP_FRANKFURT	2	01.01.2023	01.01.2024	✓	✓	✓	✓	✓	✓		20:00:00	05:55:00
TP_MUNICH - TP_STUTTGART		02.01.2023	01.01.2024	✓	✓	✓	✓	✓	✓		20:00:00	23:15:00
TP_STUTTGART - TP_MANNHEIM		03.01.2023	02.01.2024		✓	✓	✓	✓	✓	✓	00:45:00	03:10:00
TP_MANNHEIM - TP_FRANKFURT		03.01.2023	02.01.2024		✓	✓	✓	✓	✓	✓	04:40:00	05:55:00

Figure 3.40 Road Carrier Schedule: Departure Rules

You can select multiple departure rules and generate departures by clicking the corresponding button for either the whole validity period or an explicitly defined period. The departures are displayed in the **Departures** tab, as shown in Figure 3.41. All the times and durations are derived from the departure rule definitions. By clicking the **Create** button, you can create a new departure. When you select a departure, all these times and durations are displayed in the **Actual Stop Sequence** area. It's possible to manually change times and durations, even if they were generated based on a departure rule.

For ocean carrier schedules, you can maintain the vessel name and its International Maritime Organization (IMO) ship identification number on the departure rule and departure level. For carrier flight schedules, it's possible to mark intermediate stops as service stops (e.g., for refueling); service stops can't be used for loading or unloading but appear in the air freight bookings created for the schedule. It's also possible to maintain the aircraft type code on the departure rule stage level. Moreover, for multistop flights, you can define per stage whether the carrier is operating this stage itself or whether it's a code-share flight.

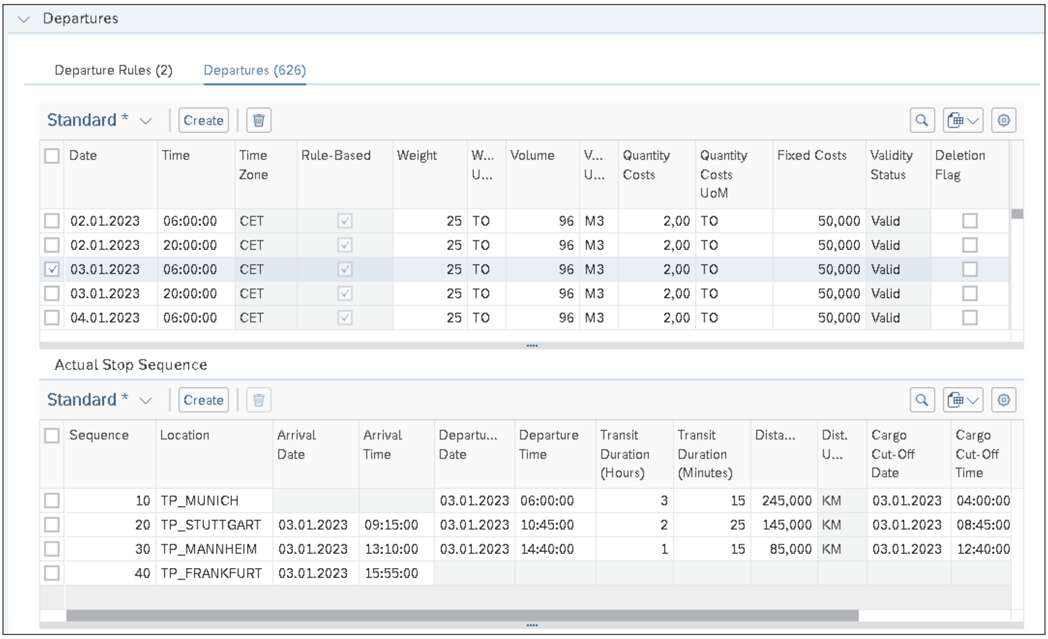


Figure 3.41 Road Carrier Schedule: Departures and Actual Stop Sequence

Maintaining gateway schedules is similar to maintaining carrier schedules, but some important additional data has to be maintained. First, you maintain the source gateway and the destination gateway, with corresponding cutoff times for the source gateway, transit duration to source port, transit duration from the destination port, and availability time for the destination gateway, as shown in Figure 3.42 for a sailing schedule. If your schedule type skips source or destination gateway, then you just maintain one gateway.

Then, you define the standard port sequence by entering the locations. By clicking the **Schedule** button and selecting the **Assign** option, you can let each stage refer to an ocean carrier schedule, from which all times and durations are taken over in the sailing schedule. For a sailing schedule without reference, you have to manually maintain all this data in the sailing schedule itself.

You define the departure rules similarly to carrier schedules. The difference is that you can reference the referenced carrier schedules' departure rules by selecting the created departure rule's stage, clicking the **Departure Rule** button, and selecting the **Assign** option to select a departure rule of the referenced carrier schedule.

With connection gateway schedules, you just maintain more stages and link them to different schedules. Each departure rule stage refers to one departure rule of the referenced carrier schedule.

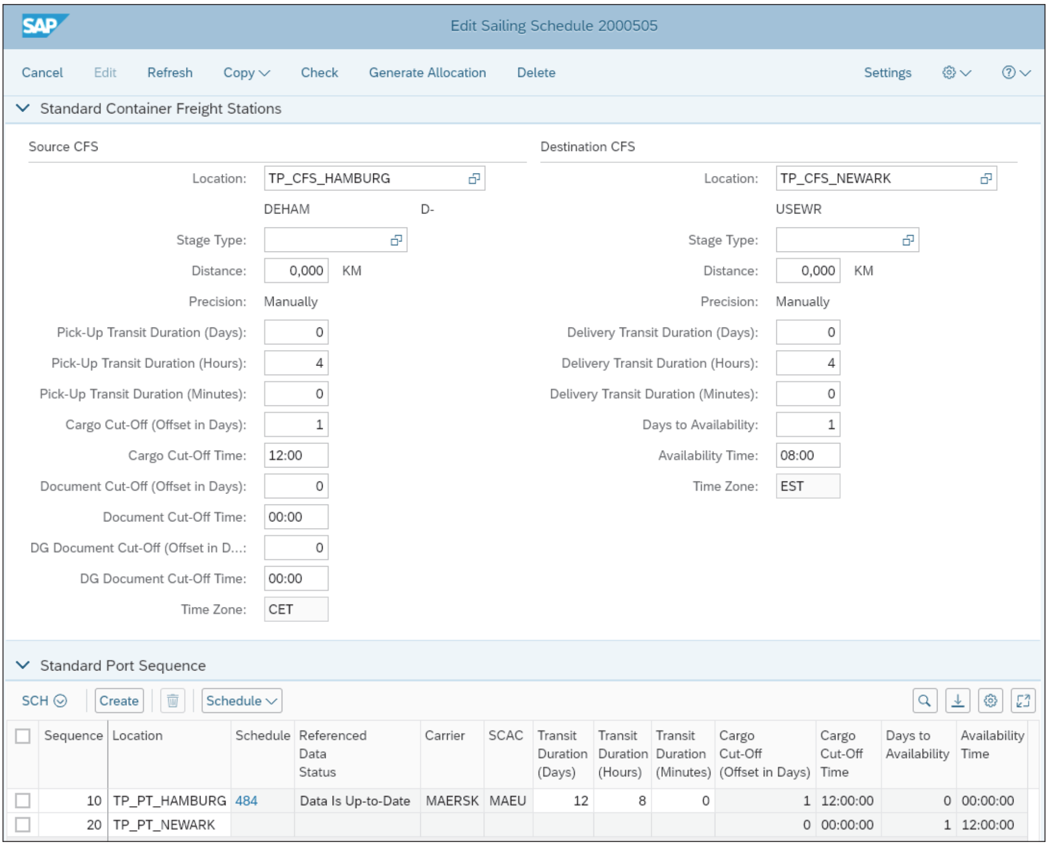


Figure 3.42 Sailing Schedule: Gateways (CFSs) and Location Sequence

The **Referenced Data Status** field indicates whether the underlying carrier schedules have changed since the gateway schedule was created. This is quite useful if you want to quickly check whether your gateway schedule is affected by weekly updates of carrier schedules that are uploaded into the system.

Several transportation businesses, such as global shippers and global freight forwarders, make frequent use of the regular schedules of ocean carriers and airlines, which publish their schedules and update them on a regular basis. For any mode of transport, schedules can be uploaded via function module /SCMTMS/BAPI_SCHEDULE_SAVEMULT, which offers create, update, and delete access to the schedules in the system. This approach requires mapping of the external data into the generic interface of the function module. Alternatively, you can choose path **Logistics • Transportation Management • Master Data • Transportation Network • Schedule • Schedule Upload** in the SAP menu, as shown in Figure 3.43, and use one of the standard-delivered upload strategies or build your own upload strategy.

For example, the carrier flight schedule upload strategy SCHUP_CS_A allows you to upload schedule data from *.xls* and *.csv* files with a specific column signature, which is described in SAP Note 1743069, based on sample files. These files are designed to represent flight schedules in a simple and compact way that is easy to understand and maintain. OAG, one of the leading data providers for flight schedules for most airlines worldwide, offers its data in the file format offered by the standard upload strategy SCHUP_CS_A, which allows a straightforward integration of flight schedules into SAP TM. See SAP Note 1857686 for more details on this efficient schedule integration, which frees the system integrator from building custom interfaces to all relevant airlines in the world.

Ocean carrier schedules can be uploaded analogously by the upload strategy SCHUP_CS_S. SAP Note 2136548 describes the column signature and sample files.

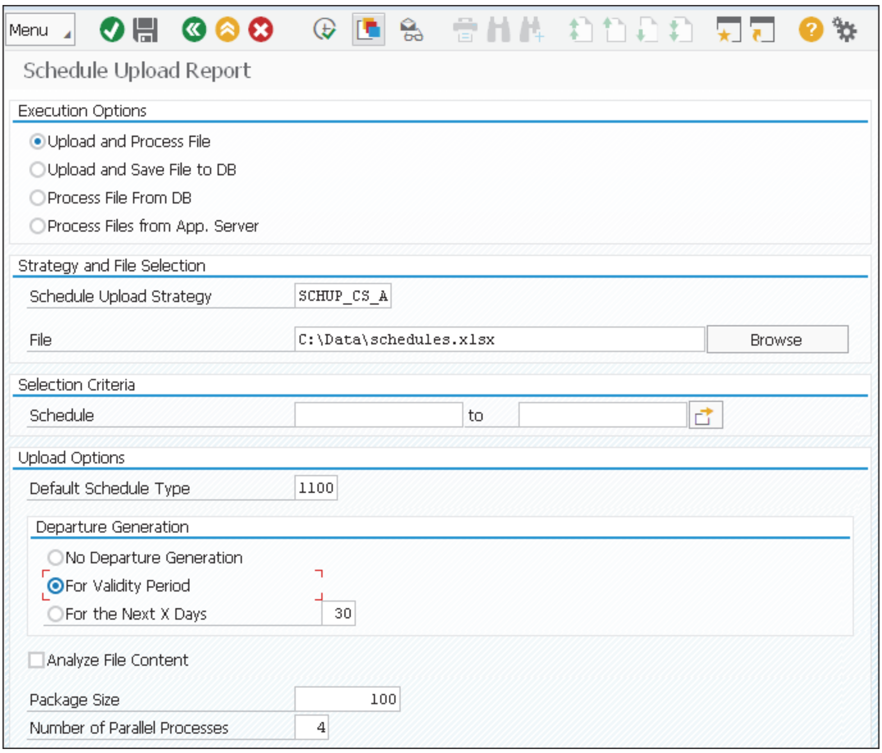


Figure 3.43 Schedule Upload Report

The upload report offers direct processing of a file, which is recommended for small and medium files. If the file is very large or will be uploaded by a background job, it can be uploaded into the database and then processed from the database. You can define an additional selection filter so that only the matching schedules out of the files are uploaded. The schedule type can be predefined; if not predefined, it has to be set in the file. You can trigger an automatic generation of departures for either the whole validity period of the schedule or a relative time period. The latter option is useful if you have departure rules that cover the whole next year, but you're used to creating freight documents for only the next four weeks. You can extract additional data out of the schedule file via the **Analyze File Content** option. In the carrier flight schedule scenario, this would return a list of the contained IATA location codes, airline codes, and aircraft codes; these are useful for verifying the completeness of your corresponding master data. The package size and number of parallel processes make it possible to adapt the schedule upload according to the expected file size, the available hardware, and the desired runtime of the upload.

Although this report can automatically create departures, there are some scenarios in which you'll want to upload schedules but not create departures immediately. If you're handling a lot of schedule data, manually triggering the creation of departures may be a tedious task, so you can choose menu path **Logistics • Transportation Management • Master Data • Transportation Network • Schedule • Creation of Schedule Departures** in the SAP menu and explicitly create departures for a set of schedules. You define a selection of the relevant schedules (based on schedule types, carriers, and schedules), as well as the time period for which the departures will be generated. It's also possible to run this report in a simulation mode first to determine how many departures will be generated. As with the schedule upload report, you can also define package size and number of parallel processes.

If schedules have limited validity (e.g., half a year), and new schedules are regularly created in the system to reflect the corresponding transportation options (here, for the next half a year), then the number of schedules in the system grows continuously. Usually, the outdated schedules aren't used anymore, so we recommend that you remove them from the system to restrict the data volume and prevent users from wasting time with useless schedules.

Of course, you can manually delete schedules (e.g., by selecting them from a query result in the transportation network worklist; see Section 3.2.8). If you follow **Logistics • Transportation Management • Master Data • Transportation Network • Schedule • Schedule Deletion** in the SAP menu, you can define a selection of schedules, choose one of the following deletion options, and delete the matching schedules automatically:

- **Complete Schedules**
  The whole schedule is deleted, with all its departure rules and departures.
- **Departures in the Past**
  This deletes only schedule departures in the past. The remaining departures and all departure rules are kept, even if they don't have a departure anymore.
- **Sched w/o Dep & Past**
  This acts like the previous option but also deletes schedules without any departure.
- **Consider Deletion Flag**
  This option deletes all schedules with an active deletion flag.

To avoid undesired deletion of schedules, you can first run a simulation of the found schedules by choosing the **Show Schedules/Departures** option, as shown in Figure 3.44.

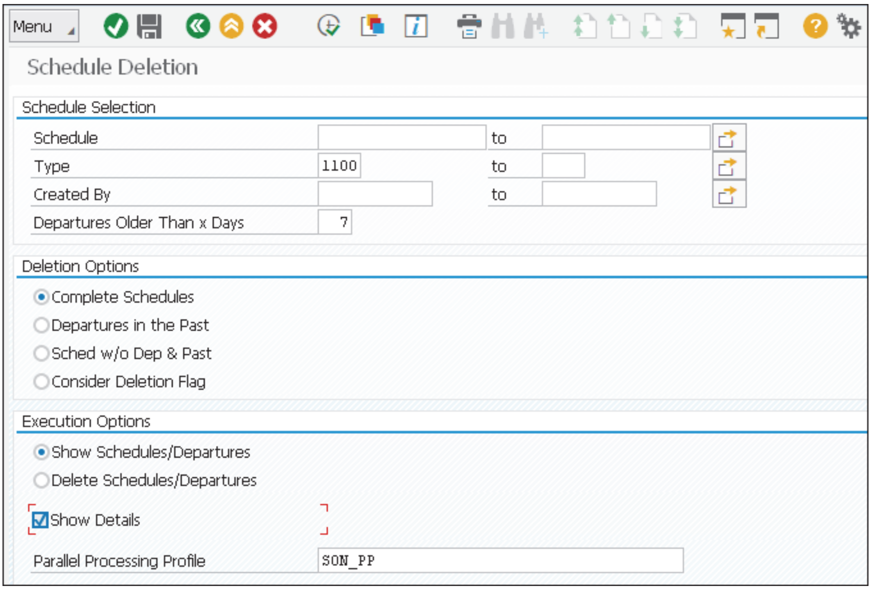


Figure 3.44 Schedule Deletion Report

If a schedule is still referenced by freight documents, allocations, or other schedules, then it's marked for deletion and can't be used for new references by those documents. A schedule is deleted only if there are no references to it. Thus, if you're running the schedule deletion report on a weekly basis, the deletion markers get set immediately, and the schedule is deleted only if the referencing documents have disappeared.

3.2.5 Transshipment Locations

In global transportation networks, an individual transportation order is usually executed using multiple modes of transport in sequence. The mode of transport is changed at the transshipment locations, where the goods are unloa,ded and reloaded.

Let's walk through the steps of an example in which goods are transported from Germany to the United States:

1. A truck transports the goods from the start destination in Germany to the port of Hamburg.
2. At the port, the goods are unloaded from the truck and reloaded onto a ship.
3. The ship carries the goods to the port of Newark.
4. The goods are unloaded and reloaded onto a truck.
5. The truck transports the goods to their destination.

In this scenario, the ports in Hamburg and Newark serve as transshipment locations. Whereas goods are unloaded and reloaded from and onto different modes of transport in this example (truck and ship), there are also transshipment scenarios in which the mode of transport remains the same. This is the case, for example, with collection trips by truck, where the goods collected are unloaded and reloaded onto other trucks at a local depot, and these trucks then carry the goods along a long-haul route to another depot.

To define a location as a transshipment location, choose the Assign Transshipment Location app. Define a set of **Locations** or **Transportation Zones** and a transshipment location, and then choose **Create/Update Assignments** to assign the transshipment location to the set of locations or transportation zones, as shown in Figure 3.45.

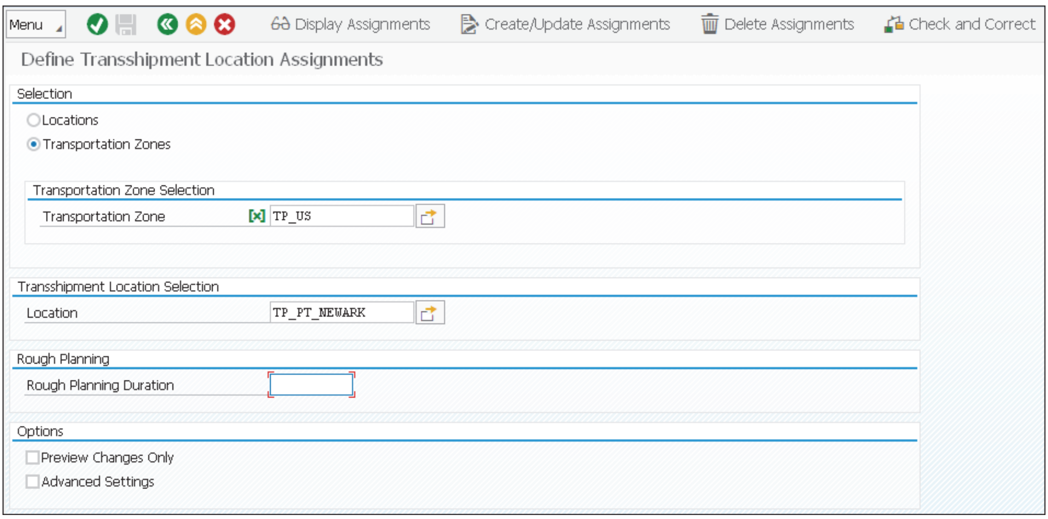
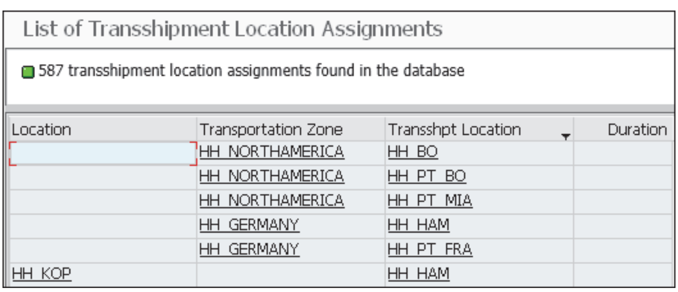


Figure 3.45 Defining Transshipment Location Assignments

You can also display already-defined transshipment location assignments, as shown in Figure 3.46.


List of Transshipment Location Assignments

587 transshipment location assignments found in the database

Location	Transportation Zone	Transshpt Location	Duration
	HH_NORTHAMERICA	HH_BO	
	HH_NORTHAMERICA	HH_PT_BO	
	HH_NORTHAMERICA	HH_PT_MIA	
	HH_GERMANY	HH_HAM	
	HH_GERMANY	HH_PT_FRA	
HH_KOP		HH_HAM	

Figure 3.46 Transshipment Location Assignments

For each transshipment location assignment, you can also define a duration that is considered by rough planning (see Chapter 5, Section 5.8.2). If rough planning is activated, and the duration is maintained, transportation from the transshipment location to the assigned locations and zones—and vice versa—is possible with the defined duration without definition of a schedule or a transportation lane. This allows the modeling of intermodal scenarios in which, for example, pre-legs and subsequent legs aren't planned in detail but should be planned in a rough way based on the maintained (rough) transportation duration instead. The rough planning concept represents a simple version of reachability for automatic planning, but no freight documents are created for the rough-planned parts of the transportation. Therefore, we don't consider it to be a complete way of expressing reachability.

The transshipment location determination finds the relevant transshipment locations for a given source and destination location in an iterative procedure. The process starts with the given source and determines the transshipment locations that are explicitly assigned to the location and its zones. Each subsequent iteration adds transshipment locations that are explicitly assigned to the locations added in the previous step. Similarly, transshipment locations are determined from the perspective of the destination location. This process determines the transshipment location network connecting the source and destination, and you can define a limit on the number of consecutive transshipment locations leading from source to destination (see Chapter 5, Section 5.8.2). In Customizing, by following menu path **Transportation Management • Master Data • Transportation Network • General Settings for Transportation Network Determination**, you can specify that the transshipment location determination will only consider directly connected transshipment locations.

Note that default routes can also be used to define transshipment locations in an explicit fashion. However, the transshipment locations in a default route apply only if the transportation is planned along the default route. (Section 3.2.6 has more details on default routes.)

In intermodal scenarios, many different schedules may touch one specific port. To allow the port to be used as a transshipment location for connecting two schedules arriving at and departing from the port, respectively, the port has to be defined as a transshipment location for all other locations covered by the schedules. In a global ocean schedule network that connects hundreds of ports, this would be an enormous, error-prone maintenance task. In a global air freight network covering thousands of airports, the task would be even larger. Therefore, TM offers automatic connection determination, which can be activated in the optimizer settings (see Chapter 5, Section 5.8.2). This means that any location covered by two schedules can serve as a transshipment location for all locations covered by the two schedules and therefore represents an implicit transshipment location definition. This significantly reduces the maintenance required for defining transshipment locations. If even the pre-legs and subsequent legs in a global network are served by schedules, no explicit transshipment location assignment is required anymore. Only if pre-legs and subsequent legs are *not* covered by schedules do the transshipment locations entering the schedule network have to be defined explicitly.

Reachability and Transshipment Locations

There are four ways to define that location A can be reached from location B:

- Define a transportation lane from A to B, on either the location level or appropriate zones.
- Define that the means of transport doesn't require a transportation lane.
- Define a schedule that goes from A to B, either directly or indirectly via other locations.
- Define a (rough) duration for a transshipment location assignment of A to B or vice versa, and use rough planning.

There are three ways to define B as a transshipment location for location A:

- Define an explicit assignment, as just described.
- Define an explicit assignment along a default route, as described in Section 3.2.6.
- Define an implicit assignment, as just described.

In scenarios that include transshipments (e.g., an intermodal scenario from Asia to Europe), you have to ensure that reachability and transshipment locations are defined appropriately. In scenarios without transshipments (e.g., a local distribution scenario within Bavaria, Germany), you have to ensure that the reachability within Bavaria is defined appropriately.

If you want to transport goods from location A to location C using location B as a transshipment location, you must implicitly or explicitly define B as a transshipment location for A or C and define reachability from A to B and from B to C using any of these possibilities.

From this perspective, the reachability network and the transshipment network together form the transportation network, where the reachability network is the set of all locations and their reachable relations, and the transshipment network is the set of all locations and their transshipment relations.

You can define a minimum goods wait time and a maximum goods wait time for a location to be taken into account in the scheduling of activities during the transshipment of a demand. The goods wait time of a demand is the length of time between the end of unloading and the start of reloading at the transshipment location.

For example, a minimum goods wait time of one day ensures that the goods delivered remain at the transshipment location for at least one day before they are transported further. With a maximum goods wait time of 72 hours, the goods delivered must not remain at the transshipment location for more than 72 hours before they are picked up.

3.2.6 Default Routes

In complex transportation networks, there may be numerous possible paths from one source to one destination. For many businesses, only a few of these possible paths are reasonable; often, business experience or careful analysis of the network leads an organization to know the most desirable route for a given source and destination. Therefore, many transportation businesses are organized by default routes; these are static rules defining how goods are to be routed geographically through the global transportation network. For intermodal transports, default routes can predefine the sequence of transshipment locations, as mentioned in the previous section. For truck and trailer scenarios involving dynamic recoupling, default routes can predefine the sequence of coupling and uncoupling locations for the trailer unit.

A default route defines a location sequence for a given source and destination, which can be locations or zones. For a transport from a source to a destination, the default route serves as a template guiding the transportation through the network.

Given a source location and a destination location, the system determines matching default routes and chooses the most specific one. A default route matches a given source location S and destination location D if the default route's source is location S or a zone containing S and the default route's destination is location D or a zone containing D. If there are multiple matching default routes, the system chooses the most specific one; a direct location match is more specific than a zone match.

The ability to define default routes with a source zone and a destination zone significantly reduces the default route maintenance efforts. Let's consider an ocean scenario in which goods from Germany are transported to the United States via ports in Hamburg and Newark. This could be expressed by maintaining many location-to-location default routes, each having one source location in Germany and one destination location in the United States. Assuming 20 source locations in Germany and 50 destination locations in the United States, this would result in 1,000 default routes. Defining one zone for Germany and one zone for the United States, you can define one default route from Germany to the United States via the transshipment ports Hamburg and Newark. This zone-to-zone default route has the same effect as the 1,000 location-to-location default routes. Another advantage of the zone-to-zone default route is that you don't have to create new default routes if new source or destination locations show up in the source and destination zone.

To define a default route, select the Create Default Route app, and enter the default route type, which you can select from the defined default route types. Besides maintaining the description and the validity period, you can restrict the applicability of a default route by choosing an option for **Dangerous Goods** (**Only Dangerous Goods**, **Non-Dangerous Goods Only**, or **All Goods**) and setting the **Shipping Type** (see Figure 3.47). By maintaining the **Transportation Stops** list, you can define the following per stage: mode of transport, means of transport, stage type, schedule and carrier, which represent constraints for planning. For example, if a schedule is defined for a specific stage, planning will only create a transportation plan using the given schedule for this stage. Similarly, if a carrier is defined for a specific stage, it will be used by planning.

You can also maintain the transit durations per stage and the lengths of stay per intermediate stop, which all gets aggregated to the transportation duration in the header. Alternatively, you can just maintain the transportation duration on the header level. When you enter a forwarding order, the system determines the matching default route and uses the transit durations and lengths of stay to determine requested pickup and delivery times for the generated freight unit stages and the ordered route of the forwarding order. Thus, the transportation duration isn't used explicitly in planning but only indirectly via the freight units' time windows.

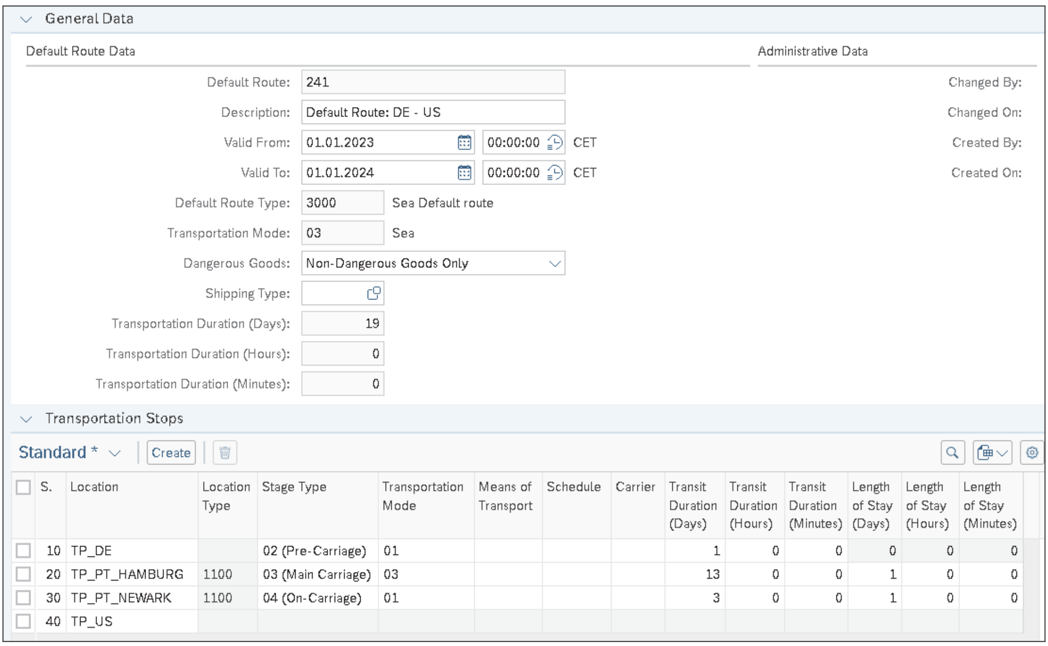


Figure 3.47 Default Route

Analogously to the transit durations, you can also define the distance per stage, which is taken over into a demand document when applying the default route. The main purpose is to provide an indication of the distance of unplanned demand document stages.

Per stage, you can also define the responsible planning and execution organization and whether this organization has to explicitly check any freight unit assignments for freight documents created for this stage. Such definition of your organization interaction model allows you to structure responsibilities for different business units in your company (e.g., for ocean freight bookings on the main legs of your default routes; see Chapter 6, Section 6.2.1).

Default route types can be maintained by selecting IMG menu path **Transportation Management • Master Data • Transportation Network • Define Default Route Types**. For a default route type, you can define the mode of transport that is passed on to default routes created for this type. Similar to the shipping type, a default route can be applied to a forwarding order if both have the same mode of transport or one mode is undefined. You can also specify whether the default route is mandatory—that is, any freight unit or transportation unit with stages built according to a default route must use the mandatory default route. For example, either the freight unit stages were built by the corresponding freight unit building option, or they were created out of a forwarding order by the schedule selection functionality using default routes. The default route type also allows defining whether the default route can be used for freight units, trailer units, railcar units, container units, or package units in the VSR optimizer.

Default routes can be used in various contexts for defining the stages of freight units, transportation units, and forwarding orders' actual routes, the latter including the selection of schedules. These use cases are described in the following sections.

Creating Freight Unit Stages

During freight unit building, freight unit stages can be automatically generated based on a default route. Given a freight unit at hand, the system determines a default route based on the freight unit's source location and destination location. Then the freight unit stages are created according to the default route's location sequence. Thus, the location sequence defines the transshipment locations to be used when moving goods from source to destination.

This functionality is useful if the transportation of goods is to be organized strictly in a rule-based fashion. For example, if goods moving from Germany to the East Coast of the United States will always be transported via the ports in Hamburg and Newark, this can be modeled by a default route with the source zone representing Germany as the first stop, the port in Hamburg as the second stop, the port in Newark as the third stop, and the destination zone representing the East Coast of the United States as the fourth stop.

As an alternative to applying default routes during freight unit building, the transportation cockpit allows you to apply default routes to selected freight unit stages, too (see Chapter 5, Section 5.7.8). Each selected freight unit stage is replaced by freight unit stages according to the most specific default route. Compared to the previous use case of strictly organizing transports according to default routes, this use case considers default routes as one option to guide the transportation through the network. However, the user can explicitly define any path through the network and use the default routes only on demand (e.g., if the user isn't sure about a good path through the network). Note that the cockpit allows splitting and merging of freight unit stages, so the system always offers the planner the manual choice to change freight unit stages that were already created by default routes.

Creating Transportation Unit Stages

You can also use freight unit building to create transportation units by specifying a transportation unit type as a document type in the freight unit building rule. Like freight unit stages, transportation unit stages can be generated automatically based on a default route. Given a particular transportation unit, the system determines a default route based on the transportation unit's source and destination locations. Then, transportation unit stages are created according to the default route's location sequence.

Different transportation unit types can cover different modes of transport, such as the trailer unit for a road and the railcar unit for a railway. For a trailer unit, the location sequence of the determined default route defines the locations where the trailer can be uncoupled from and to a truck; thus, the corresponding trailer unit stages are to be assigned to road freight orders. For a railcar unit, the location sequence of the determined default route defines the locations where the railcar is uncoupled from and to a train, and hence the corresponding railcar unit stages are to be assigned to rail freight orders. For a container unit and package unit, the default route is interpreted analogously to a freight unit (i.e., it defines the stages of the container unit and package unit, respectively).

In certain transportation scenarios, the trailers in the transportation network are moved back and forth along a predefined chain of coupling and uncoupling locations. This scenario can be modeled by a default route applied during freight unit building to create trailer unit stages. This rule-based approach greatly simplifies manual planning, allowing the planner to start with assigning trailer unit stages to road freight orders and freeing the planner from manually defining trailer unit stages. As with freight units, the planner can also manually apply default routes to selected transportation unit stages in the transportation cockpit.

Creating Forwarding Order Stages and Selecting Schedules

For a forwarding order, the system can determine the available schedules per forwarding order stage, allowing the user to choose from the alternative schedules. After a schedule is chosen, its data (e.g., departure date/time and arrival date/time) is taken into the stages of the forwarding order's actual route.

The schedule determination also considers default routes. If a matching default route is found, new stages are proposed for the forwarding order according to the location sequence of the default route. If the default route considers more specific information for a stage—such as a carrier or schedule to be used—then only schedules for this carrier are offered or only the predefined schedule is offered to the user for the stage.

When the user has chosen one alternative, the proposed forwarding order stages (in the actual route) are created according to the default route, like the creation of freight unit stages and transportation unit stages by a default route. However, additional information, such as carrier and schedule, is also taken from the default route into the forwarding order stages.

The location sequence of the default route defines the transshipment locations to be used for the forwarding order. When the user creates freight units for the forwarding order, the freight unit stages are created according to the forwarding order stages while also considering the carriers and schedules defined by the default route.

This functionality enables scenarios in which the actual routes of forwarding orders are predefined in a rule-based fashion. For example, such scenarios are relevant for ocean freight forwarders in a less than container load (LCL) scenario, in which the transportation is organized by rules guiding freight through the network. In addition to defining the sequence of ports to be used for ocean transportation, even an ocean carrier and its ocean carrier schedule can be predefined per stage in a default route.

3.2.7 Trade Lanes

The relationships of your transportation business to your carriers and customers are usually structured in a geographical fashion. For example, you may have a forwarding agreement with a certain customer from Germany to North America, a freight agreement with an ocean carrier from Germany to the United States, and an allocation with another carrier (airline) from the airport in Frankfurt to the airport in Chicago. You may also have defined a business share between your two favorite road carriers within Germany to be 40% for the first carrier and 60% for the second carrier.

Trade lanes specify the basic geographical relationships that structure all these business objects. A trade lane can have a mode of transport and a means of transport. The trade lane defines a direction for transportation, which is characterized by the orientation and a source and destination (both being either a location or a zone).

You can define a trade lane by choosing the Create Trade Lane app and entering a trade lane type. Then you can specify its description, mode of transport, means of transport, and geographical definition, which consists of the orientation, source, and destination (see Figure 3.48).

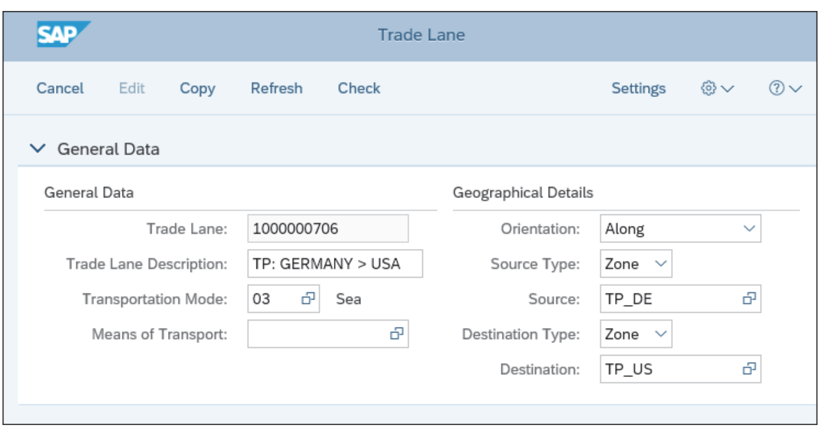


Figure 3.48 Trade Lane

You can maintain the following orientations:

- **From**
  Covers transportation starting from a selected location or zone and reaching any other location.
- **To**
  Covers transportation starting from any location and reaching a selected location or zone.
- **Within**
  Covers transportation within a zone (i.e., starting from a location in the zone and reaching another location in the zone).
- **Along**
  Represents transportation starting from a selected location or zone and reaching another selected location or zone.
- **Inbound**
  Covers transportation within and to the selected zone (i.e., all transportation that ends in the zone and starts inside or outside the zone).
- **Outbound**
  Represents transportation within and from the selected zone (i.e., all transportation that starts in the zone and ends inside or outside the zone).

The trade lane types can be defined via IMG menu path **Transportation Management • Master Data • Transportation Network • Trade Lane • Define Trade Lane Types**. Here, you can specify the number range interval per trade lane type.

Transportation Lane versus Trade Lane

Although both concepts characterize the direction of transportation between a source and a destination—both being locations or zones—they have different aims.

The *transportation lane* defines reachability—that is, which means of transport can be used to transport goods from a source to a destination and which carriers are available per means of transport. In addition, it contains many parameters that affect transportation planning, optimization, and carrier selection. Thus, the transportation lane defines how transportation can be planned and executed in your network, so it has a significant impact on transportation processes.

The *trade lane* is just the geographical basis for multiple business objects that define the relationships to carriers and customers. It can be defined for a means of transport or mode of transport, or even without reference to a mode of transport. Its orientation concept is more generic than the direction in a transportation lane. The trade lane itself doesn't contain any control parameters, so it doesn't influence any transportation processes. However, in conjunction with objects such as forwarding agreements, freight agreements, allocations, and business shares, it's the key element to structure your business from a geographical perspective.

3.2.8 Transportation Network Cockpit and Worklist

Let's look at two complementary tools for providing transparency of the transportation network and searching and maintenance capabilities: the transportation network cockpit and the transportation network worklist.

Transportation Network Cockpit

The transportation network cockpit allows the display of the transportation network or parts of it on a geographical map, as well as the creation of master data objects, such as locations, transportation zones, and trade lanes, on the map. For objects displayed on the map, you can navigate to the corresponding (text-based) maintenance UIs described in the previous sections. Visualizing the network on a map is probably the best way to understand the network structure and verify its correctness and completeness. Certain transportation network master data inconsistencies can be identified easily on the map, such as incorrect geographical coordinates for locations or missing geographical coordinates, which are frequently shown as a spot with coordinate (0,0) in the Atlantic Ocean, where there is definitely no island.

Choosing the Transportation Network Cockpit app, you can define search criteria for locations, transportation zones, transportation lanes, trade lanes, schedules, and default routes. When you click the **Go** button in the search dialog, the resulting objects are displayed on the map, as shown in Figure 3.49, for a set of schedules matching the schedule search criteria.

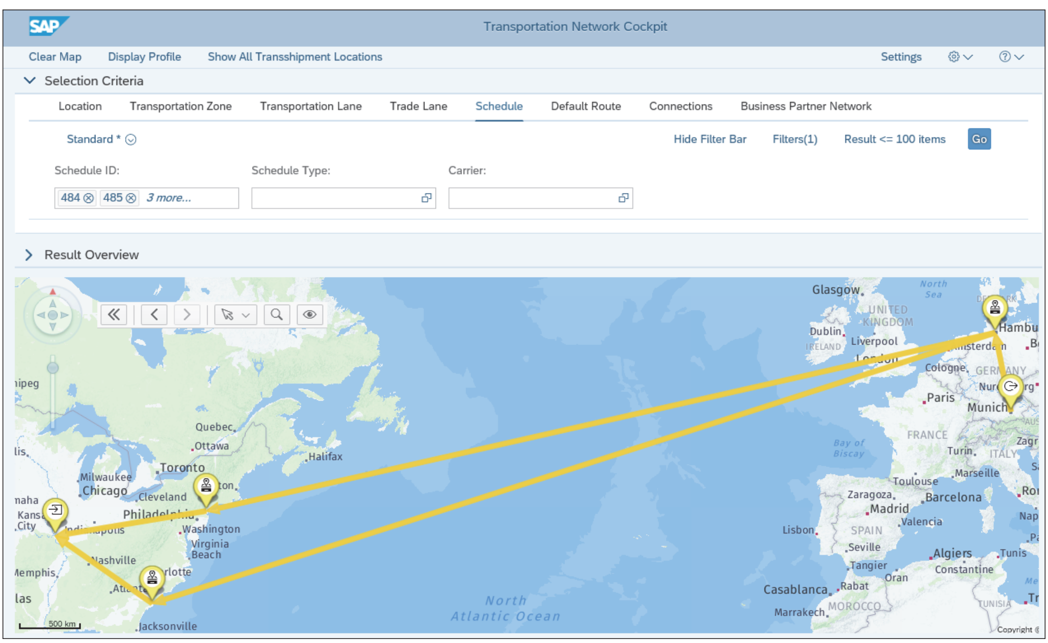


Figure 3.49 Transportation Network Cockpit

The **Results Overview** area provides a list of the search results. You can iteratively add search results to the map and clear the map to start with a new search. You can focus on the map and the master data selection screen area, respectively, by hiding the other screen area.

If some addresses in your location master data are incomplete or not correct, you can search for locations with low precision or match (Section 3.2.1) and review the results on the map and in the search result list. Then, you can check the locations individually and perform the required address corrections.

If planners detect wrong geographical coordinates in the transportation cockpit, they can use the transportation network cockpit to search for locations of given documents or by selection profiles for freight units, transportation units, consignment orders, freight orders, or freight bookings. Then, they can review the locations and perform the needed changes, with a focus on the planning scenario at hand.

If you want to see the complete network offered to you by a carrier, select the **Business Partner Network** tab to show all network master data for the chosen carrier. The set of all transshipment locations can be displayed via the corresponding button.

Use the **Connections** tab to search for paths from a source location to a destination location, which allows you to easily check whether your network definition is complete from a reachability and transshipment location perspective. The found paths are displayed on the map, and, in addition, if there is no direct reachability from source to destination, this is displayed as a red arc. If you expected connections to exist, but none are shown, this helps identify whether a transshipment location, schedule, or transportation lane is missing for the connection. Because the network definition is crucial for automatic planning, we recommend verifying the completeness and correctness of your network definition by the transportation network cockpit in case automatic planning doesn't find the transportation plan you expected.

When you right-click any object on the map, the context menu allows you to do the following:

- Show the details of the object, which opens the maintenance UI of the object and allows editing.
- Hide the object at hand, other objects, or unrelated objects.
- For a location, you can find assigned transshipment locations, related transportation zones, transportation lanes, trade lanes, schedules, default routes, and connections to another location; create a trade lane referring to the location; or move the location on the map.
- For a transportation zone, you can find assigned transshipment locations, related locations, transportation lanes, trade lanes, schedules, and default routes; create a trade lane referring to the transportation zone; or move the zone on the map.
- Display arc-based objects, such as transportation lanes, trade lanes, schedules, and default routes, on the street level or as a straight line.

Right-clicking on the map itself, you can do the following:

- Search for addresses and display them on the map.
- Define whether arcs will be displayed as straight lines or on the street level.
- Show the display profile, which includes a legend for the displayed objects and allows adjusting some aspects of their appearance on the fly, for example, switching labels on or off (see Chapter 5, Section 5.7.4, for more details on configuring the map and using the display profile).
- Remove highlighting from the results of the last search.
- Create a location or a transportation zone at the current position on the map.
- Search locations nearby, within a given distance limit.
- Personalize the map to your needs. For example, specify the initial area shown on the map (the default is the world), and choose among the map types (preconfigured maps from geographical service providers [GSP]).

Transportation Network Worklist

Whereas the transportation network cockpit represents the geographical view of the network, the transportation network worklist provides queries for all schedule types delivered in standard, default routes, and trade lanes.

As shown in Figure 3.50, you choose the Transportation Network Worklist app and the query for master flight schedules, for example. With standard POWL sorting, filtering, and personalization capabilities, you can quickly navigate through master flight schedules that are relevant for you or export the list to a spreadsheet. Many key characteristics are shown here, such as airline code, flight number, source and destination, number of generated departures, number of intermediate stops (to quickly identify multistop flights), and the corresponding carrier flight schedule. The reference data status allows you to identify master flight schedules that refer to updated underlying carrier flight schedules and may need manual adjustments (see Chapter 6, Section 6.4.3).

For any set of schedule instances selected in the results list, you can create freight documents and generate departures. You can also display, edit, copy, or delete a selected schedule instance or create a new one.

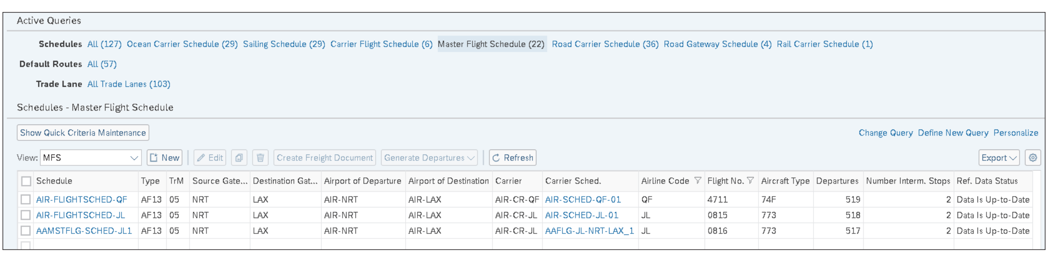


Figure 3.50 Transportation Network Worklist with Master Flight Schedule Query

3.2.9 Integration of Geographical Services

Geographical services such as geocoding or matrix routing are essential for informed decision-making. These services are offered by external providers. Algorithms required to provide the desired results are running in the computing center of the *geographical service provider* (GSP). While a company running TM can still operate its own installation of a GIS to provide the desired geographical information, nowadays it's common practice in most companies to use web services instead. Therefore, we focus our discussion on the integration of geographical web services offered by external providers. Unless stated differently, the discussion is valid for a self-hosted GIS too.

While some GSPs offer an almost global coverage, others offer only regional data, such as for North America, Europe, Australia, or China. Some TM users may already be familiar with a certain GSP when they start using TM and want to continue using services from this vendor. Global companies may even use multiple GSPs, for example, one per continent or region. For all these reasons, TM doesn't contain geographical services but offers an open infrastructure into which any GSP can be easily integrated by some ABAP development in the customer project, as described in SAP Note 1685381. This gives the customers the choice between alternative providers.

We'll discuss SAP's option for geographical services in the following sections, including configuration instructions and usage recommendations.

Geographical Services

SAP has introduced *SAP HANA spatial services* as an abstraction layer between GSPs such as HERE or TomTom and applications such as TM, as shown in Figure 3.51. This integration has been available since the SAP S/4HANA 1709 release and SAP TM 9.4 via SAP Note 2711181 and needs only proper configuration but no customer-specific development. We recommend this approach as it is the easiest way to consume geographical services in TM.

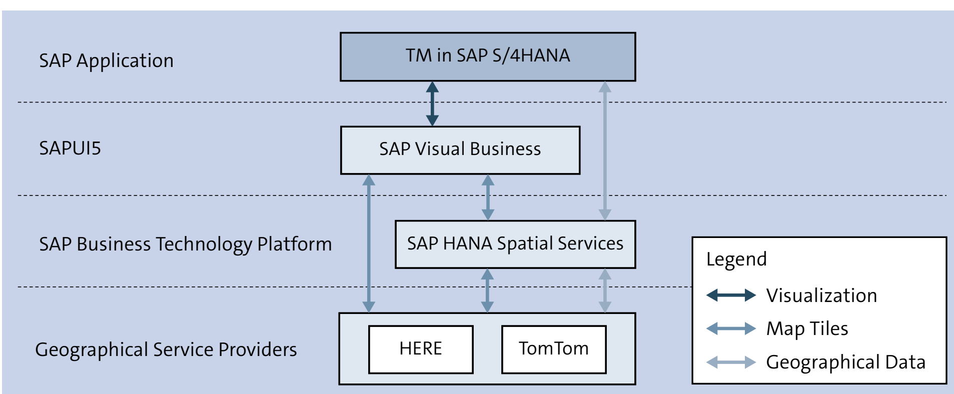


Figure 3.51 Integration of a GSP via SAP HANA Spatial Services

Note that SAP HANA spatial services is based on web services offered by a GSP and doesn't support integration to a self-hosted GIS. Unlike its name may suggest, SAP HANA spatial services doesn't have its own persistence and therefore doesn't require SAP HANA. For more information on SAP HANA spatial services, refer to *http://s-prs.co/v557503*.

Let's now review the relevant geographical services and how they are integrated via SAP HANA spatial services:

- **Geocoding**
  Given an address, the *geocoding* service determines the geographical coordinates representing longitude, latitude, and altitude. These coordinates are required to show locations at their right positions on the map and are prerequisite for single and matrix routing. TM calls the geocoding service of SAP HANA spatial services for the desired address, which calls the corresponding service of the external provider. The result from the external provider is received by SAP HANA spatial services and returned to TM.
- **Single routing**
  The *single routing* service determines the fastest way from one geographical coordinate to another, and most GSPs also allow choosing the shortest option instead. As result, it returns the total distance and duration, and it can also provide the detailed street segments of the obtained route that are needed to display it on the map. The street segments are represented by a sequence of geographical coordinates from source to destination. TM calls the single routing service of SAP HANA spatial services for the given source and destination geographical coordinates. Then, SAP HANA spatial services calls the corresponding service of the external provider, receives its result, and passes it back to TM.
- **Matrix routing**
  Given a set of source and destination geographical coordinates, the *matrix routing* service determines the distance and duration for each source-destination pair. Analogously to the previous services, TM calls the matrix routing service of SAP HANA spatial services for the given set of source and destination geographical coordinates. SAP HANA spatial services calls the corresponding matrix routing service of the external provider, receives the resulting matrix of distances and durations, and provides it to TM. While many individual single routing calls could be used to obtain the distances and durations for a set of sources and destinations, matrix routing yields the same result, provides much better performance, and is therefore used by TM in such cases.
- **Map tiles**
  The visualization of a geographical map is done by map tiles, which represent a decomposition (into rectangles of same size) of the total map to be displayed and are provided by a *mapping service*. TM uses the SAP Visual Business SAPUI5 control to visualize a geographical map and objects on it, such as locations or business

documents. SAP Visual Business can fetch the desired map tiles either directly from the GSP or indirectly via SAP HANA spatial services, as shown in Figure 3.51. The latter integration has been available since the SAP S/4HANA 2020 release via SAP Note 3234613. If the user moves the visible map area or zooms in or out, SAP Visual Business automatically fetches the required corresponding map tiles and updates the displayed map accordingly.

If a route from location A to B to C is displayed on the map, TM uses one call of the single routing service to determine the street segments across the whole location sequence, that is, from A to B, and from B to C, and then lets SAP Visual Business draw the street segments as lines on the map. This single routing call requires that the geographical coordinates for the locations A, B and C have been determined before.

Distances are required to do optimizer-based planning, minimize the total distance traveled when transporting freight, or adhere to distance-based constraints for trucks. Distances also get shown for demand and capacity documents and their stages in the transportation cockpit, and are needed for charge calculation and settlement, where the charges are calculated based on the distance of the transportation. Durations are also required for optimizer-based planning, minimizing the total duration for a transport, or considering constraints on the total duration of a transport. As with distances, durations are also shown in the transportation cockpit for documents and their stages. The system differentiates between net and gross duration, where the former represents the pure travel duration, and the latter includes potentially scheduled idle times between the first departure and last arrival of a road freight order at hand.

The single and matrix routing services are using shortest-path algorithms based on a graph of the transportation network, which usually contains the junctions of streets and highways as nodes and their connections as arcs with distances and durations. Given a source and destination geographical coordinate, the best route to the destination from the source is determined. Here, a route is represented by a sequence of geographical coordinates, starting with the source and ending with the destination. The routing is required to determine distance and duration. Individual street segments obtained during routing are only needed if they will be visualized on a geographical map, as in the transportation network cockpit described in Section 3.2.8 or in the transportation cockpit's map described in Chapter 5, Section 5.7.4.

Routing, Default Routes, and VSR

The terms *route* and *routing* are used in various contexts. In the context of GSPs discussed in this section, *routing* means determining a path through the street network, which is frequently called a route and specifies which streets, highways, and paths to use to travel from a source location to a destination location. The path connects the source and destination by very detailed intermediate physical positions, such as crossroads, highway exits, and so on, and thus it defines how a driver can execute transportation from source to destination. Such a path is stored in TM and fetched by the single routing service whenever needed to be displayed on the map.

A *default route* is a statically defined path through a transportation network consisting of locations maintained in the TM system. Usually, crossroads aren't maintained as locations. Thus, a default route is defined on a higher level of aggregation.

The VSR optimizer solves vehicle routing problems in the transportation network specified by locations in TM. For a given fleet of vehicles and transportation orders, the optimizer decides which orders will be delivered by which vehicle. In addition, the optimizer determines the best possible route for each vehicle. Here, again, a route is a sequence of locations in the network. Like the default route, routes are defined on a higher level than the level of crossroads, and so on.

While a default route is defined manually and statically, usually based on business experience, the routes obtained by the VSR optimizer are determined automatically and dynamically, based on optimization criteria. One of the criteria is the total distance traveled, which is based on pair-wise distances between the locations. Interestingly, these distances can be retrieved from routing services offered by a GSP, which internally performs a routing task between two locations to determine the distance required by the VSR optimizer to make its routing decisions on the location level.

The geographical map shows a set of transportation-relevant objects. These objects can be based on position (e.g., locations, zones, and resources) or relation (e.g., freight units, freight orders, trade lanes, and schedules). The relation-based objects can be shown as straight lines connecting two consecutive locations in an idealized way or based on the detailed routing information, which makes it possible to check the actual route along the street level. However, the higher-detail level of an actual route comes with a longer response time because many more details must be retrieved from a single routing service to draw the detailed segments on the street level.

Map visualization is extremely helpful to understand, analyze, and explain the transportation network structure, as explained in Section 3.2.8 for the transportation network cockpit. While a list of locations in a tabular representation is hard for anyone not familiar with the locations to interpret, a visualization of the locations on the map allows everybody to understand the relative geographical positions on the map and thereby also assess neighborhood relations and distances between locations.

When planning transports, a map of the freight units and planned freight orders enables the planner to identify geographical consolidation potentials, which are much harder to identify in tabular lists of freight units and freight orders. Moreover, the quality of an actual route of a freight order can easily be judged by checking it on a map. For example, good routes should not contain any crossing stages, which is hard to judge in a tabular stage list but is easily checked on a map. See Chapter 5, Section 5.7.4, for more details on map-based planning, and Chapter 5, Section 5.7.1, for examples of the transportation cockpit including a map.

The routing can be visualized on the map, enabling the user to see which streets and highways are used to reach the destination from the source. This is helpful during execution of the transportation. For example, if information about traffic jams is also shown on the map, it enables the planner to judge whether there is a risk of delays and to trigger replanning if needed.

Process controller strategies (see Chapter 2, Section 2.3.6) are used to represent the three service calls for geocoding, single routing, and matrix routing. If your company was using two different GSPs in different regions, and you need all three service call types, you would need to define six process controller strategies, three per GSP and two per service call type. If you used just one GSP globally but need all three service call types, you would need to define three process controller strategies, one per service call type.

Buffer for Distances and Durations

Because matrix routing is a performance-critical task, especially for bigger scenarios with 1,000 locations or more, the obtained distances and durations can be stored in a buffer. When the stored distances and durations are needed, they are fetched from the buffer instead of the matrix routing service. Fetching from the buffer and storing in the buffer are covered by two process controller strategy methods. Thus, if you include these two methods in your distance and duration determination strategy, the buffer concept will be used; otherwise, the buffer isn't used.

Choosing **Transportation Management • Master Data • Transportation Network • Transportation Lane • Distance and Duration Determination • Define Global Settings for Distance and Duration Determination** in Customizing, you can define whether the buffer will assume symmetric distances and durations between two geographical coordinates, which reduces the amount of stored data and improves performance. You can also specify that an undefined distance and duration is persisted if the matrix routing service isn't able to return a valid result. Such undefined entries are rather useful because you can easily identify issues such as failed calls and focus a recalculation only on the undefined entries. As alternative for undefined entries due to failed service calls, you can also choose the straight-line distance and duration calculation as fallback.

Choosing **Logistics • Transportation Management • Master Data • Transportation Network • Distance and Duration Determination** in the SAP menu, you can manage the buffer in various ways. You can determine selected distances and durations for the buffer, which can be also scheduled as a batch job. The selection capability enables you to redetermine entries that would otherwise expire soon (see the next section for the configuration of the validity period). The system differentiates buffer entries by their precision of distance and duration determination, which can be undefined, manually defined, straight-line distance, or GIS. You can manually maintain distances and durations, enabling you to replace undefined values by reasonable values. For example, you could select all undefined entries and then manually maintain realistic values. Moreover, you can delete selected buffer entries, trigger a batch job for this, or check and repair the buffer.

Following path **Logistics • Transportation Management • Master Data • Transportation Network • Geocoding** in the SAP menu, you can determine geographical coordinates or perform this task per batch report.

As geographical services are frequently paid per use, TM offers reports to provide statistics enabling an analysis of the performed geocoding, single routing, and matrix routing calls during a given period. Choosing the paths **Logistics • Transportation Management • Master Data • Transportation Network • Display GIS Metrics** and **Logistics • Transportation Management • Master Data • Transportation Network • Delete GIS Metrics** in the SAP menu, you can display and delete these statistics, respectively.

Configuration

To use a geographical service to determine distances and durations, choose **Transportation Management • Master Data • Transportation Network • Transportation Lane • Distance and Duration Determination • Set Usage of GIS Tool** in Customizing, and activate the parameter **Use GIS Tool**. Otherwise, the system will calculate the straight-line distances.

Some GSPs don't allow storing geographical coordinates or distances and durations (outside of business documents) for longer than a certain duration of, for example, 30 days. You can configure the available providers in Customizing by following path **Transportation Management • Master Data • Transportation Network • Transportation Lane • Distance and Duration Determination • Define GIS Providers**. There, you can define the validity period of geographical data and list the strategies for the provider. If certain geographical data is required after the period expires, the system fetches the geographical data synchronously for the process at hand and stores the new data asynchronously. If you're faced with the validity restriction, you can use the previously mentioned reports to ensure that geographical coordinates, distances, and durations get updated before their validity period expires. We recommend running these reports regularly to avoid fetching all geographical data only on-demand, which can deteriorate the response time for the process at hand.

A global company may want to use different GSPs, for example, one in North America and one in Europe. To achieve this, alternative strategies for geocoding, single routing, and matrix routing can be defined. By choosing **Transportation Management • Master Data • Transportation Network • Transportation Lane • Distance and Duration Determination • Define Strategy for Distance and Duration Determination and Georouting** in Customizing, you can define the single routing and matrix routing strategy to be used per *GIS zone*, which can represent a set of countries and regions. Analogously, you can select **Transportation Management • Master Data • Transportation Network • Location • Geocoding • Define Geocoding Levels** in Customizing to define the geocoding strategy per GIS zone.

By choosing **Transportation Management • Master Data • Transportation Network • Transportation Lane • Distance and Duration Determination • Define GIS Zone** and **Transportation Management • Master Data • Transportation Network • Transportation Lane • Distance and Duration Determination • Assign Country/Region to GIS Zone** in Customizing, you can respectively define a GIS zone and assign countries and regions to it.

Note

The prerequisites to set up SAP HANA spatial services are described in SAP Note 3058573, and the configuration of the integration to SAP HANA spatial services is explained in SAP Note 2751622.

You can configure the map content for SAP Visual Business in Customizing by following menu path **Transportation Management • Basic Functions • Geographical Map • Visual Business • Maintain Application Definitions**. If you want to choose a different GSP per country or region, you can do so by defining the appropriate contextual map layer stack assignments and using the same context country in the map layout definition (see Chapter 5, Section 5.7.4). See *http://scn.sap.com/docs/DOC-43251* for more details on configuring or changing a map provider for SAP Visual Business.

Recommendations

While integrating geographical services provides a lot of value for many scenarios, this value causes costs such as license fees by the external provider or SAP HANA spatial services. If you've developed your own integration to a GSP or GIS, we recommend that you build up and preserve know-how about the provider's capabilities and the integration because geographical services evolve, and you may want use the latest versions offered by your chosen provider. If you're hosting your own GIS, it's important to have local know-how to keep the system up and running.

We also recommend that you check the accuracy of the integrated GSP or GIS by explicitly checking known examples for geocoding, distances, routing, and map visualization. It's also helpful to monitor the availability of the connected services or the GIS because downtime may have a severe impact on transportation planning or charge calculation.

Of course, you can run TM without geographical services. In this case, geographical coordinates for locations are determined on the region and country level and can be maintained manually to get higher accuracy without using geographical services. However, this may be a tedious, error-prone task. Without using routing services, the distance determination can be done based on the straight-line distance, which is a reasonable approximation of the street-level distance for some scenarios. Alternatively, the distance can be maintained explicitly on the transportation lane level, which, again, is hard, error-prone work—especially if medium or large transportation networks are modeled. Nevertheless, all these options without geographical services are also valid, so it's up to the user to judge the value of geographical services for the business, decide whether to integrate geographical services, and choose the right vendor and option.

Internet Graphics Server

Internet Graphics Server (IGS) represents a former approach to determine distances and duration that we don't recommend because it requires its own server, its interface is tied to one vendor, and it uses only single distance calls, which results in acceptable performance only for small planning scenarios.

3.3 Equipment Types and Resources

Equipment types and *resources* play a central role in planning and execution. Figure 3.52 shows the available equipment types and resources required to physically transport goods within the transportation network.

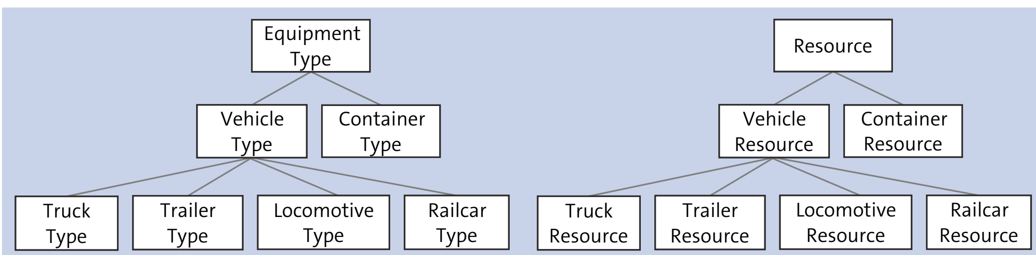


Figure 3.52 Equipment Types and Resources Required for Transportation

An equipment type and a vehicle type subsume all types below that level, and the same holds true for a resource and vehicle resource. We'll use the most specific term where possible, but in some contexts, more abstract terms are needed. Planning can be performed on the equipment type level, which is sufficient if you subcontract only. If you operate your own truck fleet or treat subcontracted trucks or containers like your own fleet, planning needs to be performed on the resource level. Of course, you could mix these two cases, for example, if you operate your own truck fleet and subcontract the loads exceeding your fleet size.

You can create a resource based on the corresponding equipment type as a template and edit the resource afterward. While the resource still refers to the equipment type, some of its properties may then deviate from the equipment type. If you operate a truck fleet with 20 trucks of the same size, this could be modeled by one truck type and 20 truck resources that have different license plates but refer to the same truck type. It's also possible to create a resource from scratch without reference to any equipment type.

Trucks, trailers, locomotives, and railcars are called vehicles. Transportation unit types and transportation unit resources represent *container* and *unit load device* (ULD) types and resources. For the sake of simplicity and to avoid confusion with transportation units as business documents (see Chapter 5, Section 5.4), we'll use the terms *container type* and *container resource* as an abstraction from ULDs and containers.

Drivers are required to operate trucks, and they combine the properties of a business partner and a resource (as described in Section 3.1.2). *Calendar resources* represent opening hours at locations. *Handling resources* generalize calendar resources, imposing additional time-dependent capacity constraints, for example, to model the number of open doors at a warehouse. While drivers are key for transportation by trucks, calendar resources and handling resources are relevant for activities at locations, such as loading or unloading. Choosing the Resources Worklist app, you get an overview of the maintained resources and drivers.

Section 3.3.1 introduces the mode of transport and the means of transport, which is the key concept to structure vehicles. Section 3.3.2 provides more details on equipment types and introduces equipment groups. Section 3.3.3 describes vehicle types and resources. Container types and resources are explained in Section 3.3.4. Calendar and handling resources are described in Section 3.3.5.

3.3.1 Mode and Means of Transport

Transportation is structured according to the following key concepts:

- **Mode of transport**
  The mode of transport defines which mode (e.g., road, rail, sea, and air) is used for transportation.
- **Means of transport**
  The means of transport is assigned to a mode of transport and models a class of vehicle types and resources with the same fundamental properties (e.g., reachability or distance and duration in the network).

Let's delve into the mode of transport and means of transport next.

Mode of Transport

The modes of transport maintained in the system are categorized into four *transportation mode categories*: road, rail, sea, and air. You can use predefined modes of transport or configure new ones (see Figure 3.53) in Customizing using menu path **Transportation Management • Master Data • Transportation Network • Transportation Lane • Define Transportation Mode**. The following parameters are available:

- **DGModTrCat**
  This parameter defines the DG mode of transport category.
- **TModCat**
  This represents the transportation mode category of the mode of transport.
- **Main Carr.**
  The mode of transport can be used for main carriage.

- **Sust. Fctr**
  The sustainability factor can be used to model the carbon dioxide emissions.
- **MTr**
  The means of transport is used as default for distance and duration determination. This default is only used if no specific means of transport could be determined for a capacity document at hand.

Transportation Mode

MT	Description	DGModTrCat	TModCat	Main Carr.	Sust. Fctr	MTr	MTr Description
01	Road	1	Road	☐		0001	Truck
02	Rail	2	Rail	☐			
03	Sea	4	Sea	☑			
04	Inland Waterway	3	Sea	☐			
05	Air	5	Air	☑			
06	Postal Service	1	Air	☐			

Figure 3.53 Configuration of the Transportation Modes

Means of Transport

Means of transport are essential to group vehicle types and resources, in particular from network and reachability perspective. To maintain a means of transport in Customizing, select menu path **Transportation Management • Master Data • Resources • Means of Transport and Compartment • Define Means of Transport**. Figure 3.54 shows the maintenance screen where, in addition to the name, description, standard code, and mode of transport, the following parameters can be defined:

- **Superordinate MTr**
  This field assigns the means of transport to another means of transport, which enables defining a means of transport hierarchy, as shown in Figure 3.55. Usually, all trucks have the same reachability properties in your transportation network, but the planning costs of small, large, cooled, and noncooled trucks differ; and the same holds true for small, large, cooled, and noncooled trailers. Using the shown means of transport hierarchy, you can assign the root truck means of transport to a transportation lane to define the reachability of this means of transport and all its children in the hierarchy, which simplifies the transportation lane maintenance considerably and makes it less error prone. The planning costs can be defined on lower levels in the means of transport hierarchy. The middle layer in this hierarchy would not be required from the planning cost perspective but could be used to define allocations for carriers, as explained in Chapter 6, Section 6.4.4. Note that you could also model the example in Figure 3.55 by 8 vehicle types representing the lowest level in the hierarchy, which are directly assigned to the two top-level means of transport. In this modeling, you would not need the intermediate means of transport to differentiate cooled and non-cooled trucks and trailers. We recommend this modeling based on vehicle types, but in some scenarios, you may need the deep means of transport hierarchy.

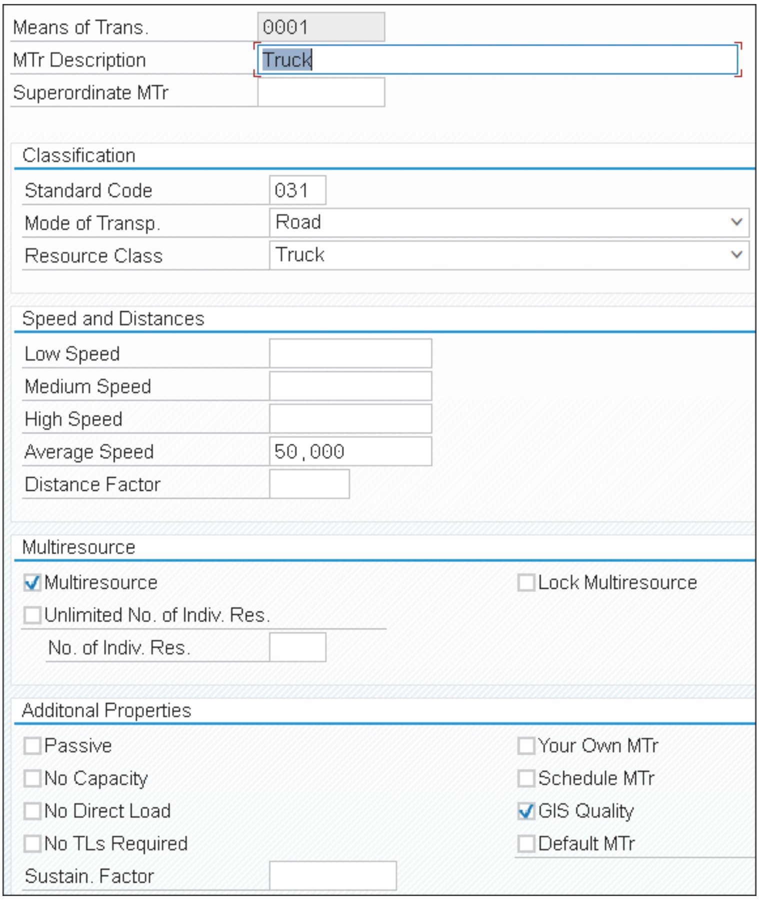


Figure 3.54 Means of Transport Configuration

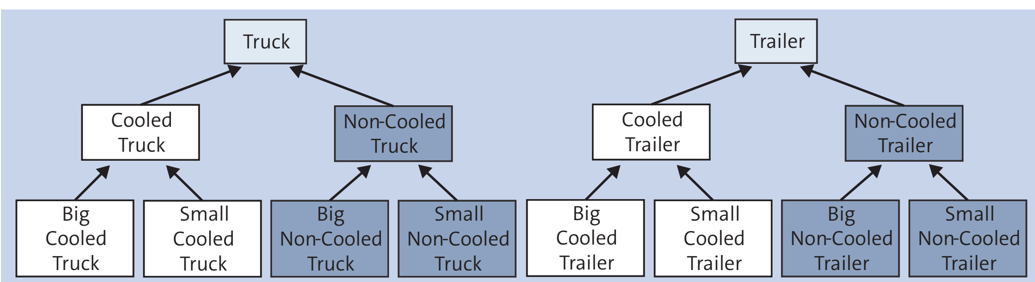


Figure 3.55 Means of Transport Hierarchy

- **Speed and Distances**
  This section allows you to specify the **Distance Factor** that defines the ratio between the distance to be considered and the straight-line distance. The **Average Speed** is used to determine the duration based on the distance. Both parameters are only relevant if distance and duration aren't determined by geographical services as

explained in Section 3.2.9. The definition of **Low Speed**, **Medium Speed**, and **High Speed** (which represent the average speeds when traveling in developed areas, on highways, and on motorways) was required when using IGS for distance and duration determination purposes, which we don't recommend anymore (Section 3.2.9).

- **Multiresource**
  This flag defines whether a resource assigned to the means of transport represents a *single resource* (i.e., it models one physical resource instance, e.g., the truck with license plate HD – DE 567) or a *multiresource* to model a resource type (i.e., a set of resources with equivalent properties). While single resources are used to plan a company's own fleet of trucks and trailers, multiresources have been used to represent subcontracted trucks for which you don't care about their license plate but just the fact that you can use a truck of that kind. Using the **Unlimited No. of Indiv. Res.** parameter, you can define that the multiresource represents an infinite number of resource instances. You can limit the number of resource instances modeled by a multiresource by the **No. of Indiv. Res** parameter. The **Lock Multiresource** parameter defines whether multiresources get locked during planning. If a multiresource is locked, it can't be used in two parallel planning sessions. If it's not locked, the system enables two or more parallel planning sessions, but it can't guarantee that the defined limit of resource instances is met. In general, we recommend planning with equipment types instead of multiresources because that is more natural and leaner. If you plan a certain number of subcontracted resources, such as resources like your own fleet, we recommend modeling this by a corresponding number of single resources rather than a multiresource with a finite limit of instances.
- **Passive**
  This parameter defines whether the resource is active or passive. While an *active resource* can move alone, a *passive resource* can only be moved by an active resource. In the road mode of transport, trucks and trailers represent active and passive resources, respectively. Analogously, locomotives and railcars represent active and passive resources for the rail mode of transport.
- **No Direct Load**
  This parameter defines that freight can't be loaded into the resource at hand—neither into the resource nor into any compartments assigned to it. Typically, this flag is used for tractors and locomotives. Similarly, the **No Capacity** parameter can prohibit using compartments for the resource.
- **Your Own MTr**
  This parameter defines whether resources assigned to this means of transport belong to your own fleet. This is just a descriptive parameter; the main planning-relevant properties are expressed by the multiresource parameters explained previously.
- **Schedule MTr**
  This parameter allows using the means of transport for schedules.

- **GIS Quality**
  This option determines whether a GSP or GIS is used for the distance and duration determination. If this option is selected, the GSP or GIS calculates the distance and duration. If IGS is used, the duration determination takes account of the low, medium, and high speeds specified. If neither GSP nor GIS is used, the distance is calculated as a product of the straight-line distance and the distance factor, while the duration is based on the average speed entered. Refer to Section 3.2.3 for details on distance determination based on a means of transport and to Section 3.2.9 for integration of GSPs.
- **Sustain. Factor**
  The sustainability factor models the carbon dioxide emissions.
- **No TLs Required**
  This parameter defines that no transportation lanes are required. As consequence, every location can be reached from every other relevant location. This is useful for customers with a simple network structure because they don't have to define transportation zones and transportation lanes. However, customers with a sophisticated network structure would not need this and would maintain the required transportation zones and lanes instead.
- **Default MTr**
  You can define one means of transport as the default for distance and duration determination. This default is only used if no specific means of transport could be determined for a capacity document at hand.

3.3.2 Equipment Types and Groups

An *equipment group* is a grouping of multiple equipment types, with the main purpose to structure equipment types. Analogously to equipment types subsuming vehicle types and container types, as shown previously in Figure 3.52, equipment groups cover vehicle groups and container groups.

In Customizing, you can use menu path **Transportation Management • Master Data • Resources • General Settings • Define Equipment Groups and Equipment Types** to define the following groups and types, as shown in Figure 3.56:

- Vehicle groups and vehicle types in the **Vehicle Groups** view
- Container groups and container types in the **Transportation Unit Groups** view
- Handling resource groups and handling resource types in the **Handling Resource Groups** view

Because planning with vehicle types and container types wasn't supported before the SAP S/4HANA 2021 release, you need to explicitly activate the planning capability by switching off the parameter **Restricted Use in Planning** for the corresponding equipment type. This behavior ensures that the planning behavior remains unchanged after a customer upgraded to release 2021 or later. If this parameter isn't active, vehicle types and container types get shown in the corresponding lists of the transportation cockpit and can be considered by automatic planning. Otherwise, planning with equipment types isn't possible. For the planning-relevant vehicle types and container types, the group is just an additional attribute and not part of the key, so the equipment types themselves must have unique names. Planning decisions can be made on the equipment type level but not on the equipment group level, but the group level can be used for selection and information purposes, as well as to define incompatibilities. Planning-relevant equipment types can only be deleted if they aren't used, for example, assigned to a capacity document or a combination vehicle type (which will be described in Section 3.3.3). To delete an equipment type, you mark it for deletion and use report /SCMB/DELETE_EQUIPMENT_TYPE. Note that planning doesn't support handling resource types but only handling resources.

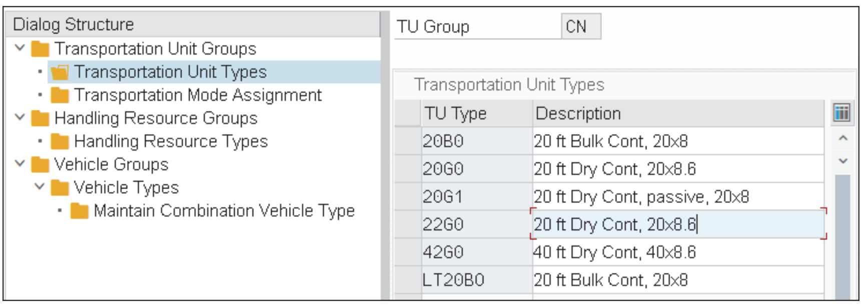


Figure 3.56 Maintaining Equipment Types

While vehicle types are structured by the assigned means of transport, in addition to the vehicle group, this isn't the case for container types that can only be structured by container groups. Figure 3.57 shows one example with two container groups consisting of four types each. While the means of transport hierarchy used for vehicle types and resources can have an arbitrary number of hierarchy levels, this container hierarchy contains just two levels: the groups and the types. In the maintenance screen, you can also assign mode of transport categories to a container group; in the preceding example, you would assign road, rail, and sea to containers and air mode of transport category to ULDs. We recommend using container groups and types to structure your container resources.

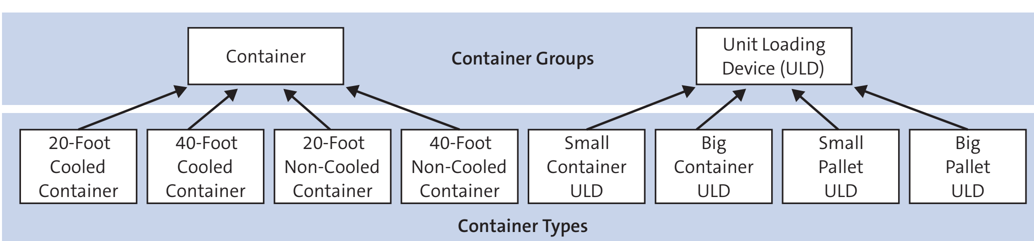


Figure 3.57 Container Groups and Types

In the same way, you can also define handling resource groups and types to structure your handling resources and copy certain properties from a type to a new handling resource.

Note that equipment groups and types can be used in a carrier profile to identify the capabilities of the carrier, as already mentioned in Section 3.1.2. The physical equipment properties are also used for forwarding order or quotation items of type container. Based on the item type configuration, the equipment group is entered automatically, and equipment types of this group are displayed for selection. Depending on the equipment group and type, the system automatically calculates the tare weight and capacity. This data, together with the physical property data of the equipment type, is relevant for the planner and is then available in the forwarding order and subsequent documents.

Resource Classes

The system contains predefined resource classes, for example truck, trailer, locomotive, railcar, container, or ULD. You can find these settings by following IMG menu path **Transportation Management • Master Data • Resources • General Settings • Define Resource Class**. The resource class is useful if you want to include or exclude ULD types or resources in the selection for a planning session.

3.3.3 Vehicle Types and Resources

Vehicle types and resources are mainly used to represent trucks, trailers, locomotives, and railcars. As the road mode of transport is relevant for almost every company dealing with transportation, we'll focus our discussion on trucks and trailers. We'll now explain vehicle resources and types in detail, before introducing compartments, vehicle combinations, and decreasing capacities.

Vehicle Resources

You can display and maintain existing resources or create a new resource by choosing the Define Resource app. From the initial screen, enter a name and resource type, and then click the **Create Resources** button. This takes you to the main resource maintenance screen shown in Figure 3.58, where you can maintain resources for all classes except for drivers. Alternatively, you can copy a resource from a template resource using path **Logistics • Transportation Management • Master Data • Resource • Copy Resources from Template** in the SAP menu. In the resource maintenance screen, the table in the top allows you to maintain some key properties that are included in the detailed tabs.

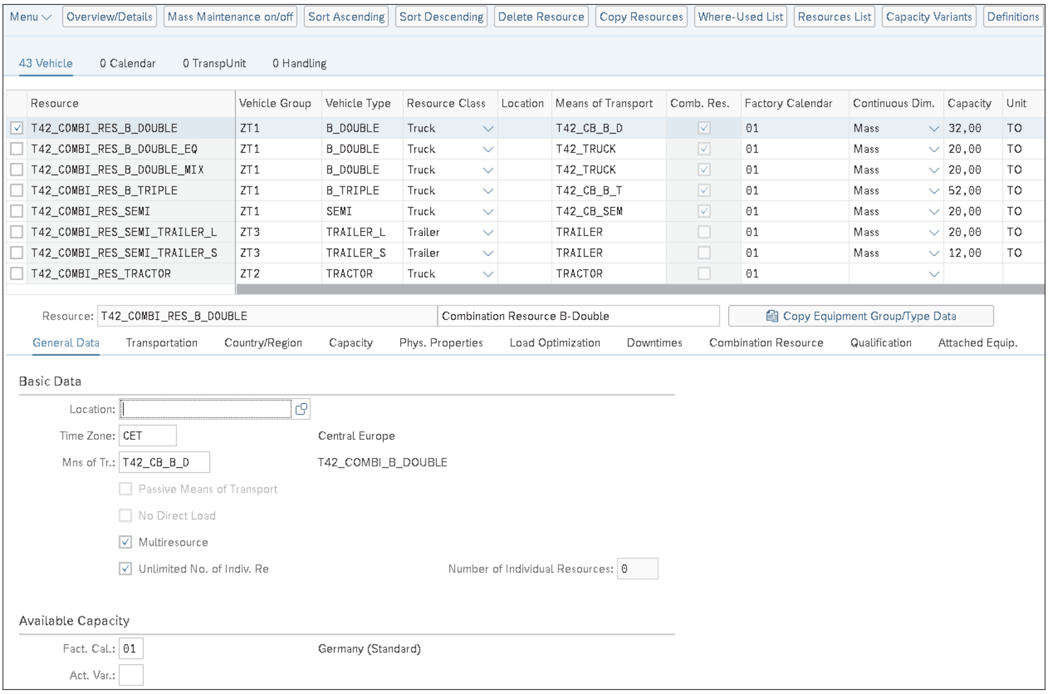


Figure 3.58 Maintaining a Vehicle Resource

The **General Data** tab allows you to define a depot location and a time zone. If a depot location is defined, the time zone is taken from it. You can assign a means of transport, which then determines whether it's a passive resource and allows direct loading, and then define that the resource is a multiresource and limit the number of instances it represents. Additionally, you can specify the factory calendar used for planning. To create or change a factory calendar in Customizing, follow path **Transportation Management • Master Data • Calendar • Maintain Factory Calendar**.

The **Transportation** tab defines the assigned vehicle type and group, the resource validity period, and its registration number that can cover the license plate for trucks and trailers. You can set a planning block, choosing among predefined reason codes that can be maintained in Customizing via **Transportation Management • Master Data • Resources • General Settings • Define Resource Block Reason Codes**. You can also define a default driver for a truck resource, which gets pulled into a road freight order if a new road freight order is created for the truck resource at hand and the corresponding freight order type requires driver assignment. A vehicle loading profile and an attached equipment profile can be assigned to the vehicle to model incompatibilities between the vehicle and a location; see Chapter 5, Section 5.8.7, for more details. You can also assign a resource-specific compartment profile (will be described later in this section); otherwise, the compartment definition is derived from the means of transport. There are additional pure descriptive fields to define, for example, ownership of the resource or when it was taken into service.

The **Country/Region** tab requires activation by localization (see SAP Note 1849189) and allows defining a country- or region-specific vehicle identification number, which can be used, for example, as a code for the Brazilian registry for motor vehicles.

The **Capacity** tab is key to defining the loading capacity of the resource at hand. You can define its capacity from a weight and volume perspective as well as additional capacities for definable units of measure. For example, you can define a unit of measure for pallets and define the resource's capacity for it. Additionally, the internal length, width, and height are defined, which are also considered during planning when assigning objects with defined sizes.

The **Phys. Properties** tab specifies more details about the resource at hand, for example, whether it's temperature controlled.

The **Load Optimization** tab defines parameters considered during load planning and load consolidation, which are described in Chapter 5, Section 5.8.8 and Section 5.8.7.

Resource Viewer to Verify and Maintain Physical Properties

Load planning and load consolidation use a lot of data maintained here, such as the width, length, height, number of axles, distance between the axles, maximum weight per axle group, and so on. It's crucial to work with correct data because even a single typo may lead to unexpected optimizer results.

Choosing the Resource Viewer app, you can search truck, trailer, and container resources and display them three-dimensionally, as shown in Figure 3.59, which is an example of a truck with a fixed double deck position. If you confuse the values for width and length of the truck in the physical properties, you can immediately detect this visually in a very intuitive way. Such a mistake would be hard to find at first glance when just checking the corresponding two data fields.

The resource viewer allows you to edit the physical properties and save them in the resource master data, as depicted in Figure 3.60. The **Resource Configurator** section allows users to maintain general properties of the resource at hand, such as the number of axle groups, the type per axle (e.g., single or tandem), and the distances between axles. The **Sections** area enables users to define flexible split decks. In the shown example, the first part of the truck's cargo space offers using beam split decks, which can be positioned in the vertical range of 1 – 2.20 meters and have a height of 0.10 meters; no beam split decks are allowed in the last part of the truck. You can also define the maximum load weight on a split deck, whether it needs to be vertically positioned on a grid or is fully flexible within the specified vertical range, and whether it's removable; that is, it doesn't consume any space if not used.

You can also choose one truck, trailer, or container type and visualize it three-dimensionally.

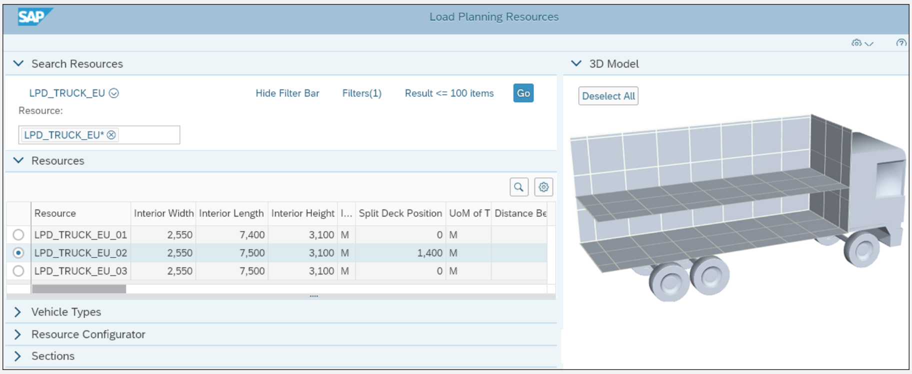


Figure 3.59 Search Criteria and Resource Overview in Resource Viewer

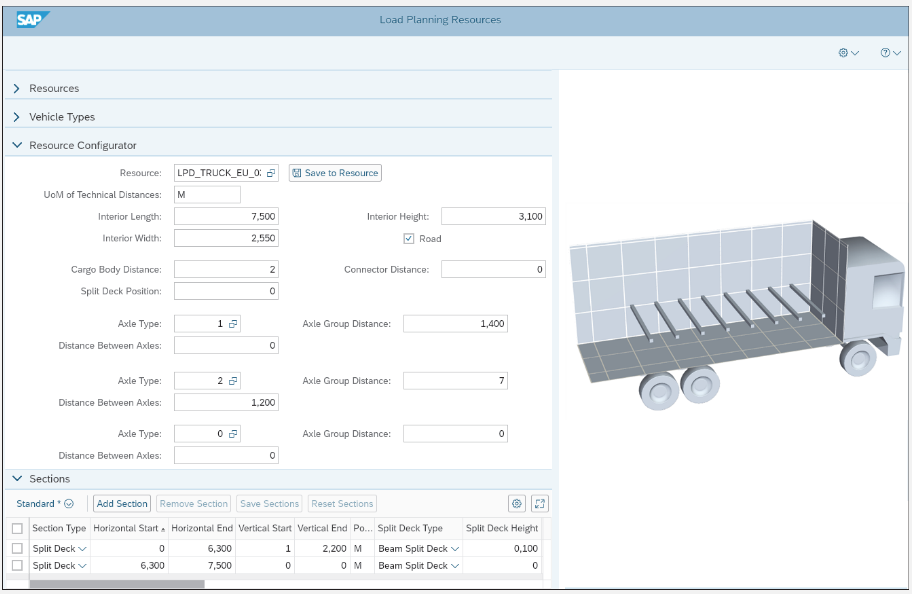


Figure 3.60 Maintaining Properties in the Resource Viewer

The **Downtimes** tab can be used to specify time segments in which resources aren't available. In general, they can be specified for all resource classes, including drivers (here they are maintained as absence times of the corresponding driver business partner). The actual availability of a resource within its validity period depends on the factory calendar, downtimes, and shift and break definitions. You can define a set of downtimes in which each downtime has a start and end date and time, a certain type (planned downtime for inspection in repair shop or resource inactive due to damage), a location, and a short description. For example, if a truck resource is planned for an inspection, you can define a corresponding downtime, including the location where the inspection takes place. Then, the transportation planner can plan the needed empty trips to move the truck to the location before the downtime begins, and any subsequent trip after the downtime would start from that location.

If you try to plan a capacity document overlapping with a downtime, the system will issue a warning message. Downtimes differ from a regular, scheduled nonworking time based on the factory calendar or the shift sequence (e.g., break or holiday) because the resource can still contain loaded goods during the weekend but not during downtime (e.g., because it gets repaired).

The **Combination Resource** tab is important if you want to do load planning considering the individual truck and trailer resources of a vehicle combination, but don't need the VSR optimizer to plan with trailer units (see also Chapter 5, Section 5.4.2). A *combination resource* consists of one truck type or truck resource (could be a tractor without own cargo space or a truck with own cargo space) and at least one trailer type or trailer resource. Figure 3.61 shows the maintenance of a combination resource, which represents a B-double that is frequently used in Australia and consists of one tractor and two trailers. The resources listed in this tab are called subresources or subtypes of the combination resource. The main idea behind the combination resource concept is illustrated in Figure 3.62. The VSR optimizer and manual planning treat the combination resource like one truck, although it may consist of a tractor with two trailers. When performing load planning for a combination resource, the system considers the individual resources in the combination resource and places the cargo into local resource items that correspond to the subresources and are children of the main vehicle item representing the combination resource. Thus, the complexity of handling trailers as individual objects is only used where needed, in load planning, but not enforced where it's not needed, in the VSR optimizer and manual planning.

Use Combination Resource Instead of Trailer Units

Prior to the introduction of the combination resource concept in the SAP S/4HANA 2020 release, you had to use trailer units if you wanted to perform load planning for trailers, although you didn't need them for the VSR optimizer because the trailer never gets uncoupled or recoupled. Thus, you've faced unnecessary complexity for the VSR optimizer, only because the trailer information was needed by load planning as a subsequent planning step. Therefore, we strongly recommend using combination resources for such scenarios instead.

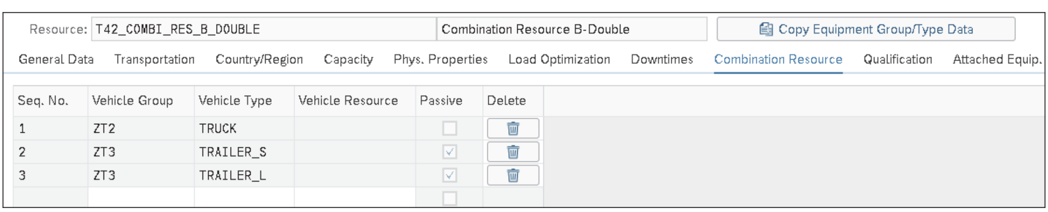


Figure 3.61 Maintenance of a Combination Resource

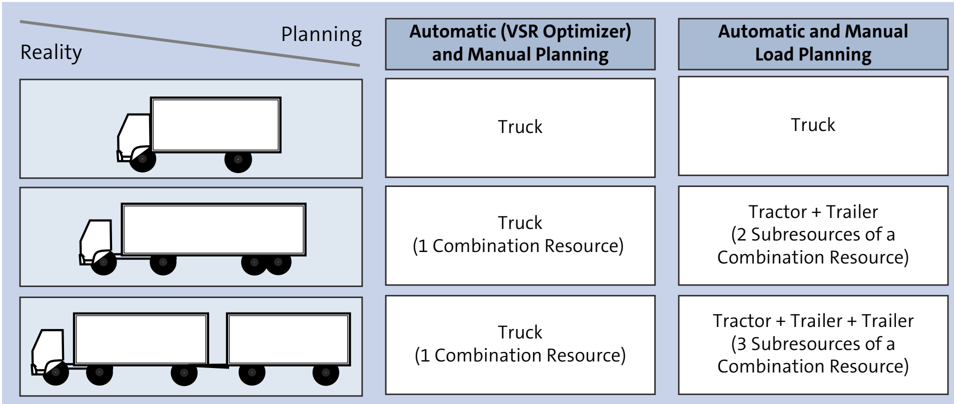


Figure 3.62 Usage of Combination Resources

Additional tabs allow users to maintain the following mainly descriptive properties, as well as short texts:

- **Qualifications**
  You can choose among qualifications that have been defined in Customizing via menu path **Transportation Management • Master Data • Resources • Resource Attributes • Define Settings for Qualifications**. When assigning a default driver to a truck resource, the system checks whether the qualifications are matching.
- **Attached Equip.**
  You can select among the attached equipment items specified in Customizing using menu path **Transportation Management • Master Data • Resources • Resource Attributes • Define Settings for Attached Equipment**.
- **Alternative Names**
  You can select among the alternative names defined in Customizing using menu path **Transportation Management • Master Data • Resources • Resource Attributes • Define Categories for Alternative Names**.
- **Grouping**
  You can select among the groupings specified in Customizing using menu path **Transportation Management • Master Data • Resources • Resource Attributes • Define Settings for Grouping Attributes**.
- **Short Texts**
  You can define language-dependent descriptions.

Vehicle Types

You can maintain vehicle types as indicated earlier in Figure 3.56 for equipment types in general. If you want to plan with a vehicle type, you need to disable the parameter **Restricted Use in Planning**, as already explained in Section 3.3.2. A vehicle type offers fewer fields than a vehicle resource, but it covers all planning-relevant information such as capacities and characteristics relevant for load optimization. You can assign a vehicle loading profile, an attached equipment profile (see Chapter 5, Section 5.8.7), and a compartment profile (will be described in next subsection), as well as define additional properties such as temperature control, which can be used to define incompatibilities for vehicle types. Analogously to combination resources, you can also define a *combination vehicle type* with one truck type and at least one trailer type as subtypes, as shown in Figure 3.63.

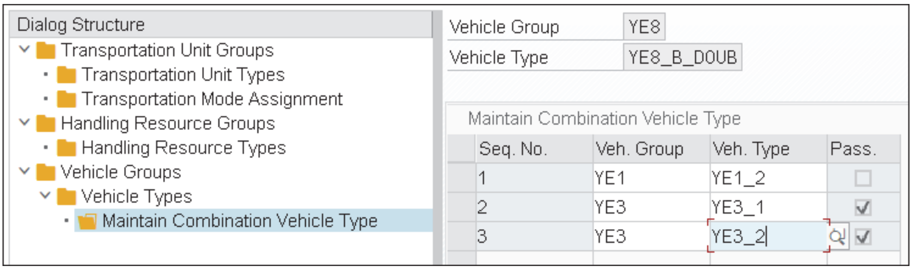


Figure 3.63 Maintenance of a Combination Vehicle Type

Compartments

Trucks and trailers frequently have multiple compartments for transportation efficiency reasons. Let's review two examples from different industries:

- **Product incompatibilities**
  Different fuel types must not be mixed when transporting fuel to gas stations. A truck with five compartments can be used to transport up to five different fuel types. Any fuel type could go into any compartment, but each compartment can carry only one fuel type at a time. Serving a gas station demanding five fuel types could be done by one truck with five compartments, which is much more efficient than using five trucks without compartments.
- **Products requiring special conditions**
  Frozen, chilled, and ambient products require transportation with special temperature conditions. A truck with one frozen compartment, one chilled compartment, and one ambient compartment can transport all three product categories together, which is much more efficient than using trucks that offer only one temperature zone and don't have multiple compartments.

The definition of compartments for vehicle types and resources is structured as shown in Figure 3.64 and can be maintained in Customizing via menu path **Transportation Management • Master Data • Resources • Means of Transport and Compartment • Define Compartment Type**, as shown in Figure 3.65. You can assign a *compartment profile* to a means of transport, and the structure and properties of the compartment profile are used for all vehicle resources assigned to the means of transport. The compartment profile can also be defined for a truck or trailer type, and a specific compartment profile can be assigned to an individual truck or trailer resource, which then overrules the assignment on means of transport level. A compartment profile contains a set of *compartment types*, and one compartment type could even be used multiple times in a compartment profile.

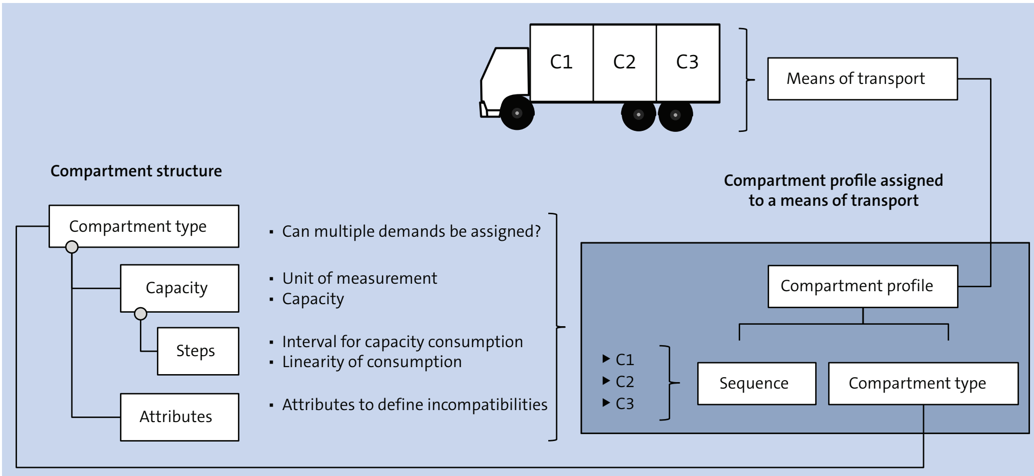


Figure 3.64 Relation between Vehicle Resources and Compartments

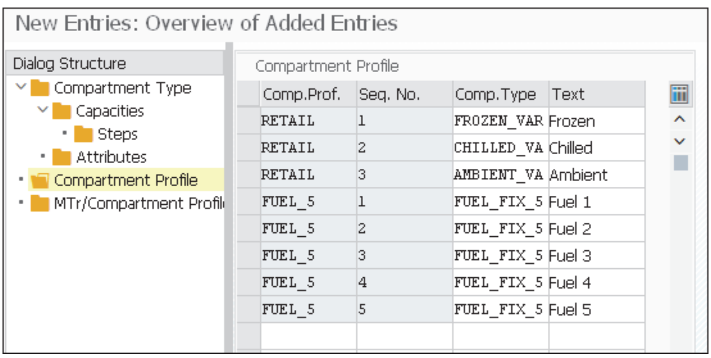


Figure 3.65 Maintaining Compartments

The compartment type defines the properties of one compartment in a vehicle, such as its capacity and its attributes, which can, for example, model its temperature-control capabilities to differentiate frozen, chilled, and ambient compartments and be used to define incompatibilities between transportation demands and a compartment with a certain attribute value. You can also define capacity steps modeling a partially stepwise and/or linear consumption of the compartment capacity by the loaded goods. This can be used for palletized goods and when compartment walls can be placed only between pallet rows; you can model that placing one or two pallets in a row that can contain three pallets already blocks the complete row from the truck perspective (because these places aren't available for other compartments anymore). Figure 3.65

shows two compartment profiles: the profile **RETAIL** contains three different compartment types containing different attribute values (not shown), and the profile **FUEL_5** contains five identical compartments.

The compartment type capacity allows users to model vehicles with *fixed compartments* and *variable compartments*. If the capacities of all assigned compartments add up to exactly the figure specified as the total capacity of the vehicle, the compartments are called *fixed*. If the capacities of all assigned compartments add up to a figure greater than the capacity of the vehicle, the compartments are called *variable*.

The compartments in retail scenarios are usually variable, meaning that the vehicle can be fully loaded with frozen goods, fully loaded with chilled goods, fully loaded with ambient goods, or loaded with any combination that doesn't exceed the vehicle capacity. In a fuel distribution scenario, by contrast, the compartments are usually fixed; that is, the total vehicle capacity can be fully used only by filling each compartment to its full capacity.

Vehicle Combinations

Trailers get moved by trucks, and a *means of transport combination* specifies which truck and trailer(s), be it types or resources, are allowed to move together in one combination. We refer to a *vehicle combination* when an actual combination of vehicle types or vehicle resource instances moves together.

Means of transport combinations can only be defined for road means of transport because rail usually offers a much wider range of combinations of locomotives and railcars, which would be quite time-consuming to maintain explicitly.

A means of transport combination represents one active vehicle and one or multiple passive vehicles. Refer to Chapter 5, Section 5.4.2, for more details and background on truck and trailer combinations.

You can define means of transport combinations in Customizing by following menu path **Transportation Management • Master Data • Resources • Means of Transport and Compartment • Define Means-of-Transport Combinations** (see Figure 3.66).

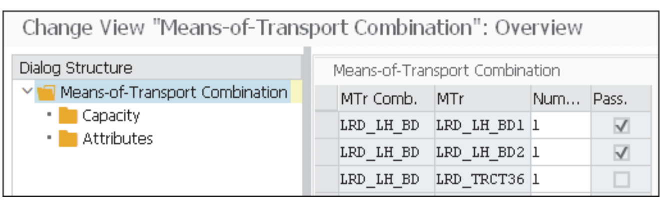


Figure 3.66 Maintaining Means of Transport Combinations

The combination contains a set of means of transport and defines the number of instances per entry. Usually, a means of transport combination can carry more goods than its individual entities. Due to legal restrictions, a vehicle combination may only be allowed to carry fewer goods than the sum of its entities could carry; this can be modeled by defining the capacity of a means of transport combination. You can also assign attribute values, which can be used to model incompatibilities, for example, between a means of transport combination and a location.

Figure 3.67 shows an example of a vehicle combination consisting of a truck and a trailer, each having three compartments. Capacity constraints can be defined for each compartment, for the truck, for the trailer, and for the vehicle combination that consists of the truck and the trailer.

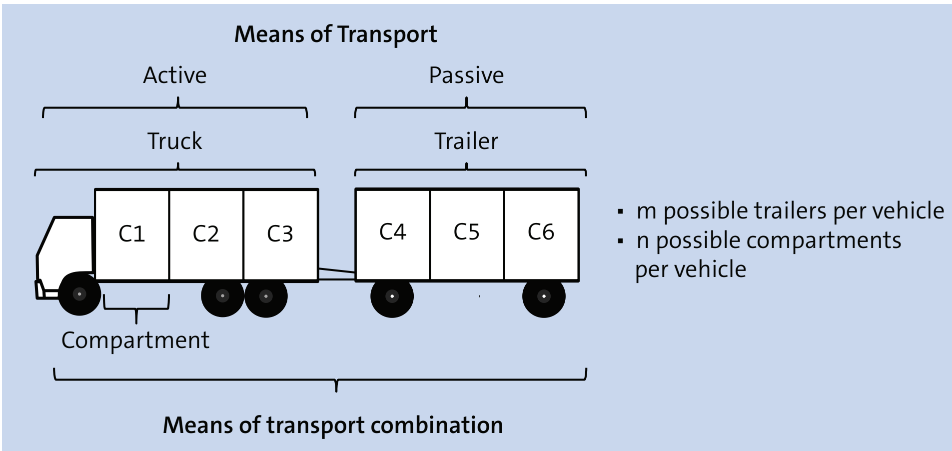


Figure 3.67 Means of Transport Combination with Compartments

Modeling Means of Transport Combinations

The VSR optimizer evaluates a succession of alternative vehicle combinations, beginning with the active vehicle and consecutively adding each of the passive vehicles. It's therefore essential to avoid any gaps in the number of permitted vehicle combinations. Consider the example depicted earlier in Figure 3.66, which contains a tractor, trailer 1, and trailer 2. If you want the VSR optimizer to use this kind of combination, you also have to define a means of transport combination that represents the tractor and trailer 1.

Vehicle/Means-of-Transport Combination versus Combination Resource/ Vehicle Type

All of these concepts sound quite similar, but what is the main difference and purpose?

On one hand, a means-of-transport combination is needed if you want to plan, automatically by the VSR optimizer or manually, scenarios with trailers being dynamically coupled or recoupled to trucks. Such plans are represented by road freight orders and trailer units, as explained in Chapter 5, Section 5.4.2. The used truck and trailer resources form a vehicle combination which may change across the stages of the involved road freight order or trailer unit. The means-of-transport combination specifies the allowed vehicle combinations.

On the other hand, a combination resource or combination vehicle type is used for scenarios without dynamic coupling or recoupling of trailers. Thus, trailer units aren't involved, and all stages of the road freight order are executed by the same combination resource or combination vehicle type, which represents a kind of vehicle combination for load planning purposes and is considered like a big truck by VSR optimizer and manual planning. The subresources or subtypes of a combination resource or vehicle type are ignored by the VSR optimizer and manual planning, but only considered by load planning.

Decreasing Capacities

One special feature is the modeling of decreasing capacities, which can be defined for both active and passive vehicle resources. In some transportation scenarios, goods are transported for several customers simultaneously and are separated by partitions within the vehicle. These partitions reduce the total capacity of the vehicle because a partition itself consumes a certain amount of capacity. The decrease in the capacity of the vehicle or transportation unit resource can be defined based on the number of stops. You can define decreasing capacities independently of compartments by choosing the Create Decreasing Capacity Settings app. Figure 3.68 shows the decreases for ranges of stops being defined for each means of transport. Each capacity decrease can be maintained absolutely or relatively and is based on the number of stops in the relevant stop range.

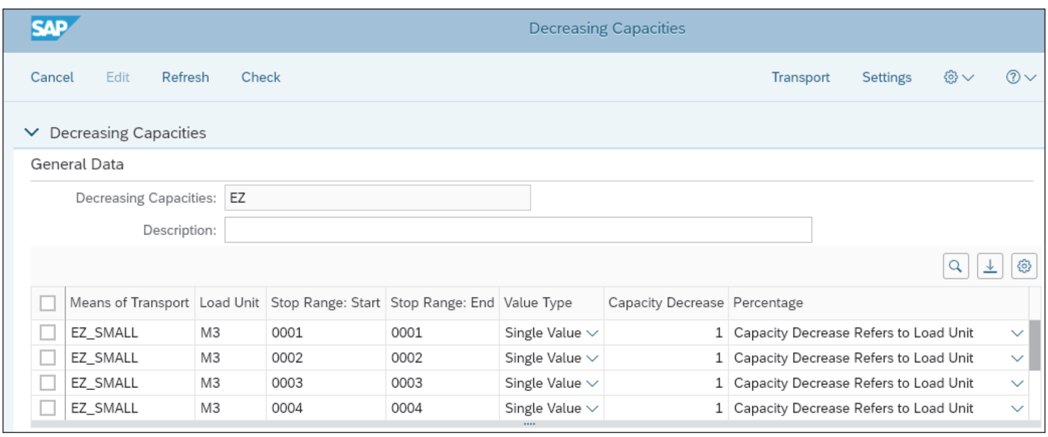


Figure 3.68 Decreasing Capacities

3.3.4 Container Types and Resources

Container resources and types, also called transportation unit resources and types, are used to model containers, which are used in road, rail, and sea modes of transport, or ULDs commonly used in air freight business. We'll explain both concepts in the following sections.

Container Resources

Figure 3.69 shows that you can maintain container resources in the same maintenance screen as vehicle resources. As the maintenance capabilities have already been described in Section 3.3.3, we just highlight some differences and a recent improvement.

A container resource isn't assigned to a means of transport. As a consequence, it's also not assigned to a mode of transport. Since the SAP S/4HANA 2022 release, you can differentiate between a single resource and a multiresource, but it's not possible to limit the number of instances for a multiresource.

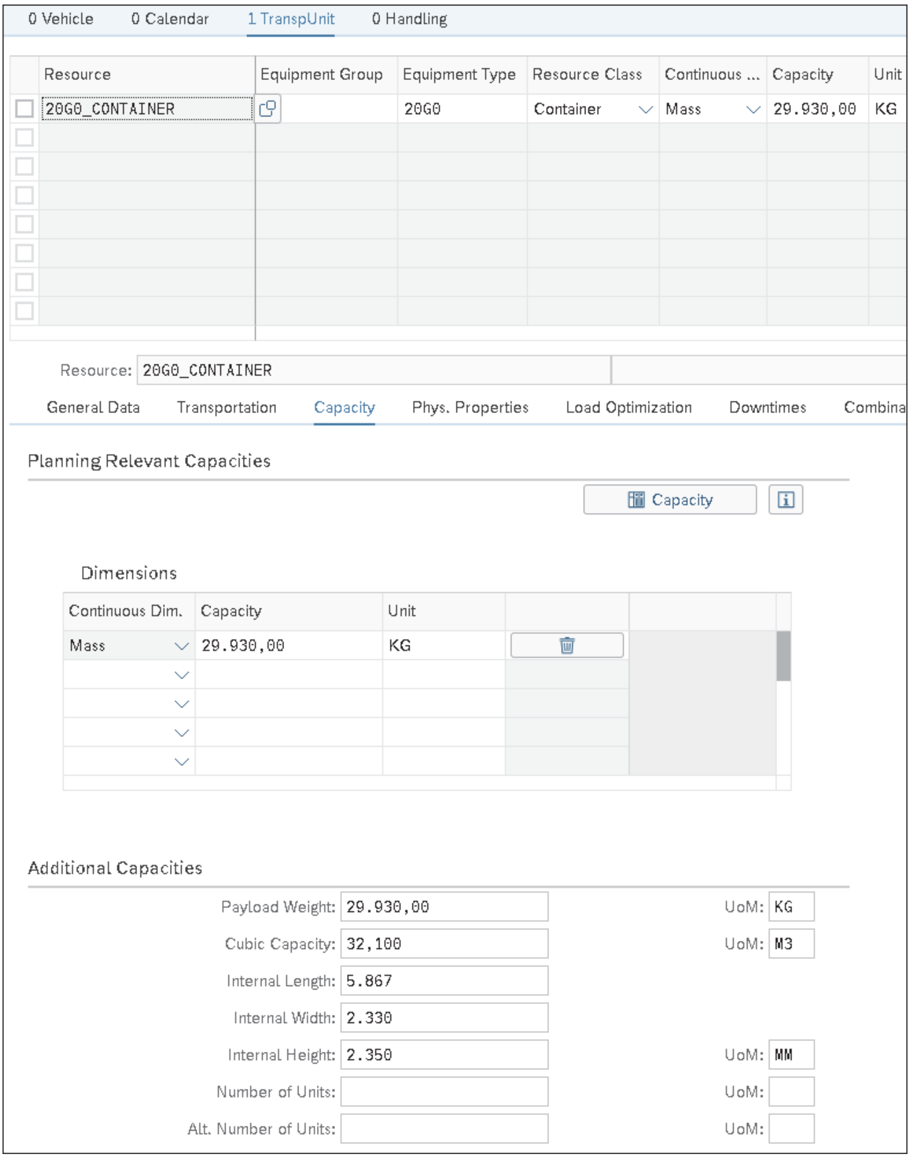


Figure 3.69 Maintaining a Container Resource

Container Types

Like vehicle resources that can be structured by vehicle groups and vehicle types, container resources can be structured by container groups and container types, as explained in Section 3.3.2. Moreover, you can also plan on the container type level, which is sufficient if you only use subcontracted containers and don't operate own container resources in your fleet.

You can maintain container types as indicated earlier in Figure 3.56 for equipment types in general. If you want to plan with a container type, you need to disable the parameter **Restricted Use in Planning**, as already explained in Section 3.3.2. A container type offers fewer fields than a container resource, but it covers all planning-relevant information such as capacities for weight and volume, and the interior length, width, and height relevant for load optimization. You can also define additional properties such as temperature control, which can be used to define incompatibilities for container types.

Transportation Units and Transportation Unit Resources

Transportation units form a class of documents representing transportation by trailers, railcars, containers, and packages. The specific documents—called trailer units, railcar units, container units, and package units—are explained in Chapter 5, Section 5.4. Transportation unit resources are used to model container resources for which you can create documents called container units. Trailer resources and railcar resources are represented by passive vehicle resources with means of transport assigned to road and rail mode of transport, respectively. There is no dedicated resource for a package; instead, the packaging material is used to define the relevant properties for a package.

As mentioned in the beginning of Section 3.3, we'll use the terms container resource and container type as synonyms for transportation unit resource and transportation unit type, to avoid any confusion with transportation units, which may also be assigned to vehicle resources and types.

3.3.5 Calendar and Handling Resources

While vehicle and container resources model the transportation of goods, calendar and handling resources define when loading and unloading can take place at a location. These resources are considered by scheduling and automated planning (see Chapter 5, Sections 5.7.10 and 5.8), and their availability and capacity can be visualized best in the Gantt chart (see Chapter 5, Section 5.7.5), which is much more intuitive than a tabular list of time periods. You can define calendar and handling resources in the same maintenance screen used for vehicle resources and container resources.

Let's briefly highlight some of the main characteristics of these resources.

Calendar Resources

Calendar resources model operating times, which define during which time periods loading and unloading can take place. You can assign a calendar resource to a specific location, but you don't have to—that is, you could even reuse the same calendar resource at various locations.

Handling Resources

Handling resources are used for handling transportation orders at a location—that is, for loading goods onto a truck (outbound) or unloading goods from a trailer (inbound). For example, handling resources can be used to map loading ramps or doors (see Figure 3.70), and they generalize calendar resources.

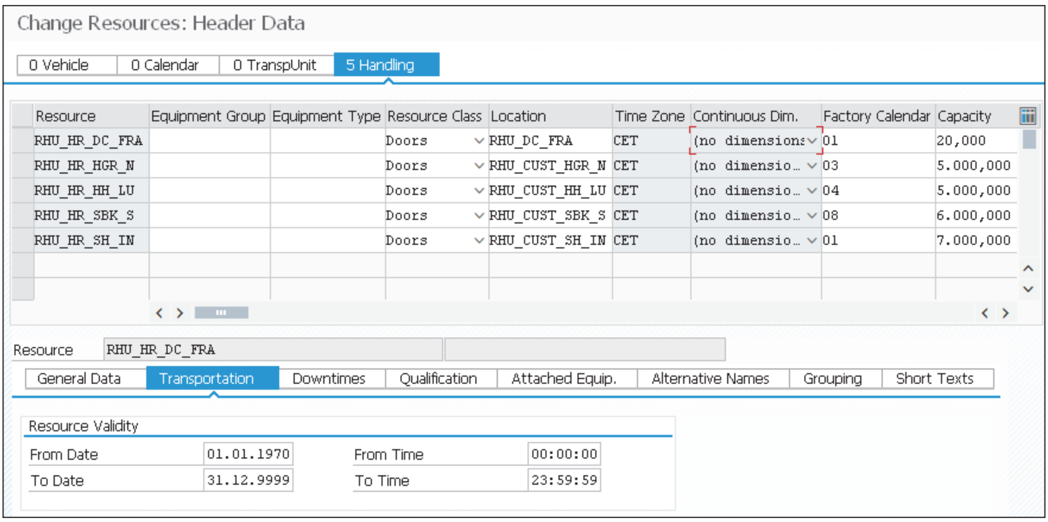


Figure 3.70 Maintaining a Handling Resource

In addition to operating times, they can define restrictions regarding the maximum number of activities that can be executed simultaneously. You can specify time-dependent capacities in the capacity profile and maintain downtimes to restrict the resource availability.

Note that you can define handling resource types as mentioned in Section 3.3.2, but these can only be used to create a handling resource instance or to group handling resources, and they aren't considered by planning or scheduling.

3.4 Summary

In this chapter, we've introduced general master data, such as the organization structure and business partners, and explained how to create and integrate them in the different deployment options of TM.

The transportation network defines how transportation demands can be executed from a geographical perspective, based on concepts such as reachability between locations and usage of transshipment locations.

We described the available equipment types and resources that represent trucks, trailers, containers, and so on that are used to move goods, and we explained calendar and handling resources that impose additional constraints on loading and unloading goods at your locations. The transportation network, equipment types, and resources are key to defining how to plan and execute your transportation.

The next chapter explains how transportation requirements are represented in TM.

Chapter 4

Transportation Requirements and Order Management

Regardless of whether you're looking from the perspective of a shipper, a logistics service provider (LSP), or a carrier, the transportation process starts with a request for transportation services. This chapter covers the different ways to start the process in transportation management (TM) and how to record the requests in the system.

When we look at a very simplified, document-driven process flow in TM, we see that not many documents are used to cover the transportation process. In fact, there are only three process steps (leaving out transportation charge management for the moment) that cover the transportation planning process, as you can see in Figure 4.1. In TM, the starting point of the process is always a *transportation request* (TRQ), followed by freight unit and transportation order.

Figure 4.1 Transportation Planning Process

TM can be used to monitor and execute the transportation processes of many different industries, so transportation process approaches can vary significantly. These approaches require different ways of starting the transportation process in the system. For example, for a shipper, transportation isn't the core business, so the focus is laid not on the ordering and execution of transportation services, but on manufacturing, materials management, and so on. The shipper will most likely use the sales and distribution or materials management functionality to cover these processes. Because the transportation process isn't the core business, the leading system in the entire value-generating process should be the core sales and distribution functionality or materials management functionality because the system handles processes that produce the competitive advantage. The TM functionality therefore *receives* information; it's not allowed to alter any information that is important for the manufacturing process.

To work within this scenario, SAP S/4HANA integrates the sales and distribution and/or materials management functionality with the TM functionality by sharing information across multiple documents. We cover this integration in Section 4.1.1.

However, if we look at the transportation process from the perspective of an LSP or carrier, the transportation process *is* the core process. Therefore, more emphasis needs to be placed on the information generated by the transportation process. Because the sales and distribution functionality doesn't provide detailed enough information for the LSP's and carrier's needs, the information needs to be generated in the TM functionality, which is now the leading information (i.e., process-driving) functionality.

Because the sales and distribution integration doesn't deliver sufficient information for transportation as a core business, the TRQ needs to be created in the TM functionality itself. So how can these different requirements be covered with only one document, as shown in Figure 4.1? The answer is that they can't. Although the main process flow remains the same, we need to take a closer look at the TRQ process step. When zooming in on this step in Figure 4.2, we can see that several documents are necessary.

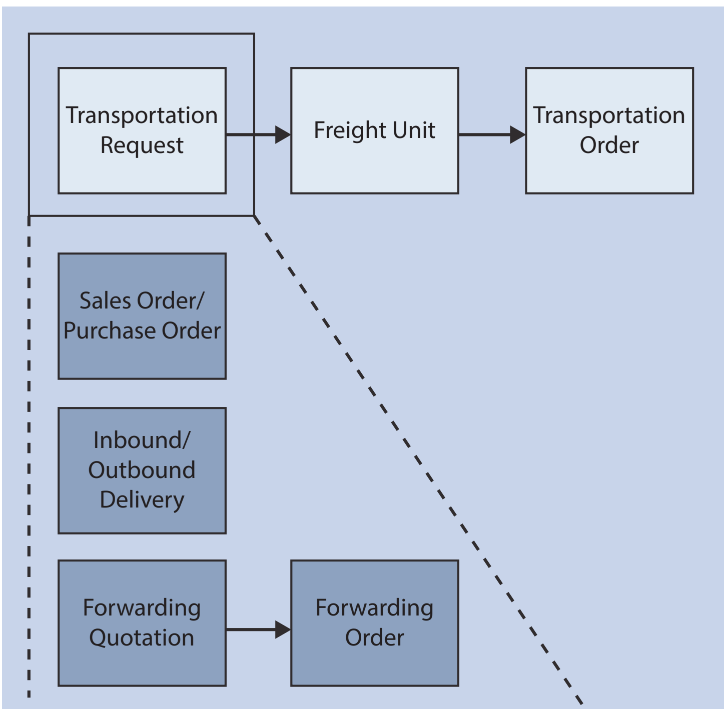


Figure 4.2 Transportation Request Documents

However, it's important to remember that all documents and the respective process variants lead to the common next step, freight unit building, which will be covered in Chapter 5.

Figure 4.2 shows the different TRQ documents. While the sales and distribution sales order, materials management purchase order, and inbound and outbound deliveries cater to the shipper's transportation process variant, the forwarding quotation and forwarding order cover the LSP's and carrier's requirements.

Now, let's delve deeper into both process variants (triggering the TM process through the integration of orders and deliveries in Section 4.1 and using forwarding orders and forwarding quotations for LSPs and carriers in Section 4.2) and focus on how these documents support the start of the transportation process.

Advanced Shipping and Receiving

In the SAP S/4HANA 2021 release, SAP introduced a new simplified integration pattern between TM, extended warehouse management (EWM), and logistics execution in SAP S/4HANA: the advanced shipping and receiving (ASR) functionality. The new integration is available for the embedded scenario only and is built based on the concepts in this chapter. The new pattern harmonizes the integration between the different logistics components and will be described in detail in Chapter 12, Section 12.3.

4.1 Triggering the Transportation Management Process

In Chapter 1, we introduced the tight integration across different functionalities as one of the major benefits of SAP S/4HANA. In this section, we take an in-depth look at how that integration can be established. First, it must be said that you don't need to be a sales and distribution component expert to establish the integration into the TM functionality, but it *is* advantageous to know a little bit about the standard sales and distribution and materials management document flow.

Triggering the Process Embedded versus Standalone

Section 4.1.1, Section 4.1.2, and Section 4.1.3 will deal with triggering the TM process if the TM functionality resides in the same SAP S/4HANA system as sales and distribution and materials management.

However, you can also run the TM functionality in a separate SAP S/4HANA TM system and connect it to an SAP S/4HANA or SAP ERP system. This integration is described in Section 4.1.4. However, in that section, we take for granted you've understood the concepts described in Section 4.1.1 to Section 4.1.3 already.

TM can integrate the following sales and distribution and materials management documents:

- Sales orders
- Purchase orders

- Stock transfer orders
- Inbound deliveries
- Outbound deliveries
- Materials management scheduling agreements
- Sales and distribution scheduling agreements (only in SAP S/4HANA TM in connection with an SAP S/4HANA or SAP ERP system)

As always, you can't immediately begin with integrating orders or deliveries into TM. First, you need to make sure the prerequisites for the integration are fulfilled. In general, there is only one major prerequisite: the master data. With the move of the TM functionality into SAP S/4HANA, this prerequisite is almost met automatically. As described in Chapter 3, the master data defined to create documents in sales and distribution and materials management is reused by the TM functionality. However, some basic considerations should be made when defining master data in SAP S/4HANA in case this master data should also be used in the TM functionality:

- **Locations and business partners**
  When defining orders in sales and distribution or materials management, we usually deal with business partners and shipping points or plants. However, the TM functionality will require entities called *locations*. If you've dealt with sales and distribution and materials management in the past, you'll notice that the entity of a location isn't used in sales and distribution and materials management. However, SAP S/4HANA now provides this kind of entity.

  For sales and distribution and materials management documents to trigger the TM process, the business partners, shipping points, and plants need to be translated to locations. This is done automatically by the SAP S/4HANA system when saving an order or delivery that is integrated with the TM component. The system checks whether locations already exist for the shipping point and business partner of the order or delivery and, if not, creates them.

  Alternatively, this can be done using program /SAPAPO/CREATE_LOCATION in Transaction SE38. The use of this program is a prerequisite to using TM in SAP S/4HANA later on because the sales and distribution and materials management functionality doesn't use locations but the TM functionality requires them.
- **Organizational data**
  In the transportation process, it's optional to assign a sales organization to a TRQ. However, if you want to represent the sales organization from the sales order in the TM TRQ, you need to transfer the organizational model to TM as you can create an independent organizational model in TM.

Furthermore, some *business functions* need to be activated for the TM integration. The following business functions are required; some of them are specifically designed for the TM integration:

- LOG_TM_ORD_INT
- LOG_TM_ORD_INT_II
- LOG_TM_ORD_INT_III
- LOG_TM_ORD_INT_IV
- LOG_TM_IV_INT
- SD_01
- OPS_ADVRETURNS_1

These business functions are necessary for the integration with the TM functionality within the same SAP S/4HANA system. In SAP S/4HANA, the functions are already activated by default. For integrating with TM functionality outside of the same system, see Section 4.1.4.

We'll walk through the different integration steps to trigger the TM process in the following sections.

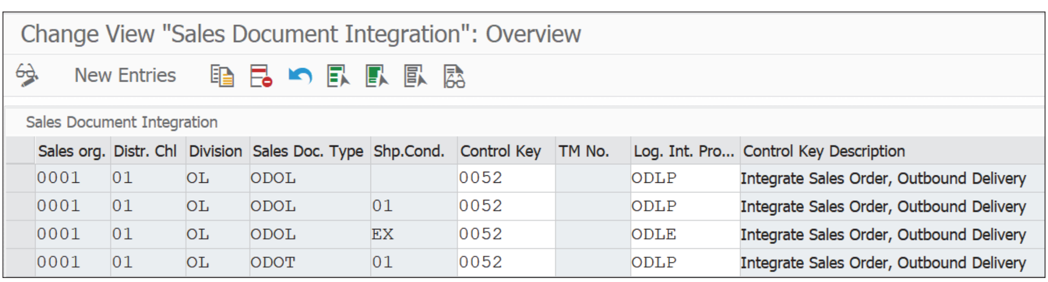
4.1.1 Sales Order Integration

The most commonly used type of integration between sales and distribution and TM is the *sales order integration*. With sales order integration, shippers use the TM functionality to organize the transport of goods sold to the customer. In this section, we focus on how to trigger the TM process from a sales order.

We activate the integration of sales orders into the TM functionality with IMG path **Transportation Management • Integration • Logistics Integration • Internal TM Component Integration • Define Transportation-Relevance of Sales Documents**.

As you can see in Figure 4.3, the activation of a sales document always depends on three things:

- Sales organization (**Sales org.**) plus distribution channel (**Distr. Chl**) and **Division**
- Sales order type (**Sales Doc. Type**)
- Shipping condition (if not relevant, you can leave **Shp.Cond.** empty)


Change View "Sales Document Integration": Overview

New Entries

Sales Document Integration

Sales org.	Distr. Chl	Division	Sales Doc. Type	Shp.Cond.	Control Key	TM No.	Log. Int. Pro...	Control Key Description
0001	01	OL	ODOL		0052		ODLP	Integrate Sales Order, Outbound Delivery
0001	01	OL	ODOL	01	0052		ODLP	Integrate Sales Order, Outbound Delivery
0001	01	OL	ODOL	EX	0052		ODLE	Integrate Sales Order, Outbound Delivery
0001	01	OL	ODOT	01	0052		ODLP	Integrate Sales Order, Outbound Delivery

Figure 4.3 Integration of Sales Documents

The activation of the sales document is done via a *control key*, which defines which document types should be integrated. Figure 4.4 shows some of the standard control keys, which can be accessed via IMG path **Transportation Management • Integration • Logistics Integration • Internal TM Component Integration • Define Control Keys for Document Integration**. Note that the control keys also define whether the sales orders are integrated with the TM functionality within the SAP S/4HANA system or are sent to an external SAP S/4HANA TM system. This is defined with the **Integration Mode**, as shown in Figure 4.4. In this section, we'll only discuss the integration with the TM functionality within the same SAP S/4HANA instance.

Change View "Control Key Parameters": Overview

New Entries

Control Key Parameters

Ctrl Key	Integration Mode	SO to TM	PO to TM	Outbd Del.	Inbd Del.	SO Sched.	PO Conf.	Pln. Stat.	Control Key Description
0001	External TM System	☑	☐	☑	☐	☐	☐	☐	Transfer Sales Order, O. Delivery; Order Scheduling inactive
0002	External TM System	☑	☐	☐	☐	☐	☐	☐	Transfer Sales Order; Order Scheduling inactive
0003	External TM System	☑	☐	☑	☐	☑	☐	☐	Transfer Sales Order, O. Delivery; Order Scheduling active
0051	I Internal TM Comp...	☑	☐	☐	☐	☐	☐	☐	Integrate Sales Order
0052	I Internal TM Comp...	☑	☐	☑	☐	☐	☐	☐	Integrate Sales Order, Outbound Delivery
0053	I Internal TM Comp...	☐	☐	☑	☐	☐	☐	☐	Integrate Outbound Delivery
0054	I Internal TM Comp...	☐	☑	☐	☐	☐	☐	☐	Integrate Purchase Order
0055	I Internal TM Comp...	☐	☑	☑	☑	☐	☐	☐	Integrate Purchase Order, Inbound Delivery
0056	I Internal TM Comp...	☐	☐	☐	☑	☐	☐	☐	Integrate Inbound Delivery

Figure 4.4 Control Keys for Order and Delivery Integration

When looking in detail at Figure 4.3, shown previously, you'll notice that a *TM number* (**TM No.**) can be entered in some cases and a *logistics integration profile* (**Log. Int. Pro**) was maintained in other cases. The TM number is used when integrating with an external SAP S/4HANA TM system, thus we'll come back to this in Section 4.1.4.

The logistics integration profile, as depicted in Figure 4.5, is crucial to the entire TM process because it consolidates all configuration that is required to trigger the process, such as the freight unit building rule or the decision regarding whether to plan on requested or confirmed quantities. You can access the logistics integration profile via IMG path **Transportation Management • Integration • Logistics Integration • Internal TM Component Integration • Define Logistics Integration Profile**.

When integrating a sales and distribution sales order with the TM functionality, a freight unit is created directly from the sales order. The logistics integration profile, which we assigned to a sales order document type and—optionally—the sales organization and shipping condition combination in Figure 4.3, defined how the freight unit was built. We'll discuss freight units in further detail in Chapter 5, Section 5.2.

In Figure 4.5, you can see a setting defining the system behavior when dealing with Incoterm locations. Usually, the freight unit created out of the order or delivery would only contain one stage, from the source to destination. Potential intermediate stops would be determined during the planning process. However, the Incoterm location defined in the order or delivery can have an impact on the routing of the freight unit.

In Figure 4.5, the **Incoterm Loc. Stage Bldng** field defines how the Incoterm location of the order should be interpreted.

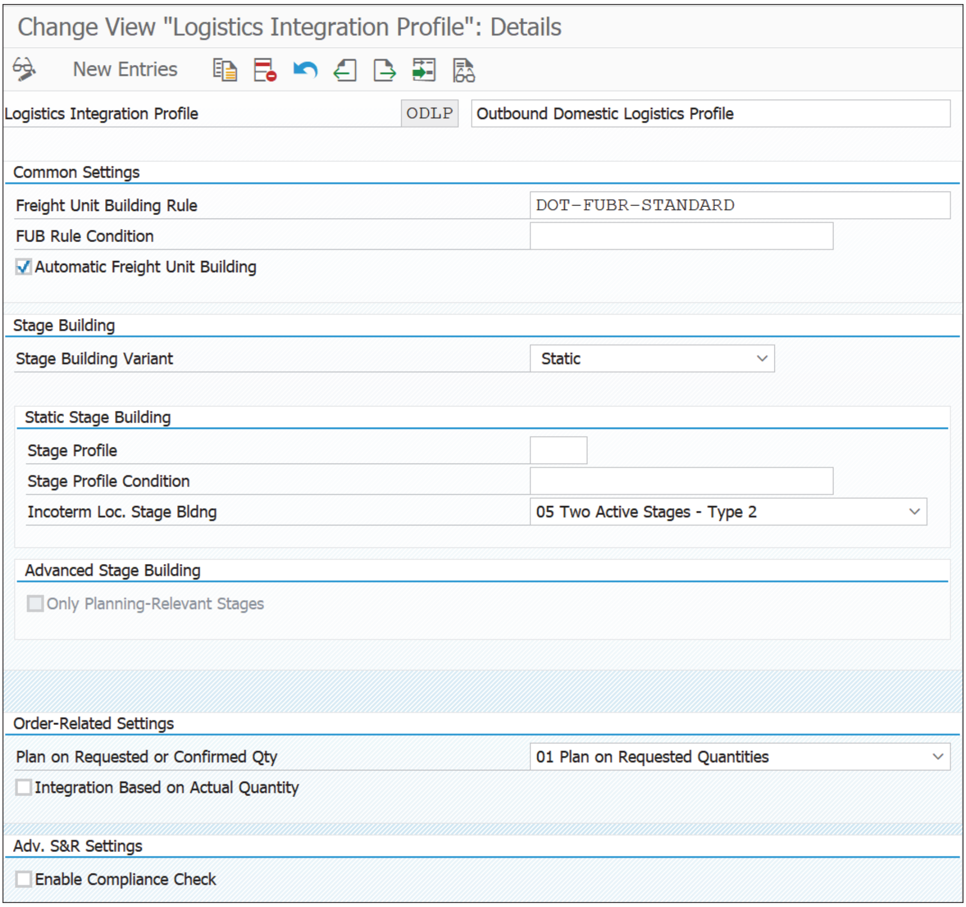


Figure 4.5 Logistics Integration Profile

Depending on the Customizing entry you've chosen, two stages are created in the freight unit. As shown in Figure 4.6, stage 1, represented by the bold line, leads from the source location to the Incoterm location. Stage 2, shown as the dashed line, leads from the Incoterm location to the destination location.

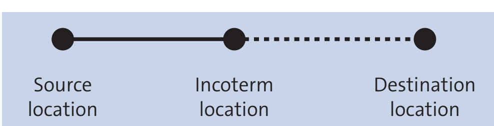


Figure 4.6 Stage Split on Incoterm Location

Depending on the scenario, the stage that is relevant for the shipper's planning can be stage 1 or stage 2. Remember, a freight unit represents an SAP S/4HANA sales order as well as a purchase order and a stock transfer order. This means that freight units can be used for both outbound transportation processes and inbound transportation processes.

Therefore, the Customizing entries apply to both outbound and inbound processes. With this Customizing entry, you can define whether the shipper is responsible for stage 1 or stage 2. The Customizing entry also defines whether the stage the shipper isn't responsible for should be created at all. If it should be created, it will be created as a *statistical stage*, meaning it has no influence on the freight unit and therefore on the planning process steps.

If you've integrated an order that represents an internal transfer of goods, such as with a stock transfer order, and the shipper is nevertheless responsible for the entire transportation, you can also choose to create two relevant stages. If no Incoterm location is entered in the order, no stage splitting is done during freight unit building.

In sales orders, you can assign multiple customers and creditors to the order using different partner functions. In the freight unit, you can see on the **Business Partners** tab that the documents in TM also apply to the participation of different business partners in the transportation process.

However, you need to map the defined partner functions of the order to the *business partner roles*. You can define the partner functions in Customizing by following IMG menu path **Transportation Management • Master Data • Business Partners • Define Partner Functions**. In a standard SAP S/4HANA system, the most common party roles are already predefined. The business partner roles are defined in the master data record of the business partner. This defines what roles the business partner can assume (e.g., vendor, driver, carrier, etc.). To use this information in the TM documents, the business partner role needs to be translated into a partner function. This can be defined in Customizing using IMG path **Transportation Management • Master Data • Assign BP Roles to Partner Functions**.

4.1.2 Integration of Materials Management Orders

The integration of materials management orders is, in many regards, similar to the integration of sales and distribution documents. The most important Customizing activity in SAP S/4HANA for the transfer of materials management documents is the specification of the control keys and logistics integration profiles, as just described in the previous section.

The integration of purchasing documents can be activated in Customizing using IMG path **Transportation Management • Integration • Logistics Integration • Internal TM Component Integration • Define Transportation-Relevance of Purchasing Documents**. Similar to the activation of sales documents, the logistics integration profile and control key define how the integration with the TM functionality is processed.

4.1.3 Integration Scenarios

Once the sales order and purchasing documents are integrated with the TM system, there are two main integration scenarios for the transportation process: integration driven by TM using delivery proposals, or integration driven by sales and distribution and materials management without using delivery proposals. We'll discuss both options in the following sections, and also provide insight into an internal versus external approach to TM integration.

Integration with Delivery Proposals

If the TM system is the dedicated system leading the transportation process, you would probably set up the integration scenario as shown in Figure 4.7.

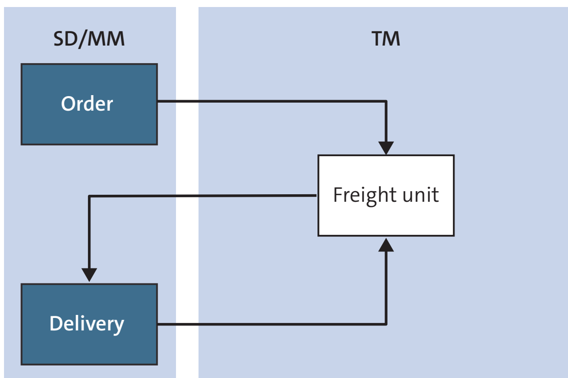


Figure 4.7 Order Integration with Delivery Proposal

The order is created in sales and distribution or materials management and then integrated into the TM functionality. In TM, the freight units are created automatically. Now the process continues in TM. The freight units are planned on freight orders according to the delivery dates, service levels, Incoterms, and so on that were defined on the orders.

After the planning of the freight unit is done, we know a more precise delivery date of the goods that were ordered. This information can then be played back to sales and distribution or materials management, where delivery documents are created accordingly. This process step is called the *delivery proposal*.

Delivery proposals are used to propagate planning information from TM to sales and distribution or materials management, where deliveries are then created. The process is called delivery proposal and not delivery creation because, in the end, sales and distribution and materials management decide how deliveries should be created. The information for the delivery proposal derives from the freight units.

After you've finished planning the freight units, follow menu path **Logistics Integration • Create Deliveries**. When you enter a selection profile (preferably the same one you've used for planning), your freight units are displayed. Select the freight units you want to create delivery proposals for, and choose **Create Delivery Proposals**. You can review the proposals at the bottom of the screen and then send the proposals to sales and distribution or materials management by clicking **Create Deliveries**, as shown in Figure 4.8.

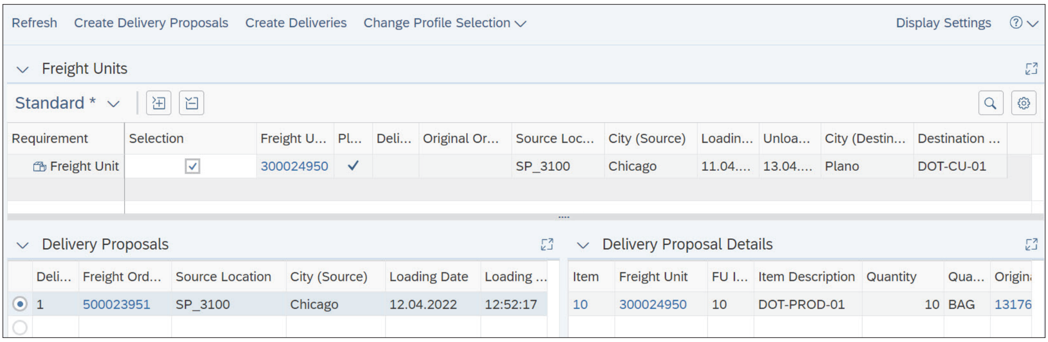


Figure 4.8 Create Delivery Proposal

The delivery proposals are created using settings and information from the freight units. While the delivery dates are collected from the freight order that is now assigned to the freight units, the quantities are taken from the freight units themselves. TM also tries to consolidate several freight units into one delivery proposal, if possible, for example, when they are planned onto the same freight order. However, the consolidation is done only if the order allows order consolidation.

Speaking of quantities, it's also possible to create delivery proposals based on the quantities actually picked up by the carrier. This scenario is especially important for bulk transportation and only applicable if delivery creation can be done only after execution has already started. In this scenario, the freight orders are created based on the freight units and sent to the carrier, and the carrier picks up the goods. As part of the execution process, which we delve deeper into in Chapter 7, Section 7.1, the carrier now reports the actual weight and volume of the goods picked up.

When the **Actual Qty** checkmark is selected in the logistics integration profile (refer to Figure 4.5), the delivery proposal is created based on the actual quantity reported by the carrier and not based on the planned quantity of the freight unit.

After the delivery proposals are released, delivery documents are created. sales and distribution and materials management might split one TM-based delivery proposal by creating several deliveries, possibly due to additional split criteria maintained in the order and delivery document type Customizing. However, no data (e.g., dates or quantities sent from TM) is changed, and separate delivery proposals created in TM aren't consolidated into one delivery in sales and distribution or materials management.

The delivery proposal in TM also takes into account that sales and distribution and materials management consume order schedule lines in chronological order. Therefore, the TM functionality proposes a delivery for a schedule line of an order item only if all schedule lines of the same order item with earlier delivery dates already have an assigned delivery.

In TM, you can also define how delivery proposals should be created. These settings are consolidated in a *delivery profile*. Although the delivery profile is optional, it makes sense to create a profile to reuse the same settings every time you want to create delivery proposals. You can define delivery profiles via the SAP Fiori launchpad menu path **Profiles and Settings • Create Delivery Profile**. The settings you can define here concern how and if freight units can be consolidated into one delivery proposal and which freight units may not be consolidated.

One option of the delivery profile is to "fix" the planning result for freight units and freight orders by selecting the **Fix Planning Results** checkbox, which is shown in Figure 4.9. Fixing the planning means after the planning results are transferred via the delivery proposals, they can no longer be changed in TM. This is a good strategy because you might continue processing the transferred data in the orders and deliveries, as well. You'll learn more about fixing freight orders in Chapter 6. You can define how the delivery proposals should be created (e.g., one proposal per item, one proposal per freight unit, etc.).

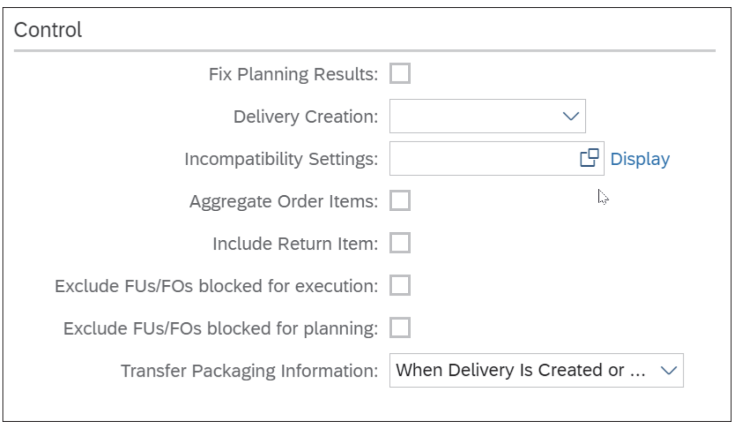


Figure 4.9 Delivery Profile

The last feature of delivery profiles that we want to mention is incompatibilities, which we introduced in Chapter 2. Incompatibilities in delivery profiles can be used to prevent certain freight units or items from being consolidated into one delivery proposal.

Delivery profiles are optional and especially unnecessary if you've already planned the freight units; in this case, TM considers the freight units consolidated on freight orders. Settings such as incompatibilities are already taken into consideration during the planning process. However, if you want to create delivery proposals *before* the freight units are planned, you can do this as well. In this case, the settings in the delivery profile are crucial to help TM decide which freight units should be consolidated.

Delivery Proposal in Background

In a daily business, you probably won't manually create delivery proposals every time you've finished planning some freight units. Therefore, background report /SCMTMS/DLV_BATCH was created for you to run as a batch job. You need to define a selection profile by selecting your freight units or freight orders; the background report does exactly what you can do interactively in the SAP Fiori launchpad (skipping your review, of course).

After the delivery proposals have been sent, deliveries are created. TM receives information about the status of the delivery creation. The delivery type being used for the delivery creation is the one defined in the sales and distribution or materials management setup. If you've activated the transfer of this delivery type to TM as well, then not only is a short message about the delivery creation transferred to TM, but even more happens—the delivery is integrated, and the freight unit, initially created for the order, is updated with information from the delivery. You might be wondering what we can do with the delivery information now because the planning process has already happened. Recall that sales and distribution or materials management might create deliveries slightly differently from the delivery proposal; this information is then represented in the updated freight unit.

If you look into the document flow of the freight unit now (see Figure 4.10, accessed via the SAP Fiori launchpad by going to **Planning • Edit Freight Unit**), you can see not only the TM documents but also the order and delivery documents. What you'll also notice is that the order is now a predecessor document of the delivery, and the delivery is again a predecessor document of the freight unit (even though the freight unit was created before the delivery).

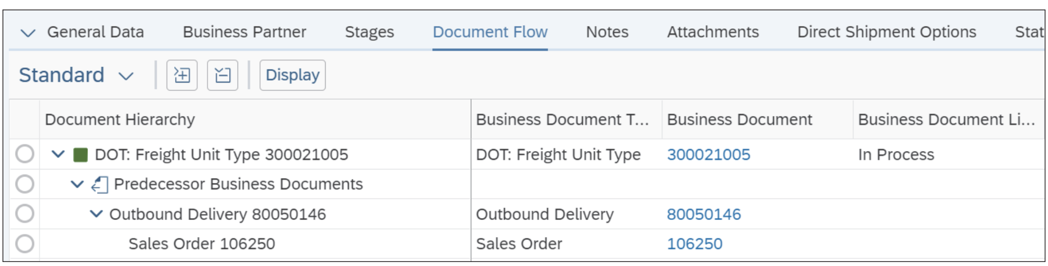


Figure 4.10 Document Flow after Delivery Proposal

Integration without Delivery Proposals

In the integration scenario described previously, TM was leading the planning process; it decided not only how the planning should be done but also whether and how the items of the order were split or consolidated. In some cases, it makes sense to leave that decision in sales and distribution or materials management. Because the freight unit can be created from the order and the delivery, you can decide whether to leave out the integration of either one. The benefit of using TM for leading the planning process is that you can start the process earlier than starting with a delivery, which is created most of the time only a few days before departure. It enables logistics departments to start negotiations and bookings with carriers earlier, and, in the end, it will reduce the cost of the transports.

Figure 4.11 shows how the integration scenario works if sales and distribution or materials management is still the leading system for delivery creation and item order consolidation. In this case, the order would not trigger the TM process and thus the freight unit creation. Only after the delivery is created for the order should freight units be created.

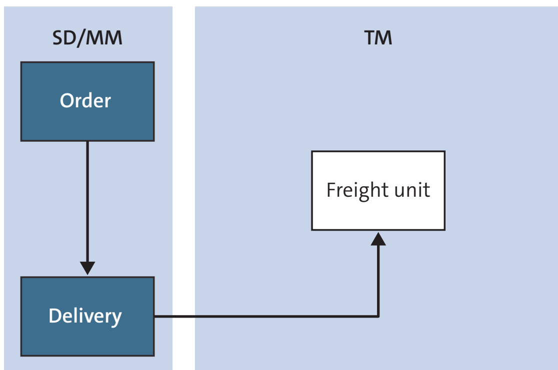


Figure 4.11 Delivery Integration without Delivery Proposals

Those freight units now better represent the splits and consolidations that have been done previously in sales and distribution or materials management. Planning can now start. Changes of the delivery date during planning will be transferred to the delivery.

Internal versus External Integration

So far in this section, we've only delved into the architectural setup of TM as part of the same SAP S/4HANA system instance as the sales and distribution, materials management, and logistics execution functionality. This setup is called *internal TM component integration*. As you can see in Figure 4.12 ❶, the TM component can directly communicate with the sales and distribution and materials management functionalities without the need of any cross-system messages.

However, there are also cases where TM isn't part of the same system instance as the sales and distribution, materials management, or logistics execution functionalities. This case is called *external TM system integration*. Scenario ❷ in Figure 4.12 describes the case of several SAP S/4HANA systems being run in parallel, of which one hosts the TM component. This makes sense in large-scale companies that require multiple SAP S/4HANA systems but still want to use a centralized TM system. The functionality and user experience in this scenario is similar to scenario ❶.

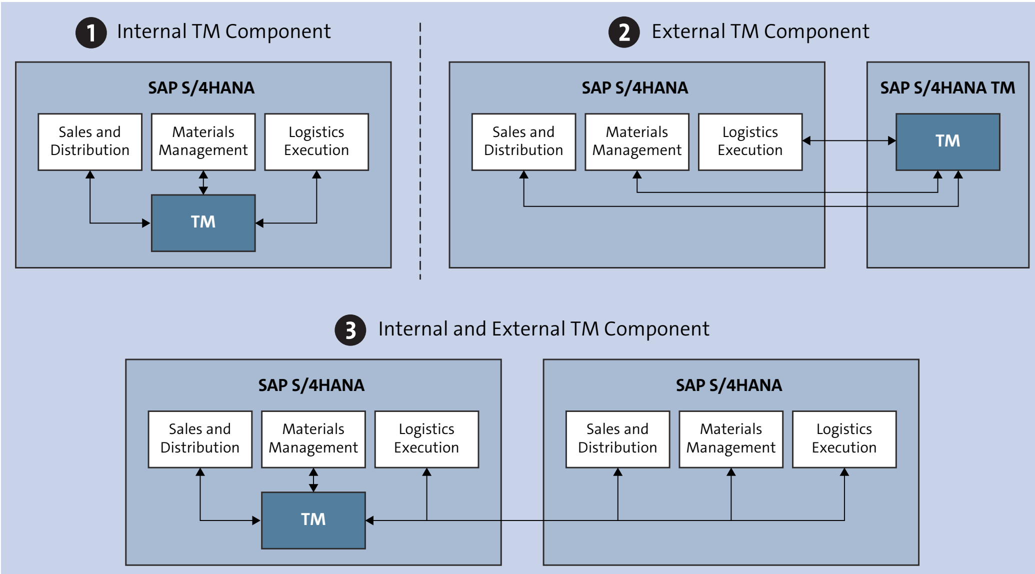


Figure 4.12 Architectural Integration Scenarios

When using an external TM system integration, we can no longer create the freight units directly from the orders and deliveries. In this case, we need an intermediary document in TM to reflect the information passed from the order and/or delivery. The document representing the order's information in TM is called *order-based transportation requirements* (OTR) and is a copy of the data maintained in the sales order or purchase order (or scheduling agreement).

The delivery documents are represented in TM by the *delivery-based transportation requirement* (DTR). Both OTR and DTR are read-only documents in TM as they represent the order and delivery information in the SAP S/4HANA system, which is the leading information system. Any change in order quantity therefore has to be maintained in the order or delivery and propagated to the OTR and DTR document. In the following section, we'll now take a more detailed look at the OTR and DTR document and how the overall process flow differs with these documents in place.

The internal and external scenario (Figure 4.12 3) is slightly different. It's also intended to serve large-scale companies with multiple SAP S/4HANA systems but with the benefit of not having a separate TM box that needs to be maintained. The internal and external integration can be used at the same time in TM. For the internal component, no OTRs and DTRs are created; for the external part, the documents are created.

4.1.4 Order-Based and Delivery-Based Transportation Requirements

Let's assume we're using an external TM component. After the sales order is created, a web service will send information from SAP S/4HANA to SAP S/4HANA TM. After the web service is successfully executed, a document is created in the TM system; this is the OTR, which represents the sales order data generated in SAP S/4HANA and carries all information relevant for the transportation process.

Orders and Deliveries Originating in SAP ERP

This section mainly covers the process of how data is sent from sales and distribution and materials management functionality to TM functionality that isn't part of the same SAP S/4HANA instance as sales and distribution and materials management. We'll discuss the integration with the example of using the sales and distribution and materials management functionality in SAP S/4HANA. However, the information described in this section also holds true when using the Sales and Distribution (SD) and Materials Management (MM) components in an SAP ERP system (IMG paths might be slightly different in an SAP ERP system than described in this section).

In the following sections, we'll look at the technology and configuration involved to transfer information to TM in SAP S/4HANA and how it's processed, starting with the integration of order documents and covering delivery documents later on.

Order Documents

Recall Figure 4.3 in which we activated the integration of sales documents. Remember that we mentioned the TM number that can be maintained in this Customizing activity, which is only relevant when communicating with an external TM component. You'll notice when you fill in this field that no F4 help is available. The purpose of this field is to link one SAP S/4HANA system to several TM systems. If several TM systems are linked to one SAP S/4HANA system, and the TM number is filled, SAP S/4HANA decides to which TM system the order should be sent, based on the entries made in the table shown previously in Figure 4.3. However, you can enter anything you like here. The "navigation" of which logical system the message is routed to is done entirely in SAP Process Integration, where the string sent from SAP S/4HANA is interpreted and translated into a logical system. If you encounter such a situation, consult an SAP Process Integration expert to ensure that the routing is performed correctly.

In contrast to the direct creation of freight units upon saving the sales order or purchase order, a message needs to be created that sends information from SAP S/4HANA to TM. Therefore, the sales order needs to create an output. Sales and distribution has a feature called *output determination* that is used to control the output—meaning follow-up activities, messages, and documents—for sales, shipping, transportation, and billing. It's used to exchange information with external and internal systems that represent business partners when looking at it from a process perspective. Output determination can automatically propose output for a sales and distribution document using the condition technique that we already know from SAP ERP (not to be mistaken with Business Rules Framework plus [BRFplus] conditions used in the TM functionality).

As you can see in Figure 4.13, the core of the output determination is the output determination procedure, which consists of steps that are supposed to be executed in the given order. Each step represents a condition of a defined condition type; this condition determines whether an output of the defined output type should be triggered.

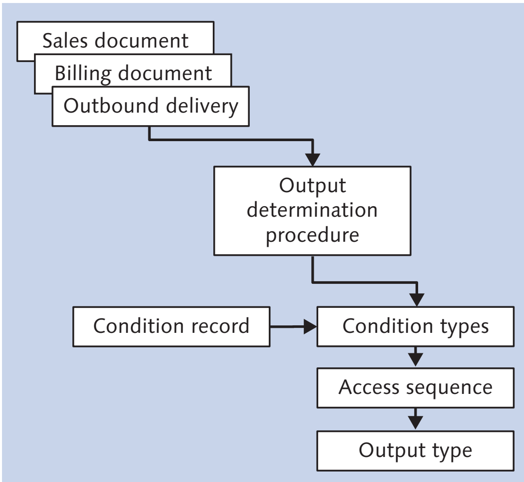


Figure 4.13 Output Determination in Sales and Distribution

The *condition type* is linked to the output type and can contain condition records that define when an output should be triggered. In terms of structure, a *condition record* is a table (like the decision table in conditions used in the TM functionality) that is used to find a value. However, in this condition technique, a condition type can contain several condition records of different structures (e.g., one condition record where the input data is sales organization and customer, and a second condition record where the input data is order type).

With the *access sequence*, you can define in which order the condition records should be processed. Because the condition type is linked to the output type, you don't need to define which output needs to be triggered. This is implicitly done in the output determination procedure, where you define a condition type.

Recall that the output type is linked to the condition type, meaning that after the condition type finds a suitable result, the output of this output type is triggered. In SAP S/4HANA, several output types are available that represent print output, Electronic Data Interchange (EDI) messages, application to application (A2A) messages, email, and so on. Some of these are shown in Figure 4.14.

For the integration of the sales order, you need to create a new output type (output type TRSO). To do this in your SAP S/4HANA system, follow IMG menu path **Sales and Distribution • Basic Functions • Output Determination • Output Determination • Output Determination Using the Condition Technique • Maintain Output Determination for Sales Documents • Maintain Output Types**.

Figure 4.14 Output Types in SAP S/4HANA Sales and Distribution

To maintain the output type TRSO, you need to define general data, processing routines, and partner functions, as shown on Figure 4.15.

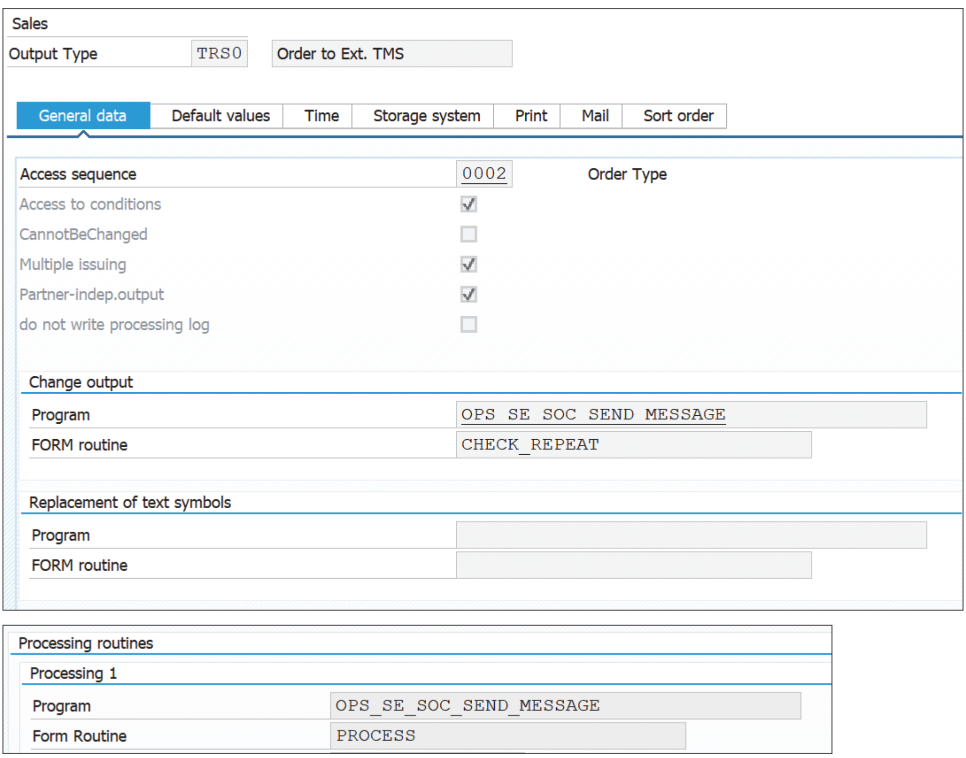


Figure 4.15 Output Type TRSO

After the output type is configured, you can add it to the output determination procedure by following IMG menu path **Sales and Distribution • Basic Functions • Output Determination • Output Determination • Output Determination Using the Condition Technique • Maintain Output Determination for Sales Documents • Maintain Output Determination Procedure**. Simply add a new step with condition type TRSO and requirement 27 to procedure V10000.

Assignment of Output Determination Procedures

This chapter assumes use of the standard output determination procedure and the standard sales order type for integration. However, it's clear that this might not always be the case. If you're using a different sales order type, you can assign an output determination procedure to the order type by following IMG menu path **Sales and Distribution • Basic Functions • Output Determination • Output Determination • Output Determination Using the Condition Technique • Maintain Output Determination for Sales Documents • Assign Output Determination Procedures**.

After you've configured these SAP S/4HANA settings, a message according to output type TRSO is always sent when sales orders are created, updated, or deleted.

In contrast to sales and distribution documents, materials management documents (e.g., purchase orders) use the workflow technology known from previous SAP ERP releases for processing the output. Therefore, error handling as described for the sales order isn't possible for purchase orders, stock transfer orders, or inbound deliveries.

The OTR is the corresponding TM document that contains all transportation-relevant information from the SAP S/4HANA orders. It can represent four things:

- Sales orders
- Purchase orders
- Stock transfer orders
- Sales and distribution and materials management scheduling agreements

For TM, it doesn't matter whether the predecessor document was a sales order, stock transfer order, purchase order, or scheduling agreement. The OTR represents all of these SAP S/4HANA document types.

Remember from Chapter 2, Section 2.3.1, that there is a singleton condition that is used to define the OTR type of integration SAP S/4HANA orders. You can create and define a condition of the condition type `/SCMTMS/OTR_TYPE` to differentiate OTRs by type, as shown in Figure 4.16.

Among other information, you can also use the sales order type used in SAP S/4HANA for the condition definition. There is a predefined data access definition that you can use for this. In Figure 4.16, sales order type **TMUB** and **TMNB** will lead to an **OTR Type TM7O**. If the condition doesn't find a result, the default type is used. The default type is defined in Customizing for OTR types with a corresponding flag.

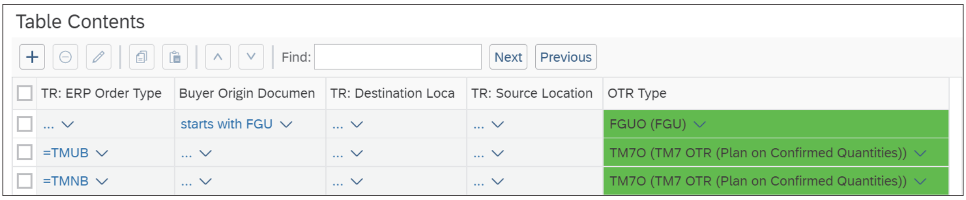


Figure 4.16 Condition /SCMTMS/OTR_TYPE to Define the OTR Type

Let's take a close look at the OTR document itself. You'll notice in Figure 4.17 that, compared to other TM documents, the amount of information is relatively low because the only information stored on the OTR is transferred from SAP S/4HANA and is crucial for the transportation process. You can access the OTR via the SAP Fiori launchpad by going to **Logistics Integration • Display Order-Based Transp. Requirement**.

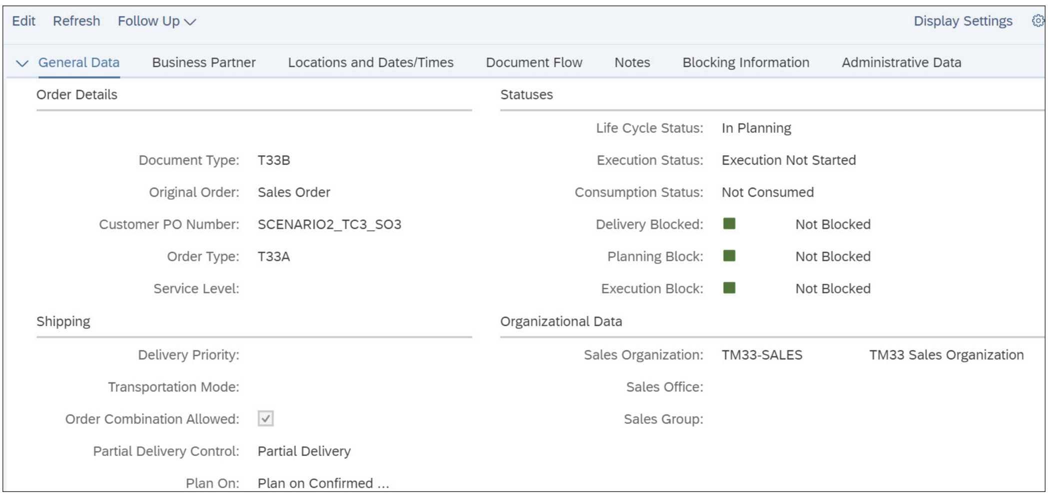


Figure 4.17 Order-Based Transportation Requirement

The most important difference from other documents in TM is that there are no action buttons on the OTR. The document is read only, with no changes allowed because, in this scenario, the SAP S/4HANA system is the leading information system, so any updates should come from SAP S/4HANA.

On the **General Data** tab, you'll see the most important information, such as the OTR document type and the total weight and volume of the freight. There is also a field for a sales organization. Recall that you can integrate your sales organization from SAP S/4HANA and put it on the OTR, but it might not serve for the purposes of TM.

Sales Organization in SAP S/4HANA and TM

When first looking at the empty **Sales Organization** field on the OTR document, you might find it strange that the sales organization used in the SAP S/4HANA sales order wasn't moved over to the OTR. However, in most cases, this is correct. Because TM covers the transportation process, the sales organization in this case isn't the organizational unit selling the *products* anymore; the sales organization in the OTR is the organizational unit selling the *transportation services*. In most cases, these are different organizational units, if the shipper even sells the transportation of products at all.

On the bottom of the screen displaying the OTR document, you can see the information area for the items. Because one OTR represents one sales order, all items of the sales order are displayed and listed here. Here you can also find the delivery date that was assigned to the items on the SAP S/4HANA sales order. The delivery date in SAP S/4HANA can be defined in many different ways, such as using a connected available-to-promise (ATP) check or simple route determination in SAP S/4HANA. No matter which way you determine the delivery date in SAP S/4HANA, it's a date the TM system will work with.

On the **Locations and Dates/Times** tab, you can see the locations of the entire transportation. The source location is the shipping point or plant for which the sales order was created. The destination location is the location that was created from the customer transferred from SAP S/4HANA. Note that the destination location isn't for the sold-to party maintained in the sales order, but for the ship-to party.

You'll notice that, in many cases, the source and/or destination locations are empty. This is because the source and destination location can vary from item to item, depending on the storage location or shipping point assigned to the items of the SAP S/4HANA order. During freight unit building, several freight units are created for the OTR because the transportation locations of the items differ. If the source location on the header level of the OTR document is empty, you can assume that it's created for an SAP S/4HANA sales order; if the destination location is empty, you can assume it's created for an SAP S/4HANA purchase order.

In Section 4.2.1, we describe how the transportation order clerk can manually predefine the routing of the transportation requirements by adding stages to the forwarding order. With OTRs, there is no such functionality. The transportation path is simply defined from shipping point to customer for a sales order, meaning that the OTR contains only one stage. (We describe one exception concerning Incoterm locations later.)

After freight unit building, the freight unit stage can be split into several stages if the transportation process requires this. This process represents the difference between the *ordered route* and the *actual route*. As its name suggests, the ordered route is the routing that was ordered by the customer (for an integrated SAP S/4HANA order, simply a direct transportation path). The actual route, on the other hand, is the route that was actually used. If the SAP S/4HANA sales order was defined from a shipping point in Germany to a customer in the United States, the ordered route is simply from Germany to the United States. However, the actual route looks different—for example, one stage is from Germany to a port in the Netherlands, one stage is from the Dutch port to an American port, and one stage is from the American port to the customer. Therefore, although the ordered route differs from the actual route, the actual route isn't reflected on the OTR; the OTR represents only the transportation *requirement* and therefore the ordered route.

When looking at the Customizing of OTR types as depicted in Figure 4.18, you'll see that, compared to other document types in TM, there isn't much to customize here. You can access the OTR type Customizing by following IMG menu path **Transportation Management • Integration • Logistics Integration • External SAP TM System Integration • Order-Based Transportation Requirement • Define Order-Based Transportation Requirement Types**.

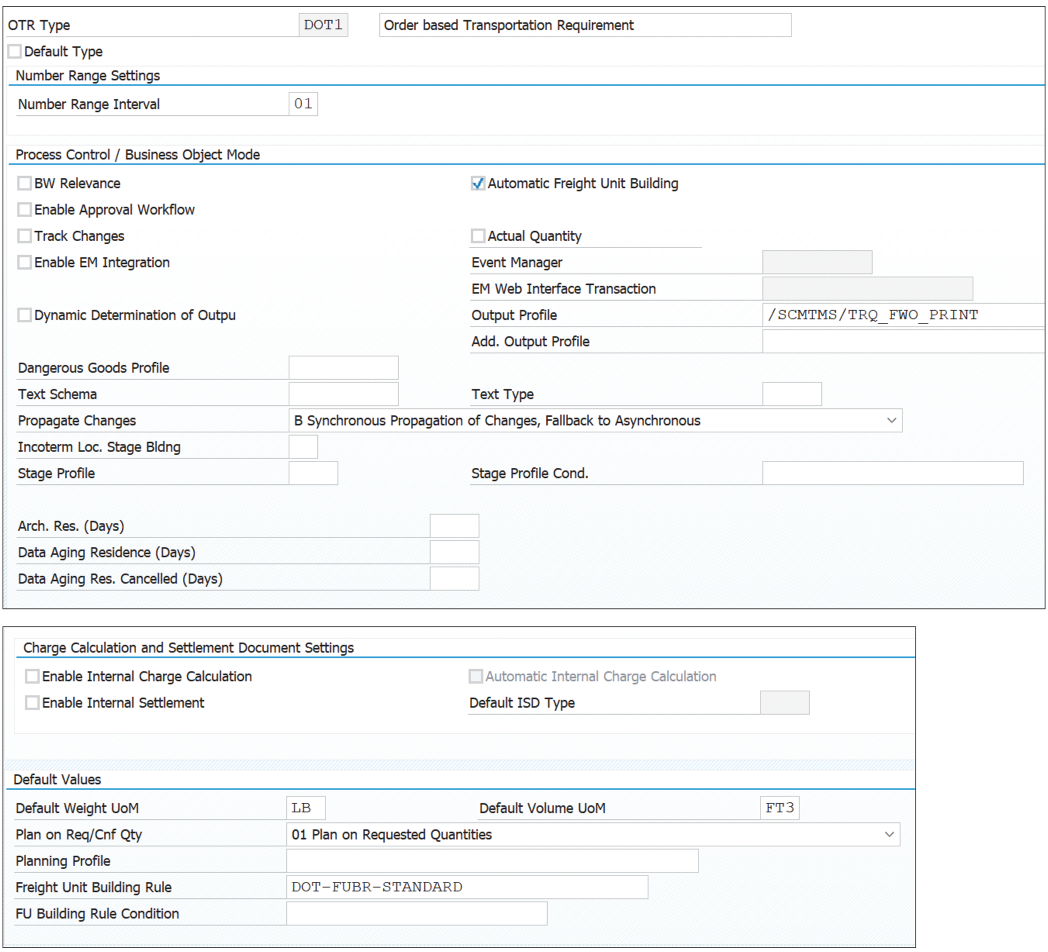


Figure 4.18 OTR Type Customizing

Rather than going into every detail of the type Customizing, we mention only the most important topics here. Because you can't do anything with the OTR itself, it's mandatory to create freight units to start planning. While we go into the freight unit building details later in this book, it's still worth mentioning that we have some options in this area.

The **Automatic Freight Unit Building** checkbox defines whether a freight unit should be built automatically after the OTR is created. This makes sense in many use cases. If you consider consolidation of sales orders, however, you might not want to create freight units directly after creation, but instead only trigger freight unit building via a batch job so you can consolidate several OTRs to one freight unit.

Regardless of whether you want to create freight units automatically or via a batch job, you need to define how the freight units should be created. To do so, you define a freight unit building rule in Customizing. If the method of creating freight units depends on some values of the OTR, you might even want to use a condition to find the right freight unit building rule.

The default units of measurement can be used to have consistent units of measurement in the TM system. If the integrated material master contains unit of measurement conversions, the default units are used on the OTR's header information. The item information will keep the units of measurement from the original SAP S/4HANA order.

The **General Data** tab includes a user interface (UI) section about the Incoterms and Incoterm location. The Incoterm and the corresponding location are assigned to the order in SAP S/4HANA, and that information is transferred to the TM system. The same logic about stage splitting based on Incoterm locations that was already discussed in Section 4.1.1 also applies to OTRs.

To recognize the Incoterms in TM, you need to maintain them in SAP Supply Chain Management (SAP SCM) Basis Customizing via IMG menu path **Transportation Management • Basic Functions • General Settings • Incoterms • Define Incoterms**. In this Customizing activity, you can also define whether the Incoterm requires an Incoterm location.

On the OTR, you'll find three important statuses: the planning status, the execution status, and the consumption status. The planning status shows whether freight units have been created (if so, the planning status is **In Planning**; if not, the planning status is **New**). If the freight units are both created and already planned on freight orders, then the planning status changes to **Planned**. If the freight unit is planned on freight orders, the execution status of the OTR shows whether the freight order is already executed, in execution, or not yet executed.

The consumption status of the OTR shows whether DTRs were already created and have *consumed* the freight units of the OTR. Figure 4.19 depicts the integration scenario with both order and delivery being sent from SAP S/4HANA to the TM system. In this case, the freight unit is initially created based on the OTR after the order is sent to the TM system.

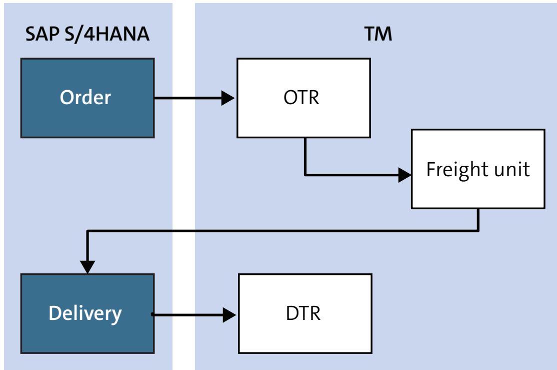


Figure 4.19 Integration Scenario with External TM Component and Freight Unit Consumption

At a later stage, when the delivery is created (either via delivery proposal or internally within the SAP S/4HANA system), the DTR is created for the SAP S/4HANA delivery. The freight unit is then reassigned to the most current SAP S/4HANA document, which is the DTR representing the delivery. We call this process *freight unit consumption* because the document flow is rearranged, and the freight unit is no longer directly associated with the OTR.

Not only statuses but also blocks are kept in sync between the SAP S/4HANA order and the OTR in TM. The mapping of block reasons is done purely on the ID of the block reason codes, meaning that the reason codes in SAP S/4HANA and TM need to be the same.

The OTR document can define two kinds of blocks: a planning block and an execution block. While the planner is still able to plan a freight unit of an OTR that has an execution block defined, the planning block doesn't even allow the planning of the freight unit. When you use Customizing path **Transportation Management • Integration • Logistics Integration • External SAP TM System Integration • Define Blocking of Transportation Requirements • Define Blocks Based on Delivery Blocks**, you can define whether a block set on the SAP S/4HANA order should automatically set a planning and/or execution block on the corresponding OTR document.

The block can be defined on the SAP S/4HANA order on the header level or each schedule line. Therefore, the blocks on the OTR document are also set on either the header level (i.e., for all items of the OTR) or only a particular item.

If you want to propagate more information from the SAP S/4HANA order to the OTR in TM, you can do this in the **Notes** tab on the OTR document. Because the OTR can't be edited, the notes of the OTR need to come from the SAP S/4HANA order.

Delivery Documents

Recall that both SAP S/4HANA orders and SAP S/4HANA deliveries can be integrated into TM. The integration setup on the SAP S/4HANA side is very close to the integration setup of SAP S/4HANA orders, so we won't go into details about the deliveries again.

Make sure you activate the transfer of the delivery documents in IMG menu path **Transportation Management • Logistics Integration • Internal TM System Integration • Define Transportation-Relevance of Delivery Documents**. Notice that this IMG activity looks very similar to what we've seen when activating the transfer of SAP S/4HANA orders and is used for the internal and external integration scenario.

Also on the TM side, the technical integration is almost the same as with SAP S/4HANA orders. Another TRQ document is created, which is the DTR. Technically, there is no difference between the OTR and the DTR; they are both instances of the business object `/SCMTMS/TRQ` and are differentiated only by different document names.

You can also see the similarity between the OTR and DTR when you compare the document type Customizing activities of both business objects. The DTR type Customizing contains exactly the same settings as the OTR, including settings concerning freight unit building, stage splits based on Incoterm locations, and so on.

The DTR is the business document representation of the SAP S/4HANA deliveries, as the OTR was for SAP S/4HANA orders. When you're setting up the integration scenario between SAP S/4HANA and TM, you have different options for which documents you want to integrate and how the interaction of SAP S/4HANA and TM documents should work. The main issue to determine is which system should be the leading system for the transportation process. The correct choice depends on what you want to achieve with the SAP S/4HANA integration.

4.1.5 Integration of Scheduling Agreements

Scheduling agreements describe recurring deliveries to a customer or to a company's own plant. We can therefore also differentiate between sales and distribution scheduling agreements, which represent recurring deliveries to customers, and materials management scheduling agreements, which describe recurring deliveries to our plants.

Availability in SAP S/4HANA Release 2022

The creation of freight units out of sales and distribution scheduling agreements isn't available in SAP S/4HANA release 2022 for the internal scenario. When using a standalone SAP S/4HANA TM system, however, OTR documents can be created from the scheduling agreements in the external scenario. For materials management scheduling agreements, both scenarios are available.

The integration of scheduling agreements uses the same configuration on both sides as the integration on sales order documents we discussed in Section 4.1.4. The activation of scheduling agreement transfer is done using the activation table for sales documents depicted earlier in Figure 4.3, for both materials management scheduling agreements and sales and distribution scheduling agreements.

When a scheduling agreement is sent to TM in the external scenario, it creates one OTR document per scheduling agreement with multiple line items—one per delivery of the scheduling agreement because the delivery quantity and date differ per line item of the scheduling agreement. In the internal scenario, TM skips the OTR document and creates a freight unit directly per schedule line (only for materials management scheduling agreements!).

Because the scheduling agreement can be updated or extended in sales and distribution or materials management or is valid for a very long time, instead of transferring all deliveries of the scheduling agreement to TM, we can consider transferring only the ones in the near future. To do so, you can use IMG path **Integration with Other SAP Components • Transportation Management • Logistics Integration • Define Settings for Sales Scheduling Agreements Integration** (or **Define Settings for MM Scheduling Agreements Integration**). In this Customizing activity, you can define the time horizon that should be transferred to TM. For materials management scheduling agreements, you can also define whether just-in-time or forecast delivery schedules should be transferred. (It can only be either just-in-time or forecast, never both.) Because this Customizing activity is optional, just-in-time delivery schedules will be transferred only if nothing was defined. This feature is also only available in a standalone SAP S/4HANA TM scenario, not in an embedded scenario.

If you decide to transfer only a certain time horizon, you need to make sure to schedule batch jobs in SAP ERP or SAP S/4HANA that transfer the new delivery lines to TM that become relevant in the course of time. There are two batch jobs available:

- `TMINT_SAGSD_TRANSFER` (for sales and distribution scheduling agreements)
- `TMINT_SAGMM_TRANSFER` (for materials management scheduling agreements)

4.2 Forwarding Orders and Forwarding Quotations

In Section 4.1, we talked extensively about the integration of orders and deliveries into the TM functionality. The integration of those documents was introduced to SAP TM with release 8.0 (at that time, only in the way described in Section 4.1.4), which was meant to be the release focusing on the shipper's business.

As you've learned so far in this chapter, integrated TRQs only serve the purpose of transferring the transportation-relevant information of orders and deliveries to the TM functionality to execute the transportation process there. Sales orders and purchase orders in sales and distribution and materials management aren't sophisticated enough to serve as the TRQ document for LSPs or carriers. In these businesses, more information is required than simply what goods need to be transported from where to where on what date. These businesses often add much more information to the TRQ when transportation service-level codes, transportation charge management, and consolidation come into play. Simply stated, transportation is the core business of LSPs and carriers, which explains why more emphasis is put on the transportation information.

Like sales orders, purchase orders, and deliveries, the forwarding orders and forwarding quotations generally act as the beginning of the operational process in TM. The issuing of a forwarding order creates a business transaction between two companies, or—in more sophisticated scenarios—even among multiple companies.

In the following, we'll discuss the details of the forwarding order document in Section 4.2.1, including what information it can contain and how to process that information. Furthermore, we'll look at quoting processes in Section 4.2.2 and Section 4.2.3 before delving into the functionality that helps users create recurring customer requests more quickly in Section 4.2.4.

4.2.1 Forwarding Order Document

The forwarding order is often called the "typewriter" TM because most of the data entered into the document is generated at the point of document creation. However, this term undervalues the forwarding order for the transportation process. The forwarding order is the only document in which you can define the data that is used for the entire transportation process of planning, transportation charge management, execution, and so on.

The central business object behind the forwarding order is the TRQ object, which we first discussed in the context of OTRs and DTRs in Section 4.1.4. The forwarding order makes use of the same object used by OTRs and DTRs, which means that comparable data is written into the same database areas.

The forwarding order is the central order business object in TM, and it helps you perform all the important order-taking processing steps in order management. Forwarding orders can be created in different ways:

- **Manual creation**
  This is the most common way of creating TRQs in TM. A customer relations manager of the LSP or carrier talks to the customer and enters all data manually in the SAP Fiori UI.
- **Incoming EDI message**
  Many big LSPs and carrier companies have been using EDI communication for a long time. Therefore, it's only logical that they also prefer EDI communication for the creation of forwarding orders in their systems. TM makes this functionality possible by providing business to business (B2B) web services that automatically create the forwarding order. This web service integration can be compared to the integration of orders into an external TM component, but more information can be transferred, such as transportation stages, dates concerning the transportation, and so on.

- **Use of a template**
  In many cases, customers order the same type of transport on a regular basis. To avoid having to enter the same data every time, the order clerks of the LSP or carrier use templates. A new forwarding order can then be created as a copy from the template. We'll talk about templates later in this chapter.

A fundamental feature of the forwarding order is that the document can be saved at practically any time during the order-taking process. If you want to create freight units from the forwarding order automatically, a few prerequisites need to be met. However, the forwarding order can still be saved in any incomplete state. After the forwarding order contains sufficient information for freight unit building, the freight units are created. This helps customers and LSPs to enter orders even if some information is missing. At LSPs or carriers, multiple employees are also often involved with the order-taking process. For instance, the customer's contact person enters all the customer's information, but the forwarding order is complete only after a transportation clerk has added data that is relevant for planning and execution.

When you browse the TM system in the SAP Fiori launchpad, you'll notice that, like master data or planning, forwarding orders have a dedicated work area called **Order Management**. When you access this tab in the SAP Fiori launchpad, you can see that the Forwarding Orders Worklists app provides a personal object worklist (POWL) with all existing forwarding order documents and their related documents.

As you can see in Figure 4.20, the TM functionality provides you with many preconfigured queries categorizing forwarding orders into the different transportation modes.

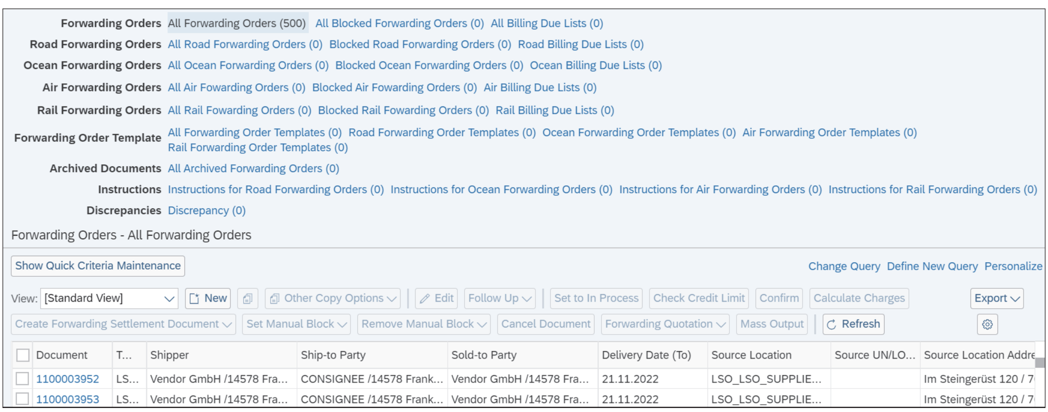


Figure 4.20 POWL for Forwarding Orders

At the top of each POWL query are some buttons that you can use to perform actions on the forwarding order documents without opening the documents themselves. For process steps such as collective invoicing and consolidated freight unit building (explained in detail in other chapters), this feature comes in very handy because the actions can be executed on several documents together.

By clicking **Show Quick Criteria Maintenance**, you can set more filters on the predefined queries. A screen area opens where all possible filter values can be defined. The quick criteria are saved so that every time you enter the POWL query again, your last entries are remembered. If you want to avoid this, you can alternatively use the filter of the POWL table itself by clicking a column's header.

If you have some selections you want to permanently display in the forwarding order POWL, you can use the **Define New Query** link on the top-right corner of the POWL table. In a guided procedure, you can enter your selection criteria, name the POWL query, and assign the query to one of the query categories (the lines on top of the table). Note that this newly created query is available only for your user and can't be used by other users.

Because the forwarding order is a very large and complex business object, this section is the longest section of the chapter. However, you won't find pages explicitly dedicated to the Customizing of the forwarding order type. Instead, we go through the forwarding order document tab by tab and delve deeper into the functionality of the different fields. If Customizing influences the process flow of the fields, we mention this while covering the corresponding section of the forwarding order document. You can find the forwarding order type Customizing via IMG menu path **Transportation Management • Forwarding Order Management • Forwarding Order • Define Forwarding Order Types**. If other Customizing activities are involved in the forwarding order, they are mentioned when they become relevant.

When starting to create a forwarding order, you'll notice that one piece of information is very crucial to the system: the transportation mode. You can predefine the transportation mode of a forwarding order in the forwarding order type. However, if you want to use one forwarding order type for several transportation modes, you can leave this setting empty. When you access the Create Forwarding Order app in the **Order Management** tab, you'll see that you can enter not only a forwarding order type but also data such as the transportation mode, a template number, or a forwarding agreement to which the forwarding order is related. You'll learn more about transportation charge management for forwarding orders later in this section.

If you haven't defined a transportation mode in the forwarding order document type, then you should decide on a mode here. Note that defining the transportation mode as air, for example, doesn't mean you can't create transportation stages of other transportation modes, such as road or rail. The transportation mode decision is relevant only for the naming of fields in the forwarding order and for which fields are displayed or hidden. In fact, you can also change the transportation mode of the forwarding order while creating it (i.e., after you've already entered some data). When doing so, you'll notice that the screen changes, and the availability of tabs and the field names change.

General Data

After you've defined a document type, you're directed to the forwarding order document. If you haven't defined a template, you'll see that the document is almost empty; only some fields are prepopulated. The **General Data** tab shown in Figure 4.21 displays the most important information that is globally relevant for the transportation contract between a customer and an LSP or carrier.

The **Order Date** near the top of the screen is prepopulated with the current date, but you can alter it as necessary. The order date is important not only for reference but also for transportation charge management. Rate tables that are used in transportation charge management can have different validity dates. Depending on the settings you've made for charge calculation, you can calculate charges based on either the actual transportation date or the order date.

In the top-right corner of the **General Data** tab, you can find the fields for the organizational data—the sales organization, office, and group responsible for the forwarding order. In Chapter 3, we discussed the importance of organizational units in TM, so we don't go into detail here again. However, it's important to note that entering a sales organization is one of the prerequisites of creating a freight unit. If no sales organization is entered, neither automatic freight unit building nor manual freight unit building will succeed.

Just as we discussed with the integration of orders and deliveries in Section 4.1.1, the Incoterm is a very important piece of information for transportation responsibilities. You can enter the same Incoterms here that you already defined in Customizing. The Incoterm location here is free text because it's agreed upon with the customer. Because you can define your stages in the forwarding order manually, no mapping or stage splitting is done based on the Incoterm location entered.

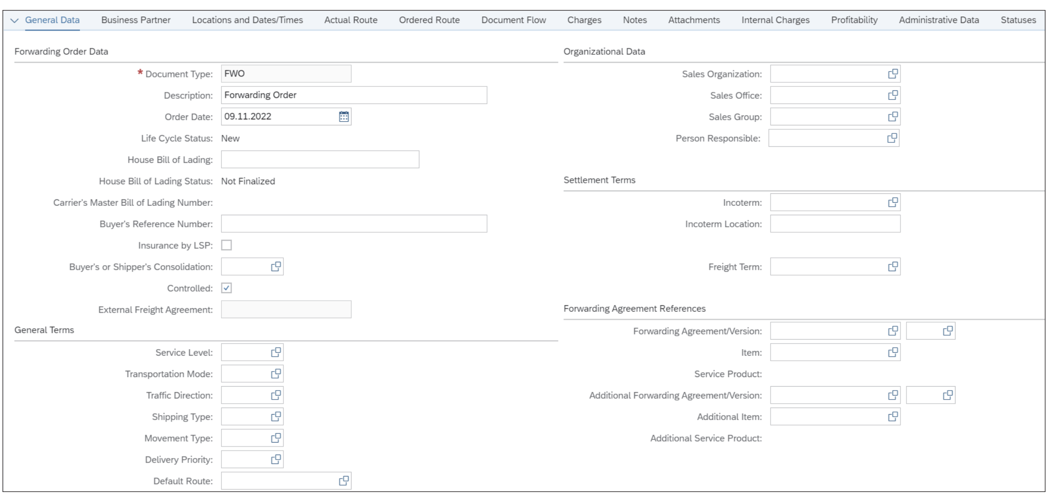


Figure 4.21 General Data of a Forwarding Order

However, the Incoterm is considered in charge calculation and settlement. Depending on the Incoterm you use, the stages are charged against different partner functions of the forwarding order. You can assign a payer partner function (i.e., which partner function should pay for which stage types) in Customizing by following IMG menu path **Transportation Management • Forwarding Order Management • Define Default Agreement Partner Functions for Stages**. We look at stage types later in this section.

The **Controlled** checkbox in the **Forwarding Order Data** section on the **General Data** tab (refer to Figure 4.21) defines whether the ordered transportation is a controlled or uncontrolled transport. With uncontrolled transports, the LSP organizes the entire transportation chain, including the main stage; however, the main stage is charged not from the carrier to the LSP but directly to the sold-to party of the entire transport (known as the ordering party in SAP TM 9.6). You can define an uncontrolled transport by deselecting the checkbox. If you deselect the checkbox, the **External Freight Agreement** field becomes editable. You can then enter the freight agreement that exists between the carrier and the sold-to party.

When doing further planning of the freight units belonging to a forwarding order that have been declared uncontrolled transports, you can find the **Controlled** checkbox and the external freight agreement on the **Terms and Conditions** tab of the freight booking that covers the main stage of the freight units. Note that you can consolidate uncontrolled freight units on one freight booking only if they all have been assigned the same external freight agreement. The pre-carriage and on-carriage of an uncontrolled transport are still charged from the carrier to the sold-to party via the LSP. Figure 4.22 illustrates the difference between controlled and uncontrolled transports, which is a scenario that often takes place in sea and air transportation and affects the main carriage only. We cover further details of the different transportation modes and their impact on the forwarding order later in this chapter.

Two more very important pieces of information are the movement type and the shipping type. These settings are crucial for the air and sea transportation processes; they influence the data entry and validation of the forwarding order. Shipping type and movement type are also prerequisites for the creation of freight units from a forwarding order.

The *shipping type* defines what kind of transportation the customer has ordered. In the transportation business, the differentiation is, roughly speaking, between a full container load (FCL) and a less than container load (LCL). In TM, these processes are shipping types. Considering that the terms FCL and LCL are mainly used in sea transportation, the shipping types may depend also on the transportation mode.

You can define shipping types in Customizing by following IMG menu path **Transportation Management • Forwarding Order Management • Define Shipping Types**. In this Customizing activity, you define all the shipping types you need. The shipping type entered in the forwarding order document determines what items may be defined on the item area of the forwarding order. In Customizing, you therefore need to define your shipping type, whether all cargo items need to be assigned to an equipment item (e.g., a unit load device [ULD] in air, a container in sea, or a railcar in rail), or whether such equipment items are allowed at all.

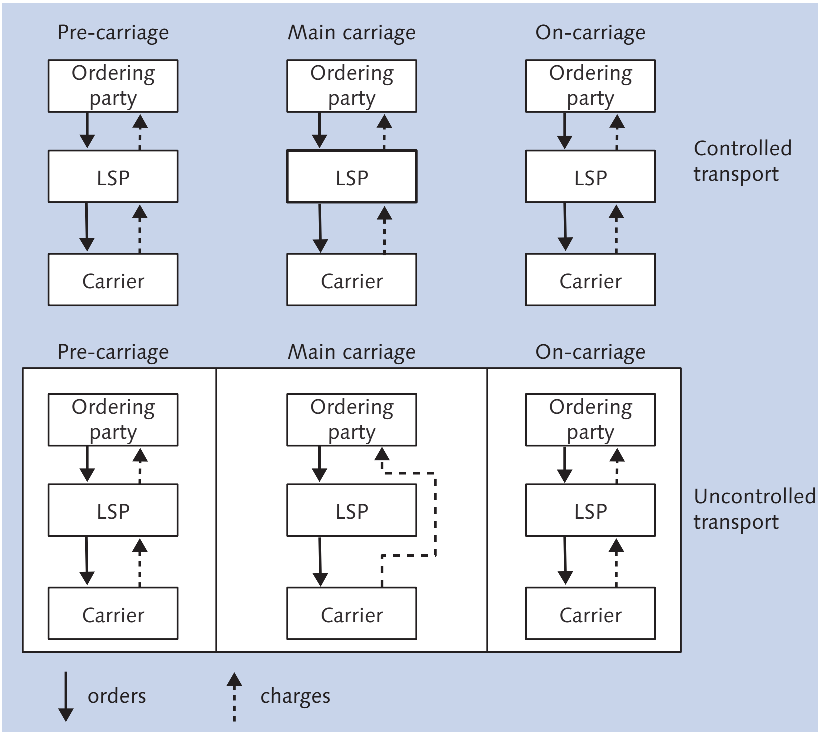


Figure 4.22 Uncontrolled and Controlled Transportation

Unit Load Device

When talking about packaging units in air transportation processes, we use the term *unit load device* (ULD) to represent special types of pallets or containers used in air transportation.

If you enter the shipping type "ULD," depicted in Figure 4.23, you get an error message in the forwarding order if not all of your items are assigned to equipment items. We look at the definition of items in the next section.

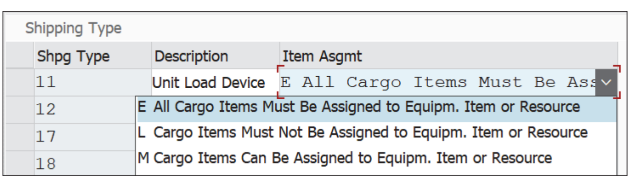


Figure 4.23 Shipping Type Customizing

In this Customizing activity, you can also define for which transportation modes the shipping type is valid. This covers the fact that the terminology is different in different transportation modes. The shipping type can be entered manually on the forwarding order or be preset in the forwarding order document type Customizing.

The second important feature is the *movement type*. The movement type in the forwarding order determines its routing. It's worth taking a detailed look at the impact of the movement type because you have to deal with it when creating forwarding orders.

In general, movement types can be defined in Customizing in IMG menu path **Transportation Management • Forwarding Order Management • Define Movement Types**. Here, you can simply define your movement type and whether the location assigned to the shipper should be taken automatically as the source location of the forwarding order. The same setting can be done with the ship-to party and the destination location.

At this point, we've only defined a movement type code. The influence on routing is determined in the Customizing activity that you can find by following IMG menu path **Transportation Management • Forwarding Order Management • Define Stage Type Sequence for Movement Types**.

Figure 4.24 shows the standard Customizing for the default movement type **DD** (door-to-door). As you can see, you can define a stage type sequence with sequence numbers. As with all sequence-related Customizing activities, the numbers don't have to be exactly sequential, at least in numerical order. For the movement type, you define the stage types that are being used. We talk about stage types later when we discuss the **Stages** tab. For now, we can state that we bring different stage types into a sequential order. In addition, we define whether the occurrence of a particular stage type is optional or mandatory. For the movement type in our example, only the main carriage (stage type **03**) must occur. The **StageProp.** checkbox defines whether some stages on the **Stages** tab should already be created when the corresponding movement type is selected on the **General Data** tab.

Define Stage Type Sequence for Movement Type

Mov. Type	Seq. No.	Stage Type	StgeTpeOcc	StageProp.	Det. Rule	Set. Rule
DD	1	01	N Stage type must occur at …	☑	Not Pl.-Rel. if Ex. and Sa…	Not Relevant for Internal …
DD	2	02	CN Stage type can occur in …	☐	Not Pl.-Rel. if Ex. and Sa…	Not Relevant for Internal …
DD	3	03	N Stage type must occur at …	☑	Not Pl.-Rel. if Ex. and Sa…	Not Relevant for Internal …
DD	4	04	CN Stage type can occur in …	☐	Not Pl.-Rel. if Ex. and Sa…	Not Relevant for Internal …
DD	5	05	N Stage type must occur at …	☑	Not Pl.-Rel. if Ex. and Sa…	Not Relevant for Internal …

Figure 4.24 Assigning Stage Type Sequences to a Movement Type

The next column defines whether the stage is relevant for planning or only statistical. On the **Stages** tab, you can manually assign a planning and execution organization to each stage. The decision about whether the stage is relevant for planning is based on the setting in this Customizing activity, which again considers the planning and execution organization. Some of the settings you can choose in the **Det. Rule** column compare the planning and execution organization with the sales organization of the forwarding order. If these two organizations belong to different companies or countries, the stage isn't declared as relevant for planning. However, you can also take the easier route here (if that applies to your business process) and simply state whether this stage is always or never relevant for planning.

The last column in Figure 4.24 (**Set. Rule**) specifies from what point in time an internal settlement document (ISD) of the stage can be created. You can choose different execution statuses here to define in what execution status the corresponding stage of the freight unit must be to start an internal settlement.

Internal Settlement

An ISD can be used to recover costs incurred in the delivering process from an internal organization in your company to another internal organization. In the standard internal settlement process, the internal settlement is between the purchasing organization of the freight order and the sales organization of the forwarding order. In the internal settlement process for resources, the settlement is between the organizations that own the resources that are used to execute the order and the purchasing organization of the freight order.

Another transportation process that is often used in air and sea transportation is the *shipper's consolidation* in export transportation and the *buyer's consolidation* in import transportation. If your forwarding order has a corresponding transportation mode assigned to it, you can set this information on the **General Data** tab of the forwarding order. The transportation for the LSP is considered like an FCL or ULD transportation because the shipper organizes the transportation to the port, but different house bills of lading (HBLs) need to be issued for each item of the forwarding order, even though only one freight unit was created.

In the transportation business, the HBL number—not the forwarding order number—is the relevant number for identifying the entire transportation. You can find the corresponding field on the **General Data** tab of the forwarding order.

You can manually enter a waybill number or HBL number in this field, which is then propagated to the freight units that belong to this forwarding order. However, the assignment of waybill numbers can also be triggered automatically using *waybill stocks*. To do this, activate the use of waybill stocks in the Customizing of the forwarding order document type by selecting the **Enable Waybill Stock** checkbox and assigning an HBL or house air waybill (HAWB) strategy. The strategy defines how the HBL should be created: per forwarding order, per container, per shipper/ship-to party combination, and so on.

To draw HBL numbers, you need to define waybill stock types in Customizing by following IMG menu path **Transportation Management • Master Data • Waybill Stock • Define Waybill Stock Types**. The waybill stock type defines how the HBL number is put together. Figure 4.25 shows how a waybill stock type is assigned to a transportation mode.

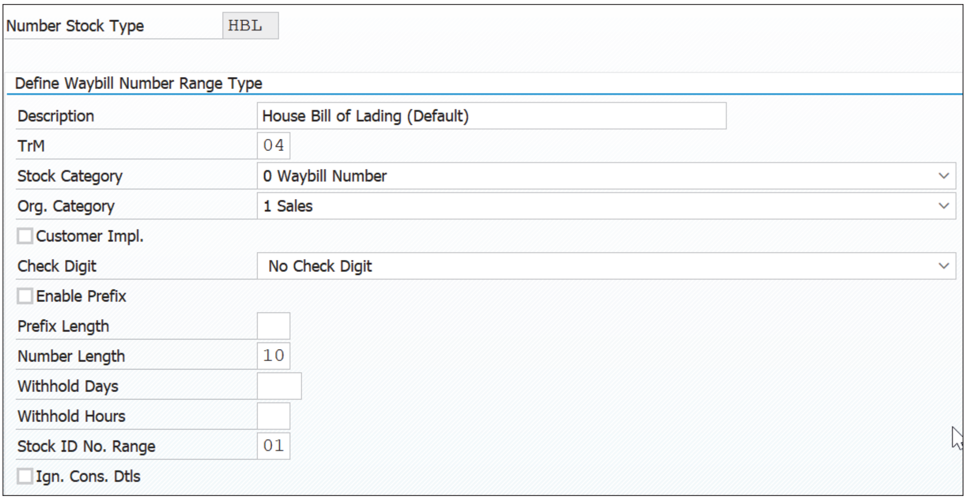


Figure 4.25 Waybill Stock Type Definition

You can further define whether the number resulting from this stock type should be used as a waybill number or a tracking number. On the bottom of this Customizing screen, you define how the number should be put together, whether a prefix is assigned, the length of the number, and how a potential check digit should look. You can also define how long the number should be withheld after being returned.

After defining a number stock type, we can use it to create a waybill stock. In the SAP Fiori launchpad, go to the **Master Data** tab, and access the Waybill Number Stocks Worklist app to create a new waybill stock based on the number stock type. Here you can define a number range from which a number should be drawn. At the bottom of the screen, you can then define when this waybill stock should be taken into account by defining certain combinations of sales organizations and ordering parties. If the combination of sold-to party and sales organization of the forwarding order matches one of the combinations defined in the waybill stock, a number is drawn from here.

If you choose to assign an HBL number automatically, the **House Bill of Lading** field on the forwarding order isn't editable. Instead, you need to select **HBL • Draw HBL Number** from the action toolbar at the top of the forwarding order screen. This works only after the sales organization, sold-to party, and cargo have been entered.

Waybill Stocks and Numbers

You can find further details about waybill stocks and waybill numbers in Chapter 7, Section 7.1.

On the **General Data** tab of the forwarding order, you can also enter the value of the goods that need to be transported. This information may become relevant for charge calculation or customs. Note that this information is only a manual entry. The values aren't taken from product master data.

We talked about the transportation service level codes when we discussed order integration. You can manually assign a service level code to the forwarding order. The service level might influence your planning and charge calculation if you've made corresponding entries.

If you want to define your own service-level codes, do this via IMG menu path **Transportation Management • Forwarding Order Management • Define Transportation Service Level Codes**. If your service-level code applies only to certain transportation modes, then you can define this here too.

Items

At the bottom of the forwarding order document, you'll find the table of items that are ordered to transport in this forwarding order. You can define several items and create item hierarchies that represent how the packaging was done. Figure 4.26 shows a simple example of an item hierarchy. You can create an item hierarchy like this by choosing **Insert • Container** to insert the first item.

Item Hierarchy	Item	Item Type	Resource	Con...	Equipment Group	Equipment Type	Quan...	Quan... Unit of Meas...	Product	Gross Weight	Gross Weight UoM
Container	10	CN			CN	20G0	1	PC		2.770	KG
Package	20	PKG					1	PAL		200	KG
Product	30	PRD					500	PC	CELL PHONES	200	KG

Figure 4.26 Item Area of the Forwarding Order

To create a subordinate item, select the superordinate item (in this case, the container), and again choose **Insert • Package**. The new item is created as a subordinate item that is displayed in a hierarchical way. Alternatively, you can enter the data of the items directly into the table and then create a hierarchy by dragging and dropping a subordinate item onto a superordinate item.

For items, the *item type* is a mandatory piece of information. The item type encompasses several settings relevant for the item.

Figure 4.27 shows the information you can define in the Customizing of the item types, following IMG path **Transportation Management • Forwarding Order Management • Define Item Types for Forwarding Order Management**. The **Item Category** field defines what kind of item this item type describes. It also impacts the way an item hierarchy can be built.

Item Hierarchy

TM predefines what an item hierarchy can look like. Whether a subordinate to superordinate item relationship is allowed depends on the item category assigned to the item type. In general, TM allows only the following item hierarchies:

- Resource (trailer or railcar)
- Container (may contain a package or product item)
- Package (may contain a package or product item)
- Product (must be the lowest item in the hierarchy)

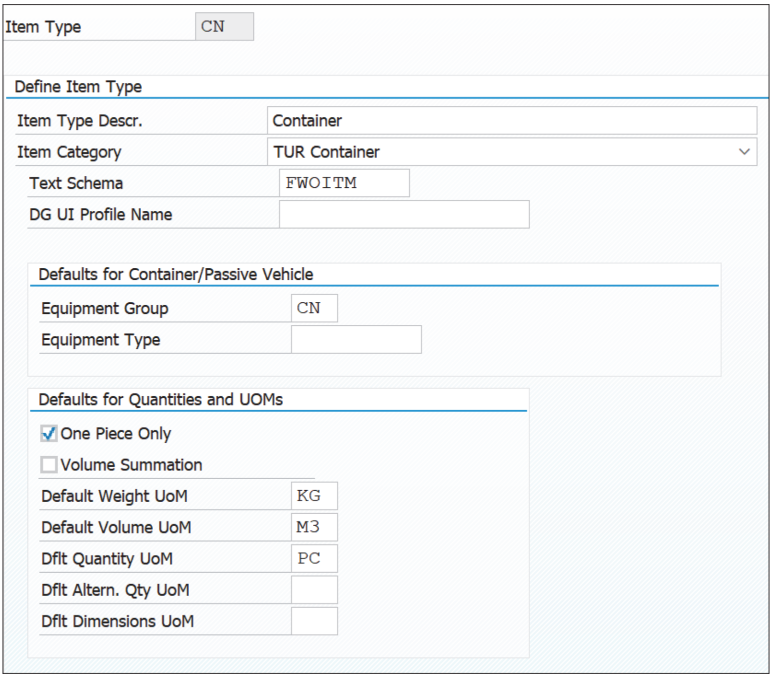


Figure 4.27 Item Type Definition

If you want to define an item type that is relevant for dangerous goods (DG) processing, you can assign a DG UI profile to this item type. You'll find further information about DG UI profiles and processing in Chapter 8, Section 8.3.

If you've defined an item category as a container or passive vehicle, you can assign equipment groups and equipment types to the item type, and all relevant data from the equipment type is then automatically put on the item data in the forwarding order. You can define equipment types via IMG menu path **Transportation Management • Master Data • Resources • General Settings • Define Equipment Groups and Equipment Types**. The physical properties of the equipment type are used as the tare weight in the forwarding order item. More information about equipment types can be found in Chapter 3, Section 3.3.

Recall that the shipping type you've defined on the forwarding order's general data determines what item categories you may use. If the shipping type defines that no equipment items are allowed, then you get a corresponding error message if you try to insert an equipment item. However, if you've defined a shipping type that requires equipment items, you can't create freight units before all items have been packed into equipment items.

In addition, you can limit the number of item types you can use on a forwarding order by assigning item types to the forwarding order type. You can do this in Customizing by following IMG menu path **Transportation Management • Forwarding Order Management • Forwarding Order • Assign Item Types to Forwarding Order Types**. After you've assigned some item types to your forwarding order type, no other item types can be selected in your forwarding order. If you've assigned several item types of an item category, you can define a default item type. When you insert a certain item category in the forwarding order, the default item type is automatically used. The default item type is especially important when you're using the B2B integration for automatically creating forwarding orders. Because the web service doesn't carry the information of the item type, this information has to be taken from Customizing.

If you define containers as equipment items in the forwarding order's items, you're working with anonymous entities, if you wish. Containers can be (but don't have to be) defined as master data, such as vehicle resources. If you define a forwarding order for rail or road transportation, however, you can assign a passive vehicle from master data (a railcar or truck trailer) to the forwarding order and use it as an equipment item.

When you define an item hierarchy, the weight of the products of the lowest items in the hierarchy is aggregated up to the highest item level. On each level, the gross weight of the subordinate item is taken over as the net weight of the superordinate item and added with the tare weight to determine the gross weight. This again is taken over as the net weight of the next superordinate item, and so on.

If you've defined default units of measurement on the item level, the quantities of the lower item levels are converted to the default unit of measurement. Note that if you've chosen a product item from product master data, no quantities are moved into the forwarding order item; the quantities need to be inserted manually.

In forwarding orders, you don't necessarily need product master data records for your product items. Even though you can choose product master data for your product items, you can also insert free text into the corresponding field. This is especially handy for LSPs and carriers that transport different materials every day because they don't need to create master data for each material.

If a customer orders the transportation of 300 cell phones, you can enter this in one line item defining a quantity of 300 pieces. However, your transportation process may require you to treat each cell phone individually to enable you to enter specific data for each phone or to simplify freight unit splitting. If so, you can still enter one line item, define pieces and weight for all 300 cell phones, select this line, and click the **Split** button at the top of the item table. The line item is split automatically into 300 individual lines. In addition, the gross weight entered is distributed equally among the new items.

When you select a line item, a new screen area appears below the item table. In this screen area, you can enter several pieces of information specific to the individual item. This information is also propagated to the corresponding freight unit in freight unit building. The item details contain several tabs.

You can access the item details by selecting the checkbox of the relevant item (the information displayed in the item details section may vary depending on the item category of the item selected). Let's look at the item details for a product item that appear on the following screen tabs:

- **Details**
  You can enter item-specific details here. Some data, such as the product name, is moved from the item table. Other data you can define only here in this screen area. If you enter a good's value for an individual item, this information is also moved to the corresponding field on the **General Data** tab of the forwarding order. The field is then not editable anymore, but the system expects you to enter this information on every item as necessary. On the **General Data** tab of the document, the values of the individual items are then added up.
- **Quantities**
  The quantities entered in the item table are taken over. In the item details section, you can then define the confirmed quantities; for example, in case of under capacity, you can confirm a lower quantity to the customer if you can't fulfill the entire order volume. Furthermore, this tab also records the feedback from the drivers concerning the actual quantities. Especially in bulk transportation scenarios, the exact quantity can't be provided by customers because it might be dependent on temperature and humidity. However, the actual quantity transported is the basis for charge calculation. Therefore, the measurements performed when loading the truck are recorded and visible on this tab. If multiple measurements are performed, a history of actual quantity records can be accessed via this tab.
- **Locations and Dates/Times** and **Business Partner**
  These tabs are visible in the item details only if they were defined in the forwarding order type. Customizing those locations, dates, and business partners can't be globally defined in the forwarding order. The **Same Locations and BPs** flag in Customizing determines whether you're required to enter the transportation locations and business partners on the item level or whether it's sufficient to define them globally on the forwarding order. If the locations and business partners are defined on the item level, this differentiation is also taken into consideration by freight unit building as a split criterion. The tabs in the **Item Detail** screen area are the same as on the forwarding order header, so we don't go into detail about defining business partners and locations here but instead cover it later in this chapter.
- **Document Reference**
  You can add references to the item on the **Document References** tab. In many cases, this tab needs to be filled manually because the document references might

be system independent. You can reference a specific item of the referenced document. To differentiate different document types, you need to use *business transaction document types* that you can define in Customizing via IMG menu path **Transportation Management • General Settings for Order Management • Define Business Transaction Document Type Codes**. As already mentioned, the document type codes can be defined independently of the system if you want to reference a photo on a server, a phone call protocol, and so on. You can also reference an item from the referenced document. You can also define type codes for items following IMG menu path **Transportation Management • General Settings for Order Management • Define Business Transaction Document Item Type Codes**. Document type codes and item type codes aren't linked to each other. For implementation projects, we recommend that you use these type codes as often as the document references are used (i.e., charge calculation or routing decisions).

- **Customs**
  You can define customs-relevant data. You'll find more about customs declarations when we cover SAP Global Trade Services (SAP GTS) integration in Chapter 8, Section 8.1.
- **Discrepancies**
  During freight unit building, the quantities of the forwarding order items are moved into the freight unit. However, if it's discovered in the execution process that the actual quantities of the freight unit differ from the quantity declared in the forwarding order, the quantities are changed in the freight unit. This results in a recorded discrepancy between the freight unit's item and the forwarding order's item. This discrepancy is displayed on the **Discrepancies** tab of the item details. The current status of the discrepancy handling is also recorded here. We'll discuss more details about discrepancy handling in Chapter 7, Section 7.1.2.

You'll notice that there is one more item category available in the forwarding order that we haven't yet mentioned: the *service item*. A service item defines—as the name suggests—services that should be performed as part of the customer order. Services are anything except the physical movement of the goods or containers (which is handled already in detail with the freight units and subsequent processes, e.g., planning, subcontracting, etc.), such as container cleaning, customs clearance, documentation, and so on.

You can assign *instruction sets* to a service item to track the progress of the service in the forwarding order, which means you can make sure that the service ordered in the forwarding order is also performed. Charge calculation can also consider service items by adding surcharges to the forwarding order's charges.

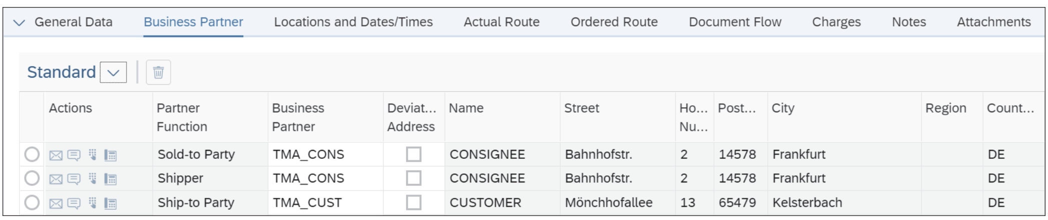
Service items aren't transferred into the freight unit, which means they can't be seen during the planning phase on the freight unit directly. They can be assigned to any level of the item hierarchy, meaning they can be added to the forwarding order as an independent item or as a subordinate item of a resource item, container item, package item, or product item. They can't, however, be a superordinate item to any other item.

Business Partners

After you define all relevant data on the **General Data** tab and enter the items that need to be transported, you can assign business partners to the transportation contract. To sketch a very simple example first, only two business partners are assigned to the forwarding order: the shipper where the goods are picked up and the ship-to party where the goods are delivered.

In the forwarding order, the business partners take over different responsibilities. These responsibilities are reflected by *partner functions* that you can see on the **Business Partners** tab. You can add party role codes in Customizing via IMG menu path **Transportation Management • Master Data • Business Partners • Define Partner Functions**.

The **Business Partner** tab, as shown in Figure 4.28, includes a table where you can assign business partners to the party roles. The partner roles **Sold-to Party**, **Shipper**, and **Ship-to Party** are mandatory in every forwarding order.



Actions	Partner Function	Business Partner	Deviat... Address	Name	Street	Ho... Nu...	Post...	City	Region	Count...
	Sold-to Party	TMA_CONS	☐	CONSIGNEE	Bahnhofstr.	2	14578	Frankfurt		DE
	Shipper	TMA_CONS	☐	CONSIGNEE	Bahnhofstr.	2	14578	Frankfurt		DE
	Ship-to Party	TMA_CUST	☐	CUSTOMER	Mönchhofallee	13	65479	Kelsterbach		DE

Figure 4.28 Business Partners in the Forwarding Order

The business partners you assign to the partner functions need to be maintained as master data. As you can see in the figure, the addresses of the business partners are taken from master data. However, if you want to use a different address than the one defined in the master data, you can do so by selecting the **Deviating Address** checkbox. If you select the row of the party role whose address you want to change in the forwarding order, you can change it in the **Printing Address** field below the table. This field is prepopulated with the address from master data. The address defined here is used for document printing.

Only three partner functions are mandatory in a forwarding order unless you define differently. *Partner determination profiles* define which additional partner functions are mandatory on a forwarding order. You define partner determination profiles in Customizing via IMG menu path **Transportation Management • Master Data • Business Partners • Define Partner Determination Profiles**. In a partner determination profile, you select the partner functions that you want to define as mandatory in the forwarding order. You can also define how business partners are copied from one partner function to another. In the example in Figure 4.28, the sold-to party and the shipper are the same business partner. Therefore, in the partner determination profile, we could define that the business partner of the sold-to party should be copied to the shipper, as shown in Figure 4.29.

Assign Partner Functions

Function	Name	Sequence	Edit Level	Srce Type	Source PF	Name
U6	Shipper	2	M Mandatory	Partner Function	SP	Sold-to Party

Figure 4.29 Partner Determination Profile

You can use a partner determination profile not only for defining fixed relationships among the party roles of a forwarding order but also for assigning a discrete business partner to a particular partner function. Of course, this is only recommended if the same business partner is relevant in all scenarios.

The partner determination profile can be assigned to the forwarding order type directly in Customizing. However, depending on the transportation scenario, you might not be able to define the mandatory partner functions with only one partner determination profile. Instead, the mandatory partner functions can depend on the Incoterms assigned to the forwarding order. Therefore, you can also define the partner determination profile depending on the Incoterms and forwarding order type. To do so, follow Customizing menu path **Transportation Management • Master Data • Business Partners • Assign Partner Determination Profiles Based on Incoterms**.

Although entering business partners in the forwarding order isn't really complicated, we can't understate the importance of the entries. The assignment of a business partner to the sold-to party is crucial for charge calculation, which we describe in Chapter 9.

Recall that business partners can be defined globally on the **Business Partner** tab of the forwarding order or individually for each item, depending on the Customizing of the forwarding order type. The definition is the same; it only has to be done on the item details.

Locations and Dates/Times

Some of the most important information for transportation planning is the definition of locations and times. On the **Locations and Dates/Times** tab, you can define the source and destination location of the entire transportation. Note that the routing isn't defined here but on the **Actual Route** tab. If you've defined that locations and business partners aren't the same for every item, you can still define either a global source location or a global destination location and leave the other location empty on the global level to fill it in on the item level.

The location you choose on this tab needs to be maintained as location master data. If you've chosen location master data, you'll see that the corresponding fields in the address area of the screen are filled with that address.

In the global transportation business, locations are always assigned a global identifier, which depends on the transportation mode. Depending on the transportation mode defined for the forwarding order, the global identifiers are displayed on the **Locations**

and Dates/Times tab. Because air transportation uses International Air Transport Association (IATA) codes and sea transportation uses United Nations Code for Trade and Transport Locations (UN/LOCODE), if you use an air forwarding order, you'll see a field **IATA code**, and if you use an ocean forwarding order, you'll see a field **UN/LOCODE**. The codes are assigned in the location master data and prepopulated in the forwarding order when location master data is selected.

If you've followed along with our example, you've defined business partners in the forwarding order. If you go to the **Locations and Dates/Times** tab, you'll see that locations are already entered. If the business partner assigned as the shipper has been assigned a location, this location is automatically taken as the source location of the forwarding order. The same applies to the ship-to party and destination location. It also works the other way around, meaning that if you define locations first, the partner functions of shipper and ship-to party are filled automatically. However, if both partner functions and locations are filled, and you change one of them, no changes are made to the other.

If a customer calls and wants to get a transportation service from a location that you haven't used before, you don't have to define new master data for this location. Instead, you can just leave the **Location** field in the forwarding order empty and enter the address directly, as shown on Figure 4.30. Entering the address creates a *one-time location*. The one-time location is no different from location master data—in fact, a new location master data item was created. The new location is represented by a number that you can use later to add more information in the location master data. Usually, the number range for one-time locations starts with 1. If you want to change this, follow IMG menu path **Transportation Management • Master Data • Transportation Network • Location • Define Number Range Intervals for One-Time Locations**.

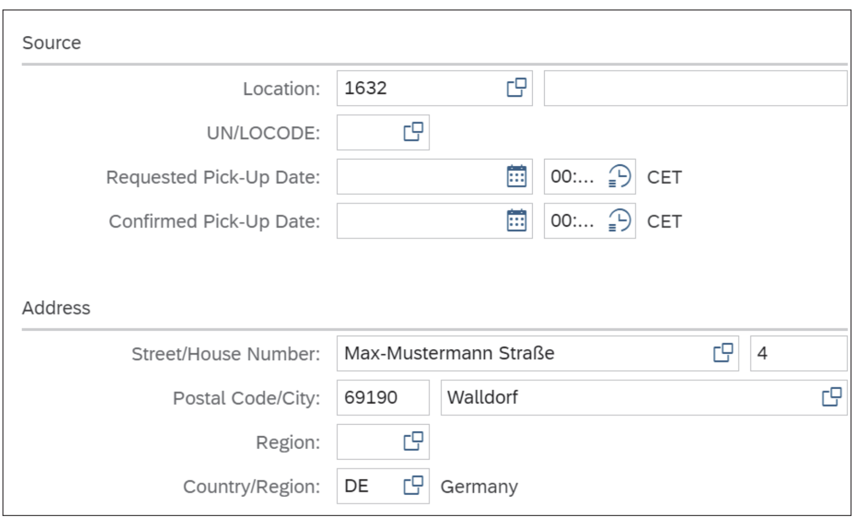


Figure 4.30 Locations with One-Time Location

Take the Term "One-Time Location" Seriously

If you've started thinking that you no longer need to create locations in master data, be aware that "one time" really should mean *one time*. Therefore, we recommend that you use one-time locations in exceptional cases only. In other cases, take the time to create a location master first.

However, when entering an address that is already used in a location master data record, the location ID of this master data record is drawn into the forwarding order. With this functionality, you can avoid having several master data records for the same address in the system.

On the same tab as the locations, you can also define the ordered transportation dates for pickup and delivery. Note that the dates entered on this tab are used for the entire cargo transport, meaning that the pickup date is from the first stage, and the delivery date is from the last stage of the transport. What you define here are the ordered dates; there is no validation of whether the time frame between pickup and delivery date is feasible (there is a validation of whether the delivery date is after the pickup date, in case of data entry errors). Pickup and delivery dates aren't both mandatory; one of the dates is sufficient for freight unit building.

The dates and times are defined in the forwarding order in the time zone that is used by the corresponding location. Transportation planning usually works with a time frame for delivery or pickup, not a single specific time. In freight unit building, the time defined in the forwarding order is rendered into a time frame, if this is required. You'll find more information about pickup and delivery time windows in Chapter 5.

When you've defined the items of the forwarding order, you'll probably come across some fields concerning confirmation. The LSP can confirm quantities and dates/times to the customer after order-taking. This process step can be automated with the **Automatic Confirmation** flag in the forwarding order type Customizing. In addition, you can define on what data the confirmation should be done. This Customizing mainly concerns the dates to be confirmed. The confirmation can be done based on order data, meaning the ordered dates are simply confirmed. Another option in Customizing allows you to do planning first and then confirm to the sold-to party the dates that result from planning. If you want to confirm manually, you need to enter dates in the corresponding fields of the confirmed dates.

If you don't want automatic confirmation, you can fill in the confirmation fields by clicking the **Confirm** button in the action toolbar of the forwarding order document.

Routing

After creating source and destination locations and dates for the entire process, the LSP usually defines the exact routing, including any potential intermediate stops that are on the forwarding order. Note that, in real life, these activities are often done by different employees. The forwarding order can be saved in every state and passed on to the next team, so enriching the forwarding order with more data isn't a problem.

The team responsible for routing the forwarding order uses the **Actual Route** tab to define the route. On that tab, you'll find a table containing all stages that have been created for the forwarding order. In many cases, some stages are predefined here, thanks to the movement type entered on the general data of the forwarding order. Recall that the movement type can be assigned mandatory and optional stage types. In Customizing, you can decide whether some stages should be proposed on the forwarding order when a particular movement type is chosen.

However, there is a second way of automatically assigning stages to the forwarding order. In Customizing of the forwarding order type, you can specify whether stage determination of the forwarding order should be done using the movement type or using a *stage profile*. Stage profiles can be defined in Customizing via IMG menu path **Transportation Management • Forwarding Order Management • Define Stage Profiles**. This Customizing activity looks very similar to the Customizing activity of assigning stage types to the movement type, which was depicted earlier in Figure 4.24. You can make the same settings here as in the movement type Customizing activity.

You might be wondering why there are two different ways of defining the same thing. With stage determination by movement type, you always get a fixed stage setup—the one you assigned to the movement type. With stage profiles, you can be more flexible.

Figure 4.31 shows an excerpt from Customizing of the forwarding order type. If you decide to use stage determination by stage profile, you can assign a stage profile directly to the forwarding order type. In this case, the stage setup is always the same for the forwarding order, no matter which movement type is chosen. You can also determine the stage profile using a condition. This offers the flexibility to determine the stage profile based on any data from the forwarding order, compared to a 1:1 assignment of a stage profile to a forwarding order type. We recommend that you fill in a stage profile even if you're using a condition. If the condition doesn't return a result, the assigned stage profile is considered as a fallback solution.

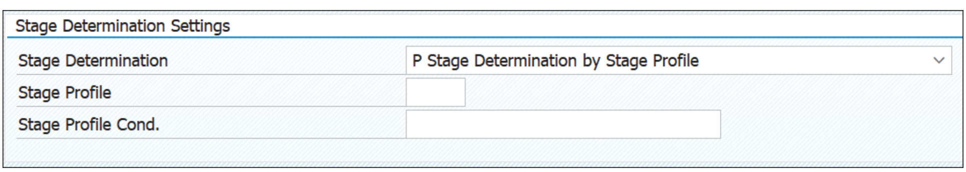


Figure 4.31 Stage Determination by Stage Profile

We've talked a lot about how stage types are assigned to stage profiles or movement types. Now we should take a closer look at what stage types actually are. *Stage types* define the characteristic of the transportation stage in the entire transportation. In Customizing, you can create stage types by following IMG menu path **Transportation Management • Forwarding Order Management • Define Stage Types**.

Stage Determination

Stage determination by movement type is independent of the forwarding order type. No matter which document type is used, the stage setup assigned to the movement type is always considered.

When you use stage determination by stage profile, the stage determination depends more on the forwarding order type.

In Customizing, you simply assign a description to the stage type, as shown on the left in Figure 4.32. You also need to determine the stage category for the stage type. Stage categories are standard categories in the TM functionality that can't be enhanced. Like item categories, stage types are clustered into six groups. Several process steps in the TM functionality use the stage category rather than the stage type. For example, in transportation charge management, you can decide for which stage categories the rate table should be taken into consideration. In addition, the stage category **Main Carriage** has several validations, which we examine later.

Define Stage Types

Stage Type	Description	Stage Cat.
01	Pick-Up	P Pre-Carriage
02	Pre-Carriage	P Pre-Carriage
03	Main Carriage	M Main Carriage
04	On-Carriage	O On-Carriage

Figure 4.32 Stage Type Definition

Because instruction sets can be assigned to stage types, it might make sense to restrict stage types to certain transportation modes. You can do this with the Customizing activity found via IMG menu path **Transportation Management • Forwarding Order Management • Define Allowed Transportation Mode for Stage Types**. Here, you can decide which transportation modes are allowed for a certain stage type. You can also define a default transportation mode, which is used for the stage type after the stage type has been assigned to the forwarding order's routing.

Now that we've talked a lot about Customizing and the prerequisites for the forwarding order's routing, we return to the forwarding order document and start with a manual routing of the forwarding order.

When looking at the tabs available in the forwarding order document, you can see that the TM functionality differentiates between the *ordered route* and the *actual route*. As the names suggest, the *ordered route* is the routing that the customer orders or that is agreed upon with the customer in a contract. Therefore, the routing of the ordered route is also considered by transportation charge management.

When you've linked a forwarding agreement item (i.e., an item of a long-term contract with a customer) to your forwarding order, you can also draw in the agreed routing from this item. In this case, the routing is defined as a default route in the agreement item and is pulled into the forwarding order. The stages of the forwarding order are then prepopulated with the stages of the default route.

However, if the LSP wants to do a different routing (e.g., to optimize costs), the LSP can insert a different actual route. The *actual route* is moved to the freight unit so that transportation planning works with the stages and dates defined in the actual route. You can see the actual route definition also in Figure 4.33.

Stage Description	Stage Type	Mode of Transp...	Source Location	UN/LO... (Source)	City (Source)	Destination Location	UN/LOCODE (Destination)	City (Destination)
Route			1633		Nanjing	TMA_CUST		Kelsterbach
Stage 1	01 (Pick-Up)	01	1633		Nanjing	CHS_SP_CNSHA	CNSHA	Shanghai
Stage 2	03 (Main Carriage)	03	CHS_SP_CNSHA	CNSHA	Shanghai	CHS_SP_NLRTM	NLRTM	Rotterdam
Stage 3	05 (Delivery)	01	CHS_SP_NLRTM	NLRTM	Rotterdam	TMA_CUST		Kelsterbach

Figure 4.33 Actual Route of the Forwarding Order

If the movement type or stage profile has already proposed some stages, those stages will be in the ordered route. The actual route will also contain those stages.

The source location and pickup date of the first stage are taken from the **Locations and Dates/Times** tab, and so are the destination location and delivery date of the last stage. If more than one stage is proposed, you need to enter the other locations and dates manually, except that the routing was drawn from a default route of the associated agreement item.

If you want to add stages, select a stage, and insert another stage either before or after it. Alternatively, you can split the selected stage into two stages and enter new intermediate stops in the forwarding order.

If you've defined schedules in your transportation network, you can directly assign a schedule instance (meaning a voyage or flight) to a stage in the forwarding order. To do so, click the **Schedule** button at the top of the stage table, and then click **Assign**. A search help appears that looks for schedules that run between the locations of the stage. After a schedule is assigned, a booking for this schedule is created. The dates from the schedule are also propagated into the forwarding order's stage. The delivery date of a stage is always the earliest pickup date of the next stage unless you define a different pickup date. When you select the stage that you've chosen a schedule for, more information from the schedule (e.g., cutoff dates) is available below the stage table.

If you don't want to assign schedules (e.g., because you're planning a road transport), you can create a freight document directly from the stage by choosing **Capacity Document • Create One per Stage**. The dates defined in the stage then serve as dates for the freight document. Alternatively, you can select an already-created freight booking for your stage.

To do all of this, you need to define in Customizing what document types should be used for the freight documents and whether the features just described should be available on the forwarding order type. You can find all of these settings by following IMG menu path **Transportation Management • Forwarding Order Management • Forwarding Order • Define Default Capacity Document Types for Stages**.

You can choose a freight document type based on the following information:

- Forwarding order type
- Shipping type
- Stage type
- Transportation mode
- Sales organization

The freight document type can be either a freight order type or a freight booking type. It's also possible to create one freight document for several consecutive stages, but make sure that all stages for which you want to create a common freight document have been assigned the same freight document type.

As you learned in Chapter 2, Section 2.3.5, TM comes with an optimizer engine that you can use for routing and scheduling instead of manually creating stages with locations and dates. As a prerequisite, you need to assign a planning profile to your forwarding order type in Customizing, and then select **Route • Transportation Proposal** on the **Actual Route** tab to start the optimizer.

The optimizer returns one or several results that you can choose from. If you accept one of the results, it's moved into the routing of the forwarding order. In the Customizing of the forwarding order type, you can choose how the transportation proposal's result should be considered in the forwarding order. If only the routing is supposed to be copied into the forwarding order, the stages are filled accordingly with dates and locations. Alternatively, freight documents may already have been created from the transportation proposal, and they are then assigned to the forwarding order's stages.

In some cases, the actual routing differs from the ordered route. If the LSP has agreed with the customer that the actual route should be the basis for charge calculation, you can copy the actual route into the ordered route. To do so, navigate to the **Ordered Route** tab, and choose **Copy from Actual Route**. When you look at the stage table on the **Ordered Route** tab, you can see that, except for copying the actual route into the ordered route and splitting stages, there isn't much you can do here. This is because all other functions for routing would affect the routing for planning and execution and are therefore available only on the actual route. You might also have noticed that it's not possible to copy the ordered route into the actual route. This is because the actual route is always kept in sync with the ordered route automatically until any changes are made to the actual route directly.

Let's return to the **Actual Route** tab again. If the employee taking the order is also responsible for the transportation planning, that employee can directly access the transportation cockpit from the forwarding order. Select **Follow-Up • Start Transportation Cockpit** in the action toolbar at the top of the document. The transportation cockpit is filled with the selection criteria that were assigned to the planning profile that is supposed to be used by the forwarding order (planning profiles can be assigned to forwarding order document types in Customizing).

Because a forwarding order can contain items with different source and destination locations, the stages displayed on the **Actual Route** tab (and on the **Ordered Route** tab, as well) sometimes need to be on the item level. TM offers an item view and a stage view for the stage table. You can switch between the stages by choosing the hierarchy in the **Change Hierarchy** dropdown list at the top of the stage table.

In our example, two items in the forwarding order have the same source location but different destination locations. We want to define a routing that delivers item 1 to its destination location via the destination location of item 2.

Figure 4.34 shows the item view before the insertion of the additional stage for item 10 ❶. After we split the stage of item 10, item 10 contains four stages, whereas item 20 still contains only three stages ❷. When we switch to the stage view ❸, we can clearly see which stages have to be planned separately for the two items and which stages can be planned together.

❶

Stage Description	Stage Type	Tr... M...	Source Location	City (Source)	UN/LO... (Source)	Destination Location	City (Destination)
Route							
Product 10			1633	Nanjing		TMS_CONS	Frankfurt
Stage 1		01	1633	Nanjing		TMS_CONS	Frankfurt
Product 20			1633	Nanjing		TMA_CUST	Kelsterbach
Stage 1		01	1633	Nanjing		TMA_CUST	Kelsterbach

❷

Stage Description	Stage Type	Tr... M...	Source Location	City (Source)	UN/LO... (Source)	Destination Location	City (Destination)	UN/LO... (Desti...
Route								
Product 10			1633	Nanjing		TMA_CONS	Frankfurt	
Stage 1	01 (Pick-Up)	01	1633	Nanjing		CHS_SP_CNSHA	Shanghai	CNSHA
Stage 2	03 (Main Carriage)	03	CHS_SP_CNSHA	Shanghai	CNSHA	CHS_SP_NLRTM	Rotterdam	NLRTM
Stage 3	05 (Delivery)	01	CHS_SP_NLRTM	Rotterdam	NLRTM	TMA_CUST	Kelsterbach	
Stage 4	05 (Delivery)	01	TMA_CUST	Kelsterbach		TMA_CONS	Frankfurt	
Product 20			1633	Nanjing		TMA_CUST	Kelsterbach	
Stage 1	01 (Pick-Up)	01	1633	Nanjing		CHS_SP_CNSHA	Shanghai	CNSHA
Stage 2	03 (Main Carriage)	03	CHS_SP_CNSHA	Shanghai	CNSHA	CHS_SP_NLRTM	Rotterdam	NLRTM
Stage 3	05 (Delivery)	01	CHS_SP_NLRTM	Rotterdam	NLRTM	TMA_CUST	Kelsterbach	

❸

Stage Description	Stage Type	Tr... M...	Source Location	City (Source)	UN/LO... (Source)	Destination Location	City (Destination)	UN/LO... (Desti...
Route								
Stage 1	01 (Pick-Up)	01	1633	Nanjing		CHS_SP_CNSHA	Shanghai	CNSHA
Product 10								
Product 20								
Stage 2	03 (Main Carriage)	03	CHS_SP_CNSHA	Shanghai	CNSHA	CHS_SP_NLRTM	Rotterdam	NLRTM
Product 10								
Product 20								
Stage 3	05 (Delivery)	01	CHS_SP_NLRTM	Rotterdam	NLRTM	TMA_CUST	Kelsterbach	
Product 10								
Product 20								
Stage 4	05 (Delivery)	01	TMA_CUST	Kelsterbach		TMA_CONS	Frankfurt	
Product 10								

Figure 4.34 Item Views and Stage View

Some validations are performed when you do the forwarding order routing. Most validations concern whether all mandatory stage types have been used and whether the transportation modes assigned to the stage types are allowed. Validations also check whether the stage type representing the main carriage uses the transportation mode for which the forwarding order was created.

The sales organization is responsible for entering the order, for example, but isn't allowed to create freight bookings for specific transportation stages or send them to a carrier. Therefore, it can propose how to transport the goods (by specifying a route and schedule and assigning a freight order or freight booking) and set the organization interaction status to **To Be Checked** to transfer the affected stages to the planning and execution organization. You can set the interaction status on the stage table by selecting **Set OI Status • To Be Checked**. The planning and execution organization checks the proposal and transportation stage details in the transportation cockpit. It can then confirm the data exactly as proposed in the forwarding order, change data such as the departure, and then confirm the proposal or reject it outright. The status for the stage in the forwarding order then changes to **Confirmed**, **Confirmed with Deviations**, or **Rejected**, respectively.

The prerequisite for this process step is that you've defined a planning and execution organization for the stage. You can directly assign an organizational unit in the stage table.

Charges and Internal Charges

The **Charges** and **Internal Charges** tabs show the result of charge calculation. Even though charge calculation is a very important topic in forwarding order management, we don't go into great detail about transportation charge management until Chapter 9. In general, these two tabs show the result of a performed charge calculation.

In the Customizing of the forwarding order type, you can enable both internal and external charge calculation. Whether internal or external charge calculation is triggered depends on the combination of sales organization and sold-to party in the forwarding order. The sold-to party can also be an organizational unit from your own company.

In this Customizing activity, you can also specify whether charge calculation should be triggered manually or automatically when the document is saved. If you want to trigger charge calculation manually, select **Charges/Settlement • Calculate Charges** or **Charges/Settlement • Calculate Internal Charges** from the action toolbar at the top of the document.

Profitability

The read-only **Profitability** tab contains valuable information for the LSP business. This tab compares the expected revenue as determined by the charge calculation performed on the forwarding order and the expected costs that derive from the charge calculation on the freight documents related to the forwarding order.

On this tab, you can differentiate between *planned profitability* and *expected profitability*. Although the two terms sound very similar, they are different because the data source for the profitability analysis is different. For planned profitability, the charges from the forwarding order's charge calculation are compared to the charge calculation that is done on the related freight documents.

Cost Distribution

Often, several forwarding orders are consolidated on one freight document. However, when you perform a profitability analysis, the costs imposed on the freight document need to be distributed to the related forwarding order.

TM offers a cost distribution functionality, which we discuss in Chapter 10, Section 10.2. To calculate profitability on the forwarding order, you need to enable and configure cost distribution, no matter whether consolidation on freight orders took place.

Expected profitability, however, considers the data from both the forwarding settlement document and the settlement documents for the freight orders or freight bookings.

Output Management

Like every business document in TM, you can also trigger output for the forwarding order. We don't want to go into the details of setting up output here; we discuss only how to assign output-related Customizing to the forwarding order and how to see the output on the forwarding order document.

In Customizing, you assign output profiles to the forwarding order type. The output profile is defined in the Post Processing Framework (PPF) (see Chapter 2, Section 2.3.3). After an output profile is assigned or dynamically determined, you can go to the **Output Management** tab on the forwarding order document. You'll see an empty table. When you select **Generate • Actions Including Condition Checks**, all output actions that meet the schedule conditions defined in the PPF are triggered. The table is filled with the actions that meet the schedule conditions. You can see whether the actions have been processed and what kind of actions they are.

As you can see in Figure 4.35 we have only print actions in our example. This means the forwarding order document is supposed to be printed. When you select a line, more details about the action are listed below the table. When you select the **Document Preview** tab in the action details view, you get a print preview of the document (only for Abode documents), filled with all the information that we filled in during this chapter or that was derived automatically.

Action Status	Actio...	Processing Type	Deactivate	Langua...	Print	Printer	No. of Print Copies
Unprocessed							
Forwarding Order		External Communication	☐	EN	☑	$A000	001

Figure 4.35 Output Management

Global Functions on the Forwarding Order

At this point, we've systematically browsed through the forwarding order tab by tab. However, there are some functionalities of the forwarding order that can't be directly assigned to tabs. We discuss these next.

Recall from Figure 4.1 that the transportation process starts with a transportation requirement and then continues with planning using the freight unit document. Consequently, the forwarding order has to build freight units to continue the transportation process.

We discuss the freight unit building step in Chapter 5, Section 5.2, but for now, we need to take a closer look at how to trigger it from the forwarding order either manually or automatically. You can define this in Customizing of the forwarding order type. If you choose to use automatic freight unit building, the freight unit is created the first time the forwarding order is saved. If you make any planning-relevant changes to the forwarding order later, the freight unit is updated accordingly.

Prerequisites for Freight Unit Building

Whether you're using automatic or manual freight unit building, some fields in the forwarding order need to be filled in to create a freight unit:

- **Sales Organization**
- **Source and Destination Location**
- **Items with Quantities**
- **Dates and Times**
- **Movement Type**
- **Shipping Type**
- **Transportation Mode**
- **Business Partners for Mandatory Partner Functions**

In some cases, even more fields are required. You can check whether you've filled all required fields for freight unit building by clicking the **Check** button in the action toolbar of the forwarding order.

You can also manually create freight units by selecting **Follow-Up • Create Freight Units** from the action toolbar, but this is only enabled if automatic freight unit building is disabled in Customizing of the forwarding order document type. Manual freight unit building is often used if freight units might be built for several forwarding orders. In this case, you can select several forwarding orders from the POWL and then create freight units from the POWL. If dates, locations, sales organization, and so on are the same on several forwarding orders, the freight unit consolidates these forwarding orders into one freight unit.

To create freight units, you need to assign a freight unit building rule to the forwarding order type in Customizing. If the way freight units should be built depends on data in the forwarding order, you can also assign a condition to determine the freight unit building rule. As with stage type profiles, you can specify a freight unit building rule in addition to a condition in Customizing to have a fallback scenario in case the condition doesn't return any result.

When a customer company orders a cargo transport from its own premises to another customer, the originating customer also often needs to be provided with a container to load prior to the actual cargo transport. You can also define in the forwarding order document that an empty container should be provided to the shipper before the cargo transport happens. The transportation activities ordered with the forwarding order can then include the actual cargo movement as well as the movement of empty containers, as shown in Figure 4.36.

To do so, you can define in the item detail that this container item should be provided to the shipper and/or returned from the ship-to party to a container yard after it's unloaded. After it's defined that the container item is subject to empty provisioning and/or empty return, new tabs appear in the item detail area where you can define the container yard where the empty container is supposed to be picked up from or returned to. Along with this information, you can also define when the container should be picked up and brought to the shipper (for empty provisioning, when it should be picked up at the ship-to party; for empty return, when it should be returned to the container yard).

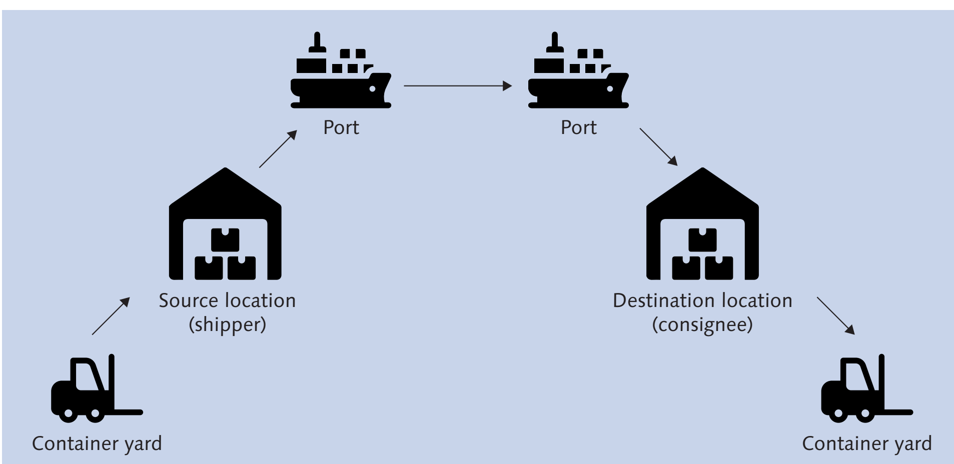


Figure 4.36 Empty Container Provisioning and Return

Note that even though empty provision and empty return are now also part of the forwarding order, the source and destination locations of the forwarding order remain the shipper and the ship-to party. The empty provisioning and empty return information remains on the container item.

When you create freight units for forwarding orders that include empty provisioning and/or empty return, freight unit building is triggered separately for the actual cargo movement (between shipper and ship-to party) and the empty container movements. This means that the freight unit for the cargo movement can be of a different document type than the empty container movement. Furthermore, you get a separate freight unit or container unit document for the empty container movement.

In an LSP business, there are multiple empty container movements that need to be organized. For the LSP, it's therefore often beneficial to transport an empty container directly from a ship-to party to a shipper instead of transporting the empty container back to a container yard and subsequently picking it up from there to transport it to the next shipper.

As you can see in Figure 4.37, the container travels directly from the ship-to party of one forwarding order to the shipper of another forwarding order. This process is called *triangulation*. You can triangulate empty container units on the container unit POWL. When you select all container units or a subset of them and choose **Triangulation • Create Triangulation**, the system automatically finds container units that can be triangulated based on the following information:

- Involved container yards
- Pickup and delivery dates
- Container types or container numbers

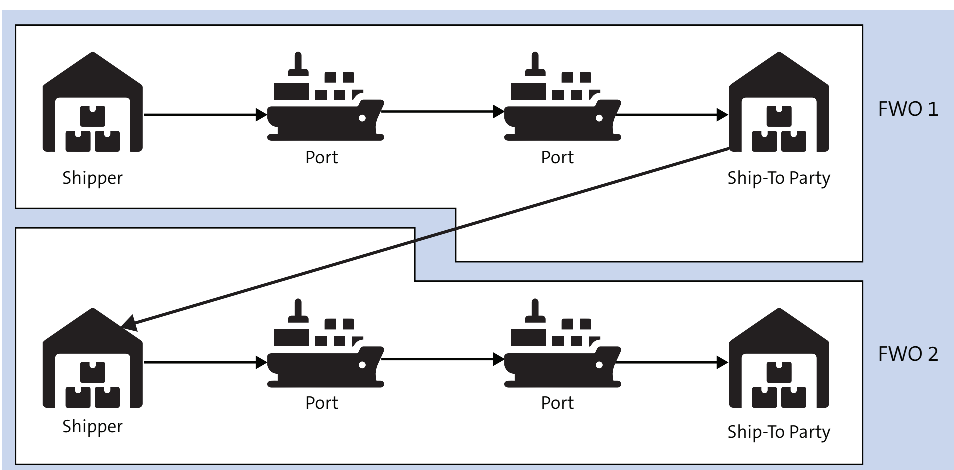


Figure 4.37 Container Triangulation

If applicable container units are found, the container unit from the container yard to the shipper of a forwarding order is merged into the container unit from the ship-to party to the container yard. This means the container yard location is no longer part of the container unit, and one of the two container units is deleted because it's now also represented with the other container unit.

Empty Provision and Empty Return

While we've talked about empty provisioning and empty return of containers only, it's important to note that it's also possible to use the same functionality for railcar items in the forwarding orders. However, if you have an item hierarchy that includes a railcar item containing one or several container items, empty provisioning or empty return is possible only for the railcar item (i.e., the highest level of the item hierarchy).

Sometimes, forwarding orders are created only for charge calculation and business administration reasons. In this circumstance, avoid passing these forwarding orders onto transportation planning by choosing restricted processing of the forwarding order in Customizing of the forwarding order type. This way, the forwarding order is always blocked for planning and execution.

TM in SAP S/4HANA provides the credit limit check feature. You can activate the credit limit check in Customizing of the forwarding order type. The activation of the credit limit check is allowed only if forwarding settlement is also allowed; this way, the credit limit check is performed when the forwarding order is created.

In Customizing of the forwarding order type, you can decide what happens if the credit limit check fails. The negative check result can either be only informative and have no impact on the forwarding order, or it can cause a planning and execution block until the credit limit check is successful.

A credit limit check is always performed again if any of the following information of the forwarding order has changed:

- Sales organization
- Credit limit check amount (usually the result of the charge calculation)
- Business partners
- Logistics data with influence on charge calculation

If you need to cancel a forwarding order, you can do this either from the action provided in the POWL or directly from the document. If you cancel a forwarding order, and freight units have already been created for this document, those freight units are canceled and withdrawn from the freight documents on which they might have been planned.

Canceling Freight Units from Freight Documents

If freight units are canceled (e.g., because the related forwarding order was canceled), then the planning is withdrawn, which means the freight units are taken off the freight order or freight booking. If you want to notify the planner automatically about this change, you need to set up your freight documents accordingly by using a change controller strategy that handles this situation.

You can find more information on the setup of freight documents and change controller strategies in Chapter 6.

When you cancel the forwarding order by clicking the **Cancel Document** button either on the document itself or on the POWL, you're asked to define a cancellation reason code. The code you choose can be used for analysis and is displayed on the **General Data** tab of the forwarding order below **Life Cycle Status**, which is changed to **Canceled**.

You can define cancellation reason codes in **Transportation Management • Forwarding Order Management • Define Cancellation Reason Codes**. You don't need to specify a cancellation reason code when canceling a forwarding order. Canceled forwarding orders can still be used for charge calculation, for example, when the cancelation reason code indicates that the cancelations were caused by the customer only.

As you've seen, the forwarding order contains a lot of information for business administration, transportation planning, charge calculation, and organizational interaction. In many LSP processes, these different process areas are usually performed by different areas within the company.

For the person who takes the order, it would be cumbersome to navigate through all the tabs we've mentioned to enter relevant data. Therefore, the order taker can use the page selector, which is located in the action toolbar in the top-right corner of the forwarding order document.

Recall from Chapter 2, Section 2.2.3, that you can customize the forwarding order screen according to your needs. However, it might be useful to switch between a **Fast Order Entry** screen and the full-blown forwarding order document. TM provides **Fast Order Entry** screens for the air, land, and sea transportation modes because the required information depends on the transportation mode.

Figure 4.38 shows a **Fast Order Entry** screen for land transportation. It displays only the data needed for order entry, including the business partners, sales organization, general terms, locations, dates, and items. If you need more information on the **Fast Order Entry** screen, you can add more fields in screen Customizing.

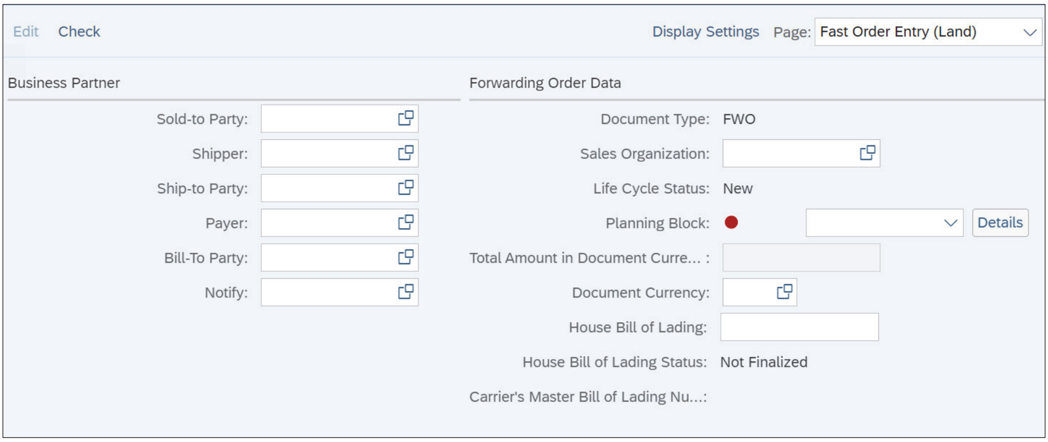


Figure 4.38 Fast Order Entry Screen

Notice that there is no action toolbar in Figure 4.38. The **Fast Order Entry** screen works only for order entry. You need to switch back to the conventional forwarding order screen for processing the forwarding order.

As already mentioned, the sold-to party can send an order via EDI messages to make the LSP or carrier create a forwarding order. This process can be automated with TM because the service interface `TransportationRequestRequest_In` works for all fields that might be relevant for creating a forwarding order. Make sure you've done the setup of the field and service mapping in SAP Process Integration properly. The forwarding order is created automatically if this service interface is triggered.

If you want to confirm data back to the sold-to party, you can also use EDI communication with the service interface `TransportationRequestConfirmation_Out`. For more information about the automatic creation of documents using service interfaces and communication with web services, return to Chapter 2, Section 2.4.

4.2.2 Charge Estimation

Customers often call the LSP to request a price for a transportation service. Although you can enter and perform charge calculation on the forwarding order, it takes a lot of time, and with the customer waiting on the phone, you might require a quicker way of calculating charges. For this reason, the Estimate Freight Charges app in the **Order Management** tab of the SAP Fiori launchpad takes you to a screen where you can quickly estimate the charges for the customer's order.

Charge Estimation

To use the charge estimation, you need to have set up the transportation charge management component. You can find more information on transportation charge management in Chapter 9 and Chapter 11.

Notice that because the charge calculation itself usually works independently of the document type, no forwarding order type is necessary to start the charge estimation; only the transportation mode needs to be entered. The charge estimation screen in Figure 4.39 looks a little like the **Fast Order Entry** screen used for forwarding orders. On this screen, you're asked to enter all data that is relevant for charge calculation. The following fields are mandatory:

- **Purchasing Organization**
- **Source Location**
- **Destination Location**
- **Sold-to Party**

Other fields may not be mandatory for system validation but are often required to perform charge calculation (e.g., **Item**).

If no pickup date is entered, the current system date is used as the pickup date for the charge calculation.

Charge Estimation Application

As described in Chapter 2, Section 2.2, TM applications can be displayed in a browser using a hyperlink. Because this also applies to the charge estimation, think about providing the customer with the link to the charge estimation application. This allows the customer to use TM's capability without contacting the LSP. If you do this, make sure you thoroughly check your authorization setup so that the customer can only estimate its own charges.

The charge estimation is read-only information; that is, the estimated charges can't be saved or turned into a forwarding order.

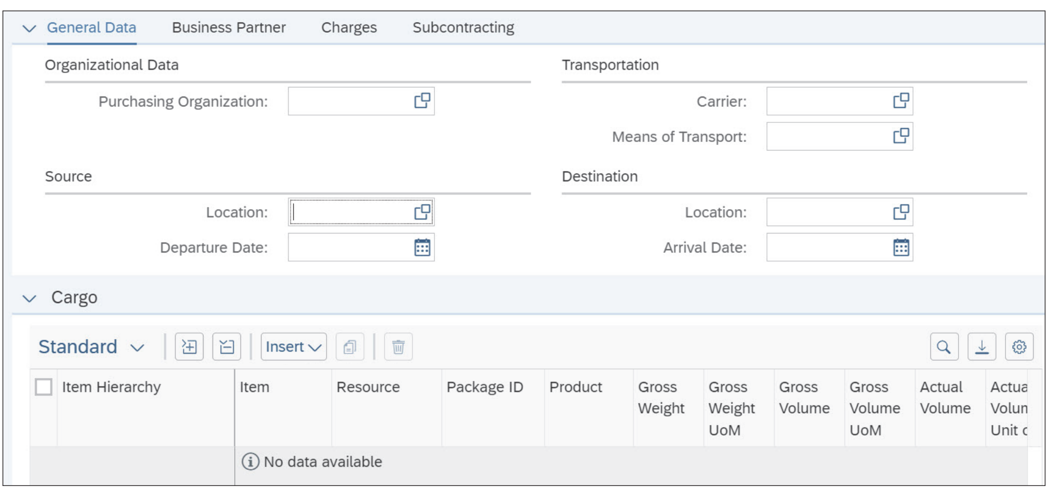


Figure 4.39 Charge Estimation Screen

4.2.3 Forwarding Quotations

We've spent a long time talking about the forwarding order, which is the document that represents the actual order or contract between a sold-to party and an LSP or carrier. However, before you can create an order in the transportation process, you often need to create a quotation, which is covered by TM with the *forwarding quotation* document. This business document helps the sold-to party send the data of a potential forwarding order with the quotation price. When the quotation is successful, the forwarding order can be created in relation to the quotation.

Notice that the forwarding quotation looks very similar to the forwarding order. In fact, you can do most of the things we talked about in Section 4.2.1 in the forwarding quotation. You can create forwarding quotations via the Create Forwarding Quotation app in the **Order Management** tab of the SAP Fiori launchpad. Just as you did with the forwarding order, when creating a forwarding quotation, you need to define a forwarding quotation document type. You can specify a forwarding quotation document type in Customizing by following IMG menu path **Transportation Management • Forwarding Order Management • Forwarding Quotation • Define Forwarding Quotation Types**.

When looking at the forwarding quotation itself and customizing its type, you'll find many similarities between the forwarding quotation and the forwarding order. The following features and processes are handled exactly the same way as in the forwarding order:

- Item definition
- Item definition with different source or destination locations
- Item type assignment to document types
- Stage determination by either movement type or stage profile
- Automatic charge calculation when saving the document
- Partner determination by partner determination profile
- Transportation proposals
- Creation of one-time locations
- Cancellation of the forwarding quotation with a reason code

Note

You can find the corresponding Customizing activity via IMG menu path **Transportation Management • Forwarding Order Management • Forwarding Quotation • Assign Item Types to Forwarding Quotation Types**. Make sure that when you create a forwarding order out of a forwarding quotation, the same item types are assigned to the forwarding order type that are used for the forwarding order creation.

Not everything is the same, though. Figure 4.40 shows the most important differences between a forwarding quotation and a forwarding order. In the quotation, you can specify a valid-to date, which is the deadline by which the quotation must be accepted or rejected.

Just like with charge calculation on the forwarding order, TM can calculate the quotation price. This takes place, for example, if the customer calls the LSP or carrier and asks for a price. The price is calculated, and you can submit it to the sold-to party by selecting **Response • Submit** from the action toolbar at the top of the screen.

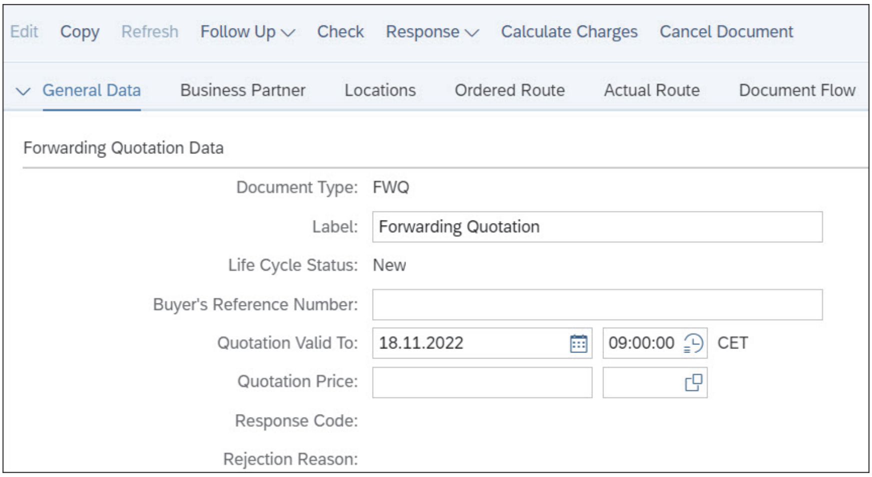


Figure 4.40 Forwarding Quotation Fields and Actions

The communication that takes place during the quotation process can vary from customer to customer. When communication occurs by phone, you can simply update the status of the quotation manually using the actions provided by the **Response** button. Below the quotation price, as depicted in Figure 4.40, you can see your response to the customer—whether you've accepted the quotation or rejected the quotation. When rejecting a quotation, you can specify a rejection reason, which can also be communicated to the sold-to party. The forwarding quotation document is canceled after the quotation has been rejected.

The forwarding quotation also supports the communication between sold-to party and LSP via EDI. In this case, the forwarding quotation can be created via the corresponding web service `TransportationRequestQuotationCreateRequest_In`. This service interface provides all the necessary fields to create a forwarding quotation in TM, just like manual creation of a forwarding quotation. The response of the carrier or LSP is then sent out to the sold-to party with the service interface `TransportationRequestQuotationConfirmation_Out`.

Service Interface

Even though the name of the service interface `TransportationRequestQuotationConfirmation_Out` suggests that you can use it only to confirm or accept quotations, you can also use it to reject quotations.

A quotation can also be made in the course of a tendering process. Imagine that the sold-to party also uses TM and starts a tendering for a freight order in its system (learn more about triggering the tendering process in Chapter 6, Section 6.6). A request for quotation (RFQ) is sent out to the LSP or carrier, and a forwarding quotation is created for the customer's RFQ.

EDI Messaging from TM to TM

It's possible to start a tendering process and communication between a sold-to party's TM system and a carrier's TM system. However, you need to make sure you have the correct SAP Process Integration setup in place so that the outgoing B2B messages of the RFQ are matched to the correct incoming B2B service interfaces.

If you want to use your forwarding quotation as part of the tendering process, you need to define this in Customizing of the forwarding quotation type. In the Customizing activity, change the setting **Quotation Mode** to **With Request for Quotation**. The forwarding quotation document UI changes slightly. You get additional fields showing the response due date and a potential price limit. As shown in the top-right corner of Figure 4.41, the response options are now restricted to **Accept** and **Reject** because you can only accept or reject an RFQ and communicate a price.

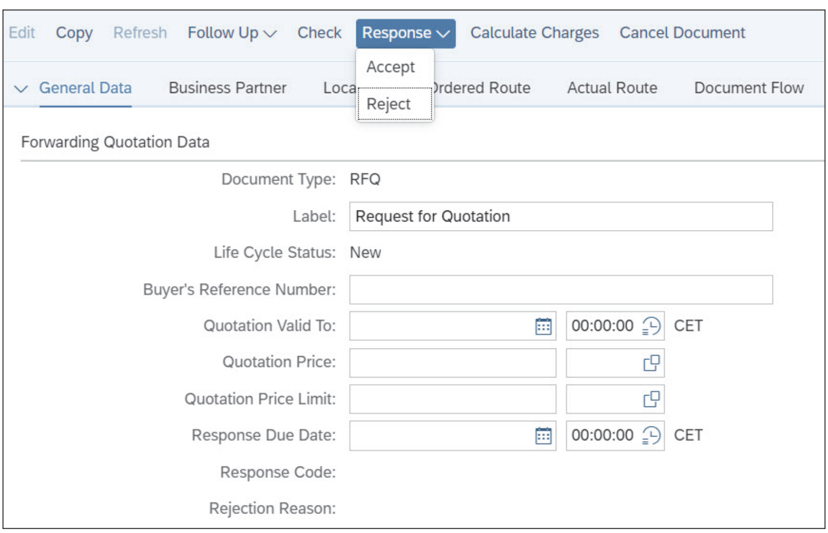


Figure 4.41 Forwarding Quotation with RFQ

Whether you're using a forwarding quotation with or without RFQ, the processing of a forwarding quotation is mostly the same. Processing a forwarding quotation isn't much different from processing a forwarding order.

When the forwarding quotation has come in, you can do the routing of the quotation manually on the **Actual Route** or **Ordered Route** tab. (Return to Section 4.2.1 for more information on how to do manual routing on this tab.) Alternatively, you can use a transportation proposal for the route determination of the forwarding quotation by specifying the freight unit building rule in Customizing of the forwarding quotation type, similar to Customizing of the forwarding order type. No freight units are built based on the forwarding quotation; the freight unit building rule is used only for the simulation of the freight unit building and optimizer planning in the transportation proposal.

After you route the forwarding quotation, you can calculate charges for the document in exactly the same way as on the forwarding order. The prerequisite is again the correct combination of sales organization, sold-to party, and existing master data in transportation charge management. As before, the calculated price is displayed on the **General Data** tab, as shown in the preceding figures. You can also manually overwrite the quotation price later. Only this value is communicated to the customer.

As with the forwarding order, you can view the detailed result of charge calculation on the **Charges** tab. Because the quotation doesn't serve as an actual order or contract, settlement isn't possible based on the forwarding quotation document.

If the customer has accepted the quoted price, you can now create an actual order for the quotation. But don't worry—you don't need to create a new forwarding order from scratch; you can create the forwarding order directly from the forwarding quotation by selecting **Follow Up • Create Forwarding Order** in the action toolbar of the forwarding quotation.

The forwarding order type that is used for creation must be defined in Customizing of the forwarding quotation type in the **Default Forwarding Order Type** field. In Customizing of the forwarding quotation type, you can specify how many forwarding orders may be created out of the forwarding order. Additionally, a forwarding order can be created out of a forwarding quotation only if the quotation was already submitted.

All relevant data is copied from the quotation to the order. The most important data copying is probably the calculated charges. Because master data in transportation charge management might change during the quotation and order-taking process, you want to avoid calculating charges again on the forwarding order when a different result could occur. Therefore, the charge calculation results are copied to the forwarding order, and the status for charge calculation indicates that no further charge calculation is necessary. If you need to do a charge calculation on the forwarding order again, you can do so using the functionality covered in Section 4.2.1.

The assignment of the forwarding quotation to the forwarding order is displayed in the document flow if you've created a forwarding order from a forwarding quotation. Later, the document flow of the freight unit and freight orders will document that the process has started with a forwarding quotation. However, in some cases, you create a forwarding order independently of the forwarding quotation even though a quotation exists for this workflow. In this case, you can subsequently assign a forwarding quotation to a forwarding order.

On the forwarding order, actions are available in the action toolbar that enable the retroactive assignment of the forwarding quotation to the forwarding order, as shown in Figure 4.42. When you want to assign a forwarding quotation to the forwarding order, select **Forwarding Quotation • Assign FWQ**. A new popup appears in which you can enter the document number of the forwarding quotation. However, checks are performed to determine that the selected forwarding quotation aligns with the current forwarding order. The standard checks include whether the locations and dates in both documents match and whether the combination of sold-to party and sales organization is the same.

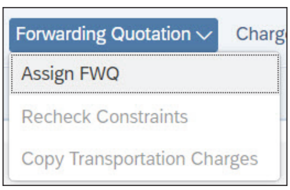


Figure 4.42 Assignment of Forwarding Quotation to Forwarding Order

Enhancing the Standard Check

You can enhance these checks with a BAdI found via IMG menu path **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management • Forwarding Order Management • Assignment of Forwarding Quotation to Forwarding Order • BAdI: Extension of Checks for Assignment of Forwarding Quotation to Forwarding Order**.

When you're creating documents for an import/export process, you can also assign an import forwarding quotation to an export forwarding order. You'll find more information on import/export processes in Chapter 7.

4.2.4 Creating Orders and Quotations with Reference

In the transportation business, LSPs and carriers often have a stock of regular customers who frequently order transportation services for the same route or with similar items. If you don't want to create new orders or quotations from scratch, you can use existing documents and create new ones from them.

One option is to copy an existing forwarding order (e.g., from a transportation service performed in the past) and update certain information, such as dates. When you copy the forwarding order, no link is established between the existing forwarding order and the copy. A forwarding order can also be copied with a new type, meaning the new forwarding order takes over most of the data from the existing forwarding order but is assigned a different forwarding order type. This method is used in import/export processes where an import forwarding order is created from the export forwarding order. (Again, Chapter 7 offers more information about import and export forwarding orders.) When you display a forwarding order, click the **Other Copy Options • Copy with New Document Type** button in the action toolbar to open a new tab in SAP Fiori. In this tab, you can specify the new document type and, if necessary, a new transportation mode.

You can get to the screen shown in Figure 4.43 by opening the Create Forwarding Order app in the **Order Management** tab of the SAP Fiori launchpad.

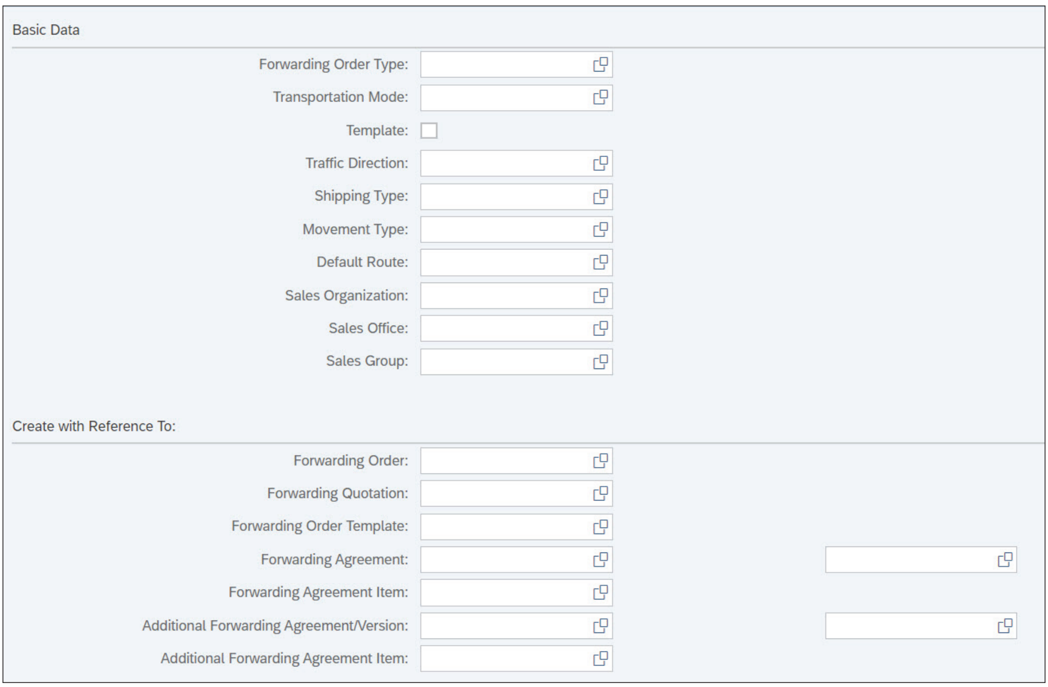


Figure 4.43 Forwarding Order Creation Initial Screen

In the **Basic Data** upper screen area, you define information that should be assigned to the new document you want to create. In the **Create with Reference To** lower screen area, you assign references to existing documents. We revisit this screen in a few pages, so keep it in mind.

You can use this initial screen to create the forwarding order as a copy from an existing forwarding order. Enter the **Forwarding Order Type** in the upper screen area and specify the forwarding order document number in the **Create with Reference To** area. The new document acquires all the data from the reference forwarding order. However, as already mentioned, no reference is shown in the document flow.

The risk with copying an existing forwarding order is that you have to be very careful with the already-existing data. Discrepancies might result if you accidentally copy item quantities that the customer did not order.

To avoid this risk, you can create templates for forwarding orders. To create a template, you use the same app as when creating forwarding orders. On the initial screen, as shown in Figure 4.43, select the **Template** checkbox in the **Basic Data** area. You don't need to customize any separate forwarding order template types, but you can use the forwarding order types.

If you look at the template document, you'll see that it closely resembles the forwarding order (which is no surprise, because it's a template for creating forwarding orders). Note that you can't trigger charge calculation or freight unit building from forwarding order templates because these functionalities are reserved for the forwarding order document itself.

The template document is missing some tabs that appear on the actual forwarding order document: **Profitability**, **Attachments**, **Internal Charges**, **Output Management**, and **HBL or HAWB**. These forwarding order tabs are concerned with the actual execution of the transportation service. Because the template isn't meant to have anything to do with process steps that trigger transportation execution, freight unit building and charge calculation are disabled.

The biggest difference is that you can't define any dates in the **Locations and Dates/Times** tab. This is because templates should be timeless, meaning that, in most cases, it's the dates that differ from order to order.

After you save the template, a document number is assigned. We recommend that you use a different number range for templates and actual forwarding orders to differentiate between the two document categories. You can assign the number range of both the forwarding order documents and the forwarding order templates in Customizing of the forwarding order type.

Now when you want to create a forwarding order from a template, you have different options. One option is to use the POWL that was shown earlier in Figure 4.20 for forwarding orders. This POWL includes queries to find template documents. For example, you can search template documents for a certain combination of sales organization and sold-to party or a specific routing. When you've found the right template, you can select it in the POWL and click the **Create Forwarding Order from Template** button at the top of the screen.

Alternatively, you can display the template by using the Display Forwarding Order app. If you know the document number of the template, you can insert it. The system automatically recognizes that you've chosen a template. If you don't know your document number, you can select the **Template** checkbox on the initial screen. If this checkbox is selected, the F4 help displays only forwarding order template documents.

When displaying the template document, you can also click the **Create Forwarding Order from Template** button from the action toolbar. If you want to copy the template with a new document type, as explained previously, the new document is also a template document.

The third option is to use the initial screen of the forwarding order creation. In the **Create with Reference To** area, you can specify a template document number. All data from the template is then copied into the forwarding order. As when you copy existing forwarding orders, no relationship between the template and order is displayed.

Creating forwarding orders from the forwarding quotation with the features described in Section 4.2.3 is not the only possible method. If you look at Figure 4.43 again, you'll see that you can also define forwarding quotations in the **Create with Reference To** area.

Creating forwarding orders with *reference* to a forwarding quotation is the same process as creating forwarding orders from the forwarding quotation—meaning that the prerequisites for creating a forwarding order from a forwarding quotation must be met. In this case, the forwarding quotation is added to the forwarding order's document flow as a predecessor document.

In the **Create with Reference To** area of Figure 4.43, you can assign forwarding agreements as a reference for the forwarding order that is being created. This referencing has a slightly different effect than the referencing of quotations, templates, and other orders.

No data is copied into the new forwarding order. The referencing here is used to avoid the system-based agreement determination, which is explained in detail in Chapter 9, Section 9.2. If you assign agreements as reference, these agreements are considered when calculating charges on the forwarding order.

Although we've primarily concentrated on forwarding orders during our discussion of the template, templates can also be used for forwarding quotations. The following features are also applicable for quotations:

- Defining different number ranges for templates
- Creating forwarding quotation templates
- Using the reference area on the initial screen of the forwarding quotation creation
  - Referencing forwarding quotations
  - Referencing forwarding quotation templates
  - Referencing forwarding agreements
- Disabling charge calculation of forwarding quotation template

Because the transportation requirement document marks the beginning of the transportation planning, charging, and execution process, it's a very important document for the whole process. The information entered in the transportation requirement is passed on to the next process steps. The transportation requirement document is the only document in which information about the goods to be transported is entered into the system.

Look back at Figure 4.2, which was shown at the beginning of this chapter, in relation to which transportation requirement documents exist and how they are used. You should be able to explain the differences between the documents and give details about each of the documents depicted by the bottom-left boxes.

4.3 Summary

We've walked through quite a lot of steps in this chapter; now, let's review the process as a whole: There are two ways of creating transportation requirement documents in TM. The first option is the integration of materials management or sales and distribution order and delivery documents into the TM functionality, which was explained in detail in Section 4.1.1. This option is used by the shipper industry that uses TM for the transportation of its own manufactured and sold or purchased materials.

You can integrate the following SAP orders:

- Sales orders
- Purchase orders
- Stock transfer orders
- Scheduling agreements

The order integration described in Section 4.1.1 and Section 4.1.2 works fully embedded. Only the activation of the transfer of orders to the TM functionality needs to be configured for sales and distribution and materials management.

After the order has been transferred to the TM functionality, a freight unit is created. The freight unit doesn't differentiate between sales and distribution and materials management orders.

After the freight units have been planned, the TM functionality can send a delivery proposal to the orders in sales and distribution and materials management. Deliveries can then be created based on the planning results in TM, but the leading functionality that determines how deliveries are created is still sales and distribution or materials management. The integration of created deliveries is configured like the integration of orders.

If you're using a separate instance to run TM, the integration needs to be set up slightly differently. In this case, the sales and distribution or materials management order or the delivery is sent to the TM instance via web service, and a document representing this order—the OTR—is created in TM. The delivery is represented by TM with the DTR document. If both order and delivery are sent to the separate TM instance, an OTR consumption can take place. The integration with an external TM system was described in Section 4.1.4.

The second option for creating transportation requirement documents in TM is creating forwarding orders and forwarding quotations. These documents are used by LSPs and carriers who need more information about the requested transportation process than what is integrated from SAP S/4HANA orders.

Forwarding orders can be created via EDI messages or manually. The forwarding order document combines various pieces of information:

- Information relevant for business administration
- Data relevant to charge calculations
- Data crucial for transportation planning

This information is displayed in the document in different tabs. The most important tabs of the forwarding order were explained in Section 4.2.1.

If customers inquire about the price of a transportation service based on existing agreements, no order has to be created. The charge estimation, covered in Section 4.2.2, calculates the charges of transportation services without creating any documents in TM. This application could possibly also be provided to the customer directly if a customer requests charge estimation very often.

In a tendering process, the customer's inquiry doesn't necessarily result in the creation of an order. Therefore, the first step of the customer engagement is to create a forwarding quotation, as described in Section 4.2.3. With the help of the forwarding quotation, the customer's inquiry can be communicated to and registered by the LSP or carrier, which then communicates a price to the customer. This communication can also be done electronically using web services. After the customer agrees to the quoted price and terms, a forwarding order can be created from the forwarding quotation.

If forwarding orders or quotations are often created for the same routing or material, the person who takes orders can make the task easier by creating template documents up front. When an order needs to be created, the data can be reused via templates, and the employee can add data specific to the individual order. Templates were covered in Section 4.2.4. After the transportation requirement is completely entered and confirmed, and freight units have been built, the transportation planning process can start.

Let's continue going into the details of transportation planning in Chapter 5. In that chapter, you'll recognize much of the information that we've entered in either the SAP S/4HANA order/delivery or forwarding order.

Chapter 5
Transportation Planning

Planning transportation activities are a key component of any transportation management solution. A proper transportation plan can help save money if it reasonably addresses the constraints present during its execution.

In previous chapters, we introduced business documents that represent a transportation need in transportation management (TM), such as sales orders, deliveries, order-based transportation requirements (OTRs), delivery-based transportation requirements (DTRs), and forwarding orders. On the other hand, vehicle resources, container resources, schedules, and freight bookings were introduced as a means to represent transportation capacity. The key objective of transportation planning is to create a transportation plan that brings together transportation needs and transportation capacity in the most efficient manner.

The first step that can be attributed to planning upon the creation of a transportation need is the creation of freight units. Freight units represent transportation requirements for planning and are obtained from their predecessor business documents via freight unit building rules. Freight units represent transportable objects that are kept together from their source to their destination (e.g., pallets and containers).

In the planning process, freight units can be assigned to multiple freight orders in a transportation chain or consolidated into one freight order, as is done in a local delivery tour. Essentially, the planning step covers the assignment of freight units to freight orders; these freight orders are the result of planning.

This planning step can be performed manually or automatically. A purely manual planning step can assign freight units to a vehicle resource using the drag-and-drop functionality in the transportation cockpit to create a freight order; it can make the same assignment using the optimizer called by a background job.

The main objective of planning is to support the user with reasonable guidance for manual planning, as well as with powerful automation capabilities. The transition between both planning alternatives is smooth because automatically created plans can be adapted manually, and manual planning processes can make use of automation. For example, you can start the optimizer interactively in the transportation cockpit.

The planning process is configured mainly by two profiles: the selection profile and the planning profile. The *selection profile* is responsible for the decision about *what* needs to be planned, and it basically selects the freight unit (stages). The *planning profile* determines *how* to plan—that is, which transportation capacities are available for planning and which constraints (e.g., incompatibilities) need to be considered.

The transportation cockpit is the central user interface (UI) for planning. It's very flexible and configurable by the definition of various layouts so that it can process many structurally different planning scenarios (e.g., from planning a local road transport to planning overseas transportation chains).

This chapter is structured in the following way. First, Section 5.1 provides an overview of the documents involved in the planning process and the decisions that may need to be made. In Section 5.2, we examine freight units and address the different properties of freight units defined by the freight unit type, their relationship to predecessor and successor business documents, and rules for their creation. Section 5.3 describes unified package building and the process of converting products and quantities into a package hierarchy. Thereafter, Section 5.4 introduces transportation units, which can be used to represent the transportation plan for scenarios involving trailers, railcars, containers, and packages. Section 5.5 describes normalized quantities, which quantify requirements regarding a standardized measure for the expected floorspace and can be used in planning. Section 5.6 presents the planning process configuration, including details on planning strategies, selection profiles, and planning profiles. Section 5.7 deals with manual planning by covering the transportation cockpit and its rich configuration capabilities based on page layouts as well as user-centric decision-making based on the transportation proposal functionality. Section 5.8 deals with automated planning. In contrast to Section 5.7, the focus here is on processes and functionality that aren't primarily interactive and user driven. Background planning and detailed insight into the optimization capabilities are in the scope of this section. Furthermore, this section includes a description of load consolidation and load planning processes. The last section, Section 5.9, deals with the integration to an external system for planning purposes.

5.1 Documents and Decisions

Planning means assigning demands to capacities, resulting in a plan that optimizes the given business objectives and meets desired constraints. Transportation planning involves various business documents and different decision levels beyond the pure assignment of demands to capacities.

Figure 5.1 shows the business documents relevant for planning and their assignment options. Demand documents and their stages can be assigned to capacity documents. A capacity document can represent the transportation of one or more demands' stages. While a freight unit only represents a pure demand and freight orders and freight bookings represent pure capacities, transportation units can represent both demand and capacity at the same time. Consignment orders can represent a demand but also consolidate demands. The documents in box ❶, freight units and package units, can be assigned to the documents in boxes ❷ and ❸. The documents in box ❷, consignment orders and container units, can be assigned to all capacity documents shown in box ❸, except for consignment orders, which don't allow the assignment to ocean and air freight booking yet.

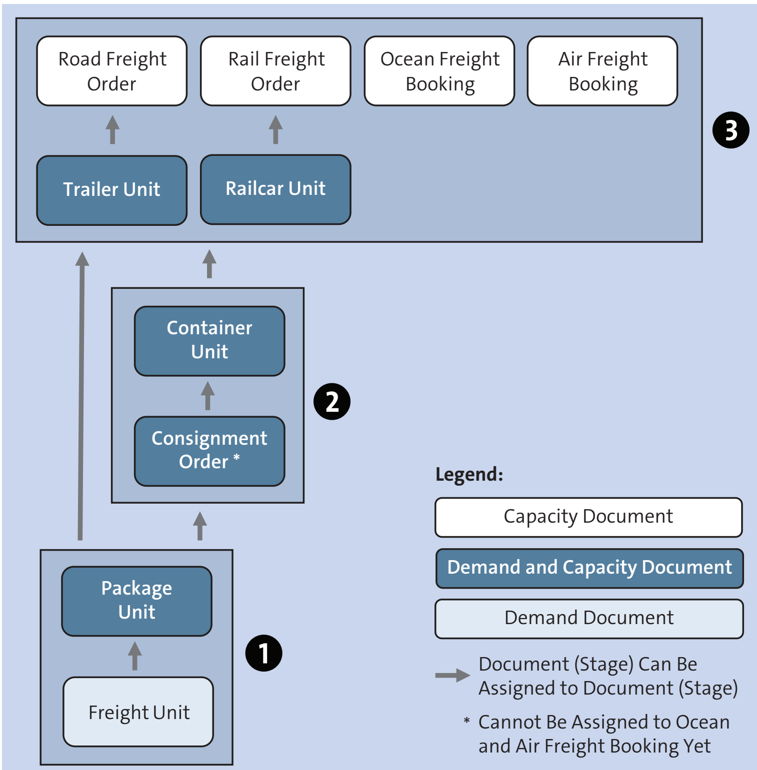


Figure 5.1 Documents and Assignment Decisions

The documents serve the following business purposes:

- **Freight unit**
  A freight unit represents an original transportation demand abstracting from forwarding orders, sales orders, or deliveries, which is transported through the complete transportation chain without splitting it on any transportation stage. As a pure demand, a freight unit consumes capacity. See Section 5.2 for details on freight units.
- **Road freight order**
  Road freight orders represent transportation by road, which can be subcontracted or executed by a company's own fleet. This document represents a capacity and can consolidate multiple demands that consume the capacity. See Chapter 7.

- **Rail freight order**
  In the same way as the road freight order, a rail freight order represents transportation by rail.
- **Ocean freight booking**
  Ocean freight bookings represent subcontracted ocean transports. Like freight orders, a booking can consolidate multiple demands. See Chapter 6, Section 6.2.1.
- **Air freight booking**
  Like ocean freight bookings, an air freight booking represents transportation by an airplane. See Chapter 6, Section 6.2.2.
- **Consignment order**
  A consignment order represents a logical grouping of one or multiple transportation demands with the same source and destination, but it doesn't represent a physical capacity. It's frequently used in communication, for example, for advanced shipping notifications, between shippers and consignees, and can also be used for subcontracting purposes. See Chapter 6, Section 6.3.
- **Trailer unit**
  A trailer unit represents demands in a trailer that get transported by a road freight order. See Section 5.4.2 for details.
- **Railcar unit**
  Railcar units represent demands in a railcar that get transported by a rail freight order. Section 5.4.3 provides details on railcar units.
- **Container unit**
  A container unit models a demand transported in a container, as described in Section 5.4.4.
- **Package unit**
  Package units represent demands that are transported together in the same packages, for example, a pallet or carton. See Section 5.4.5 for details.

While trailer units and railcar units are dedicated to the road and rail mode of transport, container units frequently involve multiple modes of transport on the container unit stages. Package units may also get shipped in multiple modes of transport, directly or indirectly via container units.

Freight orders represent the movements of trucks and locomotives. Freight bookings represent the subcontracted movement of vessels or airplanes. Without freight orders and freight bookings, neither freight units nor transportation units can be transported. However, freight orders can represent transportation without transportation units and freight units; these represent empty moves, which may make sense, although you usually attempt to avoid them.

We use the term *freight document* as abstraction from road freight orders, rail freight orders, ocean freight bookings, and air freight bookings. Freight documents can get subcontracted and form the basis for execution. They may be created in advance to reserve a carrier's transportation capacity, which is then consumed by assigning demands.

You can consolidate multiple freight units into a container unit, which serves as capacity from the freight unit viewpoint. However, the container itself also represents a demand that needs to be transported. In an intermodal container transportation scenario from China to Europe, the container may have three stages that are assigned to a road freight order for pre-carriage within China, an ocean freight booking for main carriage, and another road freight order for the subsequent carriage in Europe.

A consignment order contains only one stage. It can get subcontracted or consolidated into a freight order, which then gets subcontracted. A freight order can contain multiple consignment orders.

Note that all documents created by freight unit building don't allow consolidation; that is, you can't assign other demand documents. See Section 5.2.3 for details on freight unit building.

Planning means decision-making, and creating a transportation plan can involve the following decisions:

- **Demand document stage sequence decision**
  For any demand document, the stage sequence defines the flow through the transportation chain. For example, for a freight unit, the stage sequence defines the hub sequence used to transport from the source to the destination location. Thus, the freight unit stage sequence defines the path through the hub network.
- **Consolidation decision**
  Each demand document stage can be assigned to a different capacity document. In many scenarios, many demands get transported by many capacity documents, and the consolidation decision defines which demands get transported together by the same capacity document. Another low-level consolidation decision is involved when different products get consolidated into mixed pallets.
- **Routing decision**
  As freight orders may consolidate many demands with different sources and destinations, the stop sequence defines the routing across all involved locations, which is essential as its total distance and duration mainly impacts transportation efficiency.
- **Scheduling decision**
  The scheduling decisions for a freight order involve assigning start and end times to all activities, such as loading, unloading, and transporting. Ocean freight bookings are frequently based on predefined schedules and their departures. Both scheduling and the choice of the right schedule departure are essential for the desired service level to deliver on time.
- **Equipment type assignment decision**
  The choice of the equipment type is key to determine the available capacity for a document at hand. Truck and locomotive types can be assigned to road and rail

freight orders, trailer and railcar types to trailer units and railcar units, and container types to container units.

- **Resource assignment decision**
  While a multiresource could model a resource type (e.g., a 40 ton truck type that can carry 25 tons), a single resource corresponds to one specific resource instance (e.g., a 40 ton truck with a given license plate). The choice of a single resource is more specific than the choice of an equipment type, so you may first choose the equipment type and then the single resource. Analogously to the equipment type assignment, truck and locomotive resources can be assigned to road and rail freight orders, trailer and railcar resources to trailer units and railcar units, and container resources to container units. The assignment of single resources is commonly used when operating a company's own resource fleet or operating subcontracted resources such as their own fleet.
- **Driver assignment decision**
  Companies running their own truck fleet need to assign the right drivers to the road freight orders at hand. Decisions need to be made regarding whether a single driver or a team of two drivers is needed, as well as whether the driver assignment decision is made on the document or document stage level.
- **Carrier assignment decision**
  Companies without their own fleet subcontract their road freight orders to road carriers. Usually, several alternative carriers are available from which to choose for execution.
- **Packaging decision**
  If transportation demands contain product quantities, decisions need to be made regarding how the products get packaged for transportation. For example, different products may get consolidated into pick cartons, and both stock cartons (of one product) and pick cartons get consolidated into a mixed pallet.
- **Physical positioning decision**
  Road freight orders may involve transportation of pallets, each containing multiple cartons. Physical positioning can be relevant on two levels: positioning cartons in a pallet and positioning pallets in the truck. Positioning is important to maximize the utilization of pallets and trucks, optimize transportation efficiency, and ensure transportation safety, for example, considering axle weight constraints.

Due to the huge diversity of different transportation businesses, not every business will involve each decision type. But each transportation business requires one or multiple decisions, which can be made manually (Section 5.7), automatically (Section 5.8), or by a combination thereof. Obviously, many decisions depend on each other.

The decisions are made based on the available transportation network (described in Chapter 3, Section 3.2), equipment types and resources (see Chapter 3, Section 3.3), and various constraints imposed by the planning profile and additional settings (Section 5.6.2).

5.2 Freight Units

Freight units are an important element in the planning process because they provide the link between transportation requirements—for example, a forwarding order and the transportation document (i.e., the freight order). They can be omitted only in special circumstances if the transportation requirement exactly matches the to-be-created transportation document (called a *shortcut planning process*). This process is described in more detail in Section 5.2.3.

Let's start with the definition of a freight unit and then move into properties of the freight units defined in Customizing and the information stored in the freight unit. Section 5.2.3 deals with the process of creating freight units. How to integrate package information into this process will be the topic of Section 5.3.

5.2.1 Freight Unit Definition

The *freight unit* is a set of goods transported together through the entire transportation chain. The freight unit is the smallest unit that can be transported. This means that everything included in one freight unit stays together from its source to its ultimate destination—that is, it's always transported together.

The granularity of freight units required for transportation planning depends greatly on your business scenario. For example, if you're an electronics manufacturer, a freight unit can be one of the following:

- One USB stick if you want to send this USB stick from your distribution center directly to the final consumer (e.g., as a parcel shipment)
- A container full of USB sticks if you want to replenish your distribution center in the United States from your factory in China

Freight Unit Granularity

The more freight units are formed, the more detailed and individually you can plan. However, this makes planning more complex and requires higher processing capacity, leading to longer runtimes. Just imagine the system load and number of objects created if you had created freight units for each USB stick in a replenishment scenario. Therefore, we strongly recommend that you define the granularity of freight units only to the detail level required for your business scenario.

Given the dependency of the "optimal" freight unit granularity on the business scenario, there is no general rule for how freight units should be created. However, the following uses cases can be distinguished:

- For general cargo, freight units may be created based on handling units (e.g., pallets) or a group thereof.

- For full container freight, a freight unit usually represents the container.
- For bulk products, a freight unit may represent a quantity that corresponds to the capacity available for the transportation of the product. For example, a forwarding order for 5,000 tons of fertilizer to be transported with railcars with a capacity of 50 tons each should yield 100 freight units of 50 tons each.

Figure 5.2 shows how freight units relate to other objects in TM. They are created based on transportation requirements (n:m relationship).

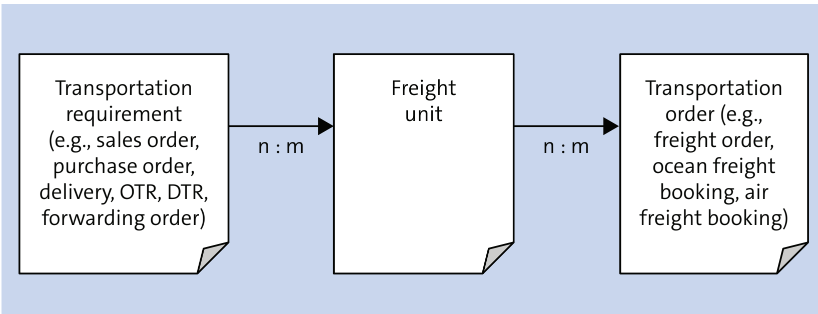


Figure 5.2 Relationship of Freight Units to Other Objects

One freight unit can have one or more transportation requirements as predecessor documents. This means that freight units can be used to consolidate items from several transportation requirements by considering the restriction that the freight unit stays together on the complete transportation chain (i.e., predecessor document items must have the same origin, destination, dates, etc.). On the other hand, one transportation requirement can yield several freight units. This is probably the more frequent case because there are many good reasons that one transportation requirement is split over several freight units:

- A sales order that consists of several items that have different transportation characteristics (e.g., frozen pizza and fresh ravioli require different temperature conditions during transportation)
- A sales order with an item that has different schedule lines (e.g., transportation should be in weekly quantities and not together)
- A sales order with an item representing a large quantity of a bulk product (e.g., the full quantity needs to be split into quantities that fit with the capacity of transportation resources)

In the planning process, freight units are assigned to transportation orders (n:m relationship). Any type of assignment is allowed (1:1, 1:n, n:1, n:m) and depends on the business scenario:

- **1:1**
  A 1:1 assignment can occur if a customer orders a full truckload directly from the plant to the customer's warehouse.
- **1:n**
  A 1:n assignment can occur for a container that is shipped across several stages. This container is then assigned to one freight order (e.g., by truck) for the pre-carriage, another freight order or freight booking (e.g., by sea or air) to represent the main carriage, and a third freight order (e.g., by rail) to represent the on-carriage.
- **n:1**
  An n:1 assignment typically occurs in distribution scenarios (e.g., if the freight order represents a truck transport that delivers the load to multiple customers [unloading locations]).
- **n:m**
  An n:m assignment can occur as a result of any combination of these scenarios.

5.2.2 Properties of Freight Units

Freight units are created based on a certain freight unit type. The freight unit type defines the properties of a freight unit and can be defined in Customizing via menu path **Transportation Management • Planning • Freight Unit • Define Freight Unit Types**.

You should use different freight unit types based on your business requirements; that is, the electronics manufacturer may have different tracking and tracing requirements for freight units that represent final customer orders compared to freight units that represent stock replenishments for the distribution center. Thus, two different freight unit types can be used that are customized differently with respect to their execution tracking relevance.

In addition, you can influence the following properties of a freight unit in freight unit type Customizing:

- **Number range settings**
  To identify freight units originating from different processes easily by their number.
- **Change controller settings**
  To individually react to document changes.
- **Planning settings**
  To default a means of transport directly or via a condition.
- **Integration settings**
  To allow retrieval of hazardous goods information or customs requirements.
- **Direct shipment options (DSOs)**
  To allow the use of freight units in a parcel process as described in Chapter 6, Section 6.1.3.

- **Output options**
  To control the outputs that are to be generated from a freight unit.
- **Organizational unit determination**
  To control which organizational unit is responsible for a freight unit. You can use a condition, retrieve the organizational unit from the user creating the freight unit, or assign a default organization.

Because the freight unit represents the transportation demand in planning, it has to answer the following questions:

- **What needs to be transported?**
  This answers the question about the set of goods being transported. Relevant information is quantities, units of measure, and characteristics (e.g., temperature conditions to be met during transport).
- **Where to transport?**
  This answers the question about the source and destination location and potentially predefined transshipment locations defined as stages in the freight unit.
- **When to transport?**
  This deals with the temporal aspect of transportation (e.g., when the freight unit should be picked up at the source and delivered at the destination location).

To represent the dates and times of pickup and delivery in the freight unit, four time stamps are defined in the freight unit for both pickup and delivery. Refer to Figure 5.3 to see how these time stamps are obtained based on the requested dates and times defined in the freight unit's predecessor document.

A condition with condition type `/SCMTMS/TOR_TIMEWIND` can be assigned to the freight unit type in freight unit type Customizing. Based on this condition, TM calculates four time stamps for pickup and delivery, which have the following interpretation later in automated planning (Section 5.8):

- **Acceptable date—start**
  No pickup/delivery is allowed prior to this date (e.g., because the product hasn't been produced yet).
- **Requested date—start**
  This is the start of the desired pickup/delivery period. A pickup/delivery between the acceptable and requested start date is allowed but can be penalized in planning as an earliness cost.
- **Requested date—end**
  This is the end of the desired pickup delivery period. A pickup/delivery within the requested start and end date doesn't incur any penalty costs in planning. This period can be used to represent the appointment time window agreed on between the supplier and customer at the source/destination location.

- **Acceptable date—end**
  No pickup/delivery is allowed after this date. Any pickup/delivery between the requested and acceptable end date is allowed but can be penalized in planning as a lateness cost.

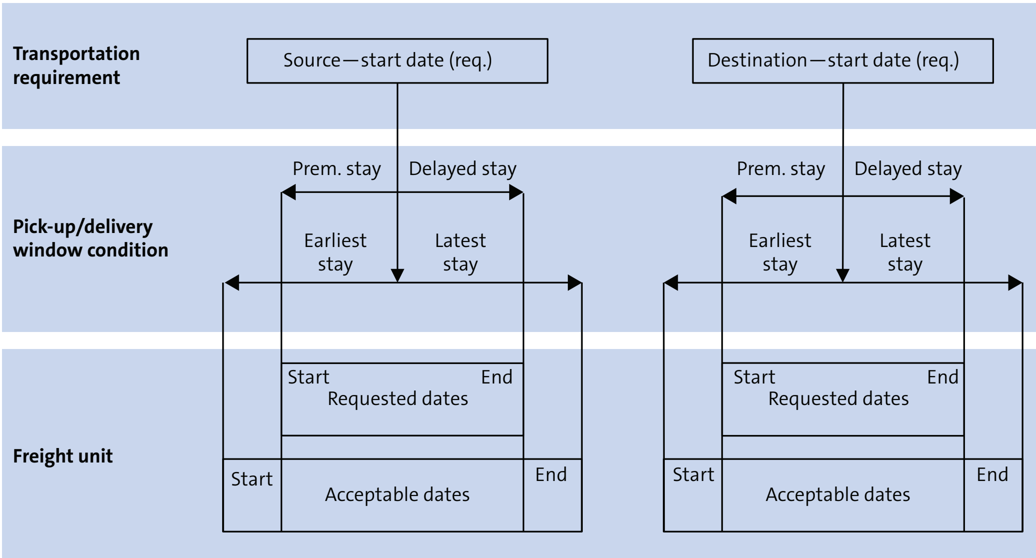


Figure 5.3 Schematic Description of Pickup and Delivery Windows

Not all of these dates have to be defined. For example, if the customer accepts all deliveries no matter how early they are, then no acceptable start date for the delivery needs to be defined. Figure 5.4 shows the logic by means of an example with the resultant freight unit dates visible in the freight unit shown in Figure 5.5. The condition differentiates between per **TO Stop Category** for the time window at the source (**O** = outbound) and the time window at the destination (**I** = inbound). At the source, the constraint for **Earliness** is a **Hard Constraint** with value **0** in the **Earliest Stay** column, meaning that only the **Start Date (Acceptable)** is filled for the freight unit at the source location, and no offset needs to be calculated for the date coming from the predecessor document (**13.02.2023** in the freight unit shown in Figure 5.5). Because **No Constraint** is defined for **Lateness** at the source location, the **End Date (Requested)** and **End Date (Acceptable)** are left empty in the freight unit.

For the dates at the destination location, a **Soft Constraint** is defined for **Earliness** and **Soft and Hard Constraints** are defined for **Lateness** with values **240.000**, **480.000**, and **2.400.000**. These values translate to hours, minutes, and seconds with reference to the date coming from the predecessor document. For example, 240.000 translates to 24 hours, 00 minutes and 00 seconds, that is one day. Likewise, 480.000 converts to 2 days, and 2.400.00 converts to 10 days. Applying this condition to the freight unit in Figure 5.5 with the delivery date 16.02.2023 from the predecessor documents yields **Start Date (Requested) 15.02.2023** (1 day earliness allowed), **End Date (Requested)**

18.02.2023, and **End Date (Acceptable) 26.02.2023** (2 days and 10 days lateness allowed, respectively).

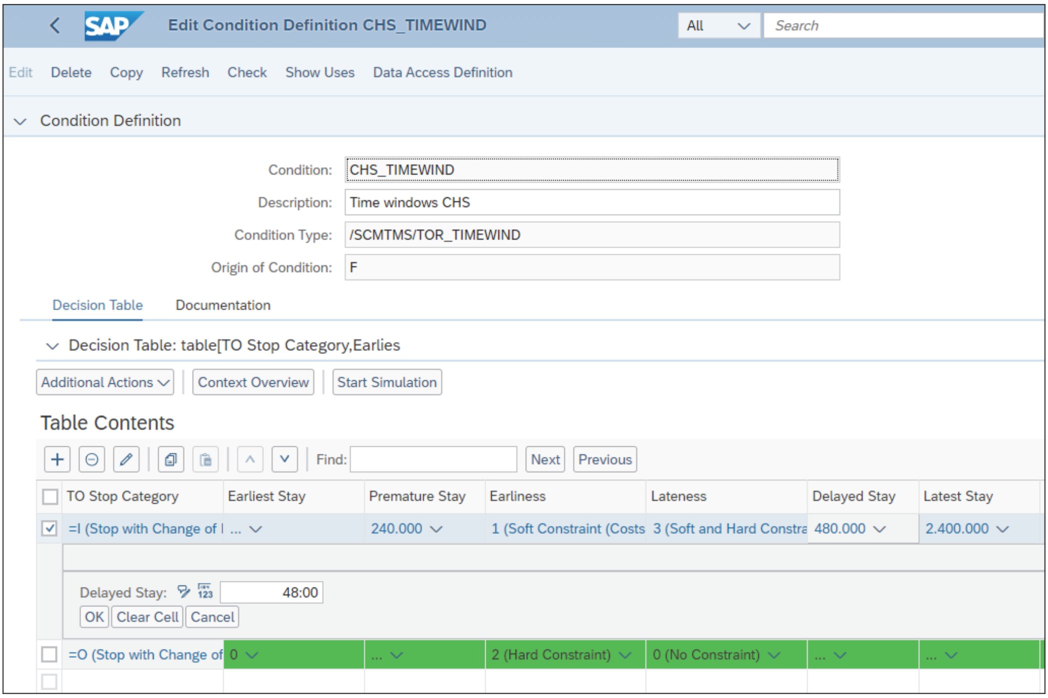


Figure 5.4 Time Window Determination Condition

Calculation Base for Pickup/Delivery Time Window

In the condition for pickup/delivery time window determination (condition type /SCMTMS/TOR_TIMEWIND), you can also control whether the start or end of the loading/unloading duration is relevant for scheduling. If a location has operating times to receive goods from 9:00 a.m. to noon and unloading at this location takes one hour, it's a significant difference if the start or the end of the unloading activity has to be within the operating times. In the **Calculation Base** field of the condition, you can select whether the start (**S**) or end (**E**) of the loading/unloading activity is relevant for scheduling.

Using the concept of conditions in the freight unit type Customizing to define pickup and delivery time windows allows for a lot of flexibility in setting up business scenarios. If the requested or acceptable dates shouldn't be the same for all freight units of the same freight unit type, the time window condition can be used to define different dates based on the destination location (customer) or goods included or any other relevant criteria of the freight unit. Thus, to increase the service level for important customers, these can be assigned a much tighter time window than for less important customers.

Freight units can be scheduled automatically in the freight unit building process (if **Distance/Duration Determination: Enable Automatic Determination** is selected in freight unit type Customizing) by clicking the **Scheduling** button in the transportation cockpit or by applying a default route to the freight unit. This allows for better information and visibility for unplanned freight units, as it will directly show realistic transportation durations calculated based on geo-coordinates.

In the TM UI, you can access freight units from different origins: by using the Edit Freight Unit app, via the link in the document flow of other documents such as forwarding orders or freight orders, or via personal object worklists (POWLs) (e.g., **Planning • Freight Units (Worklist)**). Figure 5.5 shows the standard freight unit UI.

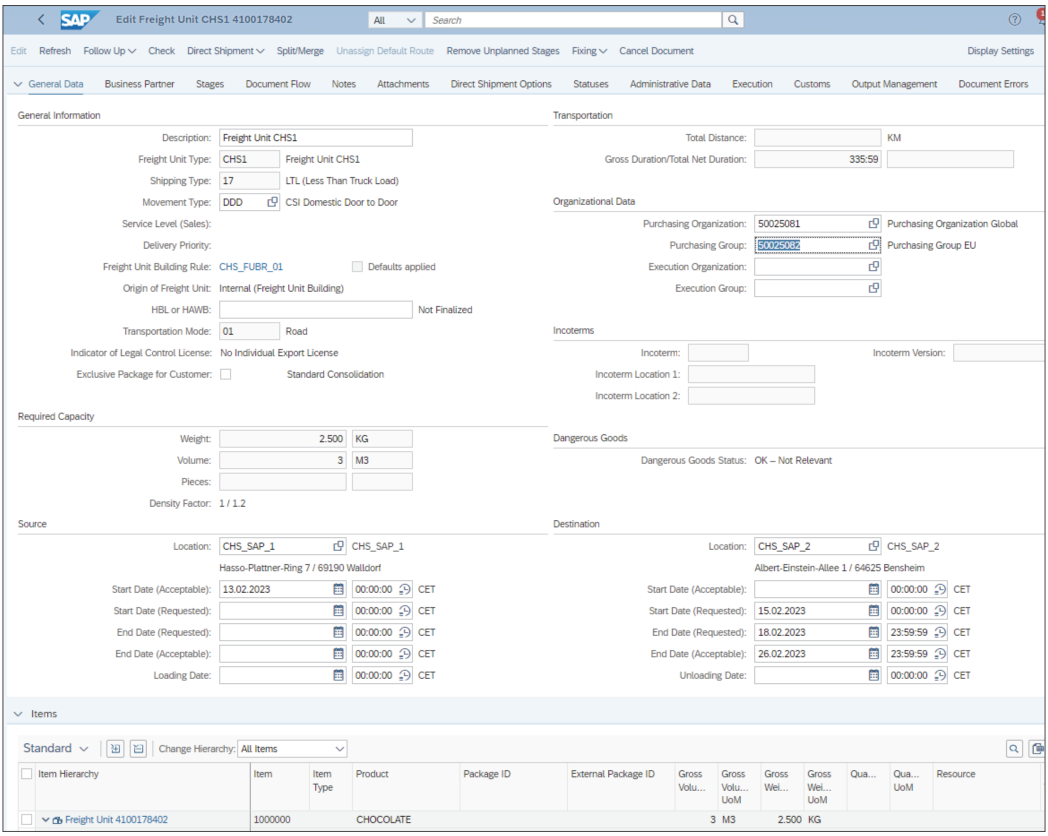


Figure 5.5 Freight Unit UI

The information contained in the freight unit is structured into different tabs. The following are the most relevant:

- **General Data**
  The **General Data** tab contains an overview of the freight unit:
  - **Source Location** (address and pickup window)
  - **Destination Location** (address and delivery window)
  - **Required Capacity** (quantities and unit of measure)

- Organizational Data
- Freight Unit Type
- **Freight Unit Building Rule** (Section 5.2.3)

  Thus, the **General Data** tab answers questions related to what, where, and when.

- **Items**

  The **Items** tab displays the information related to the content of the freight unit. It shows you the hierarchy of items (container, package, and product) contained in the freight unit, as well as the individual products with their quantities and units of measure.

- **Business Partner**

  On the **Business Partner** tab, you can find information about the relevant business partners (e.g., shipper and consignee).

- **Stages**

  The **Stages** tab can contain one or more entries. In the simplest scenario, only one stage is present—the stage from the source of the freight unit to its destination. This implies no constraints for planning; that is, the freight unit can later be transported directly from its source to its destination or indirectly via transshipment locations—whatever is the most effective way for the business scenario.

  However, additional stages can be added to the freight unit manually in the **Stages** tab by applying a default route (Chapter 3, Section 3.2.6) or by using the transportation proposal functionality (Section 5.7.9). If the transportation network allows sea transports from Europe to North America to originate from Hamburg or Rotterdam, these options may be offered to a customer based on a transportation proposal in the forwarding order, and the customer's choice is represented as stages to or from Hamburg or Rotterdam in the freight unit. This stage information is considered to be a constraint in planning.

Freight Units in Stages

The freight unit, which exists only once, appears in several virtual instances (stages) in planning. These instances can be planned independently from each other (e.g., precarriage, main carriage, and on-carriage). That is, different users can plan the individual stages at different times.

This is common business practice because the user responsible for US domestic transport (e.g., on-carriage from port to customer) often isn't familiar with domestic transport in Europe (pre-carriage from source to port) or ocean transport (main carriage from port to port). Furthermore, the individual stages are frequently not planned in the same sequence in which they occur; rather, the main carriage ocean is planned first based on the sailing calendar of the ocean vessel, while pre-carriage and on-carriage are planned later.

- **Document Flow**
  The document flow shows all related (predecessor and successor) documents for the freight unit.
- **Notes**
  Notes can be used to add texts to the freight unit.
- **Attachments**
  Attachments can be any electronic documents (e.g., PDF files) or URLs. Files and URLs can be organized in a folder structure.
- **Direct Shipment Options**
  The DSOs can be generated automatically when the freight unit is created via a process controller strategy (default: `DSO_DEF`) based on the freight unit type Customizing settings, or the direct shipment options can be manually triggered from the freight unit UI.

  DSOs are generated for each carrier and service level combination based on a freight agreement. Thus, they represent "real" costs. They can be used if freight units aren't consolidated during planning but rather are assigned directly to a carrier. In planning using the optimizer, the most cost-effective price (DSO) can be used as a reference cost to decide whether a consolidated solution for multiple freight units is more cost efficient than the sum of direct shipment options for the individual freight units. If the DSO is chosen, the freight unit needs to be converted to a freight order either manually or via a background report.

  The full parcel process using DSOs is explained in detail in Chapter 6, Section 6.1.3.
- **Statuses**
  The freight unit has several statuses. Let's take a look at the most relevant:
  - The lifecycle status shows whether the freight unit is **New**, **In Process**, **Completed**, or **Canceled**.
  - The **Fixing** status determines whether the business document can be changed or not. Fixing prevents the change of only existing planning results.
  - Possible planning statuses are **Not Planned**, **Partially Planned**, and **Planned**, depending on whether none, some, or all stages of the freight unit have been planned.
  - The **Execution** status of the freight unit is changed when any of the freight orders or bookings that the freight unit is assigned to are executed.

Freight Unit Blocking

Freight units can be blocked separately for planning and execution. Use cases for planning blocks include when not all planning-relevant information is available or when approvals are missing. Use cases for execution blocks can be missing approvals or required prepayment. Planning and execution blocks can be propagated from predecessor business documents such as sales orders depending on the block reason code in the predecessor document. That way, you can block a freight unit from planning, for example, if a failed credit limit check has created a delivery block in a sales order (item). In Customizing menu path **Transportation Management • Integration • Internal TM Component Integration • Define Blocking of Transportation Requirements • Define Blocks Based on Delivery Block • Define Blocks Based on Delivery Block**, you can decide whether a delivery block reason code yields a planning block, an execution block, both, or none.

- **Execution**
  The **Execution** tab provides the interface to tracking and tracing (see Chapter 7, Section 7.3). All events reported for a freight unit are displayed in this tab, including planned and actual dates and times. Expected events can be reported on the **Execution** tab, and unexpected events can also be inserted there.

Finally, an organizational interaction status can be maintained in the stages of the freight unit. The organizational interaction status relates to an internal business process between different organizational units (e.g., the sales organization and planning and execution organization) of a logistics service provider (LSP). The sales organization may be allowed to create stages in a forwarding order, but the planning and execution organization is responsible for assigning the stages to schedules, freight bookings, or freight orders. The organizational interaction status that is maintained independently for each stage determines which organization is tasked with the next activity. Figure 5.6 shows how the different organizational units interact and how this is represented in the organizational interaction status of the freight unit stage.

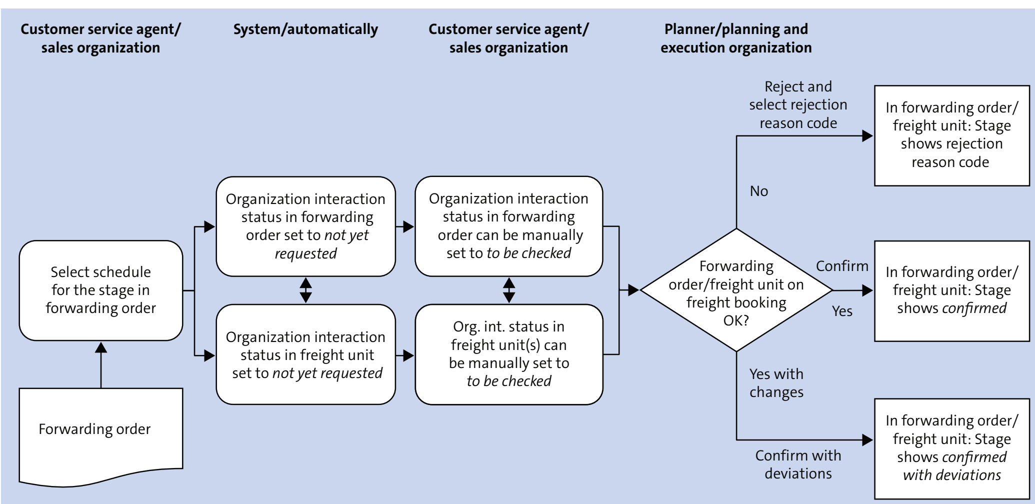


Figure 5.6 Organizational Interaction Process

5.2.3 Creating Freight Units

Figure 5.7 displays the triggers that start the creation of a freight unit from its predecessor documents (i.e., sales orders, purchase orders, deliveries, OTRs, DTRs, or forwarding orders). Freight unit building is either triggered automatically or done manually. If freight units shouldn't consolidate items from different predecessor documents, which is the most common case, then automatic freight unit building can be activated in Customizing of the logistics integration profile (**Transportation Management • Integration • Logistics Integration • Internal TM Component Integration • Define Logistics Integration Profile**) for an embedded deployment scenario or in the relevant document order type for a side-by-side deployment or a forwarder scenario:

- For forwarding orders: **Transportation Management • Forwarding Order Management • Forwarding Order • Define Forwarding Order Types**
- For OTRs: **Transportation Management • Integration • Logistics Integration • External TM System Integration • Order-Based Transportation Requirement • Define Order-Based Transportation Requirement Types**
- For DTRs: **Transportation Management • Integration • Logistics Integration • External TM System Integration • Delivery-Based Transportation Requirement • Define Delivery-Based Transportation Requirement Types**

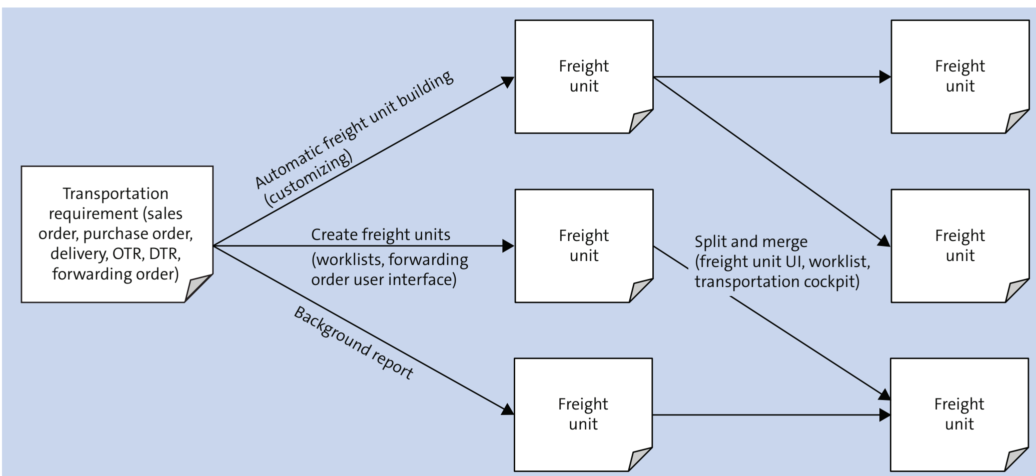


Figure 5.7 Trigger for Freight Unit Creation

In this case, freight units are created immediately upon the creation/save of their predecessor document. In addition, freight unit creation can be triggered by background reports. Report /SCMTMS/TRQ_PREP_PLNG_BATCH shown in Figure 5.8 can be used to create freight units in a side-by-side deployment scenario or for forwarding orders. In this case, the freight units are created based on an `/SCMTMS/TRQ` object. In an embedded deployment scenario, you have to use report /SCMTMS/SUBSEQUENT_FUB_LOGINT instead.

There are also manual options for triggering the creation of freight units either directly from the forwarding order UI or via worklists for any of the possible predecessor documents (i.e., OTR, DTR, and forwarding order).

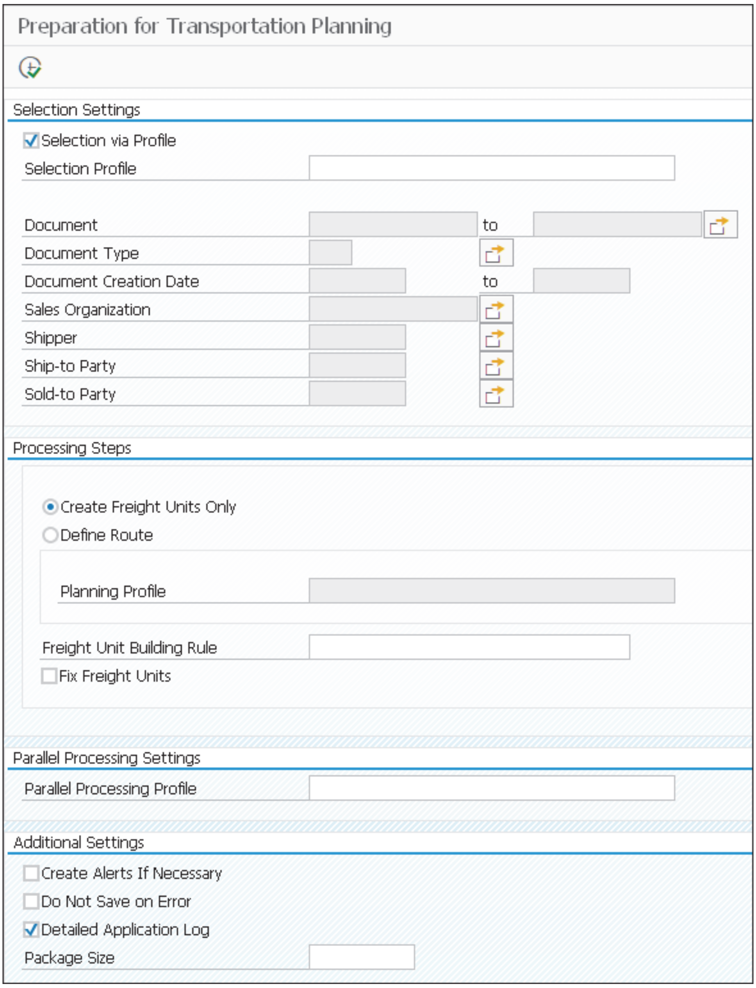


Figure 5.8 Background Report for Freight Unit Creation

After freight units have been created, you might have to change them. Changes from preceding business documents are propagated automatically to the freight unit, and change controller strategies assigned in freight unit type Customizing (**Transportation Management • Planning • Freight Unit • Define Freight Unit Types**) govern the behavior of the reaction to a change. However, manual changes also may be needed (e.g., if a freight unit needs to be split into two parts because its full quantity can't be assigned to a vehicle resource due to a capacity limitation). For this purpose, a split and merge transaction allows you to execute the required changes directly in the freight unit UI or from the transportation cockpit. If you want to prevent a manual split or merge from being revoked by automatic freight unit building, you have the option to fix the split or merged freight units in the **Split/Merge** function.

Freight unit building rules, which are defined in **Profiles and Settings • Create Freight Unit Building Rule**, govern how freight units are created from their predecessor documents. In the freight unit building rule shown in Figure 5.9, you can control the strategy used during freight unit creation. The **Consolidate as Much as Possible** option in the **Freight Unit Building Strategy** field allows you to consolidate items from one or more different predecessor business documents into one freight unit. **Consolidate per Request (Compatible Parts)** allows you to consolidate several items of the same predecessor business document, and **Consolidate per Item** creates one freight unit per item of the predecessor business document.

Additionally, you can maintain whether the freight unit building rule is allowed to split items into several freight units. This is generally allowed by all three strategies but may not be reasonable in certain planning scenarios.

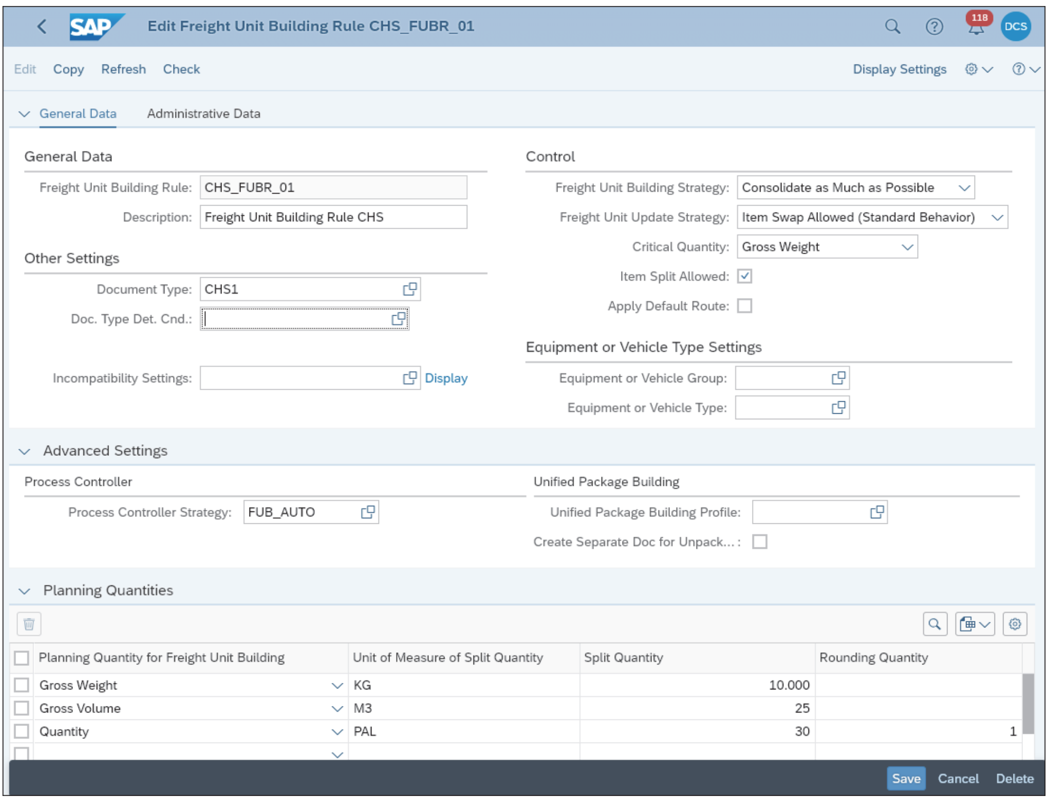


Figure 5.9 Freight Unit Building Rules

The resultant business document type of the freight unit is another important setting in the freight unit building rule. Although the name freight unit building rule may indicate that the resultant business document is always a freight unit, this isn't the case; in fact, the result of a freight unit building rule can be a freight unit, package unit, transportation unit, or freight order. Which object is created is specified in either the **Document Type** field or the **Doc. Type Det. Cnd.** (document type determination condition) field with a condition of type /SCMTMS/TOR_TYPE.

Creating a freight order directly from the freight unit building rule is called the *shortcut planning process* because, in this case, freight units as separate business documents are omitted, and additional planning steps aren't required because the freight order is created right away. A typical planning scenario that uses this feature is the zero-click scenario, which can be configured in the following way:

1. The transportation requirement (sales order, OTR, etc.) triggers freight unit creation automatically because **Automatic Freight Unit Building** is activated in its document type Customizing or the corresponding logistics integration profile.
2. The determined freight unit building rule has a resultant business document type defined that creates a freight order.
3. A background job or the creation strategy of the business document type triggers carrier selection and tendering for the freight order.

In this process, no user activity is required after saving the transportation requirement. A freight order is automatically created, tendered, and awarded to a carrier.

The freight unit building rule also needs to consider incompatibilities, which we discuss in Section 5.8.4 in more detail. Assume that certain products aren't allowed to be transported together; for example, ice cream and ketchup can't be shipped together because they have different temperature requirements. Thus, these two items of the transportation requirement need to be kept apart in freight unit building, although other items of the same transportation requirement (e.g., chocolate ice cream and strawberry ice cream) can be consolidated into one freight unit. Incompatibilities can be used to express such a planning constraint, so incompatibility settings can be assigned in the freight unit building rule.

You can also use freight unit creation to consolidate items of a business document into a container and display the freight unit as a container. To do this, you need to define **Equipment Group** and **Equipment Type** in the freight unit building rule. In this scenario, TM takes the physical properties defined in Customizing for the equipment into account (**Transportation Management • Master Data • Resources • General Settings • Define Equipment Groups and Equipment Types**) (see also Chapter 3, Section 3.3).

Last, you have to define planning quantities. Planning quantities are an integral part of the freight unit building rule because only planning quantities are copied into the freight unit from predecessor business documents. For each planning quantity, a split quantity and a rounding quantity can be defined. The split quantity defines the maximum value a freight unit can take in any of the planning quantities. If the gross weight in the transportation requirement is 9 tons, and the split value for gross weight is defined as 4 tons, three freight units with gross weight 4 tons, 4 tons, and 1 ton would be created. If the rounding quantity is defined as one piece, and the 9 tons from the previous example corresponded to six pieces of 1.5 tons each, then the result would be three freight units of 3 tons (two pieces) each.

Critical Quantity

Finding the best possible assignment of items to freight units is a knapsack problem. Because of the combinatorial nature of this task, it's too computationally expensive to solve this kind of optimization problem during freight unit building.

Therefore, a heuristic is applied that can be influenced by maintaining the *critical quantity* in the freight unit building rule. In this heuristic, all items are sorted in descending order based on their critical quantity and assigned to freight units in this sequence. This heuristic provides the optimal result unless the items are very heterogeneous; that is, some items are very small but heavy compared to large but light items.

Figure 5.10 provides an example in which the optimal and heuristic solutions deviate from each other, assuming that the critical quantity is gross weight and the split quantity for gross weight is 10 tons and 10 cubic meters for gross volume.

OTR items			Heuristic assignment				Optimal assignment		
Item	Gross weight [to]	Gross volume [m3]	FU 1	FU 2	FU 3	FU 4	FU 1	FU 2	FU 3
10	8	2	X				X		
20	6	4		X				X	
30	4	6		X				X	
40	2	1	X						X
50	2	1			X				X
60	2	1			X				X
70	2	1			X				X
80	1	8				X	X		
Total	**27**	**24**	**10 / 3**	**10 / 10**	**6 / 3**	**1 / 8**	**9 / 10**	**10 / 10**	**8 / 4**

Figure 5.10 Assignment of Items to Freight Units

Considering that freight unit building rules are so important, how does TM determine which one to use? The first attempt is to read a condition of type `/SCMTMS/FUBR` from the predecessor business document type Customizing or the logistics integration profile:

- For forwarding orders: **Transportation Management • Forwarding Order Management • Forwarding Order • Define Forwarding Order Types**

- For OTRs: **Transportation Management • Integration • Logistics Integration • External TM System Integration • Order-Based Transportation Requirement • Define Order-Based Transportation Requirement Types**
- For DTRs: **Transportation Management • Integration • Logistics Integration • External TM System Integration • Delivery-Based Transportation Requirement • Define Delivery-Based Transportation Requirement Types**
- For internal TM components: **Transportation Management • Integration • Logistics Integration • Internal TM Component Integration • Define Logistics Integration Profile**

The next step is to determine the freight unit building rule based on this condition. If there is no condition defined, or the determination fails, the freight unit building rule is determined directly from the predecessor business document type Customizing. If nothing is maintained there, default settings are applied.

You can see which freight unit building rule has been applied for any freight unit in the freight unit UI on the **General Settings** tab.

Freight Unit Consolidation

There are some important criteria that are considered during freight unit building to yield separate freight units. While we've mentioned source and destination location as well as pickup and delivery date as constitutive attributes of a freight unit, transportation requirement items that will be consolidated into one freight unit need to have the same Incoterm and carrier (if defined in the predecessor document). The delivery group used to be another such attribute, but the standard behavior was changed in SAP S/4HANA release 2021 such that items belonging to different delivery groups can be consolidated into one freight unit.

In some transportation processes, freight unit information is also required to show packaging information (e.g., number and size of pallets). We'll discuss the concept of unified package building next, which allows you to create packaging information within the items of the freight unit during freight unit creation, but is also used in other areas.

5.3 Unified Package Building

Given a set of products and corresponding quantities, *unified package building* determines the packaging hierarchy, the size (length, width, height) and weight per package item, and whether another package or product can be stacked on the top-level package items in the hierarchy. The packaging hierarchy contains product items as leaves (lowest level) and package items representing pallets or cartons, which could even be nested. While product items usually are contained in package items, some products may not require packaging and thus appear on the top-level of the hierarchy, and auxiliary package items are used for safety purposes and don't contain product items.

The *packaging hierarchy* is important for planning and execution purposes in transportation, warehousing, and logistics in general because it defines how many pallets and which pallet types are used. As the packaging hierarchy directly determines the utilization of cartons and pallets and indirectly impacts the utilization of containers, trailers, and trucks, it's essential for the warehouse and transportation efficiency for palletized goods.

In one commonly used business process, transportation planning determines the customers that get served together on the same truck and the corresponding packaging hierarchy, which is then communicated to the warehouse system, so that cartons and pallets can be built in the warehouse before the truck picks them up. The size, weight, and stackability of top-level items in the packaging hierarchy are essential inputs for load planning, which determines physical positions of packages in a truck, trailer, or container. Such a load plan can be sent to a warehouse system to define how the pallets built get loaded into the truck, trailer, or container that picks up the goods.

5.3.1 Overview

Different application domains within SAP S/4HANA have offered different approaches to determine a packaging hierarchy:

- *Packing instructions* have been used in logistics general (LO).
- *Packaging specifications* have evolved out of packing instructions and been used in extended warehouse management (EWM).
- *Package building* has been offered by TM and used within EWM in the cartonization process.

While packing instructions and packaging specifications are rule-based and share many similarities, package building offers a very different approach, which isn't based on rules but considers constraints and offers an optimization algorithm to build optimized mixed pallets. If a product is always handled and shipped in a certain packaging structure (e.g., 10 pieces per carton and 20 cartons per pallet), this could be modeled very well by a packing instruction or packaging specification. If the business at hand involves transporting mixed pallets, which contain multiple products for one or even multiple customers, package building may be more appropriate as it minimizes the number of mixed pallets required.

Unified package building abstracts from the three packaging approaches, as depicted in Figure 5.11, and allows each application to consume each packaging approach. While the underlying master data of the packaging approaches have some overlap such as the product master data, other master data (rules, constraints, additional parameters) differ significantly. Previously, each application relied on its packaging approach and the corresponding master data. Unified package building enables choosing one packaging approach and using it in all three applications (EWM, TM, LO), which leads to high consistency of the determined packaging hierarchies and eliminates the need to map the packaging master data. While unified package building can be used in all processes of TM and LO, it can be used within EWM for the following processes:

- Synchronous goods receipt for external and internal procurement (using Transaction MIGO)
- Automatic packing and pack proposal for inbound deliveries before goods receipt
- Inbound packing/deconsolidation after goods receipt at the work center
- Outbound packing at the work center
- Receive from production

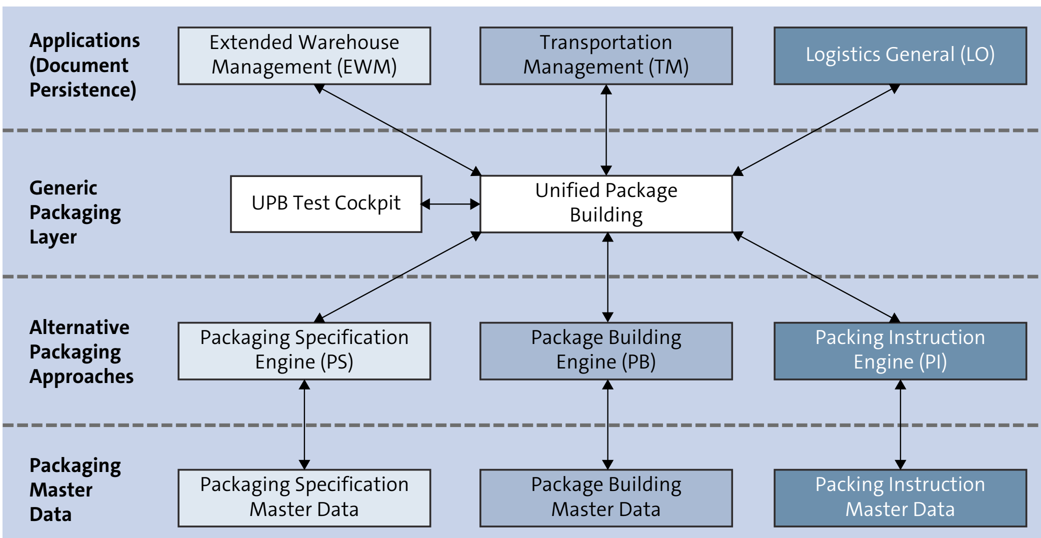


Figure 5.11 Unified Package Building as an Abstraction Layer for Alternative Packaging Approaches

The *unified package building profile* controls the behavior of unified package building and allows choosing one of the three mentioned packaging approaches. It's also possible to run one business or process, which mainly focuses on full single-product pallets, with one packaging approach like the packing instruction, and another business or process (e.g., with focus on delivery to end customers) with package building.

Unified package building offers two execution modes: build packages and determine unified package building rules. The first builds packages as described previously, that is, determines a packaging hierarchy for a given set of products and corresponding quantities. The second doesn't build packages, but just determines the rules that could be applied to the given set of products. The second mode is only applicable if packing instructions or packaging specifications are used, and it's used within EWM to offer alternative rules to the user, who can then interactively choose among them to build packages based on the selected rule.

It's important to understand that unified package building determines the packaging hierarchy but doesn't store it. The consuming application, such as EWM, TM, and LO, is responsible to persist the packaging hierarchy in its business documents. Thus, unified package building helps to ensure that all three applications can determine a required packaging hierarchy consistently, that is, in the same way and based on the same master data. However, a consistent business process across the three applications, even if it involves a packaging hierarchy, is only ensured by the applications themselves, that is, by their business and integration functionality, and not by unified package building.

Unified package building can be used in a distributed system environment, but it requires the underlying master data and the unified package building profile to be available in the system at hand. Thus, if the user wants to use it in a standalone SAP S/4HANA instance, the required master data and the unified package building profile need to be available in that instance.

The unified package building profile can be configured in Customizing by following path **Transportation Management • Planning • Unified Package Building • Define Unified Package Building Profile**. As shown in Figure 5.12, the unified package building profile provides the following generic parameters that apply independently of the chosen engine:

- The **Logging Severity** defines whether messages get logged and, if so, which ones (all messages, warning and error messages, or only error messages).
- The **Settings for Grouping (Hard)** section activates partitioning by several attributes. If **Group by Source Location** is chosen, product items with different source locations won't be put into one top-level package. If **Group by Destination Location** is chosen too, the created packages would not contain product items with different source location or different destination location. Besides these two location attributes, the system can also group by product, business partner, document type, and document ID. Note that the system is automatically partitioning product items by external delivery note. Moreover, items from different consignment orders but from the same freight order aren't consolidated into one package.
- The **Include Auxiliary Packaging Materials in UPB Result** parameter defines whether auxiliary packaging items are kept in the resulting packaging hierarchy. In some businesses, it's important to keep these as individual items in the hierarchy for transparency reasons. In other businesses, it's important to consider packaging materials per layer or separation materials during unified package building to determine the total height and weight of the created pallet, but it's not needed to store these auxiliary packaging materials in the hierarchy.
- The **UPB Engine** is the most important parameter because it represents the choice between packing instruction, packaging specification, and package building.

Depending on the choice of the engine, the unified package building profile offers additional engine-specific parameters, which will be described in Section 5.3.3, Section 5.3.4, and Section 5.3.5.

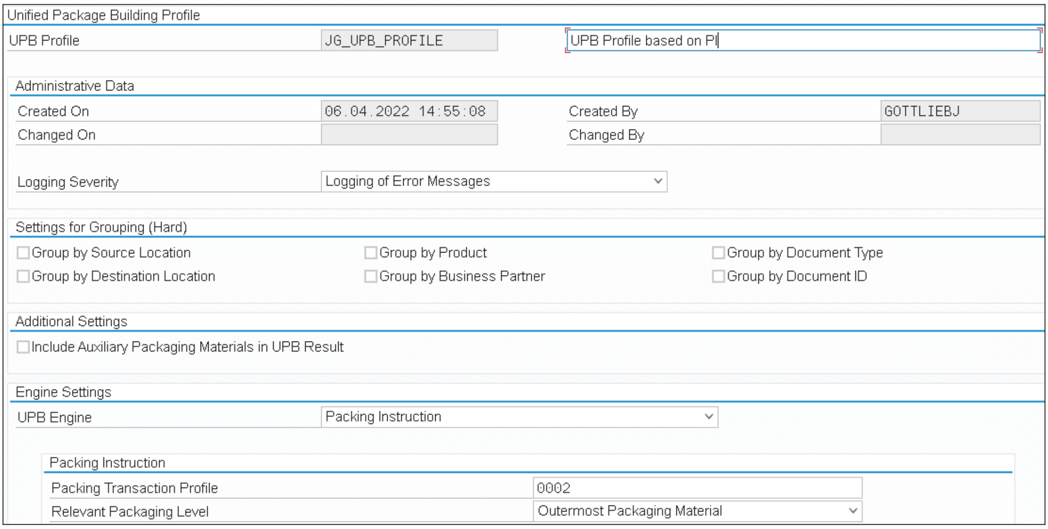


Figure 5.12 Unified Package Building Profile Using Packing Instruction

Unified Package Building Test Cockpit

Unified package building depends heavily on master data quality, and it may be difficult and time-consuming to identify the root cause of an unexpected result within a business document, such as a freight unit or a freight order in TM. By following menu path **Logistics • Transportation Management • Administration • Unified Package Building • Unified Package Building – Test Cockpit** in the SAP menu, you can use the test cockpit to apply one of the two execution modes (build packages, determine unified package building rules) to a set of product items and a given unified package building profile, without the need to create a business document. For each product item, you can define its quantity and unit of measure, as well as additional properties, such as ship-from party or ship-to party, which can be used to determine the packing instruction and packaging specification to be used.

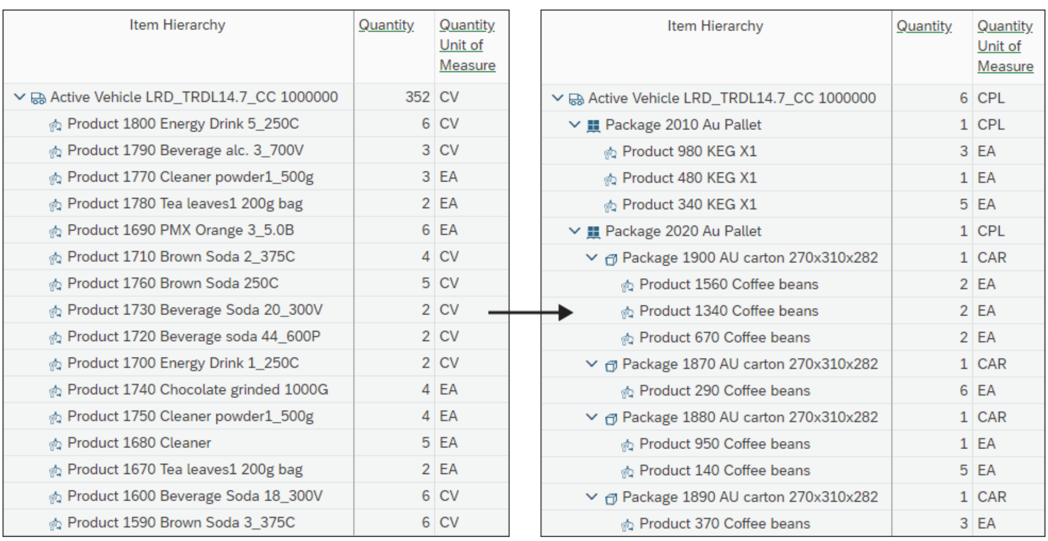
The first execution mode determines the packaging hierarchy, which you can review in the **UPB Result Hierarchy** tab. Per row in the hierarchy, you can navigate to the corresponding product master data or a dedicated screen, **PB – Product/Reference Product Hierarchy**, to review the reference hierarchy for the product at hand and to check relevant parameters and constraints defined on each level. You can also review the determined package type assignment relevant for the products at hand and navigate to the package type assignment maintenance. The second execution mode provides the determined rules, among which the user can choose to build packages. The user can activate the 3D scene to display the determined packaging hierarchy.

We recommend using the test cockpit when setting up your master data. The bigger and more complex the scenario, the harder it is to identify the root cause for unexpected results. Therefore, growing your scenario iteratively and verifying the obtained packaging hierarchies will save you a lot of time.

If you want to analyze the packaging results for a specific business document, you can use path **Logistics • Transportation Management • Administration • Unified Package Building • Unified Package Building – Test Cockpit (Document-Based)** in the SAP menu.

5.3.2 Integration into the Planning Process

Now that we've described unified package building in general, let's now continue discussing it in the context of TM. Usually, unified package building is performed automatically, but it's also possible to manually change the packaging hierarchy within a capacity document. Unless stated differently, we assume that package building is used as packaging approach within unified package building. Figure 5.13 illustrates unpackaged product items within a road freight order (left) and the packaging hierarchy determined by unified package building (right), which includes pallet items, carton items, and product items. The term *package* is used as abstraction from pallet and carton. Although there is no explicit concept for pallets and cartons in TM, we'll consequently use these terms for illustrative purposes because they are more intuitive as the technical, abstract concepts of top-level package and bottom-level package. While the shown example contains at most two packaging levels—pallets on level 1 and cartons on level 2—by using the appropriate package type assignment, you can configure the system to build even more than two packaging levels.



Item Hierarchy	Quantity	Quantity Unit of Measure
Active Vehicle LRD_TRDL14.7_CC 1000000	352	CV
Product 1800 Energy Drink 5_250C	6	CV
Product 1790 Beverage alc. 3_700V	3	CV
Product 1770 Cleaner powder1_500g	3	EA
Product 1780 Tea leaves1 200g bag	2	EA
Product 1690 PMX Orange 3_5.0B	6	EA
Product 1710 Brown Soda 2_375C	4	CV
Product 1760 Brown Soda 250C	5	CV
Product 1730 Beverage Soda 20_300V	2	CV
Product 1720 Beverage soda 44_600P	2	CV
Product 1700 Energy Drink 1_250C	2	CV
Product 1740 Chocolate grinded 1000G	4	EA
Product 1750 Cleaner powder1_500g	4	EA
Product 1680 Cleaner	5	EA
Product 1670 Tea leaves1 200g bag	2	EA
Product 1600 Beverage Soda 18_300V	6	CV
Product 1590 Brown Soda 3_375C	6	CV

Item Hierarchy	Quantity	Quantity Unit of Measure
Active Vehicle LRD_TRDL14.7_CC 1000000	6	CPL
Package 2010 Au Pallet	1	CPL
Product 980 KEG X1	3	EA
Product 480 KEG X1	1	EA
Product 340 KEG X1	5	EA
Package 2020 Au Pallet	1	CPL
Package 1900 AU carton 270x310x282	1	CAR
Product 1560 Coffee beans	2	EA
Product 1340 Coffee beans	2	EA
Product 670 Coffee beans	2	EA
Package 1870 AU carton 270x310x282	1	CAR
Product 290 Coffee beans	6	EA
Package 1880 AU carton 270x310x282	1	CAR
Product 950 Coffee beans	1	EA
Product 140 Coffee beans	5	EA
Package 1890 AU carton 270x310x282	1	CAR
Product 370 Coffee beans	3	EA

Figure 5.13 Packaging Hierarchy before (Left) and after Unified Package Building (Right)

Unified package building can be used in different steps of the planning process:

- **Early in the process, unified package building can be used during freight unit building**
  This is the right approach if packages will be built per freight unit.
- **Late in the process, unified package building can be triggered for capacity documents such as road freight orders**
  This approach is needed if customer-mixed packages will be built.
- **After freight unit building, package units can be created by applying unified package building to a set of freight units**
  This is useful if multiple freight units will be packaged and transported together. Potential scenarios involve customer-exclusive packages, packages for a soft location group such as a business complex, or packages for a hard location group such as a suburb. These scenarios will be explained in Section 5.4.5 in the context of package units.

In the early variant, during freight unit building, unified package building can be used to determine the packaging hierarchy of the transportation demand at hand. This usage can be activated by defining the **Unified Package Building Profile** in the advanced settings of the freight unit building rule depicted in Figure 5.14. Using the **Result of Unified Package Building** field, you can define whether the determined complete packaging hierarchy or only the determined number of packages is stored as an estimate. Defining a **Maximum No. of Top-Level Packages per FU** greater than zero lets freight unit building split the transportation demand into multiple freight units that contain at most the specified number of packages, as described in Section 5.2.2.

The parameter **Create Separate Doc for Unpackaged Items** allows you to separate unpackaged items into a dedicated freight unit. This enables scenarios in which customers get served by demand-specific full packages and customer- or demand-mixed packages carrying the remaining ordered quantities. During freight unit building, the demand-specific full packages are persisted in freight units, and the remaining quantities remain unpackaged in a dedicated freight unit, which can later be packaged together with remaining unpackaged quantities from other customers and demands. This scenario requires activating the parameter **Only Full Packages in PB Result** in the **Package Building** section of the unified package building profile, such that product quantities less than a full package remain unpackaged after package building. From a process viewpoint, this scenario uses both the early variant during freight unit building and the late variant triggered for a capacity document. This approach follows another recommended pattern for planning: make decisions as early as possible and as late as necessary.

Unified package building can even be used in the shortcut planning process, in which freight unit building is used to create road freight orders for transportation demands such as sales orders or deliveries. In this scenario, unified package building can determine the packaging hierarchy of the freight orders created by freight unit building.

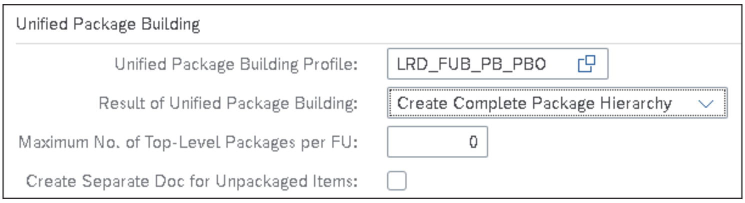


Figure 5.14 Settings for Unified Package Building in the Advanced Settings of the Freight Unit Building Rule

In the late variant, unified package building is triggered for capacity documents, such as road freight orders, consignment orders, trailer units, container units, or package units, either explicitly in the capacity document UI or in the transportation cockpit. In the cockpit, you can use the **Create Packages** button or trigger package creation automatically during a manual planning operation, such as assigning a freight unit to a road freight order, by using a manual planning strategy that includes unified package building (Section 5.6.1). You need to maintain the unified package building profile in the *unified package building settings*, which are described later in this section. To use unified package building for the capacity document type at hand, this functionality has to be activated by the **Enable UPB** parameter in the **Planning Settings** section of the document type Customizing, as shown in Figure 5.15 for a road freight order type. The **Update Load Plan** option defines whether unified package building and/or load planning will be triggered automatically by item changes in the original transportation demand.

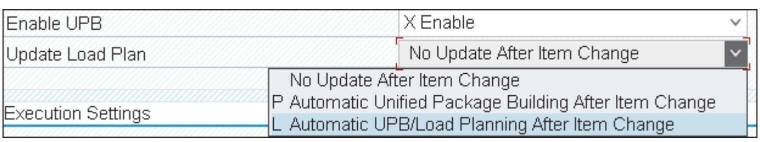


Figure 5.15 Freight Order Type Customizing to Activate Unified Package Building and Define Update Behavior for Item Changes

The main reason for using unified package building is that the original transportation demands contain product quantities but no packaging information. In addition, the packaging information is needed to enable more accurate planning or to define the packaging to be executed in the warehouse. The parameters described previously enable the following two main business scenarios:

- **A package will only contain goods of one original transportation demand**
  In this case, package building should be triggered already during freight unit building, and the determined packaging hierarchy should be stored. This approach prevents pallets containing goods from different customers and transportation demands. In execution, this means that one customer can be served by unloading all its pallets from a truck; therefore, there is no need to touch goods to be delivered to other

customers. This scenario is commonly used when serving a few customers by one truck, and each customer orders goods covering multiple pallets. Moreover, this usually assumes unloading pallets by forklifts at the customers' locations.

- **A package can contain goods of multiple original transportation demands for transportation efficiency reasons**
  This may lead to goods for different customers getting consolidated into the same pallet or carton. In this approach, you would first make consolidation decisions, that is, consolidate multiple customers' demands into a capacity document, such as a road freight order. Then, unified package building is triggered for the capacity document, storing the determined packaging hierarchy in the capacity document. In this approach, it's recommended also to call unified package building already during freight unit building by using the option to store the package number estimate because this allows making consolidation decisions based not just on volume or weight information but also considering the expected number of packages. This approach yields mixed pallets containing goods to multiple customers. Therefore, in execution, the goods for one customer get pulled out of the relevant mixed packages during the stop at the customer. This scenario is commonly used when many customers can be served by one truck because each customer orders only a few products and quantities.

Figure 5.16 shows the planning process for the first business scenario in a local distribution example. The initial situation contains a set of unplanned freight unit stages from one distribution center displayed as square on the map to multiple customers shown as triangles on the map. Unified package building has been used within freight unit building, storing the determined packaging hierarchy in the freight units. Therefore, the freight units represent a set of packages shown in the 3D view and colored by customer. As the first planning step, the vehicle scheduling and routing (VSR) optimizer (Section 5.8.1) consolidates the freight units into two road freight orders shown on the map, assigning a truck resource and defining the stop sequence for each freight order. Each road freight order contains the packages of the assigned freight units, as shown for one of the freight orders that consolidates three customers. The packages are shown as unplanned objects in the 3D load plan view because they aren't yet positioned in the truck. Load planning (Section 5.8.8) is the second planning step that determines a load plan for the packages in the truck; that is, they get positioned in the truck's cargo space. This finishes the planning process, and the road freight orders can be executed.

Figure 5.17 displays the planning process for the second business scenario, again in a local distribution example. The initial situation contains a set of unplanned freight unit stages with unpackaged goods from one distribution center to multiple customers. The freight units can be quantified by volume and weight. Additionally, they may be measured by normalized quantities (Section 5.5) to estimate the expected number of pallets required. Using the VSR optimizer (Section 5.8.1) as the first planning step, the system consolidates the unplanned freight units into one road freight order, assigns it to a truck resource, and defines its stop sequence. The road freight order contains the unpackaged products from the assigned freight unit stages, displayed as unplanned objects besides the truck in the 3D load plan view. Unified package building is used as the second planning step, resulting in a packaging hierarchy with six pallets containing the individual products. Because the pallets haven't yet been positioned on the truck, they are still shown as unplanned objects in the 3D load plan view. Load planning (Section 5.8.8) represents the third planning step that positions the pallets in the truck's cargo space. Planning is now completed, and the road freight order can be given to execution.

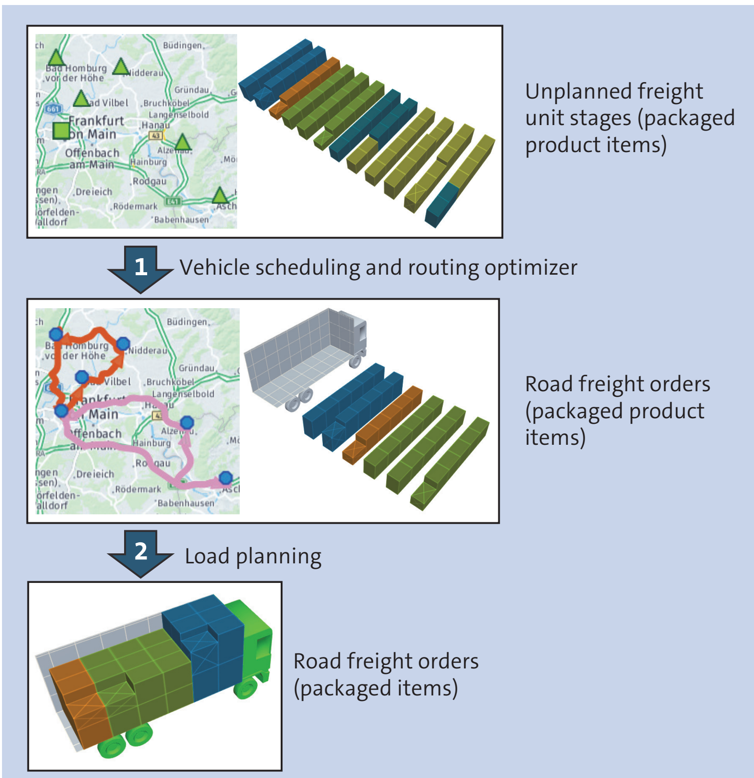


Figure 5.16 Planning Process Based on Storing the Complete Packaging Hierarchy during Freight Unit Building

Of course, there are transportation businesses in which package building isn't required at all. The most obvious example is transportation of unpackaged products. In another example, the original transportation demand (e.g., forwarding order, sales order, or delivery) already contains a predefined packaging hierarchy that must not be changed in TM.

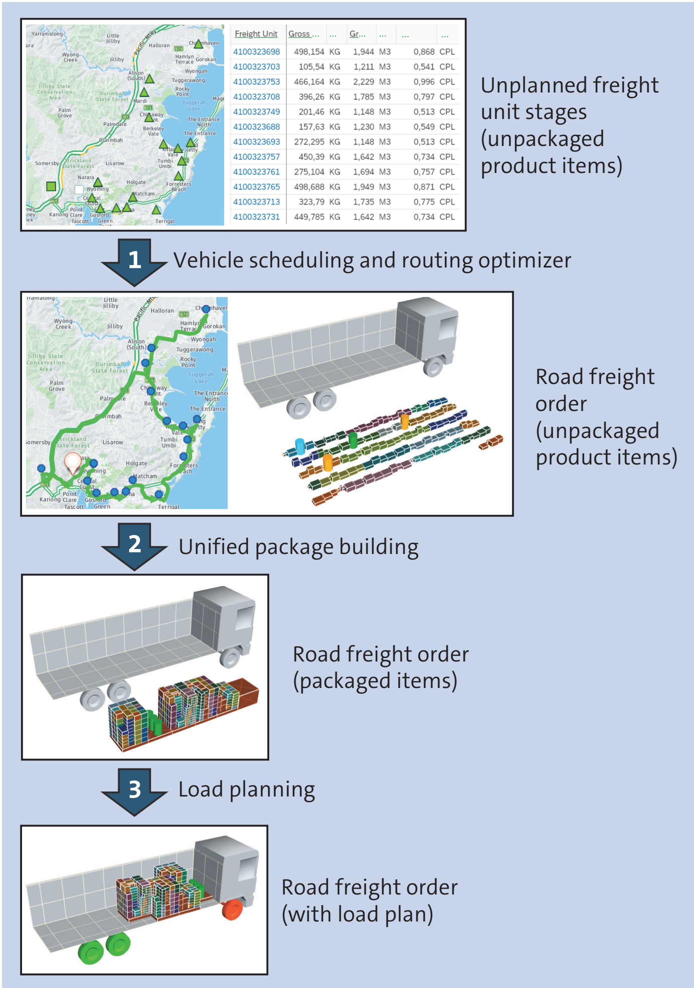


Figure 5.17 Planning Process Based on Unified Package Building for Road Freight Orders

The planning profile refers to the *unified package building settings*, a subprofile that defines how unified package building is used in the planning process. Choosing **Edit Unified Package Building Settings** or **Edit Planning Profile** and the corresponding tab for **Unified Package Building Settings**, you can maintain the unified package building settings, as shown in Figure 5.18, and define the following parameters:

- The **Unified Package Building Profile** is used by unified package building and specifies the **Unified Package Building Engine** and additional parameters described in the previous section.
- The **Filter Items for UPB by BTD Type Code** parameter specifies whether unified package building is applied to outbound items, inbound items, or outbound and inbound items. The business transaction document (BTD) type code determines whether an item is categorized as inbound or outbound. For example, sales orders,

outbound deliveries, sales scheduling agreements, and return purchase orders are considered outbound, while purchase orders, inbound deliveries, purchase scheduling agreements, and customer returns are defined as inbound. The parameter enables scenarios in which palletized goods are delivered to customers and nonpalletized returns are collected from customers. This scenario required unified package building for outbound demands but not for inbound demands.

- The **Parallel Processing Profile** is used to enable parallelization to speed up processing.

All the other parameters refer to the creation of package units based on unified package building for freight units and are described in Section 5.4.5.

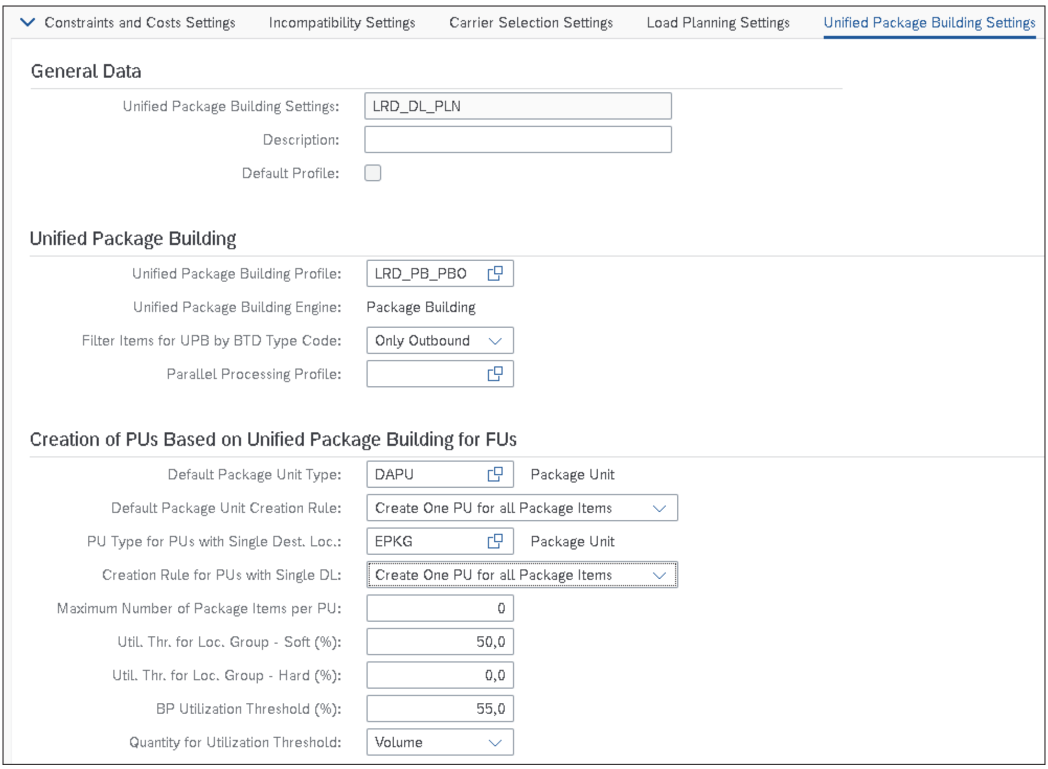


Figure 5.18 Unified Package Building Settings

5.3.3 Packing Instructions

Packing instructions are rules serving as a template to define how to pack certain goods. The system offers a flexible determination of the packing instruction to be used for a given product. A packing instruction specifies which products and quantities are packed together into a packaging material, and it can refer to another packing instruction. This recursive approach enables packing instructions to define a nested packaging hierarchy with many packaging levels. In an example with pallets that carry big cartons containing small cartons with a certain product, this could be modeled by three packing instructions: Packing instruction PI3 contains the product packaged in a small carton as packaging material, packing instruction PI2 refers to big cartons and their content specified by PI3, and packing instruction PI1 finally refers to the pallet and its content specified by PI2. Note that one packing instruction could be reused within multiple other packing instructions, which can simplify the master data maintenance.

You can create a packing instruction using path **Logistics • Logistics Execution • Master Data • Pack • Packing Instructions • Create** in the SAP menu. Figure 5.19 shows two related packing instructions. The packing instruction in the top screen represents one pallet as packaging material and one reference with quantity 27 to the packing instruction in the bottom screen, which consists of one carton as packaging material and the quantity 6 of the white wine product. Using the packing instruction in the top leads to a packaging hierarchy with one pallet containing 27 cartons carrying 6 white wine products each, which represents 162 instances of white wine in total. If an order of white wine contains the quantity 600, this would result in three full pallets representing quantity 486 in total, and in another pallet carrying quantity 114.

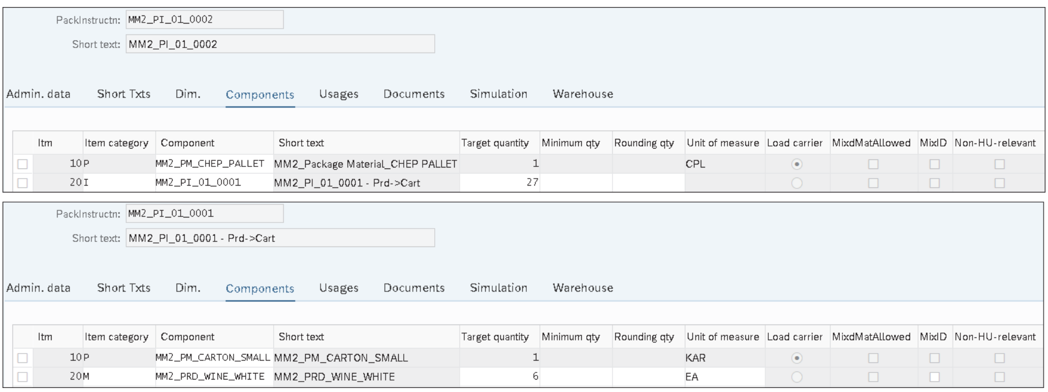


Figure 5.19 Packing Instruction with Reference to Another Packing Instruction

If packing instructions are used as the engine (by choosing **Packing Instruction** in the **UPB Engine** field), the unified package building profile offers the following parameters in the **Packing Instruction** section, as shown earlier in Figure 5.12:

- The **Packing Transaction Profile** defines the entry point to determine the packing instruction to be used by unified package building. This rule-based determination of a packing instruction is composed of a hierarchy of activities, as shown in Figure 5.20. The packing transaction profile defines which determination types are used and in which sequence. The determination type groups packing instructions that are valid for a specific area, the access sequence represents the search strategy to find valid condition records, and the condition tables define the combination of fields (e.g., material and customer), which are used to determine the packing instruction.

- The **Relevant Packaging Level** allows the choice between outermost (default) and innermost packaging material. Suppose a product is in a nested packaging hierarchy in which the innermost packaging material contains the product, and the top-level packaging material is the outermost packaging material. In an example with a pallet carrying big cartons that contain small cartons with products, the pallet is the outermost packaging material, and the small carton is the innermost packaging material. While using innermost in this example would create a packaging hierarchy that only contains small cartons and the products, the outermost option would create the complete packaging hierarchy with pallets, big cartons, small cartons, and products.

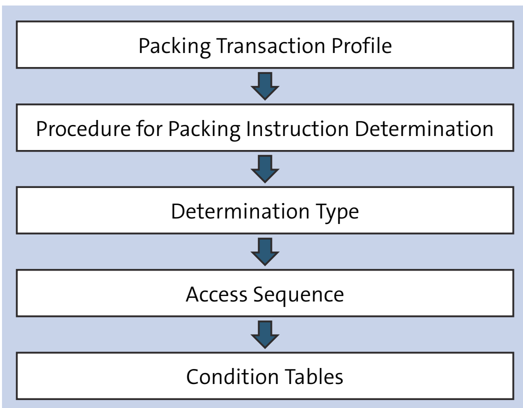


Figure 5.20 Configuration of Packing Instruction Determination

5.3.4 Packaging Specification

While packaging specifications can basically model the same packaging hierarchies as packing instructions, one main difference is that a packaging specification explicitly defines all packaging levels of a packaging hierarchy. A packaging specification doesn't allow a recursive usage of other packaging specifications.

Using path **Logistics • SCM Extended Warehouse Management • SCM Basis • Master Data • Packaging Specification • Maintain Packaging Specification** in the SAP menu, you can maintain packaging specifications, as shown in Figure 5.21. The hierarchy on the left side shows the products to be packed under the **Content** node, and two packaging levels. Selecting a row in the hierarchy, you can see additional details in the right side of the UI. Each packaging level defines the target quantity of the level below. In this example, each small carton carries 10 instances of pale beer and 10 instances of IPA beer, thus it contains 20 product instances in total. The pallet contains 20 small cartons, resulting in a total quantity of 400 product instances. The **HU** column, representing the **HU Creation**, defines whether the corresponding packaging level is contained in the created packaging hierarchy. In the shown example, both packaging levels are used. Omitting the **HU Creation** for the small carton level would lead to a packaging hierarchy with one pallet containing 400 product instances, without the small carton level. This example shows that a packaging specification can be used for a mixed pallet that carries two products. However, this mixed pallet has a rule-based and therefore very regular structure, which differs significantly from mixed pallets that can be created by package building.

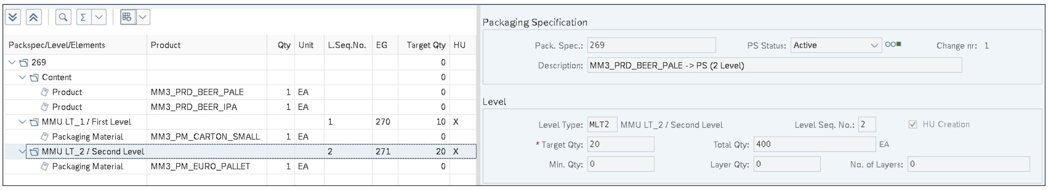


Figure 5.21 Packaging Specification with Two Nesting Levels

If packaging specifications are used as the engine, the following parameters are provided in the **Packaging Specification** section of the unified package building profile, as shown in Figure 5.22:

- The **Determination Procedure** specifies how to determine the packaging specification to be used for unified package building. As illustrated in Figure 5.23, the determination procedure contains one or multiple condition types, each of which refers to an access sequence checking fields from condition tables. Note that a packaging specification can be assigned to a condition type. In general, the determination approach is quite similar to packing instructions, as shown earlier in Figure 5.20.
- The **Relevant Packaging Level** works similarly to the corresponding parameter for packing instructions. However, the behavior is controlled by the **Consider All Pack. Spec. Levels** parameter, too. If this parameter is activated, all relevant levels of the corresponding packaging specification are considered irrespective of whether you've selected the **HU Creation** checkbox for a level in the packaging specification. Otherwise, the system considers only those levels of the packaging specification for which you've selected the **HU Creation** checkbox.

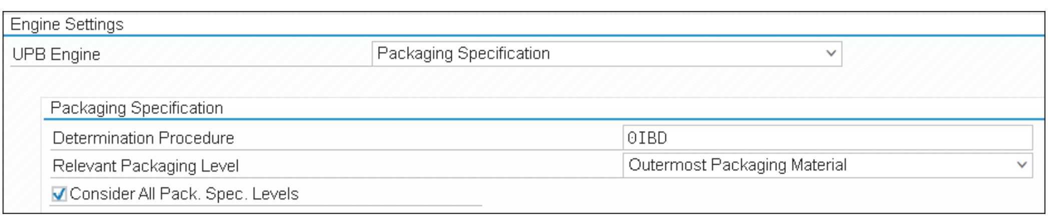


Figure 5.22 Unified Package Building Profile Using Packaging Specification

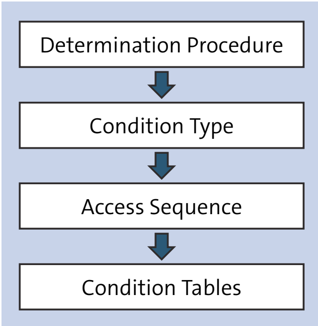


Figure 5.23 Configuration of Packaging Specification Determination

5.3.5 Package Building

While packing instructions and packaging specifications represent a rule-based approach to create a packaging hierarchy, package building uses heuristics and optimization algorithms to create a packaging hierarchy. Package building can create the following different kinds of pallets:

- Single product or mixed, that is, containing multiple products
- Full or incomplete, meaning there is still space left
- Stackable (i.e., another pallet can be stacked on it) or nonstackable

A product is stackable if its stacking factor is greater than one; otherwise, it's nonstackable. If a pallet contains nonstackable products, the pallet is nonstackable. A pallet can be layered and carry a crown on top of the layers, which contains multiple products for which no complete layer could be built. A layer is mixed if it contains at least two different products. While a full layer is considered stackable if the contained products are stackable, the crown isn't considered stackable. A layer is called flat if all items in the layer have same height but are nonflat otherwise. A nonflat layer doesn't allow stacking, that is, neither another layer nor another pallet can be stacked on it.

Package building consists of three phases that are executed consecutively:

1. **Build full packages**
   This phase creates single-product full pallets and mixed full pallets containing multiple products that all refer to the same reference product. Remaining unpackaged quantities are passed to the next phase. Suppose an example with two products A and B with quantities 170 and 50, respectively, and their joint reference product C, for which a full pallet contains quantity 100. In this example, the system would create one single-product full package for product A and quantity 100, and one mixed full package containing products A and B with quantities 70 and 30. Moreover, it passes the unpackaged remaining quantity 20 for product B to the next phase.
2. **Build layer-based mixed packages (embedded)**
   This phase builds layered pallets based on the layer definition from the product master

but without detailed positioning of the layers in the pallet and considering stacking constraints across the layers. It creates full and incomplete packages. The incomplete packages and remaining unpackaged quantities are passed to the next phase.

3. **Build mixed packages**
   This phase is based on the mixed package building mode, which can be either based on volume or detailed using the optimizer. Volume-based means that individual product quantities get consolidated until the sum of their volumes or weights hits the corresponding capacity of the pallet. Thus, the individual positions of the products aren't determined, so any resulting pallet is considered nonstackable. The detailed mode determines physical positions (x, y, z) and orientations of products and cartons, and considers a lot more constraints. It also considers the layer definition and can build complete layers, which can be mixed if the involved products have the same reference product. While the volume-based approach can add a crown to incomplete layered pallets received from the previous phase, the detailed approach ignores incomplete layered pallets; that is, their product quantities are considered as remaining unpackaged quantities. In general, this phase creates mixed pallets or incomplete single-product pallets that can't be consolidated with other products or pallets. In most cases, the pallets are incomplete, but full pallets might also be created due to the specific nature of the product quantities to be packaged.

Each phase returns packages with a packaging hierarchy and unpackaged remaining product quantities, which are passed as input to the next phase. Even the last phase could return unpackaged remaining quantities, which can be a desired result or be caused by missing master data or using too restrictive constraints.

Figure 5.24 shows 11 examples for pallets created by package building, based on an open packaging material (e.g., euro-pallet) and the assumption that all involved products are stackable:

- The pallet Ⓐ represents a full single-product pallet; that is, it only contains one product P1 and the maximum number of pieces defined in the corresponding product master data. This pallet is stackable.
- An incomplete layered single-product pallet Ⓑ is defined by the system as stackable.
- The mixed pallet Ⓒ contains two full layers, 1 and 2, of product P1, and two complete layers, 3 and 4, of product P2. This pallet is stackable because it only contains full single-product layers.
- Example Ⓓ is similar to Ⓒ, but its topmost layer is mixed, containing two products P2 and P3. As the topmost layer is full and flat, this pallet is stackable.
- The mixed pallet Ⓔ contains an incomplete layer and is therefore nonstackable if the layer completeness threshold isn't achieved (this parameter will be described later).
- Example Ⓕ shows a mixed pallet containing a mixed layer that is flat but incomplete. Therefore, this pallet is nonstackable if the layer completeness threshold isn't achieved.

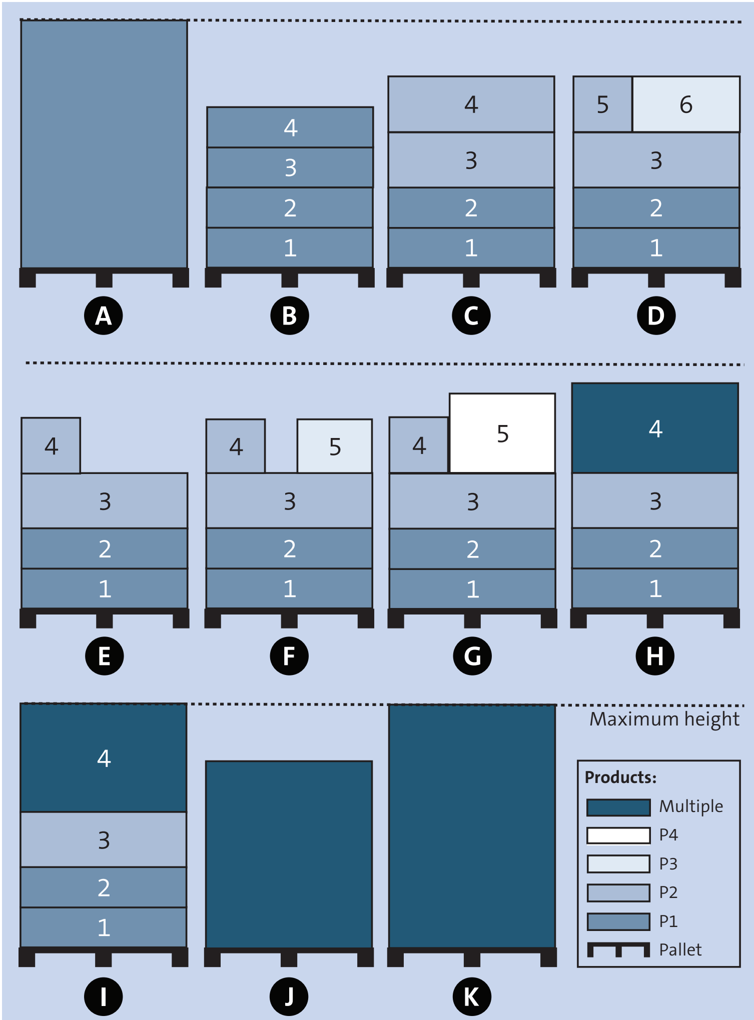


Figure 5.24 Examples of Single-Product and Mixed Pallets Built in Layer-Based (Embedded) and/or Volume-Based Fashion

- Although the mixed pallet **G** contains a mixed layer that covers the full footprint of the pallet, it's nevertheless nonstackable because the mixed layer is nonflat.
- The mixed pallet **H** shows a combination of layer-based and volume-based package building. It contains three full single-product layers and multiple products on top, which causes this pallet to be nonstackable.
- Example **I** is similar to **H**, but the volume-based portion has reached the maximum height of the pallet. Although this pallet is full, it isn't stackable because it contains a volume-based portion.
- Example **J** doesn't contain any layers, but it's built purely in volume-based style, thus it's nonstackable.

- The mixed pallet Ⓚ is full but nonstackable because it contains a volume-based portion.

If a package is based on a closed packaging material such as a pallet cage or a carton, it's stackable if and only if the packaging material is stackable.

While the first two phases only assign product quantities to packages, detailed package building uses an optimization algorithm to determine physical positions and orientations of products and cartons as well as the positions of layers in a mixed pallet. Pallets created by this approach are considered nonstackable, unless they only contain layers of stackable products or are based on a closed packaging material, which is stackable. Figure 5.25 shows the following six examples for mixed pallets created by detailed package building (objects positioned on the mixed pallets are colored by product):

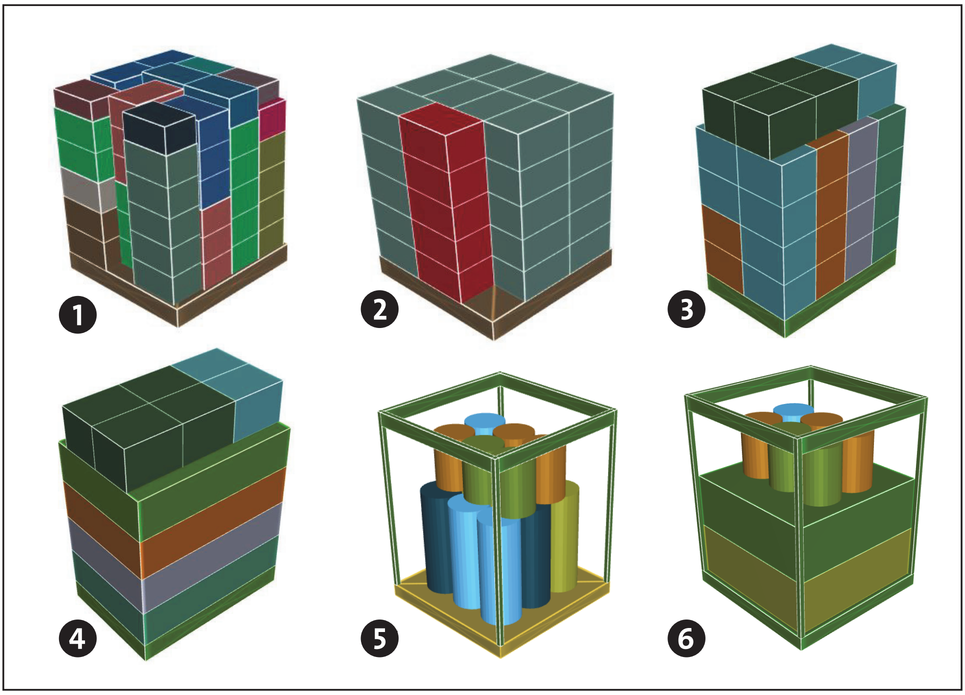


Figure 5.25 Examples for Mixed Pallets Created by Detailed Package Building

❶ This Example shows a mixed pallet with high diversity of different products and sizes. Some products are turned by 90 degrees to maximize the volume utilization.

❷ This Example contains two different products that have the same size. Again, some boxes are turned by 90 degrees for utilization purposes. The pallet has been constructed by towers, which gives easy access to all products at the same time for unloading.

❸ This Example shows a mixed pallet with five different products with the same dimension and reference product.

❹ This Example contains the same products and quantities as example 3, but it considers the layer definition from the master data. There are three layers containing one product each, and one mixed layer containing two products. Each layer is displayed by a big box covering the whole footprint of the pallet. The crown on top of the layers contains the remaining products and quantities.

❺ This Example shows a mixed pallet with cylindrical products stacked in a pallet cage, a closed packaging material. The goods are positioned in the middle of the pallet for safety reasons; the center of gravity of the load is centered as much as possible.

❻ This Example contains the same products and quantities as example 5, but it considers the layer definition from the master data. The lower layer contains one product, and the mixed layer above contains three products. Even though the products in the layers are cylindrical, their layers are visualized by a rectangular shape. The crown on top of the layers contains the remaining products and quantities.

As different packaging businesses may need to consider very different rules during package building, the system offers a rich set of configuration capabilities:

- **Product (master data)**
  Defines product-specific parameters considered during package building.
- **Package type assignment**
  Determines the packaging materials to be used and defines additional constraints and parameters depending on products, business partners, locations, equipment groups, equipment types, and packaging materials.
- **Unified package building profile**
  Determines algorithmic parameters for package building if this has been chosen as the unified package building engine. It includes references to other profiles, such as the *product relationship profile* or the *profile for package building optimizer*.

Let's take a closer look at each.

Product Master Data

Choosing the Create Material app, you can maintain the product master data that is essential for package building. Figure 5.26 shows the definition in the **Units of measure** tab of a product.

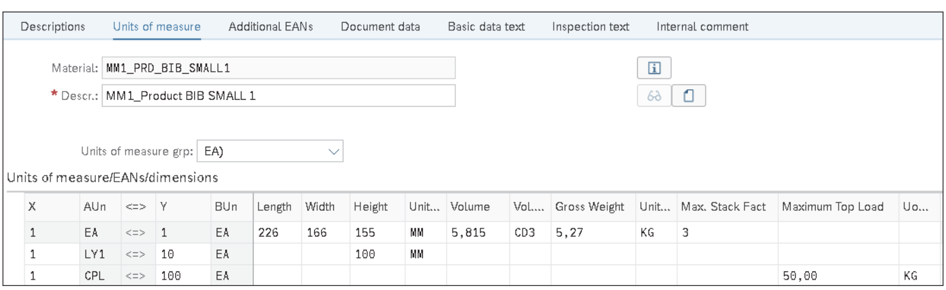


Figure 5.26 Defining Units of Measure for a Product

In this example, the base unit of measure is **EA** (eaches). The table defines its relation to other units of measures. The first row specifies the weight and size of one individual piece (**EA**). The second and third row define how many pieces fit into one full layer (unit of measure **LY1**) and one full pallet (**CPL**). You can also maintain additional constraints:

- The **Max.Stack Factor** is considered during detailed package building and defines how many pieces of the product at hand can be stacked on top of each other.
- Load planning considers the **Maximum Top Load** of a full pallet, which defines how much weight of other pallets can be stacked on top.

The **WM Packaging** tab allows you to define additional parameters for package building. The **Capacities** section specifies the following properties of a packaging material:

- The **Maximum Weight** defines how much load can be put into a package using the packaging material at hand.
- The **Closed Packaging** parameter defines whether the packaging material is open or closed. While a pallet is the most typical example for an open packaging material, cartons, pallet cages, and cool packs are examples of closed packaging materials. The main difference is that the outer volume of a closed package is independent of the load in it. For an open package, the outer volume depends on the tare volume of the package and the goods loaded.
- The **Filling Level** filling level is considered by volume-based package building to determine when to stop further consolidation into the package at hand.

The **Package Building Settings** section defines the following parameters for products to be packaged:

- The **Reference Product for Package Building** allows structuring products by reference products, resulting in a reference product hierarchy. This concept allows products to be grouped in a hierarchical fashion for package building and certain parameters and constraints to be defined on the reference product level, which reduces master data maintenance efforts greatly and is much less error-prone than maintaining all properties on the real product level. Figure 5.27 shows an example that could be used in the beverage industry.

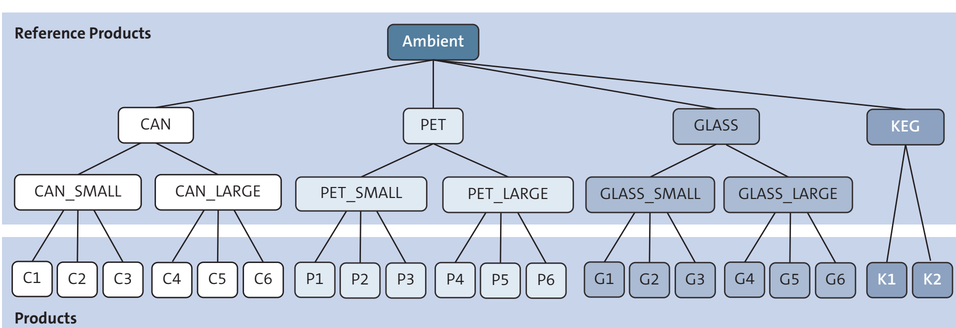


Figure 5.27 Example for Reference Product Hierarchy

The **Ambient** reference product contains four reference products that differ in the beverage's product packaging class (**CAN**, **PET**, **GLASS**, **KEG**). The level below represents the size within the packaging class, except for kegs that don't vary in size. The real products represent the leaves in this hierarchy. Using this hierarchy, you can maintain stacking factors on the lowest reference product level, and you can define incompatibilities for packing on the levels **CAN**, **PET**, **GLASS**, and **KEG**. The reference product **Ambient** can be used to differentiate from other product areas, such as chilled and raw materials (not depicted in Figure 5.27).

- The **Product Shape** can be defined as cuboid or cylindrical with axes along the length, width, or height. The shape is used for visualization purposes in the 3D load plan view for pallets and products to be loaded into trucks, trailers, or containers.
- The **Product Orientation Profile** defines how the product can be oriented during detailed package building. You can maintain a product orientation profile in Customizing by following menu path **Transportation Management • Master Data • Product • Define Product Orientation Profile**. Figure 5.28 shows an orientation profile that enables all six orientations to be used during detailed package building. The maintenance is based on six flags arranged in a matrix, in which the columns define which side of the object can be put on the ground (**Bottom Side**), and the rows define the allowed **Rotation** angles.
- The **Overhang Threshold [%]** is considered in detailed package building and defines how much of the bottom surface of the product must directly touch the products below.
- The **Absolute Height Threshold** defines the allowed height difference of other products on which the product at hand is stacked. This parameter is considered by detailed package building and allows stacking on nonflat surfaces.

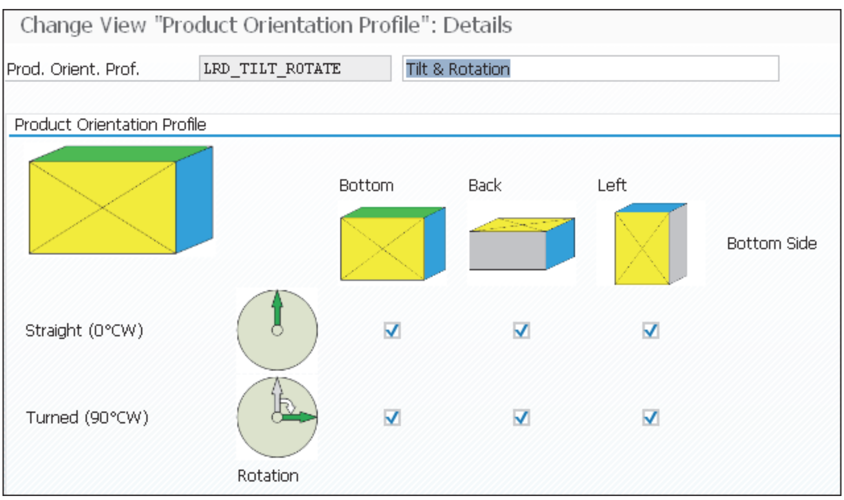


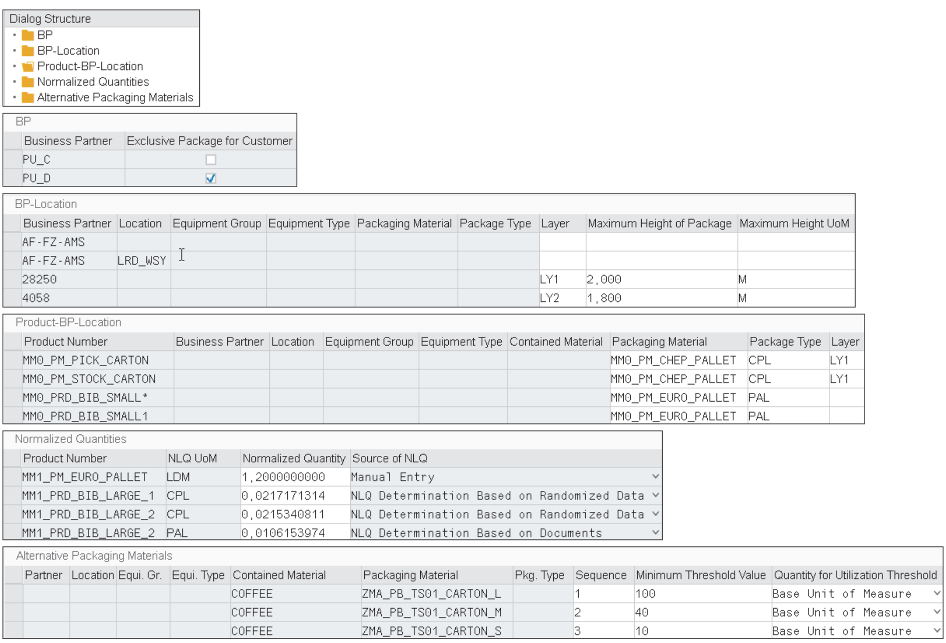
Figure 5.28 Orientation Profile Allowing All Possible Orientations

Package Type Assignment

Choosing the Change Package Type Assignment app, you can define various rules and constraints for package building. The package type assignment is composed of five views, as shown in Figure 5.29:

- **BP**
  Defines parameters specific to business partners.
- **BP-Location**
  Defines product-independent parameters.
- **Product-BP-Location**
  Defines product-dependent parameters.
- **Normalized Quantities**
  Specifies the normalized quantity per product.
- **Alternative Packaging Materials**
  Specifies alternative packaging materials and their processing logic.

The **Product-BP-Location** view allows you to define the packaging materials and other parameters for a given combination of the key fields **Product Number**, **Business Partner**, **Location**, **Equipment Group**, **Equipment Type**, and **Contained Material**. You can use explicit entries and patterns in these key fields or leave some initial. The system will choose the most specific entry in case of a tie. If the **Contained Material** is maintained, the row only applies to package items containing the defined product or only its children in the reference product hierarchy.



Dialog Structure
- BP
- BP-Location
- Product-BP-Location
- Normalized Quantities
- Alternative Packaging Materials

BP

Business Partner	Exclusive Package for Customer
PU_C	☐
PU_D	☑

BP-Location

Business Partner	Location	Equipment Group	Equipment Type	Packaging Material	Package Type	Layer	Maximum Height of Package	Maximum Height UoM
AF-FZ-AMS								
AF-FZ-AMS	LRD_WSY							
28250						LY1	2,000	M
4058						LY2	1,800	M

Product-BP-Location

Product Number	Business Partner	Location	Equipment Group	Equipment Type	Contained Material	Packaging Material	Package Type	Layer
MM0_PM_PICK_CARTON						MM0_PM_CHEP_PALLET	CPL	LY1
MM0_PM_STOCK_CARTON						MM0_PM_CHEP_PALLET	CPL	LY1
MM0_PRD_BIB_SMALL*						MM0_PM_EURO_PALLET	PAL	
MM0_PRD_BIB_SMALL1						MM0_PM_EURO_PALLET	PAL	

Normalized Quantities

Product Number	NLQ UoM	Normalized Quantity	Source of NLQ
MM1_PM_EURO_PALLET	LDM	1,2000000000	Manual Entry
MM1_PRD_BIB_LARGE_1	CPL	0,0217171314	NLQ Determination Based on Randomized Data
MM1_PRD_BIB_LARGE_2	CPL	0,0215340811	NLQ Determination Based on Randomized Data
MM1_PRD_BIB_LARGE_2	PAL	0,0106153974	NLQ Determination Based on Documents

Alternative Packaging Materials

Partner	Location	Equi. Gr.	Equi. Type	Contained Material	Packaging Material	Pkg. Type	Sequence	Minimum Threshold Value	Quantity for Utilization Threshold
				COFFEE	ZMA_PB_TS01_CARTON_L		1	100	Base Unit of Measure
				COFFEE	ZMA_PB_TS01_CARTON_M		2	40	Base Unit of Measure
				COFFEE	ZMA_PB_TS01_CARTON_S		3	10	Base Unit of Measure

Figure 5.29 Product Package Type Assignment Composed of Five Views

You can define the following parameters:

- The **Packaging Material** is used for full packages.
- You can specify the **Package Type** into which the product at hand needs to be packed. The package type is represented by a unit of measure and applies to both single-product and mixed packages. Package building will use the conversion rules in the product master to determine how many pieces fit into the package type. For example, you can introduce package types for pallets and cartons, and then define some products to be put into cartons, some products to be put into pallets, and the cartons to be put into pallets. See Figure 5.30 for such an example involving stock cartons (packaging material **LRD_CSTO_0**) and pick cartons (**LRD_CPICK_1**) put into pallets (**LRD_CHEP_PALLET**). Here, the package types are represented by the units of measure **CPL** and **CAR** for pallets and cartons, respectively.

Active Vehicle LRD_TRVAN1.8_SY	2	CPL	
Package 40 Chep Pallet	1	CPL	LRD_CHEP_PALLET
Product 10 Water	48	CV	LRD_WATR7_1.25P
Package 80 Chep Pallet	1	CPL	LRD_CHEP_PALLET
Product 90 Water	1	CV	LRD_WATR7_1.25P
Package 50 AU CARTON 270x310x...	1	CAR	LRD_CSTO_0
Product 20 Coffee beans1 1kg bag	6	EA	LRD_COFB1_1.0B
Package 60 AU CARTON 270x310x...	1	CAR	LRD_CSTO_0
Product 30 Tea leaves1 200g bag	33	EA	LRD_TEAL1_200B
Package 70 Pick carton 1	1	CAR	LRD_CPICK_1
Product 110 Tea leaves1 200g bag	1	EA	LRD_TEAL1_200B
Product 100 Coffee beans1 1kg bag	1	EA	LRD_COFB1_1.0B

Figure 5.30 Packaging Hierarchy with Two Packaging Levels

- **Maximum Height of Package** and **Maximum Weight of Package** represent the limits for a single-product package that consists of the packaging material and the products in the package.
- **Packaging Material (Mixed)** defines the packaging material to be used for mixed packages.
- **Maximum Height of Mixed Package** and **Maximum Weight of Mixed Package** represent the limits for a mixed package, including both packaging material and assigned products.
- **Ignore Limits for Full Packages** specifies whether the weight and height limits defined in this row are applied to build full single-product pallets.
- If the **Layer** unit of measure is defined, it's used to determine the layer's quantity in the product master data. If it's not defined, layers aren't considered in package building.
- **Packaging Material per Layer** defines whether the packaging material will be put below a full single-product layer. If there are multiple layers of the same product, the

packaging material is only considered once. Although this extra usage of the packaging material adds to the volume and weight of a layered mixed pallet, it can increase warehouse efficiency as it enables the use of forklifts to decompose layered mixed pallets.

- If the **Separation Material** is defined, it's used on top of a full single-product layer as soon as other products get stacked on it. If there are multiple layers of the same product, the separation material is only considered once.
- **Separation Material Mandatory** can be used to enforce usage of the separation material even if nothing is to be stacked on top. Figure 5.31 illustrates four examples regarding separation materials and packaging material per layer. In case ❶, the separation material has been defined, and its usage is enforced for product 1. Example ❷ shows that the separation material has been defined for product 2. In example ❸, separation materials have been defined for both products, and their usage has been enforced. Example ❹ is similar to ❸, but, in addition, the packaging material will be put below product 1, triggered by the previously described parameter **Packaging Material per Layer** parameter. Note that these two parameters aren't supported by detailed package building.
- You can forbid the building of mixed packages using the **No Mixed Packages** parameter.
- Similarly, **No Mixed Layers** can be used to suppress building mixed layers.
- **Single Mixed Package** is used to forbid a product being spread over multiple mixed packages.
- In the same way, **Single Mixed Layer** can suppress a product being spread over multiple mixed layers.
- **Max Number of Products** defines the maximum number of products in a mixed package.

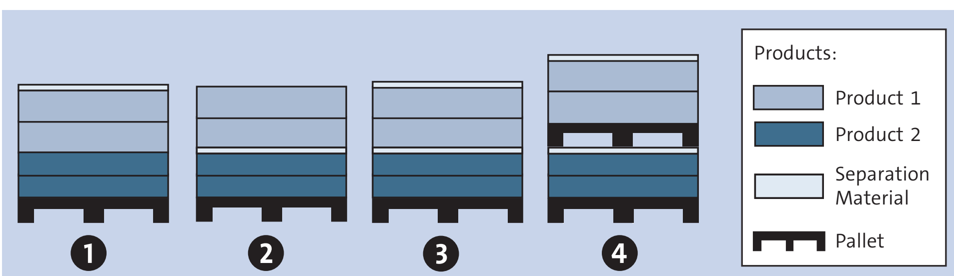


Figure 5.31 Layered Mixed Pallets and Usage of Separation Material and Packaging Material

The **BP-Location** view offers the very same parameters as the previous view for a given combination of business partner, location, equipment group, equipment type, packaging material, and package type. In the same way, you can use patterns and explicit entries or leave some key fields empty. This view offers one additional parameter—**Product Arrangement**—that specifies whether detailed package building arranges products in a layered or tower style.

The **BP** view allows you to define that certain customers require an exclusive package; that is, consolidation with goods for other customers isn't allowed for packages to the customer at hand. This can be useful to model that some customers are capable to unload pallets by a forklift, while other customers get served by manually pulling goods from a mixed pallet that may contain goods for other customers too.

The **Alternative Packaging Materials** view enables two scenarios:

- For a carton to be put on a pallet, the pallet type may depend on the content of the carton. If two products A and B have the common reference product C, then you can define that a carton with only A is put on pallet type 1, a carton with only B is put on pallet type 2, and a carton with children of C is put on pallet type 3. This kind of scenario can be modeled by maintaining the product, the contained material, and the (target) packaging material.
- Alternative carton sizes (e.g., small, medium, large) may be available for a given product, and the choice of the carton types depends on the product quantity, volume, or weight. In an example with a coffee product, small, medium, and large cartons may contain 10, 40, and 100 units, respectively. Using the **Sequence** and **Minimum Threshold Value** in the **Alternative Packaging Materials** view shown earlier in Figure 5.29, you can configure the system to first create large cartons with 100 units, then medium cartons with 40 units, and then small cartons with 10 units. In an example with 295 units to be packaged, the system would create two big cartons, two medium cartons, one small carton with 10, units and another small carton with the remaining 5 units. The **Quantity for Utilization Threshold** allows you to choose between volume, weight, and the base unit of measure of the product at hand.

The **Normalized Quantities** view contains the normalized quantity per product and unit of measure, which will be described in Section 5.5.

Unified Package Building Profile

The unified package building profile (see Figure 5.32), which we introduced in Section 5.3.1, mainly determines how packages will be built. It can be defined in Customizing via path **Transportation Management • Planning • Unified Package Building • Define Unified Package Building Profile**.

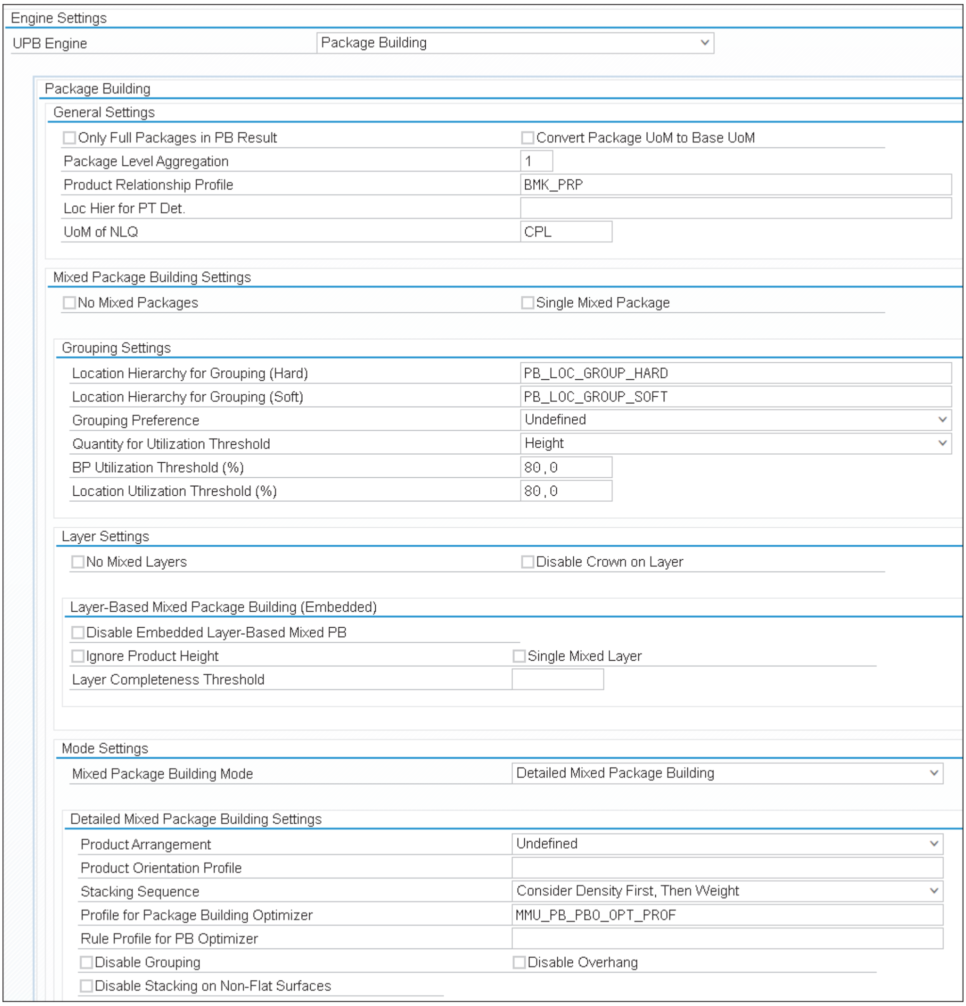


Figure 5.32 Unified Package Building Profile Using Package Building

If you choose package building as the engine, it offers the following parameters in the **General Settings** section:

- **Only Full Packages in PB Result** enables scenarios in which full packages, for one product or multiple products of the same reference product, are already persisted early in the process (i.e., during freight unit building) and remaining product quantities remain unpackaged. The remaining product quantities can then be considered later during package building on the freight order level together with remaining quantities from other freight units, which can result in customer-mixed pallets. Thus, customers would be served by full pallets per customer and additional customer-mixed pallets. If this parameter is deactivated, even less than full pallets are returned as result of package building.

- **Convert Package UoM to Base UoM** enables conversion of the created package item's unit of measure to the base unit of measure of the packaging material.
- The **Package Level Aggregation** parameter allows packaging levels to be aggregated below the top-level packages. For example, 10 pallets carrying 20 identical cartons each would result in a packaging hierarchy with 200 package items if no aggregation is used. Here, "identical" means that each carton has the same carton type and contains the same product quantity. Using the aggregation mechanism, the packaging hierarchy would consist of 10 pallet items, each carrying one carton item with quantity 20. Thus, the packaging hierarchy can be represented in a much more compact way, which can improve performance and provides a better overview in the packaging hierarchy. The parameter specifies the number of levels to be aggregated, thus you can even reduce the representation of a packaging hierarchy with nested cartons on a pallet, for example, small cartons in big cartons on a pallet.
- You can assign a **Product Relationship Profile** to define stacking constraints and incompatibilities. Choosing the Change Product Relationship Profile app, you can maintain its stacking settings and consolidation settings, as shown in Figure 5.33 and Figure 5.34, respectively.

Prod. Rel. Prof. LRD_PRP

Stacking Settings

Product 1	Product 2	Stack Product 1 on 2	Stack Product 2 on 1
LRD_BAG	LRD_CPICK	Disallow	Allow
LRD_CAN	LRD_BAG	Disallow	Allow
LRD_CAN	LRD_CPICK	Disallow	Allow
LRD_PET	LRD_BAG	Disallow	Allow
LRD_PET	LRD_CPICK	Disallow	Allow
LRD_VTR	LRD_BAG	Disallow	Allow
LRD_VTR	LRD_CPICK	Disallow	Allow

Figure 5.33 Product Relationship Profile Defining Stacking Settings

Consolidation Settings

Product 1	Product 2	Incompatible	Consolidation Seq.
LRD_RM_CAN	LRD_RM_BAG	No	20
LRD_RM_CAN	LRD_RM_PET	No	10
LRD_RM_CP_COFFEE	LRD_RM_CP_TEA	Yes (On First Level Only)	
LRD_RM_DRY	LRD_RM_AMBIENT	Yes	
LRD_RM_KEG	LRD_PM_CPICK	Yes	
LRD_RM_KEG	LRD_RM_BAG	Yes	
LRD_RM_KEG	LRD_RM_CAN	Yes	
LRD_RM_KEG	LRD_RM_PET	Yes	

Figure 5.34 Product Relationship Profile Defining Consolidation Settings

The stacking settings define for a combination of two products whether the first can be stacked on the second and vice versa. The consolidation settings specify whether two given products are incompatible for consolidation on the first or last level in the consolidation process. In an example with pallets and cartons, the system first consolidates into cartons, and then—as the last step—into pallets. The consolidation sequence number controls the processing sequence if multiple product combinations are candidates for being consolidated. The example in Figure 5.34 shows that coffee and tea must not be consolidated into the same carton but can be put into the same pallet. Dry and ambient products can't be consolidated at all, nor can kegs be consolidated with any other products, such as bags, cans, and PETs. Cans, PETs, and bags can be consolidated, but the consolidation sequence defines that cans are first consolidated with PETs and then with bags.

- You can use **Loc Hier for PT Det.** (location hierarchy for package type determination) to let the package type assignment be determined based on a location hierarchy instead of just locations. This is particularly useful if many locations have the same properties and constraints from the package type assignment viewpoint. You can define such a hierarchy in Customizing by following menu path **Transportation Management • Master Data • Hierarchy • Define Hierarchy Structure** and using hierarchy structure **PB_LOC_HIERARCHY.**
- The **UoM of NLQ** parameter can be used to let package building determine the normalized quantity regarding the specified unit of measure.

The **Mixed Package Building Settings** section (see Figure 5.32) contains the following two parameters:

- **No Mixed Packages** can be used to forbid creation of any mixed package.
- **Single Mixed Package** is used to forbid a product being spread over multiple mixed packages. If you keep it undefined, the corresponding parameter from the package type assignment is used.

Additionally, this section contains the subsections **Grouping Settings**, **Layer Settings**, and **Mode Settings** offering more parameters. The subsection **Grouping Settings** provides the following parameters that all specify how items will be grouped:

- **Location Hierarchy for Grouping (Hard)** allows you to define location groups by hierarchy. Package building ensures that products to customers of one group aren't consolidated into a package together with customers outside the group. You can use this to ensure transportation safety when serving multiple towns connected by highways and avoid carrying partially unloaded mixed pallets on the highway. Another use case is to forbid consolidation of products to customers that require serving from the right side of the truck with customers that get served from the left.
- **Location Hierarchy for Grouping (Soft)** is very similar to the previous one, but it just defines a soft instead of a hard constraint. Thus, the system tries to consider it but is allowed to violate the constraint if unavoidable. For example, in a business serving many customers in a shopping mall, the driver can unload more efficiently if all

products for the shopping mall are located in the same mixed packages. However, it's acceptable that some leftovers are contained in mixed packages serving other customers.

- **Grouping Preference** guides package building to keep either products of the same customer or the same product together.
- A separate package is built for a business partner if the items for the business partner result in a package meeting the minimum utilization specified by the **BP Utilization Threshold (%)**. Otherwise, the items for the business partner at hand get consolidated with items for other business partners into a mixed package.
- Analogously, a separate package is built for a location or a soft location group if items for the location or the soft location group yield a package meeting the minimum utilization defined by the **Location Utilization Threshold (%)**. Otherwise, the items for the location or soft location group at hand get consolidated with items for other locations or soft location groups into a mixed package.
- The **Quantity for Utilization Threshold** parameter defines whether the previous two threshold parameters refer to height, volume, or weight of the package to be created. Note that similar threshold-related parameters are also offered in the unified package building settings, which will be described in Section 5.4.5 in the context of creating package units by unified package building. While the parameters described here influence the structure of the packaging hierarchy, the top-level package items don't result in a company's own business documents. This is the major difference to the parameters in the unified package building settings, which control the creation of package units as a company's own business documents.

The subsection **Layer Settings** offers the following parameters:

- **No Mixed Layers** is used to suppress creating any mixed layers.
- **Disable Crown on Layer** is used to avoid a crown being placed on a layer.

The **Layer-Based Mixed Package Building (Embedded)** subsection offers additional parameters:

- **Disable Embedded Layer-Based Mixed PB** can be used to skip this phase of package building. This makes sense if detailed positions of layers are required or the stackability of products will be considered when stacking the layers, which both are only possible when using detailed package building.
- **Ignore Product Height** defines whether mixed layers can contain products of different heights. If a mixed layer contains products of different heights, it's nonflat, and therefore nothing can be stacked on it.
- **Single Mixed Layer** can be used to avoid a product being distributed among multiple mixed layers. If these parameters are active, they overrule the corresponding parameters in the package type assignment.

- **Layer Completeness Threshold** can be used to define layers as full already if the defined percentage of the footprint is covered. If not maintained, a layer is only full if 100% of its footprint is occupied. Recall that stacking goods on a layer is only allowed if it's full. This parameter enables stacking on layers that are defined as virtually full although they are actually not full.

Under the **Mode Settings** subsection, you can use the **Mixed Package Building Mode** to choose between volume-based and detailed mixed package building. Note that a crown can be built with both modes, detailed and volume based. If detailed mixed package building is activated, you can maintain additional parameters in the **Detailed Mixed Package Building Settings** subsection (refer to Figure 5.32):

- The **Product Arrangement** defines whether mixed packages will be arranged by towers or layers. Layers are usually easier to handle in the warehouse but hard to unload by a driver if many different products are contained in the pallet. This parameter defines the default for package building, which can be overruled by more specific product arrangement definitions from the **BP-Location** package type assignment view. Note that the layer has a double meaning in this context. Detailed package building can build layers following the corresponding product master data definition, as explained previously. The crown on top of such layers can also be built in a tower or layered style. While the tower style leads to placing instances of one product in the vertical direction (until the height limit is hit, then a new tower is created beside), the layer style leads to covering the ground by multiple instances of one product before growing in vertical direction. Note that a layered crown doesn't meet the full layer definition from master data (because the products would otherwise have been placed in a complete layer according to the master data definition of layers).
- A **Product Orientation Profile** is applied to all products for which no orientation profile is defined for the product itself nor for any of its reference products.
- The **Stacking Sequence** can enforce a strict ordering of products stacked on each other. The ordering can be by weight first, then density; by density first, then weight; or undefined. Note that all stacking constraints apply together: the stacking sequence, the stacking settings defined in the product relationship profile, and the stacking factor defined in product master.
- For product handling efficiency reasons, a grouping heuristic is used to consolidate similar products together on mixed pallets. Here, similarity is defined by the reference product hierarchy. In an example based on the reference product hierarchy shown earlier in Figure 5.27, it's desirable to keep all can products together on a mixed pallet, and the same holds for PET, glass, and keg products. Cans will be mixed with PET or glass only if this reduces the number of mixed pallets. You can skip the grouping heuristic by selecting **Disable Grouping**.
- **Disable Stacking on Non-Flat Surfaces** can be used to forbid stacking on nonflat surfaces.

- If you want to avoid any overhangs, but you have still some overhang parameters defined, for example, in the product master, you can use the **Disable Overhang** parameter.

This subsection also allows assigning a **Profile for Package Builder Optimizer**, which you can maintain via **Transportation Management • Planning • Unified Package Building • Package Building • Define Profile for Package Building Optimizer** in Customizing and offers the parameters shown in Figure 5.35:

- You can define the **Maximum Optimizer Runtime [ms]** and **Max. Optimizer Runtime Without Impr. [%]** to ensure that the run will be finished after a certain time without improved results.
- The **Optimization Emphasis** controls the trade-off between exploration and exploitation, that is, searching for different solutions and fine-tuning already found solutions.
- You can set the **Optimizer Dump Level** and **Optimizer Trace Level**, which are relevant for support and analysis purposes.

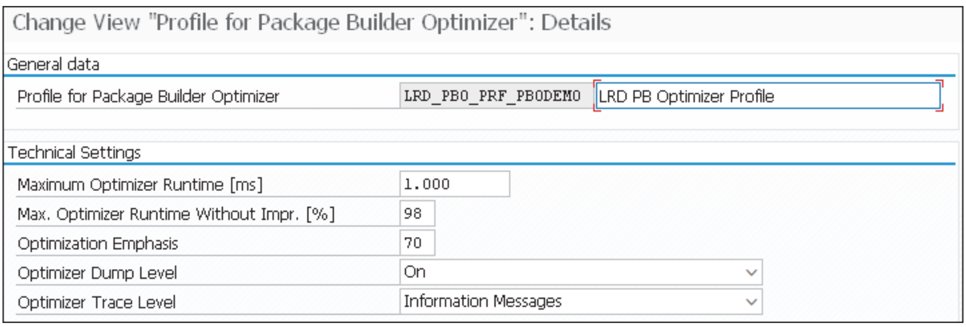


Figure 5.35 Package Building Optimizer Profile

In this subsection, you can also assign a **Rule Profile for PB Optimizer**, which you can maintain via **Transportation Management • Planning • Unified Package Building • Package Building • Define Rule Profile for Package Building Optimizer** in Customizing and allows defining additional rules, as shown in Figure 5.36:

- Using the rule to **Minimize height difference on capacity**, detailed package building minimizes the height differences of the surface of the package to build a stable package with a surface that is as flat as possible. This objective is defined as standard deviation of the heights of the different cartonized or noncartonized products that form the surface of the package, weighted by the sizes of these individual product surfaces. You can define the target deviation from the standard deviation in the **Value** field.
- The **Center the center of mass [%]** rule allows the center of mass to be placed into the middle of the pallet (with respect to length and width). This objective is modeled as

a soft constraint based on the distance of the center of mass from the middle. The **Value** field defines the allowed relative distance from the middle that doesn't cause penalty costs for violating the soft constraint. For example, if the pallet has width 80 cm, length 120 cm, and therefore the diagonal 144 cm, the **Value** 10% defines a circle with diameter 14 cm around the middle.

- The **Lower the height of center of mass [%]** rule works similarly and puts the center of mass as low as possible on the pallet. This objective is modeled as a soft constraint based on the distance of the center of mass from the pallet material. The **Value** field defines the allowed height that doesn't cause penalty costs for violating the soft constraint, and it's defined as a percentage relative to the maximum allowed height of the goods on the pallet. For example, if the allowed height is 180 cm, the **Value** 30% represents a threshold of 54 cm.

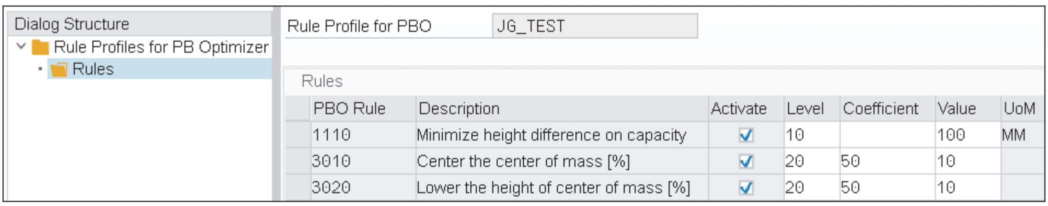


Figure 5.36 Rule Profile for Package Building Optimizer

You can activate certain rules in the rule profile. Using **Level**, you can define the dominance of certain rules against rules with a lower **Level**, and **Coefficient** allows you to weight multiple rules within the same level. In the example shown in Figure 5.36, the first rule with level 10 dominates the two others with level 20, and both rules on level 20 get the same weight, that is, they are considered equally important regarding the objective function based on the represented soft constraints.

Note

Refer to SAP Note 2581421 for more details and examples on package building.

5.4 Transportation Units

Transportation units can represent both demand and capacity. They share some similarities with freight units and others with freight orders, but they also differ from both freight units and freight orders. From the viewpoint of the possible document assignments shown earlier in Figure 5.1, transportation units are located between freight units and freight documents.

Scenarios involving trailers, railcars, containers, and packages can be modeled by transportation units, abstracting from the specific documents called *trailer units*, *railcar units*, *container units*, and *package units*.

Section 5.4.1 explains transportation units' similarities and differences to freight units and freight documents. Trailer units and relevant scenarios involving trucks and trailers are described in Section 5.4.2, followed by Section 5.4.3 and Section 5.4.4 discussing railcar units and container units, respectively. Finally, package units are introduced in Section 5.4.5.

5.4.1 Transportation Units versus Freight Units, Freight Documents, and Consignment Orders

Like freight documents, transportation units have stages defining their paths through the network. While trailer, railcar, and container resources can be assigned to the corresponding transportation units, package units represent one or multiple packages, each having an assigned packaging material.

On one hand, transportation units can't move themselves; instead, they require being moved by a truck, locomotive, vessel, or airplane and thus need to be assigned to a freight document. Therefore, they represent a demand for transportation, like freight units. The assignment of a transportation unit to a freight document can be done directly—for example, trailer unit to road freight order—or indirectly, such as container unit to trailer unit, which is then assigned to a road freight order. While a freight document can't be assigned to another freight document, transportation units allow nested assignments within this document category. For example, consider the following assignment chain: freight unit → package unit → container unit → trailer unit → road freight order. In this case, the transportation units represent three consolidation levels between freight unit and road freight order. It isn't possible to consolidate a trailer unit into another trailer unit, and this holds true as well for railcar units, container units, and package units. Freight documents and consignment orders can be subcontracted, but transportation units and freight units can't be subcontracted. To be transported and subcontracted, they have to be assigned to freight documents. Note that package units and freight units can get assigned to consignment orders and subcontracted on this level instead of the freight document level.

On the other hand, transportation units can consolidate other demands. Therefore, they also represent a capacity for transportation, like freight documents. A consignment order can consolidate demands but doesn't refer to any equipment type or resource. Therefore, it doesn't provide any capacity, which is an important difference from transportation units.

While a freight unit represents a single transportation demand, the transportation unit can represent a set of transportation demands that may even have different source and destination locations. For example, a trailer is moved from location A to B to C, delivering three freight units: the first from A to B, the second from A to C, and the third from B to C.

In general, transportation units provide a lot of modeling capabilities but that requires additional planning decisions and adds planning complexity. Therefore, we recommend avoiding using transportation units if your business can be modeled without them. Of course, for many transportation scenarios, using transportation units is mandatory because it's the only feasible way to model your business.

Like freight units, transportation units can be created by freight unit building, as described in Section 5.2.3. However, such transportation units don't allow consolidation of other demands, so they represent pure demand documents. Therefore, we focus the following discussion of transportation units on the more interesting case of transportation units allowing consolidation of demands. Note that consignment orders can't be created by freight unit building.

Each transportation unit has a specific type, which you can maintain in Customizing by following menu path **Transportation Management • Planning • Transportation Unit • Define Transportation Unit**. The similarity of transportation units to freight units and freight orders is reflected directly in the transportation unit type, so we won't describe it in detail; instead, refer to Section 5.2.2 for freight unit types and Chapter 6, Section 6.1.1, for freight order types. It's important to mention that you can assign item types to the transportation unit type, which is useful for multi-items in railcar units, as mentioned in Section 5.4.3.

There are many ways to create transportation units:

- Manual planning can be done in the transportation cockpit, as described in Section 5.7.8.
- The VSR optimizer can create trailer units and railcar units based on freight units, container units, and package units.
- Load consolidation can create trailer units and container units based on freight units and package units. See Section 5.8.7.
- Package units of defined and linear type can be created by unified package building for freight unit stages. Package units of linear with distribution type can be extracted out of road freight orders. Both approaches are described in Section 5.4.5.
- Freight unit building can create trailer units, railcar units, container units, and package units, but these transportation units represent pure demand documents and don't allow consolidation.
- You can manually create the corresponding documents by using the apps Create Trailer Unit, Create Railcar Unit, Create Container Unit, or Create Package Unit.
- You can get an overview of trailer units, railcar units, container units, or package units in the corresponding worklist by choosing the Trailer Units Worklist, Railcar Units Worklist, Container Units Worklist, or Package Units Worklist apps. From here,

you can edit, create, and cancel trailer units, railcar units, container units, and package units.

5.4.2 Trailer Units

Many road transportation businesses involve trailers, but not all them require being modeled by trailer units. Let's first review a few examples to define our terminology. Figure 5.37 shows different trucks and trailers. Box trucks have their own loading capacity, while tractors don't have their own capacity. Full trailers can be coupled to box trucks, and semitrailers can be coupled to tractors. From a planning perspective, full trailers and semitrailers are handled identically, so from now on, we refer only to *trailers*. We also don't differentiate between box trucks and tractors and simply use the term *trucks* for both. Only where required do we explicitly refer to tractors.

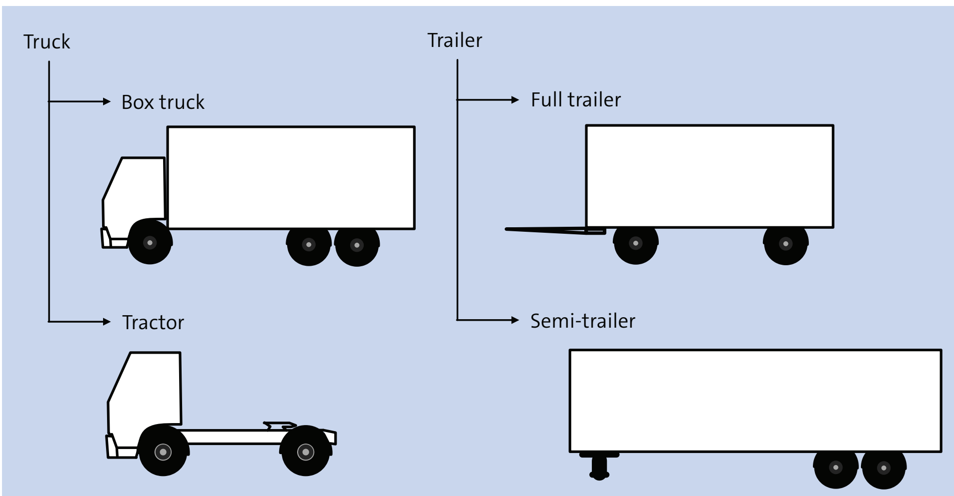


Figure 5.37 Truck and Trailer Examples

The combination of a truck and trailer moving together is also called *vehicle combination*. While the preceding examples represent vehicle combinations with one truck and one trailer, in some regions of North America and Australia, tractors can carry two or three trailers—such a combination is called a *road train*.

Transporting a trailer requires it being coupled to a truck. Although the last trailer in a road train is physically coupled to its predecessor trailer, this is simplified and abstracted from the planning viewpoint to coupling all trailers to the truck. For example, for a road train with one tractor and three trailers, all trailers get directly coupled to the tractor.

Trailers can get loaded and unloaded even when not being coupled to a truck, and they can be moved consecutively by multiple trucks. Thus, trailers bring more flexibility and cost efficiency, but this may also lead to more planning decisions to be made and hence planning complexity.

A trailer unit can consolidate multiple demands, such as freight units, package units, or container units. The stages of the trailer unit define the trailer's planned movements in the transportation network. Each trailer unit stage needs to be assigned to a road freight order, providing flexibility to assign each trailer unit stage to a different road freight order and truck resource. However, this flexibility results in complexity, and we recommend carefully checking whether you can model your scenario without trailer units.

Trailer units are required in the following cases:

- Trailers get loaded or unloaded while not being coupled to the truck.
- The truck is operating in different vehicle combinations across the stages in its freight order.
- You want to plan on an individual trailer resource level.

Let's review some examples, in order of increasing planning complexity, and how they can be modeled:

- **All tours of a trailer always done by the same tractor**
  If a trailer resource is always attached to the same tractor resource, the scenario can be modeled by a vehicle resource resembling a box truck. All transportation demands are assigned to the road freight order, and there is no need for trailer units.
- **All tours of a trailer always done by the same box truck**
  If a trailer resource is always attached to the same box truck resource, the scenario can be modeled by a vehicle resource with two compartments—one for the box truck and one for the trailer. Like the previous case, using trailer units isn't required. However, if the box truck or the trailer contain compartments relevant for planning, the simplification by using compartments to model the truck and trailer isn't applicable, and you have to use trailer units.
- **Each trailer tour done by the same truck, but trailer resource used with multiple trucks**
  If a complete trailer tour is done by the same truck but different tours of the same trailer resource can be done by different truck resources, you can use trailer units to enable dynamic assignment of truck resources to trailer resources. Here, planning needs to decide which vehicle resource moves the trailer unit at hand.
- **Trailer tour done by multiple trucks (dynamic recoupling)**
  The trailer is consecutively carried by two or more trucks. This requires a trailer unit with at least two stages, and the stages are assigned to different vehicles. For example, the trailer unit is moved along locations A, B, and C; the movement from A to B is done by vehicle V1, and the movement from B to C is done by vehicle V2. Thus, the trailer is coupled to V1 at location A, moved to B, uncoupled from V1, coupled to V2, moved to C, and then uncoupled from V2.

- **Road train with the same tractor and trailer resources**
  A road train permanently operated with the same tractor and trailer resources can be modeled analogously to case 2, with one compartment per trailer. If the trailers have compartments relevant for planning, you have to use trailer units.
- **Road train with dynamic recoupling**
  This represents the highest planning complexity. Multiple trailer units can be moved by one road freight order, and one trailer unit can be moved by multiple road freight orders, one per trailer unit stage.

If you use trailer units, the transportation plan is represented by trailer units and road freight orders, which resemble the perspectives of the trailer and of the truck. Due to the stage-wise assignments of trailer units to road freight orders, you can't change the stages of the trailer unit without changing the stages of the corresponding road freight order, and vice versa. The planner has to think from the trailer perspective and from the truck perspective, which requires quickly changing the perspective or, ideally, having both perspectives at the same time—a function that is offered by the transportation cockpit, as described in Section 5.7.1.

Dynamic recoupling is frequently used in scenarios where the distance from source to destination is so large that the driver of the truck can't make the trip in one shift. Trailer swaps are introduced to maximize utilization of the trailer fleet. Suppose one trailer has to be moved from Hamburg to Munich, and another trailer has to be moved from Munich to Hamburg. The first truck may take the first trailer from Hamburg to Fulda, which is located roughly halfway between Hamburg and Munich. The second truck may take the second trailer from Munich to Fulda. In Fulda, both trailers are uncoupled and then coupled to the other truck. Then the first truck takes the second trailer from Fulda to Hamburg, and the second truck moves the first trailer from Fulda to Munich.

This plan allows each of the drivers to be back at home at the end of their shifts. The first trailer unit has stages from Hamburg to Fulda to Munich, and the second trailer unit has stages from Munich to Fulda to Hamburg. The first road freight order has stages from Hamburg to Fulda to Hamburg, and the second road freight order has stages from Munich to Fulda to Munich. Figure 5.38 shows such a scenario in the Gantt chart, both from truck view (upper part) and trailer view (bottom part). You can see that loading and unloading of the trailers takes place while not being coupled to the corresponding tractor.

In Australia, road trains may consist of tractors carrying two trailers in urban areas and three trailers elsewhere. Suppose that the trailers are systematically moved from A to B to C and then back from C to B to A. Two trailers can be carried between A and B, and three trailers between B and C. Here, the planning decision involves defining the road trains—in other words, which trailers are moved together by which tractor. Using two default routes for the systematic movements from A to C and back, the trailer units' stages can be determined in a rule-based fashion, and then planning only has to decide about the tractor assignment to the trailer units' stages.

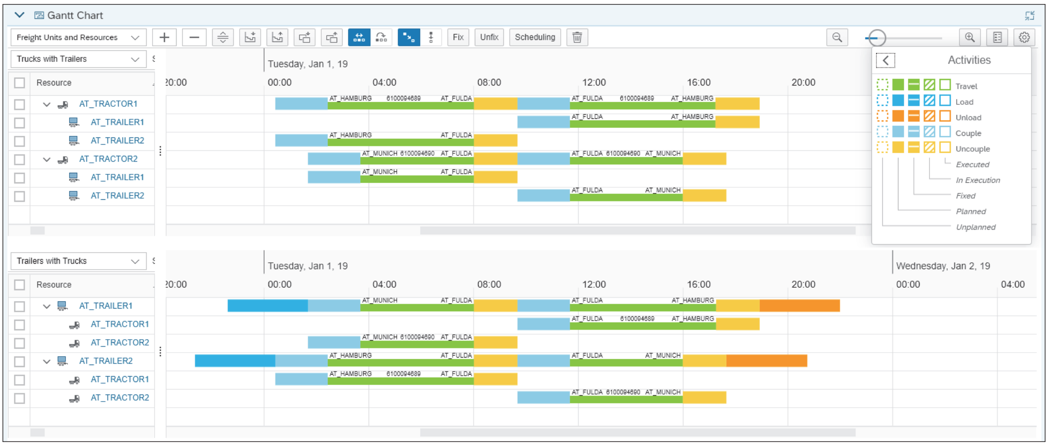


Figure 5.38 Trailer Swap Depicted in a Gantt Chart

5.4.3 Railcar Units

Rail transportation is done by trains, which may consist of one locomotive resource and a set of railcars. There are scenarios in which the whole train is subcontracted, and demands such as freight units, package units, or container units are assigned directly to rail freight orders. In other scenarios, planning is required on the individual railcar level, which is supported by railcar units that can play a role similar to that of trailer units in truck and trailer scenarios.

Manual planning supports the same functionality as for truck and trailer scenarios; that is, you can assign a locomotive to rail freight orders, create railcar units with assigned railcar resources and freight units, and assign a railcar stage to one rail freight order.

While trailer units and road freight orders have the same stages during their joint movement, railcar units and rail freight orders have only the stops in common, where the railcar is loaded, unloaded, coupled, or uncoupled. The main motivation for this modeling is the reduction of data volume because usually a rail freight order contains many more railcars than a road freight order contains trailers.

Some companies ship a lot of cargo by railcars. If 25 complete railcars full of a certain product are to be shipped, this would create an enormous number of railcar units. To reduce the number of documents, you can use the concept of multi-items to have one railcar unit that represents the load of 25 railcars. Via menu path **Transportation Management • Forwarding Order Management • Define Item Types for Forwarding Order Management** in Customizing, you can define an item category as a passive vehicle resource and enable multi-items. The multi-item can represent multiple subitems without explicitly generating the subitems. Alternatively, the multiple subitems can be generated automatically by expansion. For the subitems, you have to specify an item type that can be a subitem of a multi-item.

5.4.4 Container Units

A container unit can be assigned directly to any freight document, but it can also add one nesting level. Multiple freight units can be consolidated into a container unit, and multiple container units can be put into a trailer unit or railcar unit. In this case, container units involve four object layers relevant for assignment decision-making: Which freight units are transported in which container units, which container units are carried by which trailer unit or railcar unit, and how are these trailer units and railcar units moved? While the freight unit has the same volume and weight along all its stages, both the transportation unit and the freight order may have different (loaded) volumes and weights per stage. If package units are involved too, even five object layers are relevant for assignment decision-making.

Companies that don't own container resources may order empty containers and return the empties after delivery, as described in Chapter 4, Section 4.2.1, and they care mainly about the container movements of the cargo. They don't care about the choice of the physical container instance; instead, they just consider the required container type, for example, 20-foot versus 40-foot. Companies that receive such forwarding orders (including empty provisioning and empty returning for containers) have to plan these empty movements and can do so by container units covering the empty stages.

Companies that own and provide container resources with special properties, such as cooling capability or special construction to carry dangerous liquids, face the challenge that the container resources may be spread in the network of container yards and customer locations. If a customer requires a container transport from a source location to a destination location, an empty container resource has to be identified and transported from its current location to the required source. In the chemical industry, product-dependent cleaning activities may be required in advance. Suppose that a previous product has been delivered with a container resource that is now empty at a container yard. If the next product to be delivered isn't compatible with the previous one, an additional movement from the yard to a cleaning station is required.

Figure 5.39 illustrates the complexity of container planning with a real-world example from a road carrier with its own truck, trailer, and container equipment to demonstrate how the required business documents relate to each other:

- **Freight unit**
  Freight is to be transported from location D to G.
- **Container unit**
  The planner decides to use a container resource located at B, clean it at C, bring it to D to load the freight unit, transport it to rail hub E, transport it to rail hub F, and then deliver it to destination G.
- **Trailer unit**
  The planner has decided to use the company's own trailer resource located at A to transport the container from B via C and D to E.

- **Road freight order 1**
  The company's own truck carries the empty trailer from A to B, where the empty container is loaded to the trailer, moves to cleaning station C, and subsequently moves to D and E.
- **Rail freight order**
  This represents the rail transportation from rail hub E to rail hub F. This is done by subcontracting to a rail carrier.
- **Road freight order 2**
  The final transportation from rail hub F to the destination location G is done by subcontracting to a road carrier.

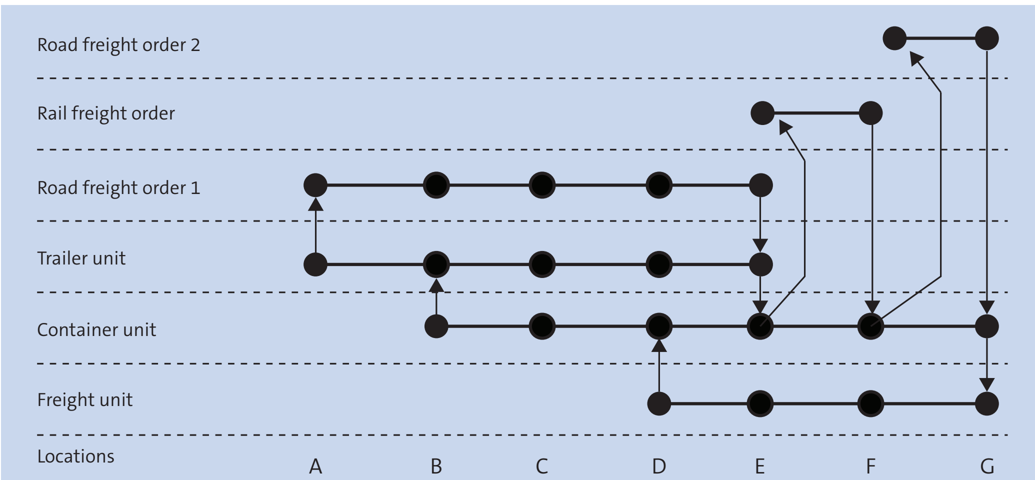


Figure 5.39 Container Unit Stages and Involved Business Documents

The stages of the involved business documents are shown in Figure 5.39. The up arrows show that a demand is assigned to a capacity, and the down arrows indicate that the demand is unassigned from the capacity.

You can see that the freight unit is the only pure demand document, the three freight orders are pure capacity documents, and both trailer unit and container unit represent both demand and capacity documents at the same time. From the container unit perspective, the freight unit is a demand document and the trailer unit, rail freight order, and second road freight order are capacity documents. From the trailer unit perspective, the container unit is a demand document, and the first road freight order is a capacity document.

We just described the plan, but how does it come together? The planner has to make many decisions to create this plan in the following sequence:

1. Select the container resource, based on its current location.
2. Choose the cleaning location.

3. Define the container's route through rail hubs E and F.
4. Create the rail freight order based on the available rail carrier schedules' departures.
5. Choose the trailer resource and truck resource.
6. Choose the road carrier for the last stage.

All these decisions can be made in the transportation cockpit by creating the relevant business documents, defining their stages, and assigning demand documents to capacity documents. Most of these decisions can even be made automatically.

5.4.5 Package Units

A *package unit* can represent one or multiple packages to be transported together. Pallets, pallet cages, and cartons represent typical examples for packages. Like a freight document, a package unit contains a packaging hierarchy that may include multiple top-level packages. Each stage of a package unit represents a transportation demand that needs to be assigned to freight documents, either directly or indirectly, as already discussed in Section 5.4.1. If your package unit only contains one stage, you may not need the package unit at all and should consider modeling your scenario by local package items instead.

From a planning viewpoint, the package unit is very similar to the container unit. It can be assigned to any freight document, trailer unit, and railcar unit, and you can assign multiple freight units to a package unit. In addition, you can assign a package unit to a container unit or a consignment order. As already mentioned, the package unit can't be assigned to a resource dedicated to packaging.

It isn't possible to assign a package unit to another package unit. If a deep packaging hierarchy is required, the package unit can model the top-level package(s), and the packaging substructure is represented by the package unit's packaging hierarchy.

Besides the pure manual creation, package units can also be created automatically by two approaches:

- Create package units by unified package building for selected freight unit stages. This approach covers creating package units for a specific location (e.g., one specific customer), a soft location group (e.g., multiple customers in a business complex), or a hard location group (e.g., a suburb).
- Create package units for a road freight order based on its packaging hierarchy, which has been created manually or by unified package building. This enables the *integrated delivery and line-haul planning* process.

We'll now describe some special parameters for package units and then describe the two approaches to create package units.

Specific Parameters for Package Units

The package unit offers some special concepts and features that aren't available for container units. We'll now give an overview of the specific package unit type parameters and then describe how they can be used in the two mentioned approaches to create package units:

- **Sequence type of stages**
  This parameter allows differentiating between the *defined and linear* and *linear with distribution* types. The first type represents a linear stage sequence as in freight units or container units; that is, the stages must be executed in a strictly linear fashion. The linear with distribution type allows one or more "normal" linear stages followed by one distribution stage, which represents distribution to multiple customers by the same truck. The sequence of the customers is undefined in the package unit, but when assigned to a road freight order, the stop sequence of the freight order determines the sequence of the customers contained in the package unit's distribution stage. Figure 5.40 shows a package unit with a linear stage from warehouse to hub and a distribution stage from hub to multiple customers, which is displayed on the map in a star-like fashion because the customer sequence is undefined.

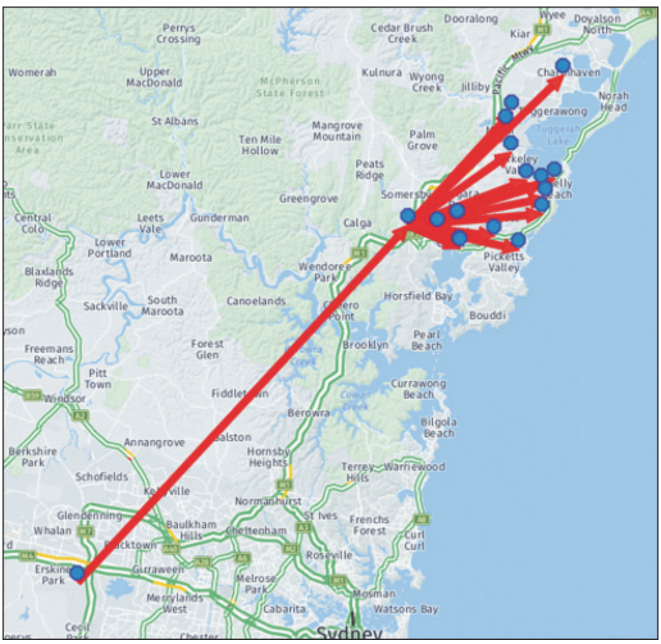


Figure 5.40 Package Unit with One Linear Stage and One Distribution Stage

- **Assignment of predecessor documents**
  You can define whether freight units must be fully assigned to the package unit at hand or whether you allow a *multi-assignment*; that is, the product quantities of a freight unit stage are distributed across multiple package units. Figure 5.41 illustrates

the multi-assignment concept in an example with three freight units, two package units, and one road freight order. The quantities of each freight unit are distributed across the two package units, which both are assigned to the same freight order. A multi-assignment is only allowed if all quantities of a freight unit stage are assigned (indirectly) to the same freight order. If you assign one of the package units to a different road freight order, this would trigger a freight unit split to reach a consistent status; that is, the product quantities of a freight unit stage are fully assigned to one freight order.

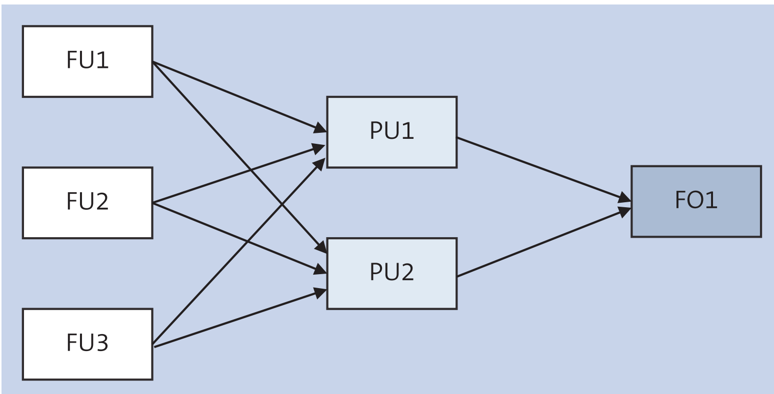


Figure 5.41 Package Units with Multi-Assignment of Freight Units

- **Package unit creation rule**
  This parameter allows defining whether all packages at hand get assigned to one package unit or each package gets assigned to an individual package unit. The first option bundles multiple packages, ensuring that they are always planned together. While this option considerably reduces the number of package units relevant for planning, it also reduces flexibility for assignment decisions. The second option results in more package units and maximum flexibility for assignment decisions, as each package unit could be assigned to a different capacity document. The second option is the most natural one, but, in some cases, the first option might be useful as well.

Creation of Package Units by Unified Package Building for Freight Unit Stages

The system can build package units based on unified package building (Section 5.3) applied to a set of selected freight unit stages. This approach is useful for the following reasons:

- In general, making the decisions about freight units being consolidated into package units reduces the complexity of the remaining planning problem. This approach follows the idea of making decisions as early as possible.
- If an average package unit contained 5 freight units, the number of demand documents in the planning scenario would get reduced by the factor 5. As a consequence,

the planner has a better overview of the real demands and the decision-making is easier.

- If it's already known that certain freight units will be transported and packaged together, this aspect can be perfectly represented by a package unit.
- Package units lead to higher accuracy for planning because they already contain the real packaging hierarchy instead of just a packaging estimate or no estimate on the number of packages at all. For example, the package unit includes the weight and volume for the required packaging material, which is hard to estimate on the freight unit level.

This function can be triggered interactively in the transportation cockpit or by a report using path **Logistics • Transportation Management • Administration • Background Processing • Create Package Units Based on Unified Package Building for FUs** in the SAP menu. Its behavior is defined by the unified package building settings depicted earlier in Figure 5.18 (see the **Creation of PUs Based on Unified Package Building for FUs** area of the screen), and it covers the following use cases:

- **Customer-exclusive package unit**
  Some customers may insist on exclusive pallets for technical reasons (e.g., forklift can be used to unload) or business reasons (e.g., they usually order a bigger volume). In the transportation cockpit, freight unit stages can be explicitly marked as exclusive packages. Alternatively, you can define a business partner to require an exclusive package (see our discussion of package type assignment in Section 5.3.5). All customer-exclusive freight units to the same customer get consolidated into a package unit.
- **Package unit for soft location group**
  Customers in the same business complex should be delivered together by the same pallets, for efficiency reasons. If the unified package building profile contains a location hierarchy for grouping (soft constraint) to model the customers in the business complex, as explained in Section 5.3.5, all freight unit stages delivering to the same group are consolidated into a package unit, if they meet the predefined threshold (**Util. Thr. For Loc. Group – Soft (%)** in the unified package building settings).
- **Package unit for hard location group**
  Customers in one town should be delivered together by the same pallets, for safety reasons. If the unified package building profile contains a location hierarchy for grouping (hard constraint) to model the customers in a town, as explained in Section 5.3.5, all freight unit stages delivering to the same group are consolidated into a package unit, if they meet the predefined threshold (**Util. Thr. For Loc. Group – Hard (%)** in the unified package building settings).
- **Package unit for business partner**
  If one customer has ordered enough volume or weight, it may be more efficient to serve the customer by dedicated pallets instead of customer-mixed pallets. All

freight unit stages delivering to one business partner are consolidated into a package unit if they meet the predefined threshold (**BP Utilization Threshold (%)** in the unified package building settings).

All thresholds refer to the selected **Quantity for Utilization Threshold**, which can be selected among volume, weight, and height. The system builds packages for one of these groups of freight unit stages, and if at least one pallet meets the utilization threshold, all the packages in the respective group are captured as package unit(s). The use cases are processed in the previously stated sequence. Thus, if a freight unit belongs to a hard location group and requires a customer-exclusive package, a customer-exclusive package unit will be created, and the freight unit is no longer a candidate for a package unit for a hard location group. The following additional parameters are offered in the unified package building settings:

- The **Default Package Unit Type** is used for the package unit to be created.
- The **Default Package Unit Creation Rule** defines whether one package unit is created for all package items, or one package unit is created per package item.
- The **PU Type for PUs with Single Dest. Loc.** defines the package unit type that is used if the package unit to be created only serves one destination location. Using a defined and linear type for a single destination improves usability because it allows displaying the unique destination location, for example in the transportation cockpit, which is not possible if a package unit of type linear with distribution is used.
- The **Creation Rule for PUs with Single DL** applies if the package unit serves only one destination, and it defines whether one package unit is created for all package items, or one package unit is created per package item.
- The **Maximum Number of Package Items per PU** defines a hard constraint for the number of top-level package items in a package unit, and it only applies if one package unit will be created for all package items. Suppose that a delivery truck can't carry more than 12 pallets. If you created a package unit with 13 or more pallets, this can't be planned, the package unit would remain unplanned, and you would need to cancel it and plan the assigned freight units individually. To avoid the manual cancellation, you could use a limit of 12 package items instead. In the example with 13 pallets, no package unit would be created, and the planner could directly work with the freight units.

While this approach to create package units early in the planning process is the right modeling for many cases, such as customer-exclusive pallets, there is another planning process in which it's key to create certain package units late in the process, even after creating road freight orders. In some business scenarios, all these cases and planning processes are used together to ensure efficient and effective planning. The next section describes the planning process with late creation of package units.

Integrated Delivery and Line-Haul Planning Based on Package Units

Let's now discuss the integrated delivery and line-haul planning process, in which the package unit with distribution and multi-assignment plays the key role to link delivery planning with line-haul planning. The business scenario is sketched in Figure 5.42. Products are transported from the warehouse to customers. The warehouse is located in a metropolis, and delivery trucks can directly serve customers from the warehouse by metropolitan tours. Customers in remote regions get served by delivery trucks from regional hubs, which get served from the warehouse by line-haul trucks. As there are many customers in each region, and customers usually order many different products but with small quantities, mixed pallets must be built containing goods for many different customers. For example, you may have a delivery truck containing 12 pallets that serve 50 customers—which means that the driver has to pull the ordered product quantities out of the mixed pallets for each customer.

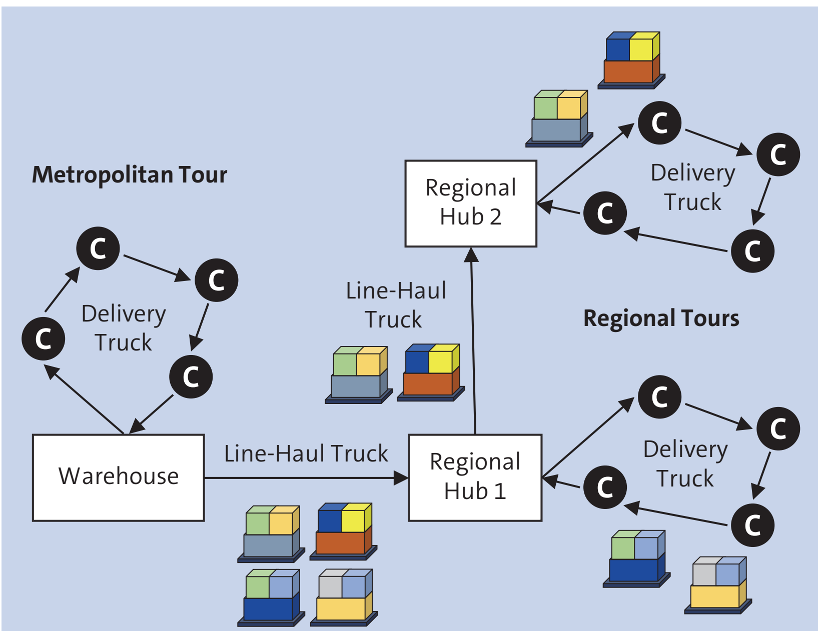


Figure 5.42 Integrated Delivery and Line-Haul Tour Scenario with Mixed Pallets

For warehouse efficiency reasons, the mixed pallets for the delivery tours are already built in the warehouse to avoid any rebuilding of pallets in the regional hubs. This leads to the main challenge in this scenario: the mixed pallets are built in the warehouse, but their structure depends on the customers that are consolidated into the same delivery tour. The solution of this challenge is to decompose the planning process as follows:

1. Plan delivery tours, build the mixed pallets for the delivery tours, and create the load plan for the delivery tours.
2. Plan line-haul tours based on the mixed pallets originating from the delivery tours, and determine the load plan for the line-haul tours.

Package units represent the mixed pallets that form the result of delivery planning and serve as input for line-haul planning. Roughly speaking, package units represent the document that links delivery planning with line-haul planning. One subtle aspect of the process is that delivery planning is done before line-haul planning, while line-haul tours get executed before the corresponding delivery tours.

Let's review the process steps in detail. As the transportation of each freight unit to a regional customer will cross the hub, we define default routes from the warehouse via the regional hub to the customers in the regions. Applying the default route already during freight unit building results in two freight unit stages: one from warehouse to hub, and one from hub to customer. Based on these freight units, the integrated delivery and line-haul planning process is composed of the following steps, which are depicted in Figure 5.17, Figure 5.43, and Figure 5.44:

1. The VSR optimizer is run for each regional delivery planning scenario, which consists of the unplanned freight unit stages from the regional hub to the customers and the available delivery trucks. The freight units contain estimates of the number of pallets, represented by normalized quantities that will be described in Section 5.5, but no detailed packaging structure yet. As a result, unplanned freight unit stages get planned and consolidated into road freight orders.
2. Package building is run for all road freight orders. As a result, the freight orders contain a packaging hierarchy.
3. Load planning is applied to all road freight orders, resulting in a load plan attached to each freight order.
4. The packages in the freight orders need to be finalized first, expressing that the planner doesn't expect any more changes. Then, package units are created for all top-level packages in the freight orders' packaging hierarchies. Before this step, freight units are directly assigned to freight orders. After this step, freight units are assigned to package units that are assigned to the freight order.

   One prerequisite for this step is to use the **Linear with Distribution** package unit type, and we strongly recommend activating multi-assignment in the package unit type, as this step otherwise could blow up the number of freight units significantly (due to freight unit splits needed to ensure that each freight unit is completely assigned to one package unit).

   The creation of package units based on road freight orders can be triggered manually in the transportation cockpit or via report by choosing **Logistics • Transportation Management • Administration • Background Processing • Create or Cancel Package Units for Road FOs** in the SAP menu, which also offers to cancel package units and to merge them into the original freight order.

   One key functionality to link delivery with line-haul planning is that the creation of package units also considers preceding freight unit stages. If a package only contains freight unit stages that all have the same preceding stages—which is the case in our scenario because they all have one common line-haul stage from warehouse to hub—the system will also plan these freight unit stages and assign them to the package unit created. As a result, the freights units are completely planned, that is, not just the delivery stage but also the line-haul stage. The package units contain an unplanned linear stage that represents the line-haul stage to be planned next and a planned linear with distribution stage assigned to the delivery road freight order.

5. After the preceding steps have been completed for all delivery regions, line-haul planning starts by running the VSR optimizer for all unplanned package unit stages from the warehouse to the regional hub and considering the available line-haul trucks, which are usually much bigger than the delivery trucks serving the customers. As a result, the package unit stages get planned, and the line-haul freight orders get created. In the example shown in Figure 5.44, the line-haul freight order is assigned to a tractor carrying two trailers, represented by two trailer units. Thus, each package unit has been assigned to one of the two trailer units that are both assigned to the road freight order.
6. As the last step, load planning is triggered for the road freight order, resulting in a load plan for each trailer that considers all axle weight constraints across the whole vehicle combination.

Delivery planning (steps 1–4) is performed for all regions. Line-haul planning (steps 5–6) is started only after delivery planning has been finished for all regions, and all required package units have been created based on the delivery freight orders.

The preceding process contains many automatic components, such as VSR optimizer, package building, and load planning. In practice, we recommend automating as much as possible and reworking manually only where required. Of course, all process steps can also be performed in a pure manual fashion.

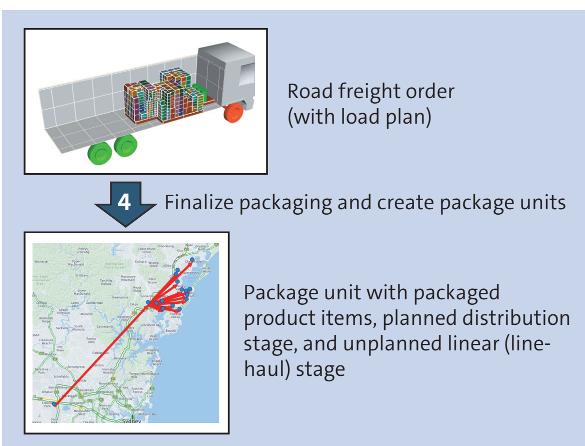


Figure 5.43 Creation of Package Units after Delivery Planning

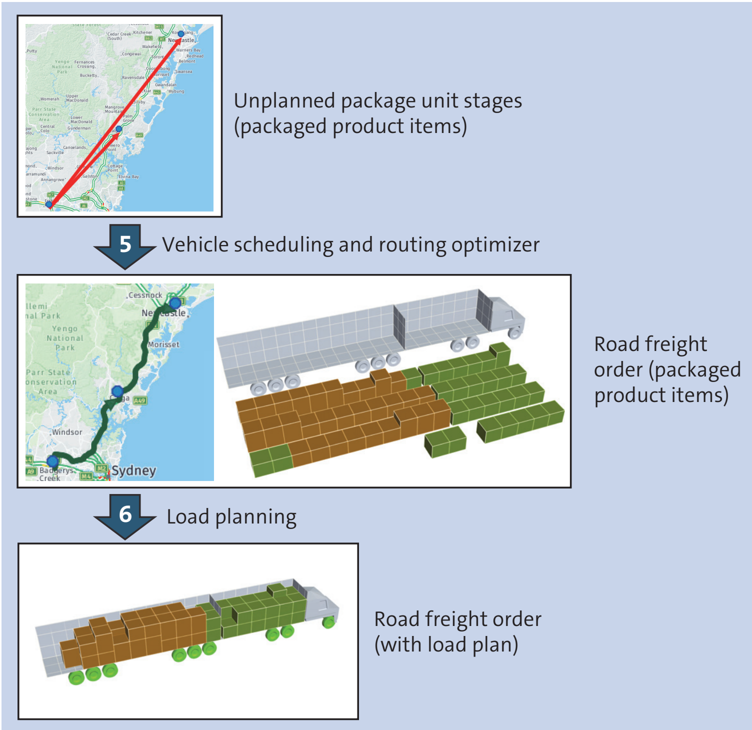


Figure 5.44 Line-Haul Planning Process

5.5 Normalized Quantities

While a transportation demand is usually quantified by its required volume and weight, it's common in many regions and businesses to measure the demand by an additional quantity that represents the required floor space or cargo space in a truck. For example, a euro-pallet with length 1.2 m and width 0.8 m has a footprint of 0.96 square meters. You could measure the required floor space by the number of needed euro-pallet places in a truck. Alternatively, the loading meter (LDM) concept is used frequently in Europe, too. Assuming a standard trailer size with width 2.4 m, the required floor space of a load is divided by 2.4 m, yielding the length of the load from the front of the cargo space to its back. One euro-pallet occupies 0.4 LDMs, so you can convert these two measures into each other. A standard trailer can carry 13.6 LDMs and thus 34 euro-pallets. In Germany, a special pallet type (called the Düsseldorf pallet) with half the size of a euro-pallet is frequently used in the retail business for efficiency and flexibility reasons, and it's measured by 0.5 euro-pallets and therefore 0.2 LDMs. For example, if the transportation demand consists of 3 euro-pallets and 3 such half-sized retail pallets, this is measured by 4.5 euro-pallet places and 1.8 LDMs.

Now, let's take a closer look at how to model our example by normalized quantities.

5.5.1 Normalized Quantity and Additional Normalized Quantity

As it's common practice to measure transportation demands and loads by the number of standardized pallet spaces or LDMs, freight units can be measured by the *normalized load consumption quantity* (normalized quantity, NLQ) and the *additional normalized load consumption quantity* (additional normalized quantity, ANLQ). For both NLQ and ANLQ, you can define its unit of measure. In the previous example, you can use EPL to measure NLQ regarding the number of euro-pallets and LDM to measure ANLQ regarding the LDMs. The system can measure all transportation demands regarding these two units of measure, and the resources, equipment, types, and capacity documents offer corresponding capacities.

The information flow to determine the normalized quantity in a freight unit and subsequently in a road freight order is shown in Figure 5.45. The key to determine the normalized quantity is the normalized quantity per product and unit of measure, for which the system offers multiple alternatives to define it. Before describing these in detail in Section 5.5.2, let's look at how the normalized quantity is determined and configured. We'll conclude with a look at planning with normalized quantities.

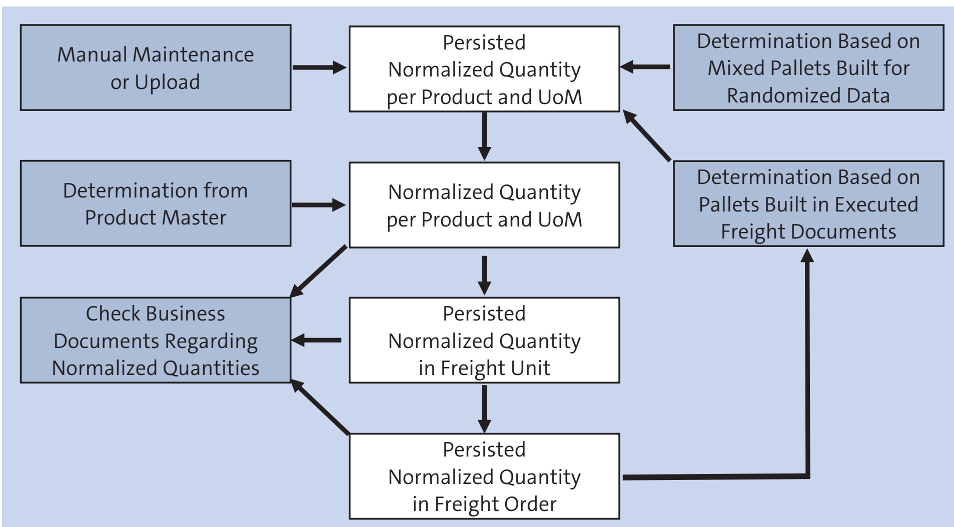


Figure 5.45 Interplay of Components Regarding Normalized Quantity

Determination

Let's assume an example of a freight unit with three product items, as shown in Table 5.1. Each product item has a quantity referring to the product's base unit of measure, which gets multiplied with the normalized quantity per product and unit of measure and results in the normalized quantity regarding its defined unit of measure. The NLQ is calculated per item and then aggregated on freight unit level.

Item	Product	Quantity (Base UoM)	NLQ per Product and UoM	NLQ (EPL)	ANLQ (LDM)
10	A	20 EA	0.05 EPL	1.00 EPL	Not available on item level
20	B	5 CS	0.25 EPL	1.25 EPL	
30	C	12 EA	0.10 EPL	1.20 EPL	
Total (Header Level)				3.45 EPL	1.38 LDM

Table 5.1 Example Calculation for Normalized and Additional Normalized Quantity

Then, the determination of the ANLQ is rather straightforward. The additional normalized quantity is determined only on the header level, as shown in Table 5.1, by a simple conversion factor that can be configured centrally. We'll now describe the required configuration for NLQ and ANLQ in general.

Configuration

As not all businesses require normalized and additional normalized quantities, the corresponding functions must be activated explicitly as follows:

- Using path **Transportation Management • Planning • Freight Unit • Define Freight Unit Types** in Customizing, you need to define the following parameters in the **Defaults Units of Measure** section. If the **Default UoM for Normalized Quantity** is maintained, the normalized quantity in the freight unit gets determined. The additional normalized quantity in the freight unit is determined if the **Default UoM for Additional Normalized Quantity** is defined and the normalized quantity has been determined. The **Aggregate Load Consumption Quantity** parameter enables displaying the packaging material overview, which shows the used packaging materials in a compact overview that is very useful if different packaging materials (e.g., two europallets, four industry pallets, and three pallet cages) are used within one freight unit.
- Choose path **Transportation Management • Freight Order Management • Freight Order • Define Freight Order Types** in Customizing to maintain the analogous parameters in the **Defaults Units of Measure** section for the freight order type. The **Default UoM for Normalized Quantity** and the **Default UoM for Additional Normalized Quantity** enable determining the normalized and additional normalized quantity in a freight order. The packaging material overview on the freight order level is enabled by the **Aggregate Load Consumption Quantity** parameter. Additionally, using the parameter **NLQ Utilization Rule**, you can choose whether the free capacity in a top-level package item is considered as available for further consolidation or not. Consider an example with 10 pallets each having a utilization of 75%. If you select the **Default Calculation**, all 10 pallet spaces are considered fully utilized although each pallet still has 25% free capacity. If you choose **Consider Package Utilization for NLQ Consumption** and the pallets aren't yet finalized, the 10 pallet spaces

are considered with a utilization of 75%, thus even more freight units can get put into the freight order. In this case, you can trigger package building on the freight order level again to make use of the available capacity on the existing pallets. Finalized pallets are always considered fully utilized, independent of the chosen utilization rule.

- You can use the same parameters for transportation units by selecting path **Transportation Management • Planning • Transportation Unit • Define Transportation Unit Types** in Customizing.
- In Customizing, choose path **Transportation Management • Freight Order Management • Define Conversion Between Normalized Qty and Additional Normalized Qty UoMs** to define the conversion factor between NLQ and ANLQ, as shown in in Figure 5.46. Note that this conversion is product-independent and only required if you want to populate the ANLQ too.

Conversion Betw. Normalized Qty and Add. Normalized Qty UoMs

NLQ UoM	ALQ UoM	Conversion Factor Between NLQ and ALQ
EPL Euro Palett	LDM Loading Meters	0,4000000000

Figure 5.46 Conversion from Normalized Quantity to Additional Normalized Quantity

- To determine the normalized quantity during freight unit building, choose the Create Freight Building Rule app. In the **Advanced Settings** tab, choose the **Unified Package Building Profile**, which must define **Package Building** as **UPB Engine** and the desired **UoM of NLQ**, as shown earlier in Figure 5.32. As already mentioned in Section 5.3.2, you can use the **Result of Unified PB** parameter to define whether the packaging hierarchy is persisted or only the estimated package count is persisted as normalized quantity regarding the chosen unit of measure for the NLQ.
- To show the capacities of resources and equipment types regarding the normalized quantity, you need to define the **Default UoM for Normalized Quantity** in the transportation cockpit settings, which will be introduced in Section 5.7.1.

5.5.2 Normalized Quantity per Product and Unit of Measure

The normalized quantity per product and unit of measure is the key to determine normalized quantities and therefore additional normalized quantities. It's stored in a table, which is contained in the product package type assignment depicted earlier in Figure 5.29. You can manually maintain the values or upload them. Additionally, the system offers two methods to populate the table automatically, which we'll describe in more detail in the following sections.

If the normalized quantity is calculated for a document at hand, the system looks up in the table for the normalized quantity per product and unit of measure. It even considers the reference product hierarchy; that is, if no entry is found for product P but for a reference product Q, then the definition for Q is used for P too. For companies with huge amounts of products, this greatly reduces the number of entries in the table and makes the definition more efficient and less error prone.

If no definition is found in the table, the full package quantity defined in the **Units of measure** tab of the product master data (refer to Figure 5.26) is taken as fallback. Let's assume EPL as the unit of measure of the normalized quantity and a product P with base unit of measure EA. If the product master data for P defines that 1 EPL represents 100 EA, the normalized quantity for P and EPL is 0.01. If no appropriate conversion can be found in the product master data, the system can't determine the normalized quantity per product and unit of measure, and therefore the normalized quantity for the item at hand remains empty.

Now, let's discuss the two methods to populate the table for the normalized quantity per product and unit of measure automatically.

Determination Based on Randomized Data

The first method is triggered by choosing the Determine Normalized Quantity Based on Randomized Data app and results in the screen shown in Figure 5.47. The main idea is to provide an expected (statistical) distribution of products for the business at hand, let the system create randomized transportation demands according to the given distribution, apply package building to create mixed pallets, and then deduce normalized quantities per product and the predefined NLQ unit of measure. This deduction is based on the relative volume of a product in the pallets it's assigned to. As package building is minimizing the number of pallets required, the rationale of this approach is to approximate the real demands and consider mixed pallets as in reality, including blends, stacking constraints for the products, and therefore a realistic pallet structure. We expect this to be more accurate for a mixed pallet business than the fallback approach based on the conversion rules defined for one single product only because this assumes homogeneous single-product pallets, which aren't representative for a business with small product quantities and therefore many mixed pallets.

The **General Execution Settings** section provides the following parameters:

- The **Update Mode** offers the **Overwrite** option to store the results directly in the table, and the **Simulation** option to present the result without storing them.
- **UoM of NLQ** defines the unit of measure of the normalized quantity.
- The **NLQ Determination Level** defines whether the NLQ is determined for products, reference products, or for both.
- The parameter **Calculation Runs** specifies how many runs are performed to determine the normalized quantity per product and unit of measure. The weighted average result across the runs performed is returned as result. As each run is randomized, it makes sense to perform multiple runs to avoid statistical anomalies.
- The last four parameters define the desired amounts of randomized demands and items per randomized demand, both accompanied by a corresponding standard deviation.

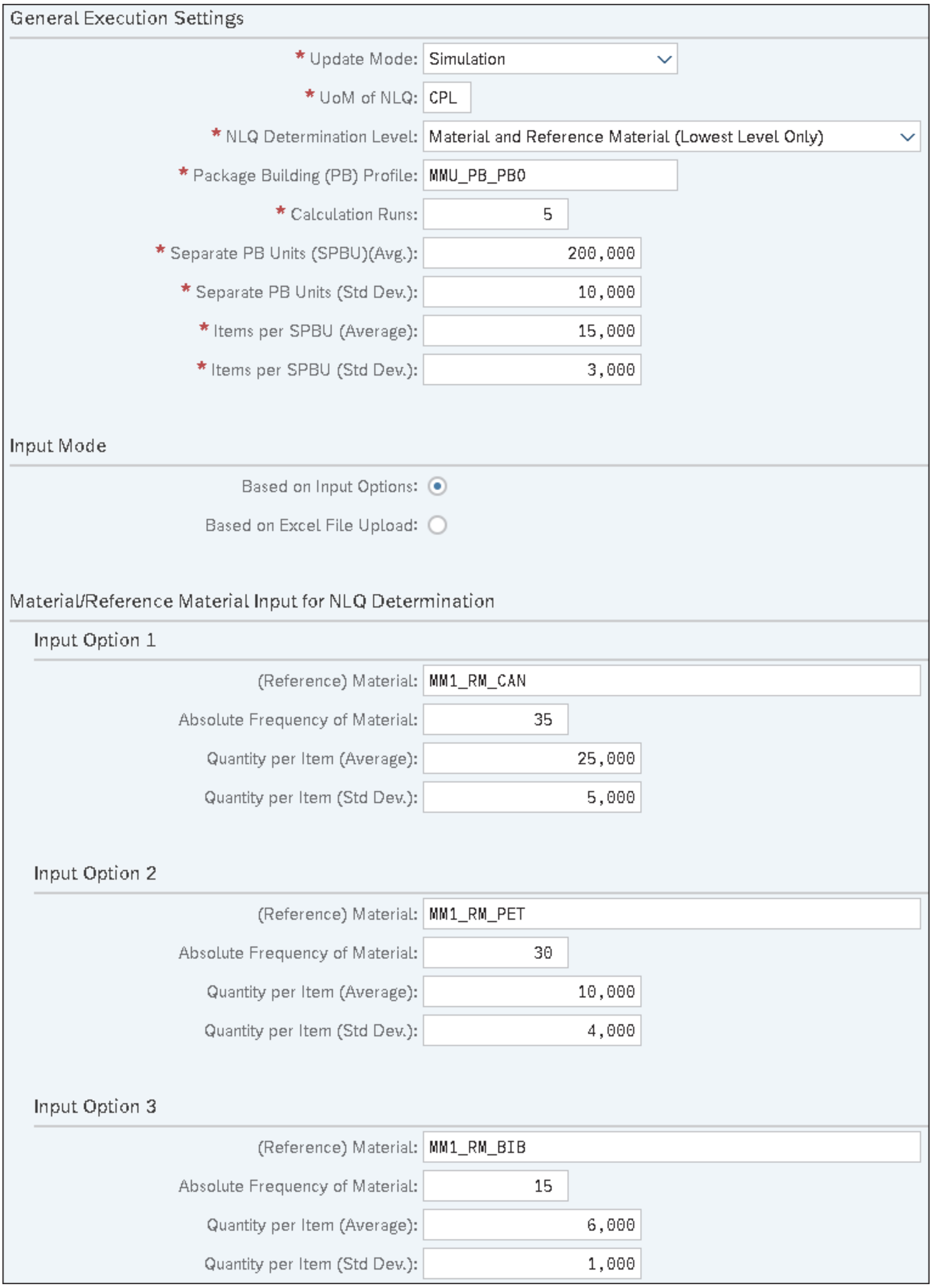


Figure 5.47 Determination of Normalized Quantities Based on Randomized Data

Under the **Material/Reference Material Input for NLQ Determination** section, you can list a set of products explicitly, each with the absolute frequency and both the average quantity and the standard deviation regarding the base unit of measure. The absolute frequencies are mapped to relative frequencies during the creation of the randomized demands. Alternatively, you can provide this distribution information in an XLS file.

Using the **Execute** button, you can execute the NLQ determination right away or schedule a corresponding background job. The UI allows you to adjust the distribution, review the results, compare the currently stored normalized quantity per product and unit of measure, and check messages provided by the determination algorithm.

Determination Based on Documents

The main idea of the second method is to adapt the normalized quantity according to your current business, that is, consider freight orders that have been executed and use their pallets as input to deduce the normalized quantity per product and unit of measure. The deduction is equivalent to the first method, but the input data isn't based on randomized virtual demands but on real pallets built and contained in freight orders that have been executed to serve real customers' demands.

The second method is triggered by choosing the Determine Normalized Quantity Based on Documents app and offers the following parameters, as shown in Figure 5.48:

- The **Selection Profile** defines the freight orders to be used as input.
- Analogously to the determination based on randomized data, **UoM of Normalized Quantity** defines the target unit of measure for the normalized quantity per product, and **NLQ Determination Level** defines whether the normalized quantity gets determined for products, reference products, or for both.
- The **Weighting Factor for Calc. Values (%)** defines the impact of the selected freight orders and the current normalized quantity on the new normalized quantity. This parameter controls the speed of adaptation. A factor of 0 means that the current normalized quantity is preserved independent of the freight orders, and a factor of 100 means that the current normalized quantity is completely replaced by the new value derived from the selected freight orders. Normally, you would choose a value between these two extremes, because ignoring both the past and the new business seems to be inferior to a good trade-off between the two.
- The **Maximum Tolerance for Outliers (%)** allows ignoring certain outliers, which may otherwise lead to undesired adaptation of the normalized quantity. The percentage refers to the current value of the normalized quantity per product and unit of measure. If there is a normalized quantity 0.1 EPL, the tolerance 10% would ignore a new normalized quantity less than 0.09 EPL and greater than 0.11 EPL, and the tolerance 100% would ignore a new normalized quantity greater than 0.2 EPL.
- The **Threshold for Saving New NLQs (%)** defines that only relative changes above the threshold get saved. Given the current normalized quantity 0.1 EPL, the threshold 10% would allow saving only normalized quantities smaller than 0.09 EPL and greater than 0.11 EPL. As changing the normalized quantity per product and unit of measure may invalidate existing freight orders, this threshold allows avoiding insignificant changes of the normalized quantity per product and unit of measure.

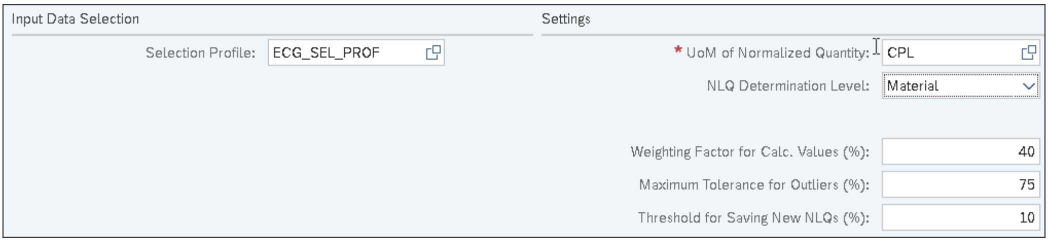


Figure 5.48 Determination of Normalized Quantities Based on Documents

The system allows comparing the new with the current value regarding their absolute and relative difference. This helps the user check the results, focusing on the biggest changes.

Alternatively, you can use path **Logistics • Transportation Management • Administration • Background Processing • Determine Normalized Quantity Based on Documents** in the SAP menu to trigger a corresponding report, which offers the same main parameters but also offers a test mode, in which the results don't get stored so that the user can review them first.

Of course, when using the determination based on documents, you need some reasonable initial values for the normalized quantity of a product and unit of measure before you can let the system learn based on executed documents. For the initial values, you could use values derived from the product master data or explicitly maintain reasonable values. Alternatively, you could use the determination based on randomized data to determine reasonable values.

Consistency of Business Documents Regarding Normalized Quantities

If the normalized quantity per product and unit of measure gets changed, already existing documents based on the previous values become outdated, which may cause unexpected planning results such as overutilization or underutilization. Manually checking such a situation could be difficult, time-consuming, and consequently error prone. Therefore, choosing **Check NLQs and Cancel Documents**, you can identify documents of the selected types, for example, freight units or road freight orders, without any defined normalized quantity or with a deviation above a given relative threshold regarding the current normalized quantity per product and unit of measure. The system provides a list of the documents, the product items, and the deviations regarding the normalized quantity. You can use this list to analyze the deviations and to select documents for cancellation. In general, this simplifies the analysis of inconsistencies and increases the robustness regarding normalized quantities. This functionality is available as a report as well by choosing path **Logistics • Transportation Management • Administration • Background Processing • Check NLQs and Cancel Documents** in the SAP menu.

5.5.3 Planning with Normalized Quantities

Normalized quantities are used to estimate the expected amount of required floor-space or volume of requirements. For planning purposes, these estimates should be as accurate as possible. For example, if unified package building is applied to road freight orders created by the VSR optimizer, and load planning is used afterwards, too optimistic or too pessimistic estimates could lead to undesired results. If more packages are created than estimated, load planning may not be able to position them correctly on the truck. If fewer packages are created than estimated, the truck utilization may be lower than desired. In both cases, the planner may want to adjust the plan to avoid overutilization and underutilization of the truck.

The accuracy of the estimates, represented by normalized quantities, is crucial to avoid these two undesired cases. The two determination methods, based on randomized data and documents, are tools to define normalized quantities that are as realistic and accurate as possible. If unified package building can be used before the VSR optimizer for the business scenario at hand, either during freight unit building or to create package units up front based on freight units, this improves the accuracy for planning, because the packaging hierarchy is already known before the VSR optimizer, which then doesn't have to rely on estimates. If the normalized quantities are too optimistic by a certain factor, say 3%, you could also adjust the capacities of your resources and equipment types by an adjustment factor, which can be defined in the constraints and costs settings.

5.6 Planning Strategies, Profiles, and Settings

Planning strategies define the different steps performed in manual and automatic planning. You can use standard planning strategies and incorporate your own enhanced strategies too. Section 5.6.1 reviews the available planning strategies. Section 5.6.2 presents planning and selection profiles that—together with additional settings—define the planning scenario and configure planning parameters.

5.6.1 Planning Strategies

Planning contains many different decision levels, as described in Section 5.1. When performing a certain manual or automatic planning step, you may want to define which additional decisions will be made automatically by the system. In one example, you may want to trigger load planning after each manual planning step to see the effect of the decision on the load plan immediately. In another example, you want to run carrier selection immediately after the VSR optimizer.

A *planning strategy* defines the system behavior for different planning steps in manual planning and automatic planning. The system offers the following standard planning strategies for manual planning:

- VSRI_DEF for manual planning
- VSRI_SCH for manual planning with subsequent scheduling
- VSRI_CHK for manual planning with subsequent checking
- VSRI_ALP for manual planning with subsequent load planning
- VSRI_CPB for manual planning with subsequent package building
- VSRI_PBLP for manual planning with subsequent package building and load planning
- VSRI_1STEP for manual planning with subsequent carrier selection

The following standard strategies are available for automated planning, specifically VSR:

- VSR_DEF for VSR optimization
- VSR_1STEP for one-step optimization (which calls VSR optimization and then carrier selection optimization) and for transportation proposals (carrier selection is called for each determined transportation proposal)
- VSR_ALP for VSR optimization with subsequent load planning
- VSR_CPB for VSR optimization and consecutive package building
- VSR_CPBALP for VSR optimization with consecutive package building and load planning

Additional strategies are available for the following purposes:

- VSS_EMBED for embedded scheduling, which has replaced VSS_DEF (scheduling based on optimizer server) as the default for scheduling purposes and doesn't require the optimizer server anymore
- VSR_CHECK for checking the plan
- TSPS_DEF for carrier selection optimization
- ALP_DEF for load planning
- ALC_DEF for load consolidation

Each strategy consists of a sequence of methods. If you want to refine the standard behavior, you can build your own strategies, which can reuse the standard methods. After these are defined, you can use your own strategies in the profiles to replace the default standard strategies. Refer to Chapter 2, Section 2.3.6, for more details on defining strategies and methods.

5.6.2 Profiles and Settings

Besides the configurability of the UI, which we'll describe in Section 5.7, many additional parameters define the planning scenario and how planning can be performed. The selection of objects relevant for planning can be handled by selection profiles, and planning parameters are covered by planning profiles. We'll cover both in the following sections.

Selection Profiles and Selection Attributes

The selection profile defines which documents are considered for planning and can be created by choosing the Create Selection Profile app. The selection profile consists of three building blocks: time-related selection attributes, geographical selection attributes, and additional selection attributes, as shown in Figure 5.49.

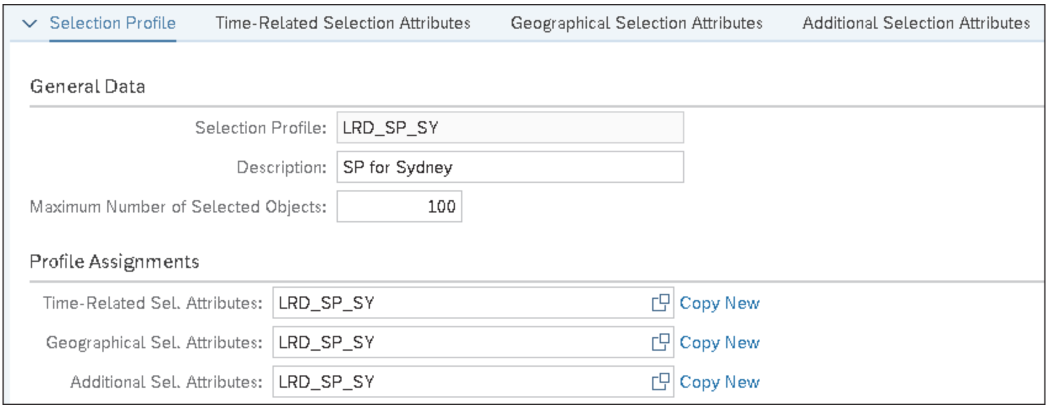


Figure 5.49 Selection Profile

You can create the three attribute objects independently of each other and the selection profile by choosing **Create Time-Related Selection Attributes**, **Create Geographical Selection Attributes**, and **Create Additional Selection Attributes**. The building block principle allows reuse of the same attribute definitions in different selection profiles. Selection according to the selection profile returns objects that meet the criteria of the time-related selection attributes, geographical selection attributes, and additional selection attributes. The selection profile allows you to define a limit for the number of selected objects.

The time-related selection attributes use two horizons—one for the pickup time windows and one for the delivery time windows—as shown in Figure 5.50. You can define the horizons as relatively, relatively with fixed start time, relatively with fixed end time, or absolutely. The **Simulate Demand Horizon** button allows you to simulate the effect of the chosen parameters in a popup, which displays the determined date and time of pickup start, pickup end, delivery start, and delivery end for a defined anchor time that is defaulted with the current date and time but can be changed arbitrarily.

Using the **Absolute** option, you can explicitly maintain the pickup horizon and the delivery horizon, which is quite useful if you want to reproduce one planning session.

The **Use Relative Horizon with Fixed Start Time** option enables defining a time period by a fixed start time and a relative duration. In the example, the start time is fixed at 7:00 and the duration is 6:00, so the resulting horizon is 7:00–13:00. Such a scenario is useful if you plan the morning tours first and then the afternoon tours. The **Use Relative Horizon with Fixed End Time** option works analogously but is based on a fixed end time.

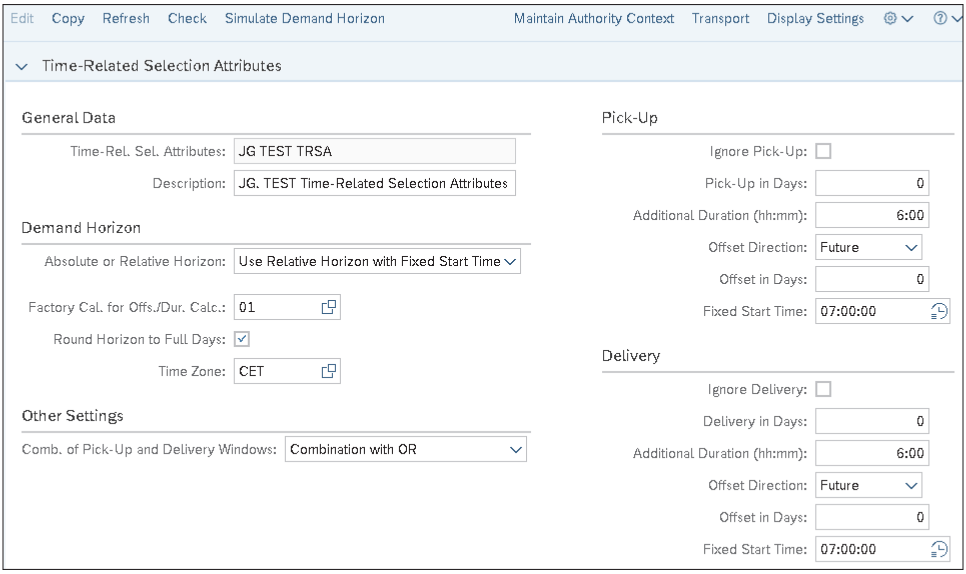


Figure 5.50 Time-Related Selection Attributes

In all three relative options, you can define a range by specifying the number of days and an additional duration in hours and minutes. Additionally, you can define an offset in days, an offset in minutes and seconds for the pure relative option, and an offset direction that points into the past or into the future. The system takes the current time and adjusts it by the offset to determine the start of the horizon. Adding the range to this yields the end of the horizon.

For all relative options, you can specify a factory calendar, which enables the system to consider nonworking days when determining the start of the relative horizons. If the determined start day is a nonworking day, the horizon's start is moved to the next working day, and the range remains the same. The relative horizon is useful if you always plan objects in advance (e.g., for the next three days).

You can round the horizon to full days and define the time zone to be used for this rounding. Using the **Ignore Pick-Up** and **Ignore Delivery** flags, you can focus selection on the dates of only pickup or delivery. If both are marked as relevant, you can define whether both pickup and delivery or only one of them must be within its horizon.

Alternatively, you can enforce a combination of pickup time window with a source location and delivery time window with a destination location. This option selects objects with a source location matching the geographical source selection attribute and the pickup time window falling into the pickup horizon, along with objects with a destination location contained in the geographical destination selection attributes and the delivery time window in the delivery horizon. This allows scenarios to consider all inbound and outbound objects in the same horizon at a certain location.

Transportations within different countries or regions can often be planned independently of one another, enabling a geographical decomposition of the global transportation planning scenario into multiple local and independent planning parts. Geographical selection attributes allow you to select objects based on geographical criteria, which you can maintain in the **Source Locations**, **Source Zones**, **Destination Locations**, and **Destination Zones** tabs, as shown in Figure 5.51.

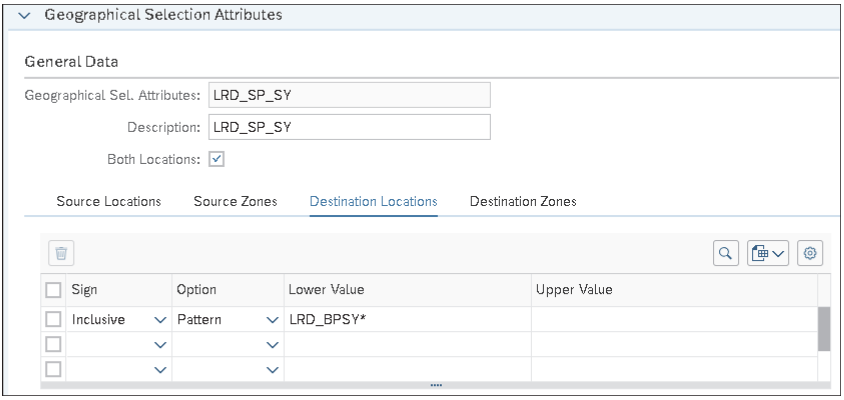


Figure 5.51 Geographical Selection Attributes

You can enter several criteria for each tab. All source locations and locations in source zones marked as **Inclusive** are relevant, but the corresponding locations marked as **Exclusive** aren't. The destination locations are determined the same way. The **Both Locations** checkbox defines whether the selected objects must meet the criteria for their source and destination or whether it's sufficient if only their source or destination matches its criterion.

You can use the additional selection attributes to define more selection criteria specified the same way as the location selection in the geographical selection attributes, but here you can refer to any other fields available in the queries for freight units, capacity documents, and original transportation demands, such as forwarding orders. Multiple criteria for the same object and field are combined with the logical OR, and the criteria for different fields are combined with the logical AND. Additionally, you can specify the following:

- Planned objects are included or excluded from both the selection and the cockpit session. The last option only applies to freight unit stages and ensures that they neither get selected nor shown in the transportation cockpit when they have reached the status **Planned**. This option leads to a good overview in the cockpit and improves its performance.
- Objects blocked for planning are included or excluded.
- All or only selected container unit stages are selected.
- All or only selected package unit stages are selected.

Planning Profiles and Settings

The planning profile defines numerous parameters that control how planning is to be performed. Besides the parameters defined in the planning profile itself, it contains 12 building blocks: the capacity selection settings, the capacity availability settings, the capacity document creation settings, the manual planning settings, the scheduling settings, the optimizer settings, the constraints and costs settings, the incompatibility settings, the carrier selection settings, the unified package building settings, the load planning settings, and the transportation cockpit settings. As with the selection profile's building blocks, all these settings can be maintained independently of each other and the planning profile and can therefore be reused in different planning profiles. An additional block covers administrative data to show the dates for creation and last change. You can create a planning profile and additional settings by choosing the following apps: Create Planning Profile, Create Capacity Selection Settings, and so on.

The planning profile itself contains many parameters grouped into different sections, as shown in Figure 5.52. The **Planning Horizon** area is identical to the horizon definitions already explained in the context of time-related selection attributes. However, the planning horizon defines the horizon in which new capacity documents can be created by planning and documents can be scheduled.

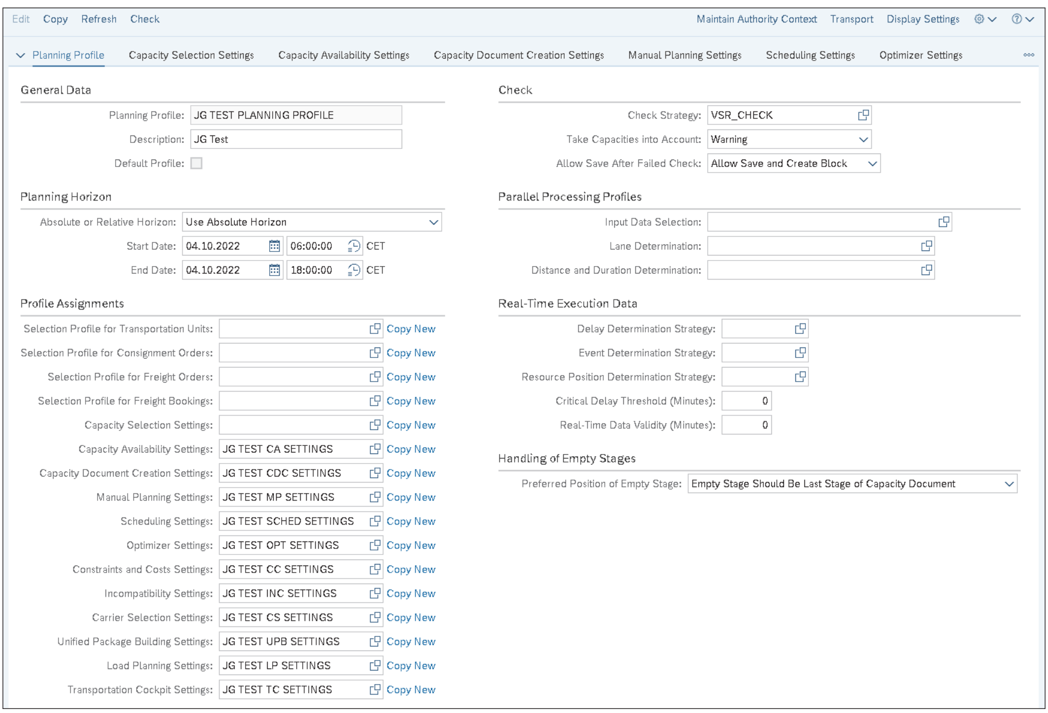


Figure 5.52 Planning Profile

The **Check** section defines the check strategy and the handling of capacity violations. The system issues either a warning (in which case, you can continue planning and save the affected document) or an error (in which case, the planning operation can't be executed), or it simply ignores the capacities. Moreover, you can allow documents to be saved even after failed checks, which is useful if some constraints are violated but you want to adjust the affected documents later. These failed checks cause blocks that prevent execution. Alternatively, you can strictly forbid saving if at least one check failed, which forces you to adjust the plan before saving.

The **Parallel Processing Profiles** section allows you to define profiles to control parallel processing for the optimizer input data selection, transportation lane determination, and distance and duration determination. Via path **Logistics • Transportation Management • Current Settings • Define Parallel Processing Profile** in the SAP menu, you can specify the server group used for parallel processing, the maximum number of parallel processes, the package size that determines the number of relevant objects to be grouped together in a package for parallel processing, and the queue time that defines how long the system has to wait for resources to become available for further processing. Parallelization can reduce the runtime for large planning scenarios.

The **Real-Time Execution Data** section allows you to incorporate execution data into the visualization on the map and the Gantt chart, which will be explained in Section 5.7.4 and Section 5.7.5, respectively. The execution data includes the resource position, delays for freight orders, and additional events that could represent incidents on the route between the last reported resource position and the next destination. Incidents can refer to traffic, weather, or something else. You can define strategies to determine delays, events, and resource positions. Either you use the existing standard strategies **TES_D_TM** and **TES_R_TM**, which fetch the delay stored in the execution tab of the freight order and the last reported position of the resource, respectively, or you define your own strategies that could pull the corresponding information from external providers. You can specify a threshold for delays to become visualized. For example, a threshold of 15 minutes ensures that only delays greater than or equal to 15 minutes get displayed. Additionally, you can define the caching duration of real-time data. After the validity period, fresh data get pulled again via the defined strategies.

The **Handling of Empty Stages** section defines whether necessary empty stages get assigned as the first or last stage of a capacity document. This parameter gets considered by both manual and automated planning.

In the **Profile Assignments** area, you can reference the 12 planning-relevant settings and include additional selection profiles to select freight orders, freight bookings, consignment orders, and transportation units, which is useful for scenarios in which you want to explicitly include certain freight documents and transportation units in planning. With the **Copy** and **New** links, you can copy the assigned profiles and settings or create new ones, respectively.

In the **Capacity Selection Settings** area shown in Figure 5.53, you can select the vehicle resources and types, drivers, container resources and types, and schedules for the planning scenario at hand. You can define multiple criteria based on attributes of the vehicle resource. The mode of transport can be maintained explicitly, allowing selection of different road and rail resources within one selection. You can use the **Means of Transport** attribute to select active or passive vehicle resources. The definition of criteria for drivers, container resources and types, and schedules is analogous to vehicle resources. For containers, you can use the **Resource Class** attribute to include or exclude unit load devices (ULDs).

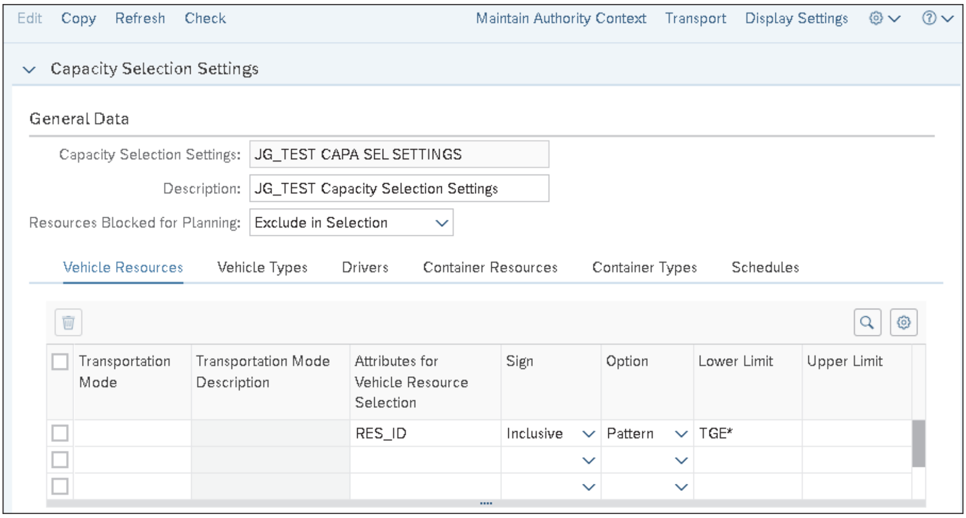


Figure 5.53 Capacity Selection Settings

The **Capacity Document Creation Settings** section shown in Figure 5.54 contains the **Default Business Document Type** area to define the types of documents created by planning. You can use the default types per category, which are all marked as default in the corresponding type Customizing; use a condition for document type determination; or explicitly maintain the document types per category. You can maintain the document types for road freight orders, rail freight orders, ocean freight bookings, air freight bookings, consignment orders, trailer units, railcar units, container units, and package units. If no explicit document type is specified, the corresponding default type is chosen. If the condition doesn't specify the document type, then the explicit type definition is used as the fallback.

Additionally, you can assign one **Requirement Grouping Profile** per document type, which is used when creating capacity documents based on groups, either manually in the transportation cockpit or automatically by a report, using path **Logistics • Transportation Management • Administration • Background Processing • Create Capacity Documents Based on Groups** in the SAP menu. This function groups requirement documents by the attributes specified in the requirement grouping profile and then creates one capacity document of the chosen capacity document category per group. Choosing **Create Requirement Grouping Profile**, you can choose the grouping rules in the requirement grouping profile and define which incompatibility settings are considered in the determination of the groups, as shown in Figure 5.55. Using menu path **Transportation**

Management • Planning • General Settings • Define Grouping Rules for Requirement Grouping in Customizing, you can define the available grouping rules, which can be chosen in the requirement grouping profile and are based on rule classes.

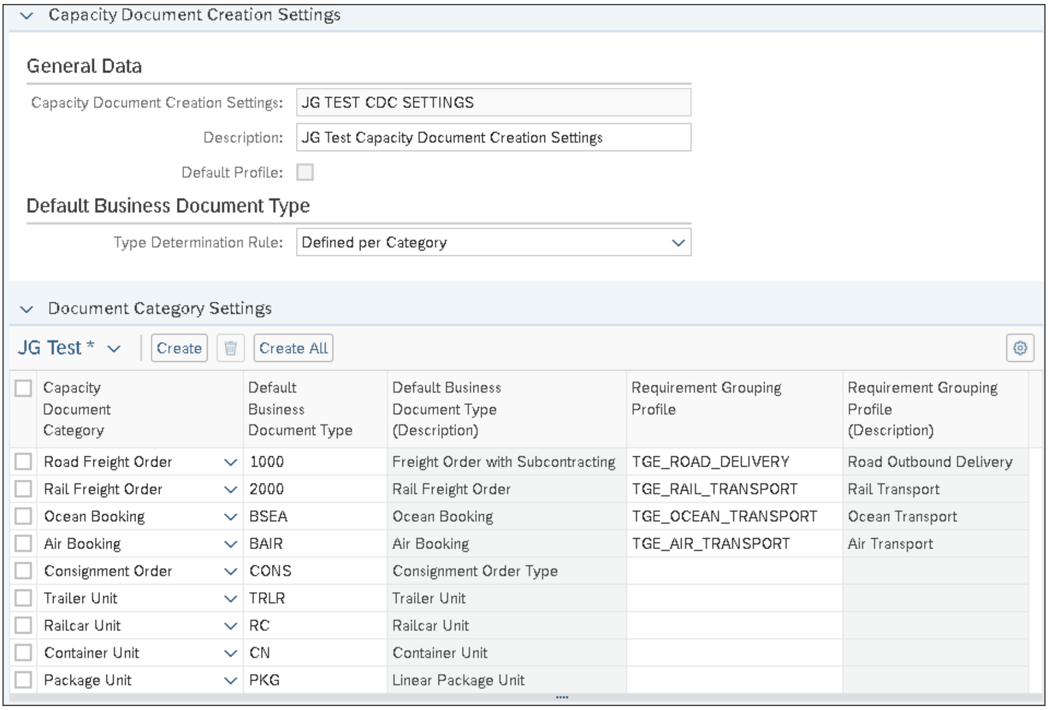


Figure 5.54 Capacity Document Creation Settings

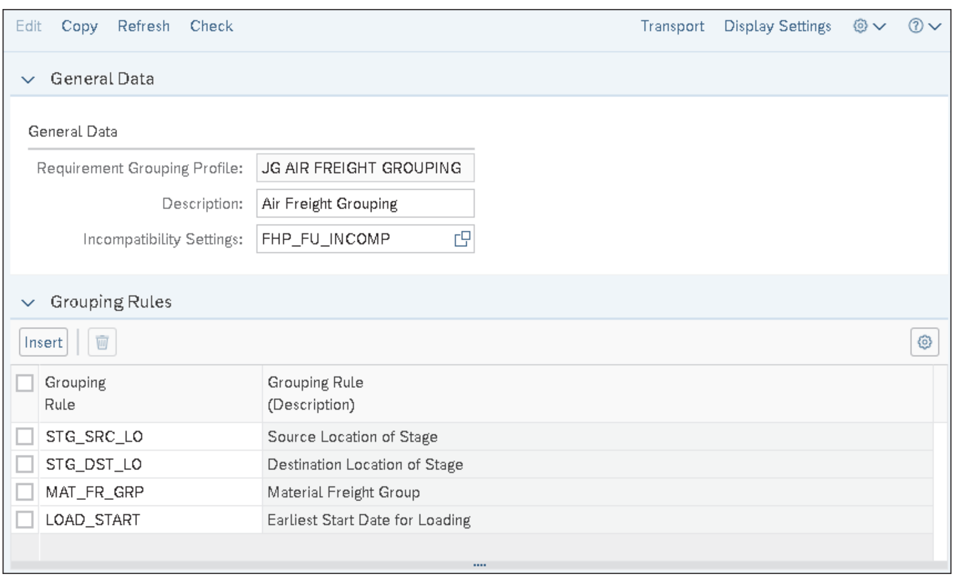


Figure 5.55 Requirement Grouping Profile

For the remaining settings, refer to the sections that describe them in detail: The capacity availability settings are explained in Section 5.8.4. The manual planning settings are discussed in Section 5.7, and the scheduling settings are described in Section 5.8.4. The optimizer settings are presented in Section 5.8.2, except for the transportation proposal parameters, which are explained in Section 5.7.9. The constraints and costs settings are discussed in Section 5.8.3 and Section 5.8.4. The incompatibility settings are covered by Section 5.8.4 as well. Chapter 6, Section 6.5.4 explains the carrier selection settings. The unified package building settings have been presented in Section 5.3.2. The load planning settings are relevant for load consolidation and load planning, which are described in Section 5.8.7 and Section 5.8.8, respectively. The transportation cockpit settings are explained in Section 5.7.1. Choosing the Profiles and Settings Worklist app takes you to a POWL containing queries for all profiles and settings. This provides a good overview and allows you to navigate to the individual profiles and settings as well as create new ones.

Default Profiles and Settings

What is the system behavior regarding all the available parameters if you haven't selected a planning profile or haven't even created one? In this case, the system will use a default planning profile, which contains assigned default settings. If it's not available, the system will create it when needed and save it when the planning result gets saved. All profiles and settings contain one default flag, which is only set for the default instance so that you can easily identify it. If you want to check the default behavior, you can look it up in the default planning profile and its assigned settings. Although SAP may decide to improve the default behavior in a new release by changing a parameter value in the default planning profile and its assigned default settings, this doesn't impact customers who already run TM and upgrade to that release because they have either defined planning profiles and settings themselves, or a default profile and its default settings have already been created in their system instance when planning for the first time. While the settings assigned to the default planning profile can be replaced by other settings, it's not possible to mark another planning profile as default.

Transporting Profiles and Settings

Click the **Transport** button for planning profiles, selection profiles, and settings to trigger a transport (software) for them from one system into another. This avoids you having to maintain the same profiles and settings in development, quality, and production systems and is less error-prone than maintaining the same profiles multiple times—or once per change in each system.

5.7 Manual Planning

Manual planning concerns manually creating or changing the transportation plan. The transportation cockpit is the main UI for displaying the transportation plan and planning manually, but you can trigger automatic planning in it as well. Section 5.7.1 describes the need to configure the transportation cockpit and provides many examples from different transportation planning scenarios. The page layout concept is key to configuring the transportation cockpit and is explained in Section 5.7.2.

Section 5.7.3 introduces hierarchical views and dual views that provide visibility into the substructures of documents and enable efficient comparisons and replanning of capacity documents.

The main visual components used in the transportation cockpit—the map, Gantt chart, and load plan—are presented in the next sections. Section 5.7.4 presents the map that can be used to display and change the plan from the geographical perspective. The Gantt chart provides an intuitive view on the plan from the time and resource availability perspective and is explained in Section 5.7.5. The load plan view described in Section 5.7.6 is key for package building and load planning, as it shows the packaging hierarchy in detail and offers a 3D view on all relevant aspects.

The entry options for the transportation cockpit are discussed in Section 5.7.7. Section 5.7.8 explains how to use the transportation cockpit by describing all its functionalities (e.g., manual planning, automatic planning, navigation through object lists and hierarchies, changing the optical appearance on the fly, etc.).

Section 5.7.9 presents the transportation proposal, which is a semiautomatic planning approach that combines automatic planning with a UI that enables a manual decision about the determined alternative transportation proposals. We describe how to configure and use the UI, as well as special parameters for automatic determination of transportation proposals. Section 5.7.10 describes scheduling, which can be triggered out of the transportation cockpit and systematically determines start and end times for selected freight documents.

5.7.1 Transportation Cockpit

The ultimate goal of planning is to define a transportation plan that matches transportation demands with transportation capacities. The *transportation cockpit* is the central UI for performing any planning operation. However, due to the vast structural variety of planning scenarios in practice, it's impossible to define one UI statically that perfectly fits all scenarios of all transportation businesses in the world. Therefore, it's essential to configure the transportation cockpit, adapting it to the planner's needs so that all relevant information is visible and all irrelevant information is hidden.

The configuration of the transportation cockpit is done by *page layouts* that allow you to adapt the appearance of the transportation cockpit to the planning scenario at hand, and the *transportation cockpit settings* that define its behavior and will be described in Section 5.7.2. A page layout defines the number of screen areas, their positions and sizes, the tabs contained in the screen areas, and all buttons that are visible in the cockpit's toolbar, as well as in the individual tabs per screen area. In addition to flat lists, more advanced concepts, such as hierarchical views and dual views, can also be incorporated, as well as graphical components, such as a geographical map, Gantt chart, and 3D visualization of a load plan. Besides the page layout concept, the column sets for all lists and hierarchies can be personalized; that is, the relevant fields can be selected, ordered, sorted, grouped, filtered, and aggregated according to the planner's needs. Moreover, you can use conditional formatting to highlight certain values.

To illustrate the variety of different planning scenarios and the need for flexible page layout definitions, we describe a few examples, each accompanied by a dedicated page layout. Afterwards, in Section 5.7.2, we describe how to configure a page layout and to maintain the underlying Customizing.

> **Note**
>
> It's important to note that there is an administrative object called page layout that defines the visual page layout of the transportation cockpit in a specific planning session. We don't introduce separate terms to differentiate the administrative and the visual aspect because the meaning becomes clear from the context of the discussion.

Example 1: Local Distribution without Own Fleet

In one local distribution scenario, the company ships goods from a distribution center in Frankfurt to multiple customers. The company doesn't own a truck fleet and therefore only uses external trucks. The transportation planner is very experienced with the geography of the different customers and doesn't need a map. This scenario can be covered by the page layout shown in Figure 5.56.

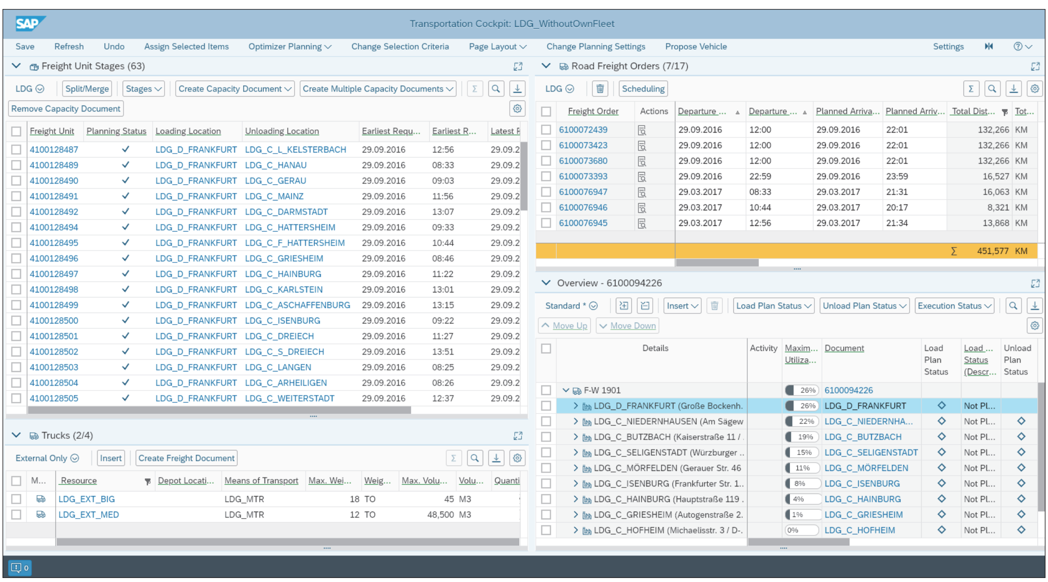


Figure 5.56 Location Distribution without Own Truck Fleet

It contains freight unit stages in the top-left area, available truck (types) in the bottom-left corner, a list of road freight orders in the top-right corner, and overview details in the bottom-left area. In this example, multiresources have been used, but you may also use truck types that could be shown in the trucks area too.

Example 2: Local Distribution of Palletized Goods with Own Fleet

In another local distribution scenario, the company is using its own truck fleet to ship palletized goods from the distribution center in Frankfurt to multiple customers. The planner may use the page layout shown in Figure 5.57. The top-left area contains a Gantt chart with two views, one for the freight units to be planned and one for the trucks and the assigned road freight orders. The bottom-left area displays a list of road freight orders. The top-right corner shows a map that includes the road freight orders and the current positions of the trucks. The bottom-right area shows the load plan for one of the road freight orders. The screenshot shows the results of automated planning using the VSR optimizer and load planning. The freight units have been palletized using package building.

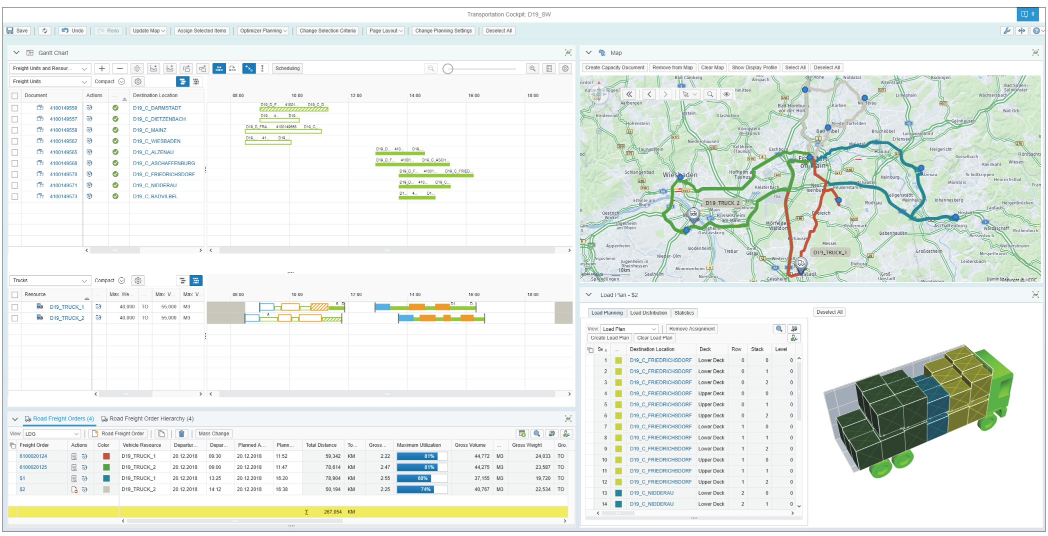


Figure 5.57 Local Distribution of Palletized Goods with Own Truck Fleet

Figure 5.57 contains a lot of information. In a realistic scenario, the planner needs to handle many more freight units, trucks, and freight orders than shown here. We recommend running the transportation cockpit on two or three windows and assigning each window to one physical screen. This provides much more space for decision-making, and it's a great usability improvement because this significantly reduces the demand for scrolling (vertically or horizontally) and tab switching. Figure 5.58 shows one window containing the map to focus on the geographical aspect of the plan, Figure 5.59 shows one window consisting of the Gantt chart to focus on the time-related aspect of the plan, and Figure 5.60 displays a window consisting of a road freight order hierarchy (to show the detailed stop information of multiple freight orders) and the 3D load plan view. This setup with three screens containing these three page layouts provides the planner with a much better overview to work more efficiently.

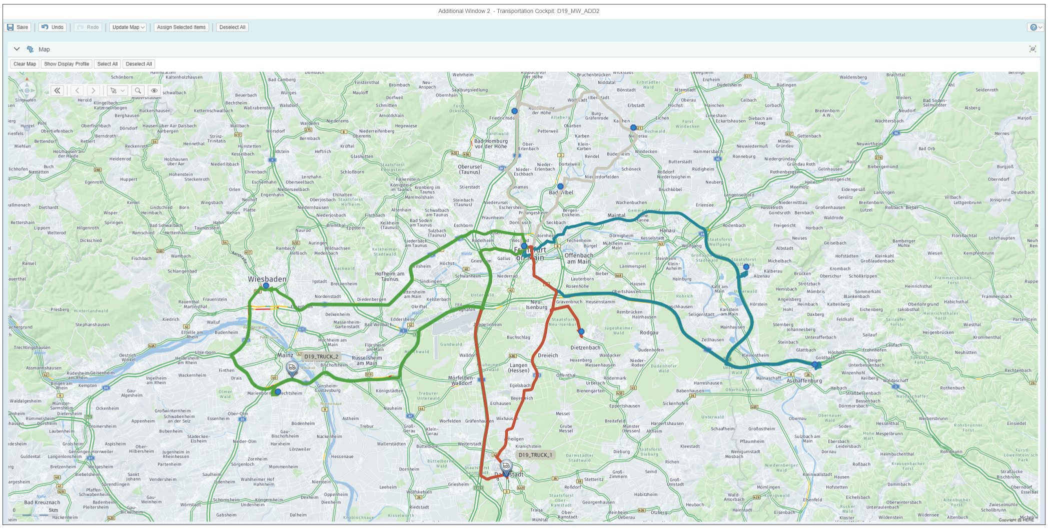


Figure 5.58 Map Window in Planning Session with Three Windows

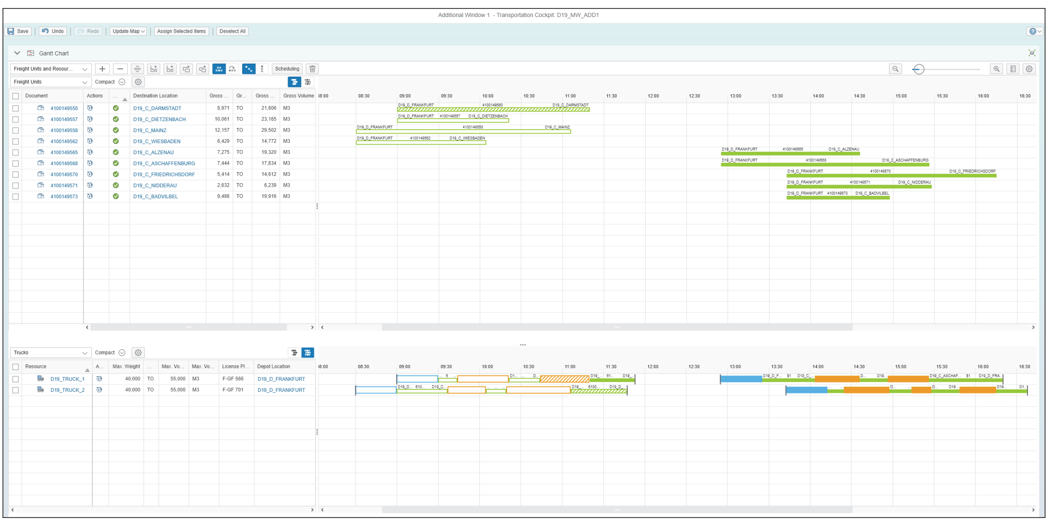


Figure 5.59 Gantt Chart Window in Planning Session with Three Windows

The basic idea of spreading the content of one page layout to three to use three screens for better overview and usability purposes is applicable to all scenarios.

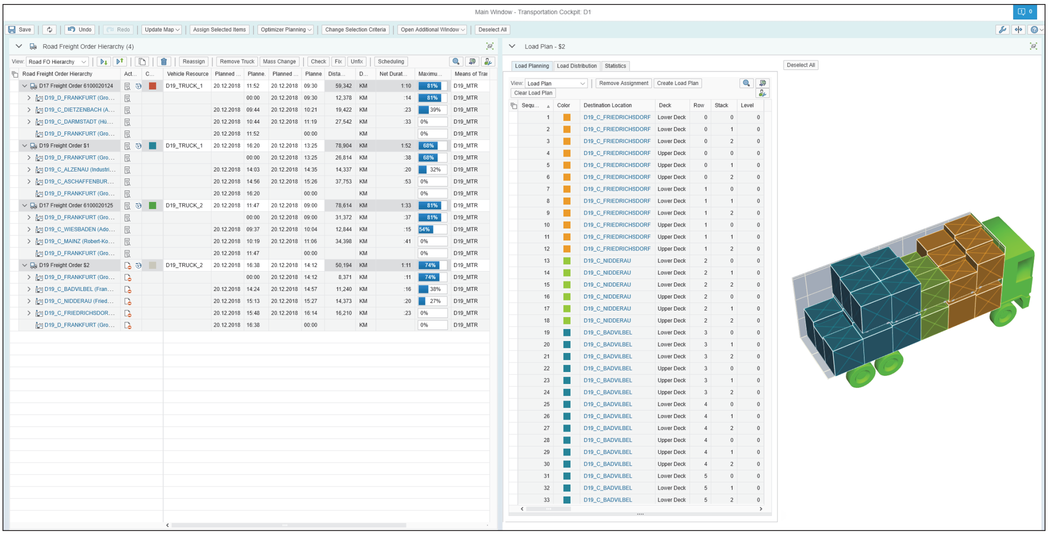


Figure 5.60 Road Freight Order Hierarchy and Load Plan Details in Planning Session with Three Windows

Example 3: Integrated Delivery and Line-Haul Tour Planning without Own Fleet

An integrated delivery and line-haul tour planning scenario as described in Section 5.4.5 can be modeled by two dedicated page layouts.

The delivery planner can use a page layout, as shown in Figure 5.61. It contains freight unit stages and package unit stages in the top-left area. Initially, the planner would only focus on the freight unit stages, but after creating package units, the planner would certainly review the created package unit stages. The bottom-left corner contains the available truck types and additional detailed areas to show the distribution stops of a package unit stage with distribution, and the assignment of a freight unit to multiple package units. The top-right corner lists the created freight orders in a list-based view or in a hierarchical view. Conditional formatting has been used to highlight the progress of the planning process. The bottom-right corner shows the map that initially contains the unplanned freight units and displays a road freight order created by the VSR optimizer. Moreover, the bottom-right area contains the load plan detailed area.

The line-haul planner can use a page layout depicted in Figure 5.62, which includes two views on package units and their stages in the top-left corner. Available truck and trailer types are displayed in the middle-left and bottom-left areas. The top-right area contains a road freight order list and hierarchy, as well as a trailer unit hierarchy. As in the delivery planning page layout, the bottom-right corner shows the map and the load plan.

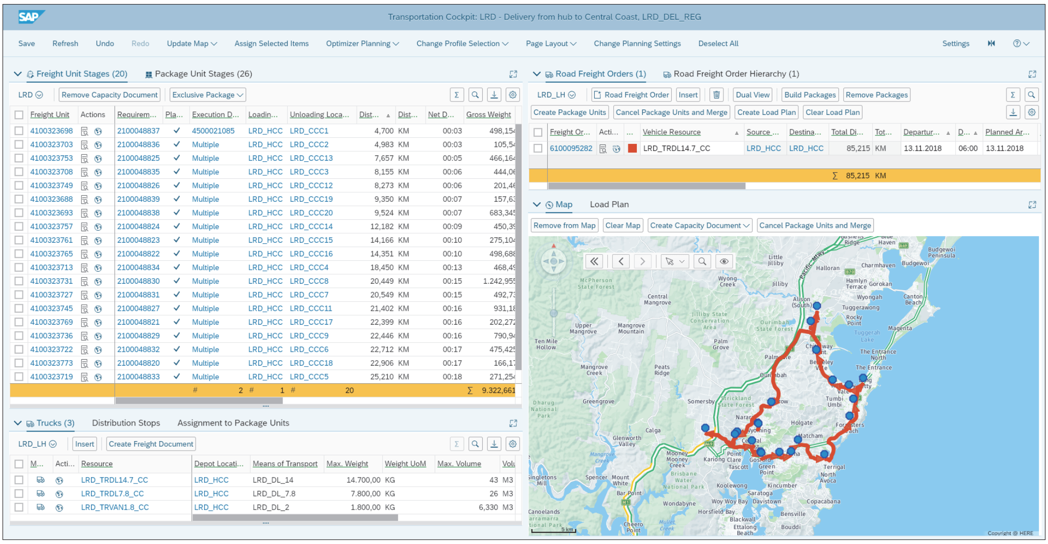


Figure 5.61 Delivery Tour Planning

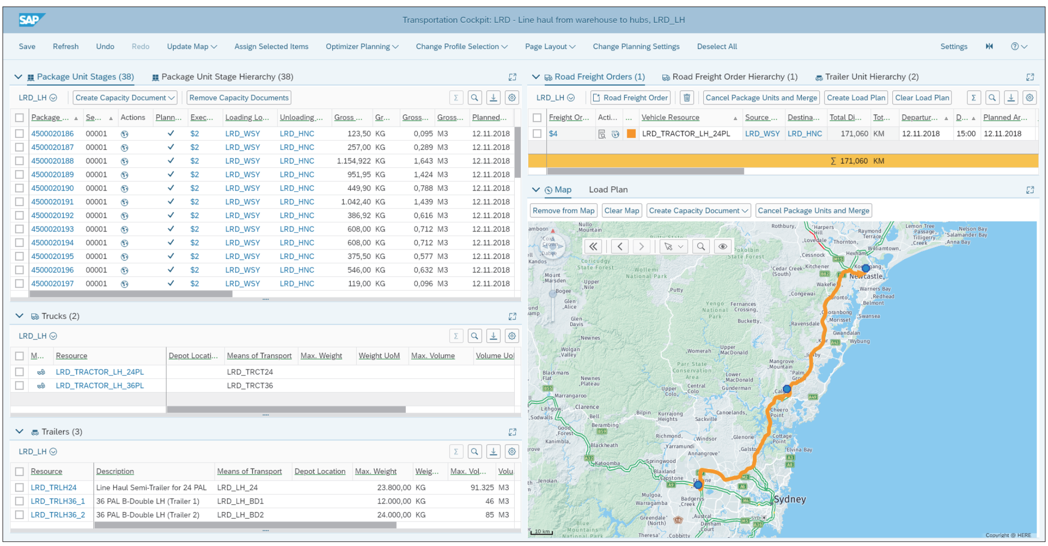


Figure 5.62 Line-Haul Tour Planning

Note

See *http://s-prs.co/v557504* for a video showing this planning process.

Example 4: Load Planning

A company producing metal products (e.g., rods) is using a two-phase planning process. First, the transportation planner consolidates freight units to multiple road freight orders, minimizing total distance and focusing on weight limits of the available truck types, and then the load planner optimizes the load plans of the determined freight orders with automated and manual load planning. While the transportation planner may use the page layout already shown in Figure 5.56, the load planner can use the page layout depicted in Figure 5.63, which includes a list of road freight orders in the top and the detailed load plan view in the bottom. In the shown example, the load planner manually positioned the rods from the freight units assigned to the freight order at hand in the cargo space of the truck and then manually inserted and positioned wooden blocks between the rods for safety reasons.

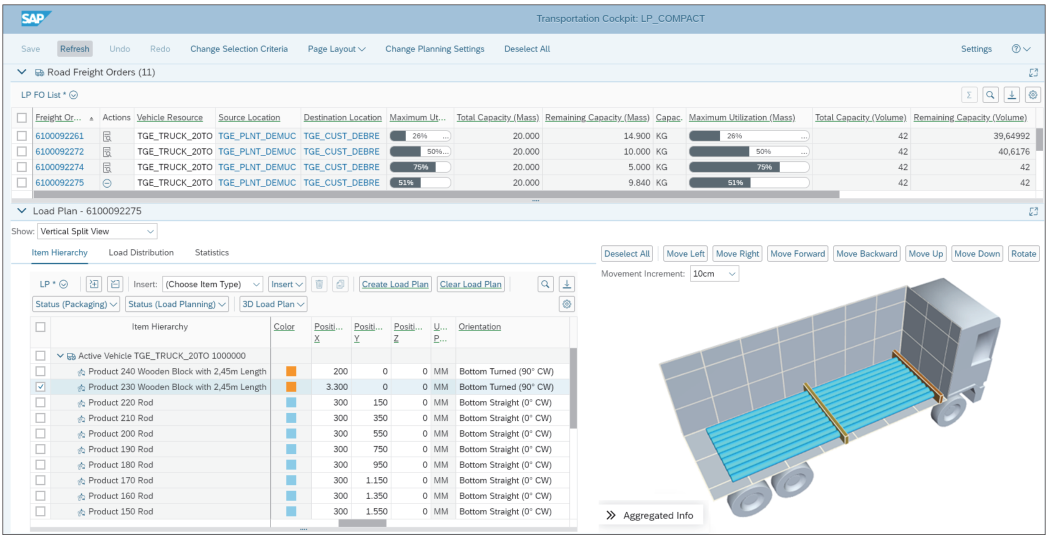


Figure 5.63 Load Planning

Example 5: Road Carrier for Full Truckloads

A road carrier operates a truck fleet and executes full truckloads (FTLs) across the United States. As all freight units fully cover a truck, there are no consolidation decisions to be made. However, the assignments of the freight units to the truck fleet and the sequencing on each truck are crucial to minimize the overall empty mileage of the truck resources. The planner may use a page layout shown in Figure 5.64. It contains a Gantt chart on the left side that includes three views for freight units, truck resources, and road freight orders. The right side shows a map that includes the unplanned freight unit stages as thin arcs, colored by document number to establish the link to the demands in the Gantt chart. Moreover, the map can show the last planned location of each truck resource as pins, and road freight orders are displayed as thick arcs, also colored by document number. This page layout combines the time-related view of the Gantt chart and the geographical view of the map so that the planner can make decisions considering all relevant aspects, for example, the last planned locations of the trucks, their availability times, and the geographical and time aspects of the unplanned freight units.

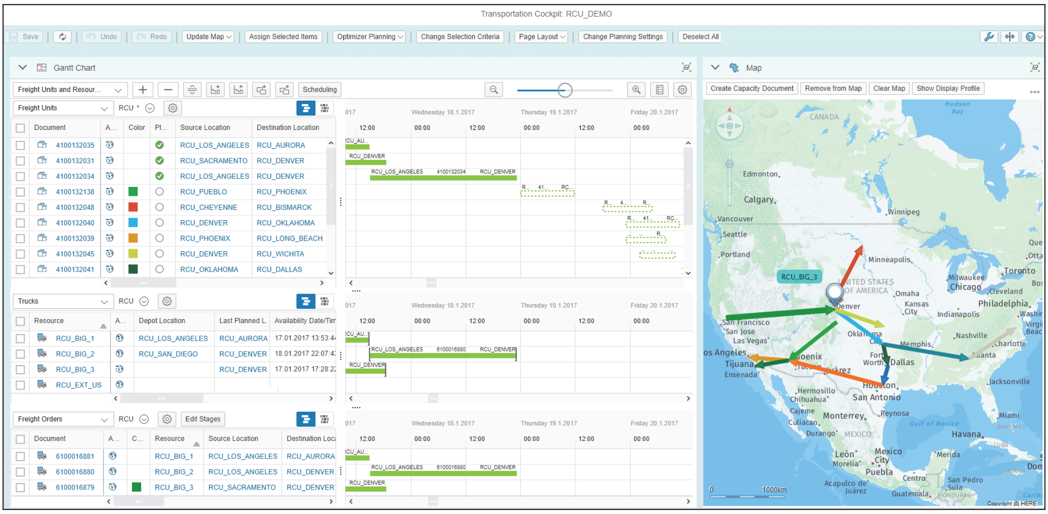


Figure 5.64 Road Carrier Scenario

Example 6: International Container Transportation

In an international container transportation scenario, a company transports palletized goods from a plant in Mannheim (Germany) to a distribution center in Chicago (USA). First, the planner needs to determine the optimal number of 20-foot and 40-foot containers for the transportation orders at hand. Then, the planner needs to determine how to transport the containers through the transportation network.

This planning scenario can be covered by two page layouts that focus on the two main planning steps and are used consecutively. Figure 5.65 shows the first page layout, which contains the freight unit stages to be transported from Mannheim to Chicago (top-left corner), the available container types (bottom-left corner), the determined container units that still contain only one stage each (top-right corner), and the load plan consisting of a tabular and 3D view (bottom-right corner). The planner used load consolidation to assign unplanned freight unit stages into the optimal number of container units. The freight units are planned, and the transportation demands are now represented by container units, which get planned in the second step.

Figure 5.66 shows the second page layout, which contains container units and their stages in the top-left corner, schedules and trucks in the bottom-left corner, freight documents in the top-right corner, and the map and overview details in the bottom-right corner. Figure 5.66 shows the result of the VSR optimizer, which determined the two ports, consolidated the main legs of all the container units into one ocean freight booking, and assigned the pre-leg and subsequent leg of the container units into corresponding road freight orders.

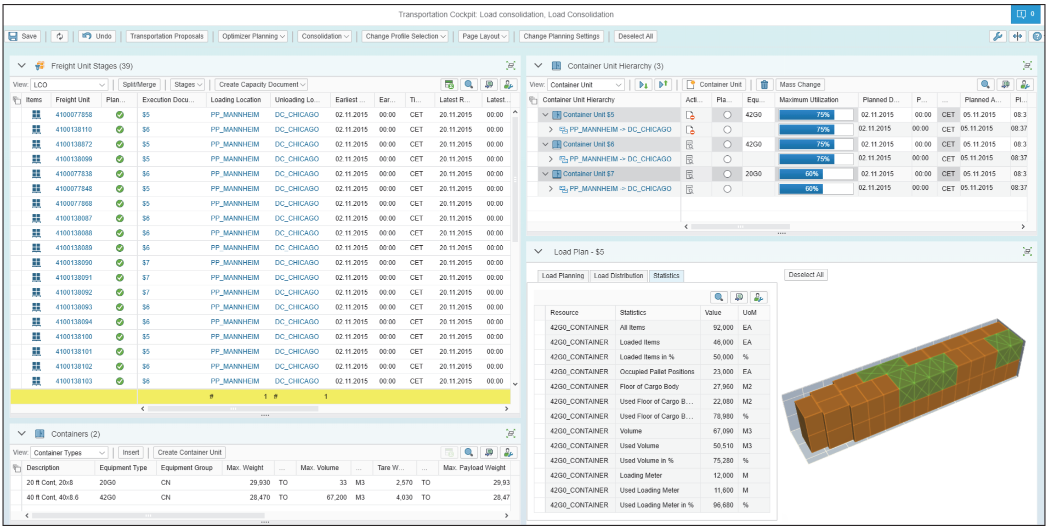


Figure 5.65 International Container Scenario with Load Plan for One Container

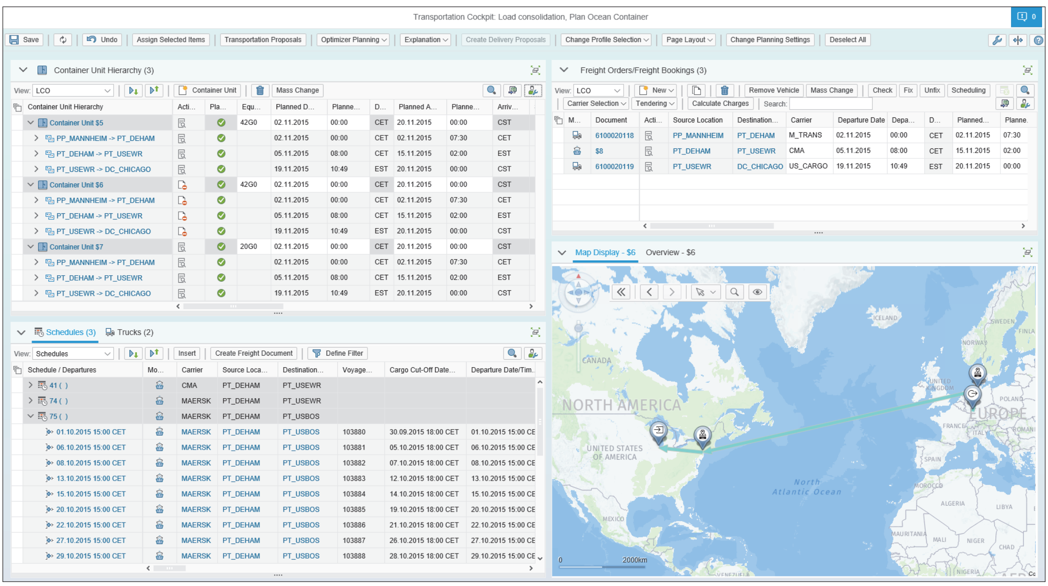


Figure 5.66 International Container Scenario with Planned Container Unit Stages

Note

See *https://video.sap.com/media/t/1_kyczbo10* for a video showing this planning process.

Example 7: Manage Inbound Freight from Suppliers

A manufacturer wants to review the expected freight by its suppliers. The demands are represented by freight units, grouped into consignment orders, which are assigned to freight orders. While the assignment of these objects normally gets communicated electronically, it may be required to do the assignments manually. Therefore, the user could use a page layout with lists for freight unit stages, consignment orders, and road freight orders, as shown in Figure 5.67. Additionally, the consignment order hierarchy and the freight order hierarchy can be used as detailed views to see the assigned freight unit stages.

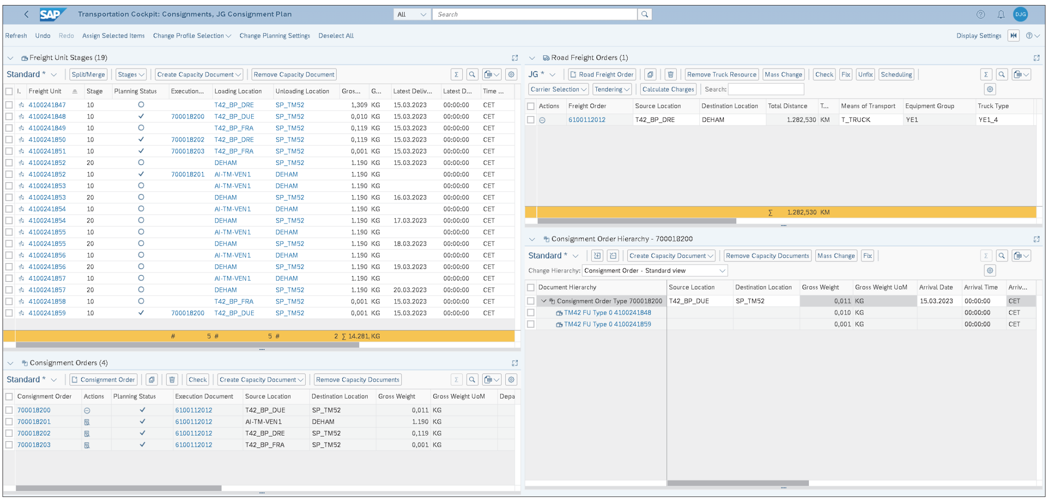


Figure 5.67 Manage Inbound Freight from Suppliers

Example 8: Freight Forwarding

In a global forwarding company, the ocean freight planner needs freight units, ocean freight bookings, and schedules. Similarly, the air freight planner needs freight units, air freight bookings, and maybe schedules. The planners responsible for the pre-legs and subsequent legs require freight units, road freight orders, and schedules or vehicle types. Therefore, within the same company, different planners need very different set-ups.

5.7.2 Page Layouts

The transportation cockpit offers a rich set of building blocks, each tailored to a certain transportation business domain. The planner can compose a preferred page layout by choosing the building blocks relevant for the planning scenario and defining their positions and sizes on the screen. Note that certain planners may require multiple page layouts, each dedicated to certain planning phases or decision types, as explained in the previous section for the integrated delivery and line-haul planning and the international container transportation example.

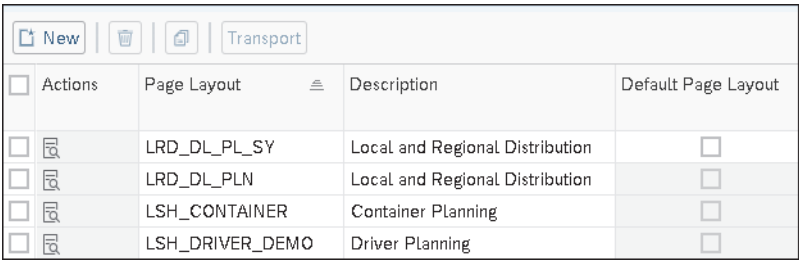
The system already provides a set of more than 20 page layouts tailored to different scenarios and modes of transport whose names all start with "SAP". We recommend you check these first. Ideally, one of them will perfectly meet your needs. Otherwise, you may copy one of them and then adjust it according to your scenario, or you can create a new page layout from scratch.

Defining Page Layouts

Page layouts are tailored to one of the following applications:

- **Transportation cockpit**
  This is the central planning UI, as just mentioned. Because it offers the biggest range of configuration possibilities, the rest of this section focuses on the transportation cockpit. Configuration for the next three applications is much more straightforward and is therefore mentioned only briefly, without discussion of details.
- **Carrier selection**
  This layout focuses on freight documents and their details, which is sufficient for carrier selection purposes. From this perspective, these page layouts are special cases of page layouts for the transportation cockpit. Refer to Chapter 6, Section 6.5, for more details on carrier selection.
- **Delivery creation**
  This layout is required for order integration scenarios in which delivery proposals are created in TM for the freight units resembling sales orders or purchase orders, for example. The layout consists only of freight units and delivery proposals. The delivery proposals are used to create deliveries. See Chapter 4, Section 4.1.3, for more details on delivery proposals.
- **Transportation proposal**
  This is a semiautomatic planning approach in which layouts consist of transportation proposals and may also include screen areas for preferences and a map. Transportation proposals are described in Section 5.7.9.

To define a page layout for the desired context, choose the Page Layouts for Transportation Cockpit, Page Layouts for Carrier Selection, Page Layouts for Delivery Creation, or Page Layouts for Transportation Proposal apps, respectively. Next, you reach a page layout worklist, as shown in Figure 5.68. Here, you can create a new page layout, copy and delete a page layout, or transport the layout to another system. It's also possible to declare one page layout as the default, which will be used by the system in case the transportation cockpit is started without defining a page layout. Using personalization, you can show additional columns indicating when the layout got created and changed, and by whom, and other general fields from the page layout.



New | | | Transport

	Actions	Page Layout	Description	Default Page Layout
☐		LRD_DL_PL_SY	Local and Regional Distribution	☐
☐		LRD_DL_PLN	Local and Regional Distribution	☐
☐		LSH_CONTAINER	Container Planning	☐
☐		LSH_DRIVER_DEMO	Driver Planning	☐

Figure 5.68 Page Layout Worklist

You can maintain a page layout by clicking on the icon in the **Actions** column. Figure 5.69 shows the following generic sections of the page layout, which allow you to define the included properties:

- **General Data**
  You can define the name of the page layout and choose a page layout for the transportation proposal, which is used if you determine transportation proposals out of the transportation cockpit (see Section 5.7.9). You also can activate command-line planning, which is explained in Section 5.7.8, and hide quick views, which show additional information for a document or master data object when you hover over the corresponding field in a list or hierarchy.
- **Users**
  The **Users** section allows you to explicitly assign specific users or roles to the page layout at hand or to declare it available for all users.
- **Page Layout Switch**
  You can allow the user to switch to any other page layout or explicitly list the page layouts to which the user is allowed to switch. This is particularly useful if the system contains many alternative page layouts, but the user would only need a few or none of them to switch to.
- **Additional Windows**
  The **Additional Windows** section allows you to assign one or two additional windows. For each additional window, you can specify its page layout and whether it will be opened by default. The main concept behind planning on multiple windows is a master window to which you can assign one or two additional windows. When planning in such a setup, you can close additional windows and reopen them, but closing the master window terminates the planning session. In the example depicted previously in Figure 5.58, Figure 5.59, and Figure 5.60, the (master) page layout is shown in Figure 5.60, and it's assigned to two additional windows containing the map and the Gantt chart, respectively.
- **Pushbuttons for Application Toolbar**
  You can select buttons in the **Pushbuttons for Application Toolbar** section to make them available in the global toolbar of the transportation cockpit. Section 5.7.8 describes the available functionalities.

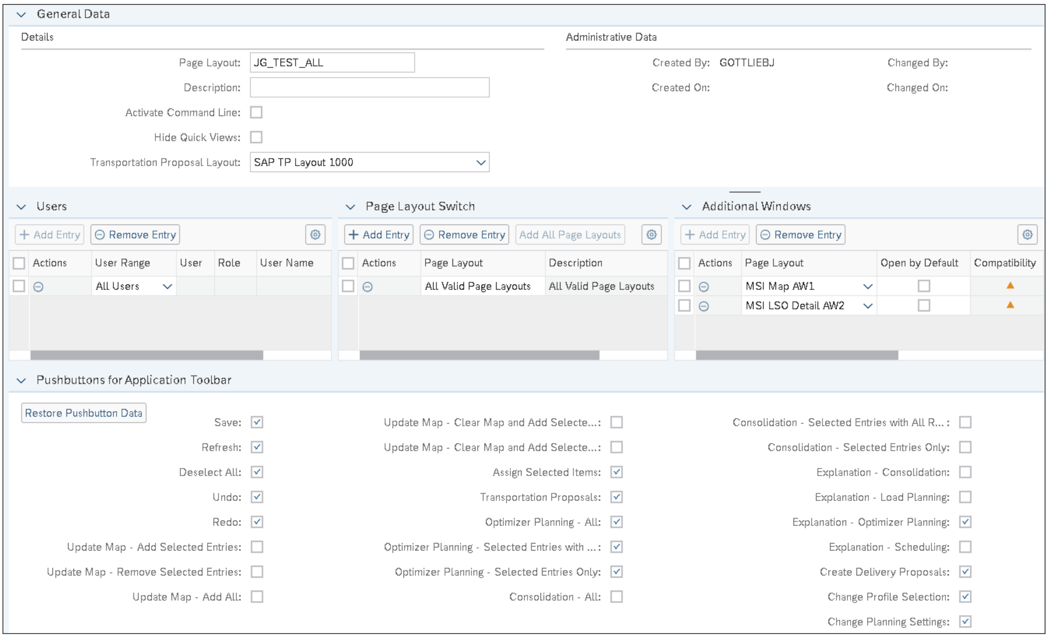


Figure 5.69 Defining General Data, Users, Switches, Additional Windows, and Buttons for Global Toolbar in a Page Layout

Figure 5.70 shows the configuration of the content areas, which are placed in the page layout maintenance as they will appear in the transportation cockpit.

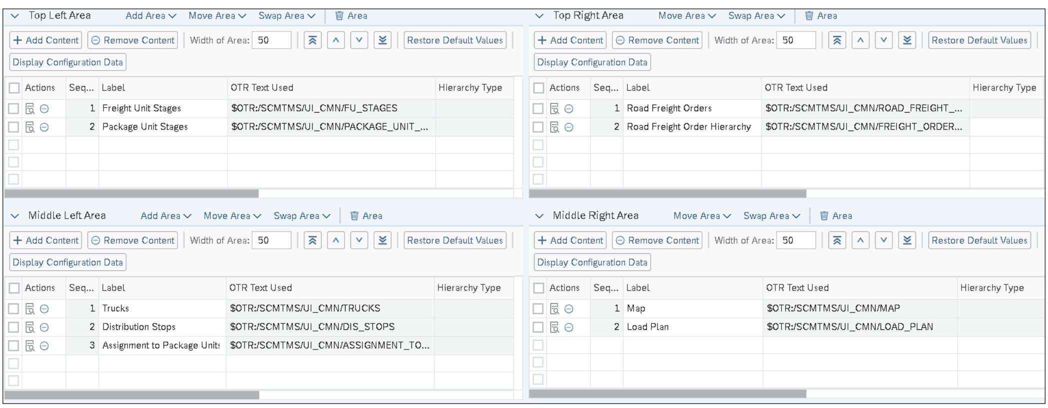


Figure 5.70 Defining Content Areas in a Page Layout

In the depicted example, which results in the page layout shown earlier in Figure 5.61, there are four content areas:

- The top-left area contains freight unit stages and package unit stages.
- The bottom-left area contains trucks and the detailed areas for distribution stops and assignment to package units.

- The top-right area contains the road freight order list and the road freight order hierarchy.
- The bottom-right area consists of the map and the load plan.

You can maintain the content areas as follows:

- Add new content areas until you've reached a virtual grid with two columns and three rows.
- Delete a content area.
- Move complete areas to a new position in the virtual grid or swap the positions of two content areas.
- Adjust the relative width of two content areas beside each other. If you maintain the left area as 60, the right one will automatically be adjusted to 40 so that the total is 100.

Within each content area, you can add and remove content and change the relative ordering of the content in the area. This ordering defines the sequence of the tabs shown in the transportation cockpit.

For each content area, you can define which icon is used in the tab's headline. You can click on the details icon in the **Action** column and select the buttons to appear in the local toolbar and define additional parameters, as shown in Figure 5.71.

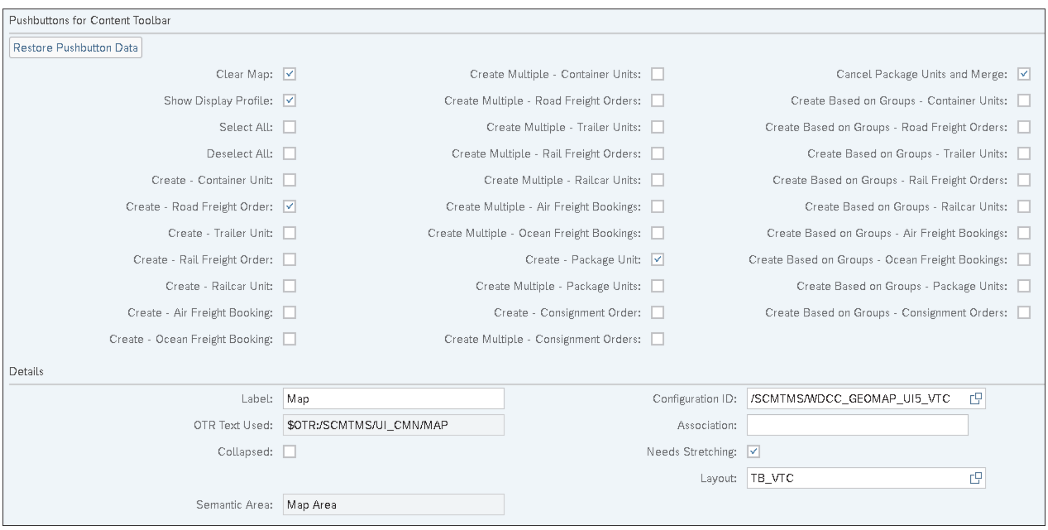


Figure 5.71 Defining Buttons and Additional Parameters for the Map Content Area in the Page Layout

For example, you can define that the content will be collapsed initially and specify the configuration and the association to retrieve data. For the graphical components, such as the map, Gantt chart, and load plan, you can stretch them and specify their layout, which will be described in Section 5.7.4, Section 5.7.5, and Section 5.7.6, respectively. Because the load plan can contain multiple components, you can choose one view each to personalize the columns and the hierarchy type, as shown in Figure 5.72. You can define dual views and the hierarchy type for hierarchies, which are both explained in Section 5.7.3. The dual view can only be defined if the corresponding button has been activated.

Embedded Configurations of Load Plan

Configuration ID	View	Hierarchy Type
/SCMTMS/WDCC_LSO_LOAD_DISTRIB	Standard View	
/SCMTMS/WDCC_LSO_LOAD_STATS	Standard View	
/SCMTMS/WDCC_TOR_LSO	uv	YELSO

Figure 5.72 Defining Views and Hierarchy Type for Embedded Configurations of the Load Plan

You can place every available content object in any content area. While many content objects can display many objects at the same time, the detailed content objects focus on detailed information for one object at hand. It's possible to put multiple lists, hierarchies, and detailed views into the same content area. When adding content, the system issues a popup to choose the content object (see Figure 5.73) among a list of more than 90 options, including more than 50 detailed views. The list is grouped by nine semantic areas, making it easy to find the desired content.

JG View

	Icon	Label	Detailed View	Configuration ID	Description	Association
Capacities Area (8) (Semantic Area)						
...		Containers		/SCMTMS/WDCC_PLN_RES_CONTAINER	Transportation Cockpit: Container R...	RESOURCE_CONTAINER
...		Drivers		/SCMTMS/WDCC_PLN_DRIVERS	Transportation Cockpit: List of Drivers	DRV
...		Equipment Types		/SCMTMS/WDCC_PLN_EQUI_TYPE	Transportation Cockpit: List of Equip...	RESOURCE_EQUI_ROAD_RAIL_CONT
...		Locomotives		/SCMTMS/WDCC_PLN_RES_LOCO	Transportation Cockpit: List of Loco...	RESOURCE_ACTIVE_RAIL
...		Railcars		/SCMTMS/WDCC_PLN_RES_RCAR	Transportation Cockpit: List of Railcars	RESOURCE_PASSIVE_RAIL
...		Schedules		/SCMTMS/WDCC_PLN_FO_SCHEDULES	Transportation Cockpit: Schedules	SCHEDULE
...		Trailers		/SCMTMS/WDCC_PLN_RES_TRAILER	Transportation Cockpit: List of Trailers	RESOURCE_PASSIVE_ROAD
...		Trucks		/SCMTMS/WDCC_PLN_RES_TRUCK	Transportation Cockpit: List of Trucks	RESOURCE_ACTIVE_ROAD
Consignment Order Area (2) (Semantic Area)						
Gantt Chart Area (1) (Semantic Area)						
Map Area (1) (Semantic Area)						
Order Details Area (40) (Semantic Area)						
Orders Area (9) (Semantic Area)						
...		Air Booking Hierarchy		/SCMTMS/WDCC_PLN_AIR_TREE	TC: Air Freight Booking Hierarchy (T...	TORACTFBA
...		Air Freight Bookings		/SCMTMS/WDCC_PLN_FBA	Transportation Cockpit: Air Freight B...	TORACTFBA
...		Freight Orders/Freight Bookings		/SCMTMS/WDCC_PLN_FOBO	Transportation Cockpit: Freight Orde...	TORACT
...		Ocean Booking Hierarchy		/SCMTMS/WDCC_PLN_OCEAN_TREE	TC: Ocean Freight Booking Hierarch...	TORACTFBO
...		Ocean Freight Bookings		/SCMTMS/WDCC_PLN_FBO	Transportation Cockpit: Ocean Freig...	TORACTFBO
...		Rail Freight Order Hierarchy		/SCMTMS/WDCC_PLN_LOCOMOTIVE_TREE	TC: Rail Freight Order Hierarchy (T...	TORACTFO_RAIL
...		Rail Freight Orders		/SCMTMS/WDCC_PLN_FO_RAIL	Transportation Cockpit: Rail Freight ...	TORACTFO_RAIL
...		Road Freight Order Hierarchy		/SCMTMS/WDCC_PLN_TRUCK_TREE	TC: Road Freight Order Hierarchy (...	TORACTFO
...		Road Freight Orders		/SCMTMS/WDCC_PLN_FO	Transportation Cockpit: Freight Orde...	TORACTFO
Requirement Details Area (12) (Semantic Area)						
Requirements Area (7) (Semantic Area)						
Transportation Units Area (13) (Semantic Area)						

Figure 5.73 Adding Content for One Area in the Page Layout

Several content objects can even be placed in two content areas. For example, in a combined inbound and outbound planning scenario, you may want to have two freight unit stage lists, one for inbound and one for outbound. You can model these by using the freight unit list twice in the page layout and by defining appropriate filters to ensure that each of the two lists only contains inbound and outbound freight unit stages, respectively.

The semantic areas contain the following content:

- The **Capacities Area** offers lists for trucks, trailers, locomotives, railcars, containers, equipment types, drivers, and schedules. The truck list contains truck resources and types, and the same holds true for the trailer, locomotive, railcar, and container list. The equipment type list contains truck types, trailer types, locomotive types, railcar types and container types. The schedule hierarchy contains the available departures per schedule.
- The **Consignment Order Area** offers a list and hierarchy for consignment orders. The list can be used to consolidate demands into consignment orders and consignment orders into freight documents. The hierarchy is useful to show the structure of the consignment order, for example, the set of its assigned demands.
- The **Gantt Chart Area** contains only one entry for the corresponding visual component. The Gantt chart can display all documents and resources, enables manual planning, and is highly configurable, as explained in Section 5.7.5.
- Analogously, the **Map Area** only contains one entry for the respective visual component. The map can display all documents and resources at the same time. It offers interactive planning and rich configuration capabilities, as described in Section 5.7.4.
- The **Orders Area** contains freight document lists and hierarchies for road freight orders, rail freight orders, ocean freight bookings, and air freight bookings, which can be used to consolidate demands. One list includes freight orders and freight bookings, which is useful for intermodal scenarios. The hierarchies are useful to replan stops in freight orders or to reassign demand documents between freight documents, as described in Section 5.7.3.
- The **Requirements Area** contains lists and hierarchies for requirement document stages. Freight unit stage lists and freight unit hierarchies represent pure demand documents, which need to be assigned to capacity documents. Different configurations are offered for freight unit stages, each with a focus on one of the four modes of transport, road, rail, ocean and air. The combined list for freight unit stages and package unit stages and the corresponding hierarchy are useful for scenarios in which freight unit stages and package unit stages serve as demands at the same time.
- The **Transportation Units Area** offers transportation unit lists, transportation unit stage lists, and transportation unit hierarchies for package units, container units, trailer units, and railcar units, which can be used for multiple purposes. While the stage lists primarily focus on the demand aspect, similar to a freight unit stage, the document list can be used for consolidation purposes. As previously mentioned, hierarchies are useful for replanning and reassigning purposes.

The **Order Details Area** contains detailed views that can be updated for the order at hand by the corresponding button in the **Actions** column of any list, of any hierarchy, or of the Gantt chart. The following detailed views are offered:

- The single document hierarchies **Road Freight Order Hierarchy**, **Rail Freight Order Hierarchy**, **Ocean Freight Booking Hierarchy**, **Air Freight Booking Hierarchy**, **Consignment Order Hierarchy**, **Trailer Unit Hierarchy**, **Railcar Unit Hierarchy**, **Container Unit Hierarchy**, and **Package Unit Hierarchy** provide detailed information and enable replanning by drag and drop, both within the document at hand and from here to another document in a cockpit list or hierarchy.
- The **Allocation** and **Carrier Ranking** views provide additional information on the affected allocation and the carrier ranking of the freight document at hand.
- Four **Cargo Management** views provide cargo details for a road freight order, rail freight order, ocean freight booking, and air freight booking, respectively.
- The **Charges** view offers details on the calculated charges of the freight document at hand.
- The **Driver Assignment** view provides details on the driver assignment for the road freight order at hand.
- The **Equipment** view provides detailed equipment information for the road freight order, rail freight order, ocean freight booking and air freight booking at hand, respectively.
- The **Execution Information** view provides details on planned and actual events for the freight document at hand.
- The **Load Plan** views show the load plan for a road freight order, trailer unit, container unit, or package unit at hand. Refer to Section 5.7.6 for more details.
- The **Map Display** view displays the capacity document at hand on a geographical map. See Section 5.7.4 for more details on configuring the visual appearance.
- The **Overview** presents the quick overview for the document at hand, including its stop sequence and the assigned demand documents per stop. It includes an overview on utilization and certain status values.
- The **Predecessor Documents** view shows freight documents that must be executed before the capacity document at hand because they are assigned to a predecessor stage of a demand document stage assigned to the freight document at hand. Similarly, the **Successor Documents** view lists freight documents that must be executed after the capacity document at hand.
- Four **Stages** views represent the stages for the road freight order, rail freight order, ocean freight booking, and air freight booking at hand, respectively. Each view provides the stop sequence with detailed address, distance, and execution information, as well as planned and actual arrival and departure date and time, which can be edited.
- The **Status Management** view provides details on the various status values of the capacity document at hand.
- The **Utilization** and **Utilization Overview** views display a graphical and hierarchical view for the capacity document at hand, as shown in Figure 5.74 and Figure 5.75,

respectively. The hierarchical view is very helpful for analyzing the capacity calculation, in particular when multiple object levels are involved, such as in the depicted example with a tractor carrying two trailers.

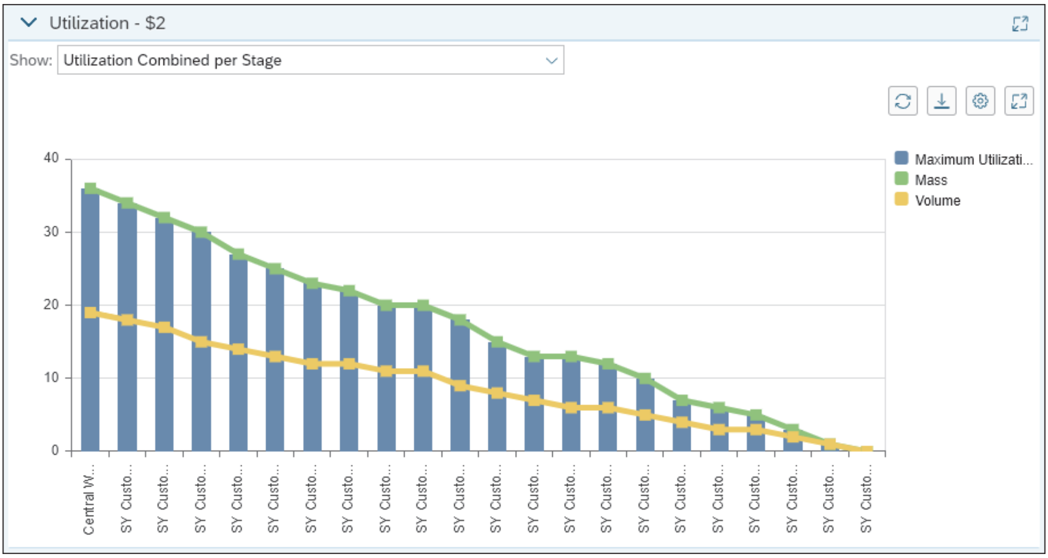
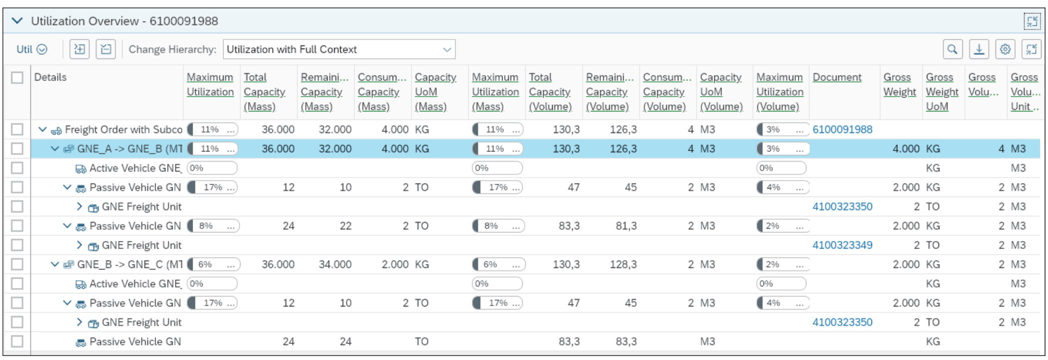


Figure 5.74 Utilization Graph



Utilization Overview - 6100091988

Util | Change Hierarchy: Utilization with Full Context

Details	Maximum Utilization	Total Capacity (Mass)	Remaini... Capacity (Mass)	Consum... Capacity (Mass)	Capacity UoM (Mass)	Maximum Utilization (Mass)	Total Capacity (Volume)	Remaini... Capacity (Volume)	Consum... Capacity (Volume)	Capacity UoM (Volume)	Maximum Utilization (Volume)	Document	Gross Weight	Gross Weight UoM	Gross Volu...	Gross Volu... Unit ...
Freight Order with Subco	11% ...	36.000	32.000	4.000	KG	11% ...	130,3	126,3	4	M3	3% ...	6100091988				
GNE_A -> GNE_B (MT	11% ...	36.000	32.000	4.000	KG	11% ...	130,3	126,3	4	M3	3% ...		4.000	KG	4	M3
Active Vehicle GNE_	0%					0%					0%			KG		M3
Passive Vehicle GN	17% ...	12	10	2	TO	17% ...	47	45	2	M3	4% ...		2.000	KG	2	M3
GNE Freight Unit												4100323350	2	TO	2	M3
Passive Vehicle GN	8% ...	24	22	2	TO	8% ...	83,3	81,3	2	M3	2% ...		2.000	KG	2	M3
GNE Freight Unit												4100323349	2	TO	2	M3
GNE_B -> GNE_C (MT	6% ...	36.000	34.000	2.000	KG	6% ...	130,3	128,3	2	M3	2% ...		2.000	KG	2	M3
Active Vehicle GNE_	0%					0%					0%			KG		M3
Passive Vehicle GN	17% ...	12	10	2	TO	17% ...	47	45	2	M3	4% ...		2.000	KG	2	M3
GNE Freight Unit												4100323350	2	TO	2	M3
Passive Vehicle GN		24	24		TO		83,3	83,3		M3				KG		

Figure 5.75 Utilization Overview

The **Requirement Details Area** offers the following detailed views for requirement documents:

- The **Assignment to Package Units** view helps to identify how a freight unit's quantities are distributed to package units, which is relevant for the multi-assignment case described in Section 5.4.5.
- The **Cargo per Stage** view shows the assigned requirement documents for a capacity document at hand.

- The **Distribution Stops** view displays the stops of a package unit stage with distribution, as introduced in Section 5.4.5.
- The **Freight Unit Stage Hierarchy** and **Package Unit Stage Hierarchy** provide hierarchical information on a freight unit at hand, which may, for example, include its items or original demand document, such as a forwarding order.
- The **Load Plan per Stage** view is offered for a trailer unit stage, container unit stage, or package unit stage, and provides the same information as the **Load Plan** view. Because load planning only supports the document level, the document level gets shown even if it's triggered for a stage of a requirement document. Note that only one load plan can be shown in detail in the transportation cockpit, thus it's not possible to show the load plan of a road freight order and a requirement document stage beside each other.

The number of rows used by the **Maximize** button (Section 5.7.8) can be specified for any list and hierarchy. If you've created a personalized view for the tab, which defines the number of rows, column set, ordering, and so on, you can set it as the initial view for the tab. Otherwise, the standard view is used. By clicking the **Display Configuration Data** button, you can show the association used and change the UI configuration to use your own configuration.

Defining Settings for Page Layouts

The content offered to be chosen in a page layout can itself be configured in Customizing by following path **Transportation Management • Planning • General Settings • Define Settings for Page Layouts**. Buttons and content objects represent the main building blocks, and you can configure which of these are offered in a page layout for the four applications mentioned previously (transportation cockpit, carrier selection, delivery creation, and transportation proposal).

You can define the following properties of buttons:

- The **Row Action** parameter defines whether the button is available as a row action or in the toolbar. For example, you can enable the row action for pushing objects to the map or removing them from the map. This is useful because it saves one click when pushing an object to the map. Without row action, the user must select the row first and then use a button in the toolbar, which results in two clicks.
- **Event** defines the action triggered by the button.
- You can also define **Button Text**, **Tooltip**, **Icon**, and **Hotkey**. These enable keyboard shortcuts to trigger the button.

Content objects allow configuring the following properties:

- You can define content object's **Title** and **Description**.
- The parameters **Detail Area Display** and **Req. Details Area Display** define whether the content object at hand represents a detailed area for a capacity document or a requirement document.

- The **Multiple Display** parameter specifies that the object can be used twice within the same page layout.
- You can assign multiple Web Dynpro configurations to the content object and assign local toolbar buttons to each configuration. For each button, you can define whether it's available for the page layout, whether it's initially selected in a new page layout, and its **Button Text** and **Tooltip**. Moreover, the ordering of the buttons in the local toolbar can be specified.
- For each configuration, you can define it as **Available** for the page layout definition and choose an **Icon** for its headline. Moreover, you can define whether the content object needs stretching. For example, for a Gantt chart or map, this is useful to utilize the available vertical space in the transportation cockpit. If two objects above each other use stretching, both will consume the same vertical size.

These configuration capabilities are very powerful because they even allow you to configure what can be configured in a page layout. This enables including your own objects developed in a customer project into the standard page layout maintenance and streamlining page layout maintenance by not offering objects or buttons that aren't relevant at all for your business. However, if you change the preceding configuration, this may have an impact on already-defined page layouts that were based on the previous configuration. Therefore, we recommend synchronizing the page layout with the underlying Customizing after you change the Customizing. You can do so by choosing the Synchronize Page Layouts with Customizing app. This tool allows you to choose a layout context and check all existing page layouts regarding new buttons, changed buttons, deleted buttons, deleted content objects, changed content objects, and deleted configurations. You can run the tool in simulation mode to report the affected page layouts or to clean up the page layouts immediately.

5.7.3 Hierarchical View and Dual View

Whereas in many planning scenarios, the information shown in flat lists for requirement documents and capacity documents is sufficient, several planning scenarios require visibility of the substructures of the business objects to make the right planning decisions. For example, if you want to assign an unplanned freight unit stage to one of the existing freight orders, you need to know the stop sequences of the freight orders to choose the best fit. Another example is improving the ratio of volume and weight for your air freight bookings, for which it's necessary to see the reassignment potentials of the freight units already assigned to the air freight bookings.

In this section, we'll dive into two views that achieve this effect: the hierarchical view and the dual view.

Hierarchical View

Hierarchical views can be used for all demand and capacity documents. The substructure of a hierarchical view is defined by a hierarchy type, which can be configured a priori.

Hierarchical views allow planners to dynamically drill down into the substructures of the relevant objects in their transportation cockpit sessions. Figure 5.76 shows an example of a road freight order hierarchy with three hierarchy levels: freight order, location, and freight unit. You can expand all nodes or selected nodes in the hierarchy and collapse them afterward. Using the **Change Hierarchy** dropdown menu in the toolbar, you switch between alternative hierarchical views for the same document type, for example, between a stop-based and a stage-based hierarchy.

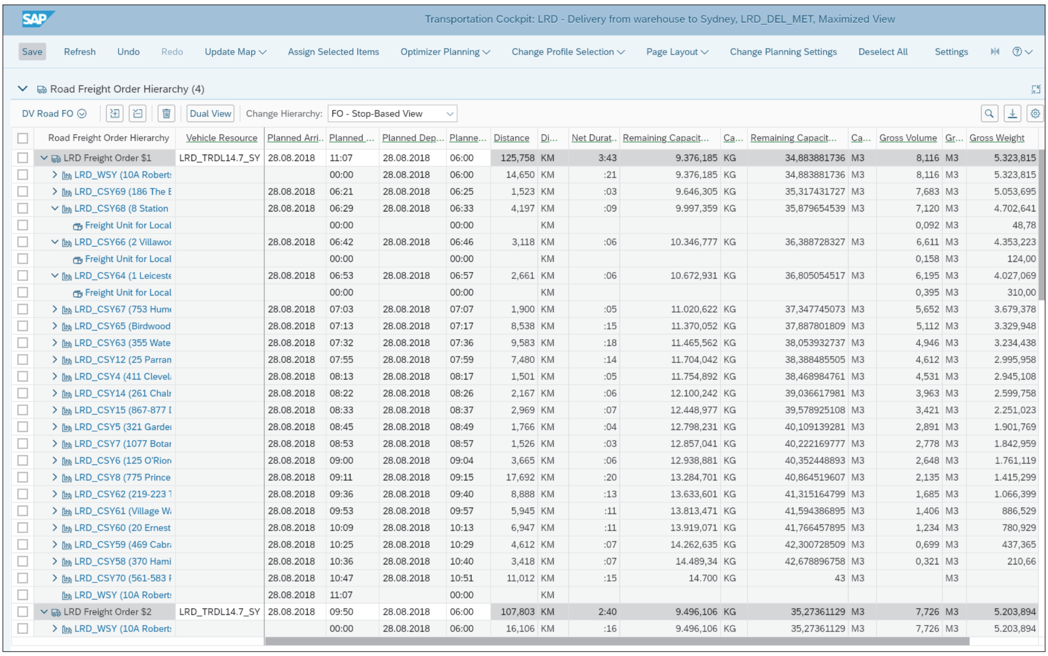


Figure 5.76 Freight Order Hierarchical View

To define a hierarchical view, select the Customizing menu path **Transportation Management • Planning • General Settings • Define Hierarchical Views for Business Documents**. You can edit an existing hierarchy type or create a new one. First, you choose its **Consumer** from the following alternatives (see Figure 5.77):

- The consumers **Transportation Cockpit: Requirement Document Stages**, **Transportation Cockpit: Transportation Units**, **Transportation Cockpit: Consignment Orders**, and **Transportation Cockpit: Freight Orders/Freight Bookings** represent the document hierarchies that can be used in the transportation cockpit. These hierarchies offer filtering that preserves parents of the filtered hierarchy level. You can use the **Filter Type** to activate the filtering by the **Show Results with Reduced Context** option, or to define that all sublevels of the parents are shown by the **Show Results with Full Context** option. Using the **Related Documents** parameter and its **Use Standard Behavior** option, the system shows assigned capacity documents and all requirement documents created by freight unit building. Using the **Show Only Directly Assigned Docu-**

ments option, you can focus the hierarchy on the direct assigned documents. Suppose a freight order with two package units, of which the first contains three freight units and the second was created by freight unit building, the system would omit the freight units and only display the freight order with its two package units. The standard behavior would display all assigned objects, including the freight units.

- **Freight Document: Overview**, **Freight Document: Utilization**, **Freight Document: Load Plan**, **Freight Document: Cargo**, and **Freight Document: Equipment** are used in the corresponding tabs of the single-document UI and also as a detailed view in the transportation cockpit. The **Display Layers** parameter enables showing a dedicated layer level in the load plan hierarchy, which is useful when reviewing results from detailed package building considering the layer definition from the master data (Section 5.3.3). The **Editability** parameter defines how to handle editable fields in the hierarchy. You can forbid editability, use the standard behavior based on the editability property per field, or offer an edit button to activate editable fields. As editable fields have an impact on the performance of the hierarchy and editing may not always be required, we recommend using the last option for the load plan hierarchy.
- **Freight Document: Simplified Item View**, **Freight Document: Advanced Shipping and Receiving**, and **House Bill of Lading** represent the corresponding tabs of the single-document UI.

The consumer ensures that only reasonable hierarchy levels can be defined. Then you choose the **TrM Category** (mode of transport category), which also restricts the possible entries for the hierarchy levels.

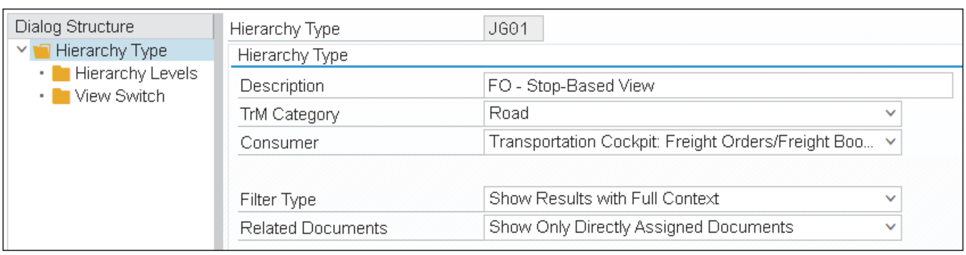


Figure 5.77 Hierarchy Type Header

The next step is to define the hierarchy levels, as shown in Figure 5.78. You choose among the available levels via the **Show Level** column. For each selected hierarchy level, you define whether the hierarchy is initially expanded. The example shows a freight order hierarchy with the freight order on the first level (which is expanded by default), locations on the second level, and assigned requirement documents on the third level. The system automatically arranges the selected levels in the semantically correct ordering.

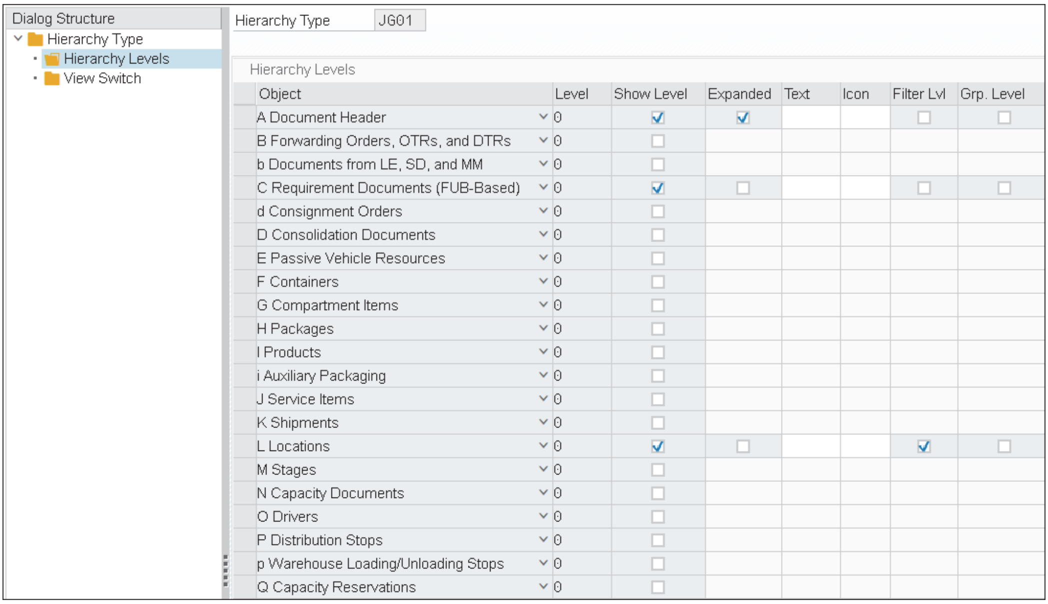


Figure 5.78 Hierarchy Levels

It's also possible to define the text and icon displayed in the hierarchical view. By activating the filtering option by the **Filter Lvl** field, you can suppress displaying locations at which no loading, unloading, coupling, or uncoupling takes place. For example, if a freight order delivers 50 freight units from one source to 10 different locations, you may want to see for each stop only those freight units that are loaded or unloaded at that stop, as shown earlier in Figure 5.76. Alternatively, you can configure the hierarchy so that all freight units still on the truck are displayed for each stop. Thus, the freight units going to the last destination would be shown at all previous stops.

The **Show Topmost Item** parameter (not shown in Figure 5.78) can be used to reduce the hierarchy levels of a nested packaging hierarchy of a document. Consider a packaging hierarchy with pallets that include big cartons containing small cartons. You can use the parameter to focus on the top-level package items; that is, all cartons below the pallets aren't shown. Using the **Show Only the Topmost Items in the Complete Hierarchy** and **Show Only the Topmost Items for Each Document** options, the reduction is applied for the complete hierarchy and the business document at hand, respectively. Alternatively, you can use the **Show All Items** option.

With the grouping functionality, you can aggregate multiple objects into your own hierarchy level based on a grouping rule, which can be based on a standard grouping attribute, grouping class (implemented by you), or data access definition. For example, if you want to group freight unit stages by their destination location, you can choose the stage object type, activate **Grouping Level**, define grouping rule **Standard Grouping Attribute**, and choose attribute **Destination Location**.

Note that it's even possible to define multiple grouping levels, which is useful if you want to structure your freight units according to source location and destination location. You can define that by adding a second entry for the stage object type, choosing the attribute **Source Location**, and assigning it a higher level. If you have hundreds of freight units to be planned manually, this kind of grouping structures the freight units according to your needs, enabling you to get a quick overview of the different freight unit groups by collapsing all hierarchy levels except for the groups.

You can introduce grouping levels in lower hierarchy levels also (e.g., to structure the freight units assigned to a stop of a freight order by product). Note that you can drag and drop freight unit groups to a freight order, which allows many similar freight units to be handled by one manual planning operation, without worrying about the individual freight units in the group.

The **Empty Grps** parameter (not shown in Figure 5.78) defines whether groups without any children are shown. You can use the **Sorting** parameter to specify the sorting behavior for the hierarchy level at hand. By default, sorting is allowed for all hierarchy levels except for locations and stages because these represent the stop sequence of a capacity document at hand and are protected against sorting. For each hierarchy level, you can specify whether it will be sorted or not sorted, or the default will be used.

If you want to switch dynamically between alternative hierarchical views, you can define multiple hierarchy types and list the alternatives in the **View Switch** list of one hierarchy type. In the example shown in Figure 5.79, you can switch from the hierarchy type **JG01** to the alternative hierarchy type **JG02**, which enables dynamic switching between a stop-based and a stage-based hierarchy type.

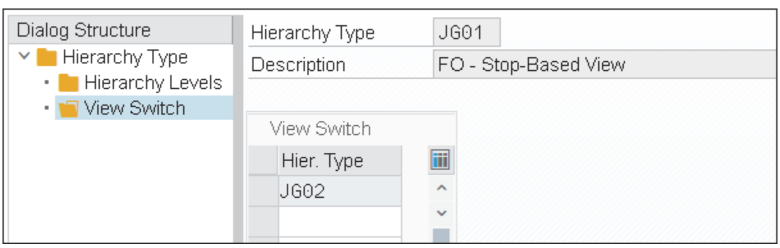


Figure 5.79 Hierarchy Type View Switch

Performance of Hierarchical Views

A hierarchical view contains much more information than a flat list and therefore may be slower than a flat list with the same set of objects. Consider a road freight order hierarchy with locations and freight units on the second and third hierarchy level, respectively. Imagine a scenario with 100 road freight orders, each having, on average, five stops and each stop containing five freight units in the hierarchy. The fully expanded hierarchical view then contains 2,500 rows, instead of 100 rows in the flat road freight order list.

The greater level of detail doesn't come for free, as each row and column has an impact on the response time. Therefore, if you're defining a hierarchical view, avoid defining too many hierarchy levels, and include only hierarchy levels that are very important for your business. We recommend that you do rough estimations of the average number of nodes per hierarchy level first to get an estimate of the expected number of rows for your hierarchical view if all nodes are expanded. If this number is much too big—for example, if it contains 10,000 rows—check whether you can cut your scenario into pieces by appropriate selection profiles or omit hierarchy levels in your definition.

We recommend displaying only items with action at the current location because displaying all items would yield even more rows in the hierarchical view. The grouping functionality helps aggregate the objects, but it also creates more rows, so keep this in mind when introducing one or multiple grouping levels. Displaying product items and package items may cause large amounts of rows too. Therefore, when displaying package items, we recommend considering only the topmost items.

Although it's nice to see the full substructure of an object, usually not all columns in the hierarchical view can be meaningfully filled for all rows. While the source and destination location, as well as certain times, can be meaningfully defined for the freight order level and stage level, several fields (e.g., carrier or vehicle resource) are only meaningful on the freight order level. Therefore, we recommend checking whether all intended columns are needed and focusing on the most important pieces of information. In a nutshell, be aware of the number of columns and rows created by your hierarchy type and chosen columns, and use the smallest possible hierarchy that meets your needs.

Dual View

If you've already created a plan, either manually or automatically, you may want to check it in detail for local improvements, such as reassigning a freight unit from one freight booking to another or moving a whole freight order stop with all its freight units to another freight order. Hierarchical views allow you to browse through the freight documents and their substructures. However, when you've found one freight order that you want to optimize manually by adding or removing freight units, you need to search for another freight order to perform the reassignment. Usually, you want to keep the first freight order and its substructure visible while identifying the second freight order. Because both freight orders are in the same hierarchical view, scrolling within one hierarchy may hide your first freight order. The *dual view* overcomes this issue by offering two hierarchies at the same time, which allows scrolling and searching within one hierarchical view while keeping the other hierarchical view constantly visible. The two views show the same information, but from a different angle, so if you change something in one hierarchy, you immediately see the effect in both hierarchies.

Depending on your scenario, you may want to see as many rows as possible or as many columns as possible. The dual view allows you to switch between the vertical view and the horizontal view, as shown in Figure 5.80 and Figure 5.81.

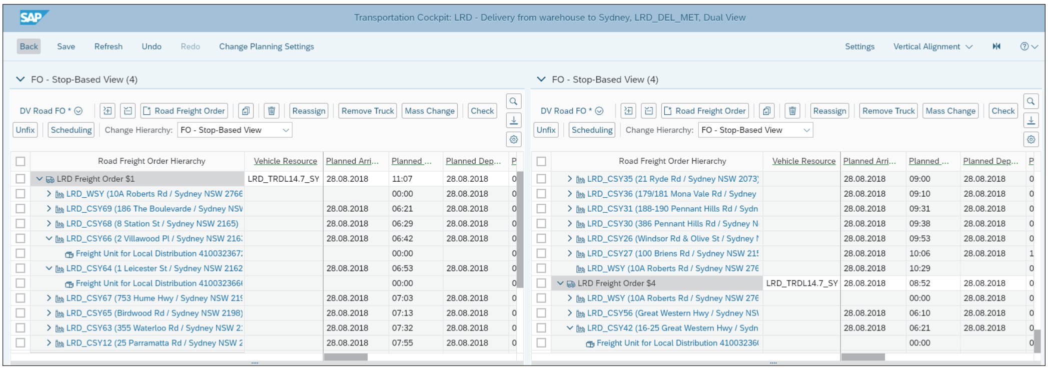


Figure 5.80 Vertical Dual View for Road Freight Orders

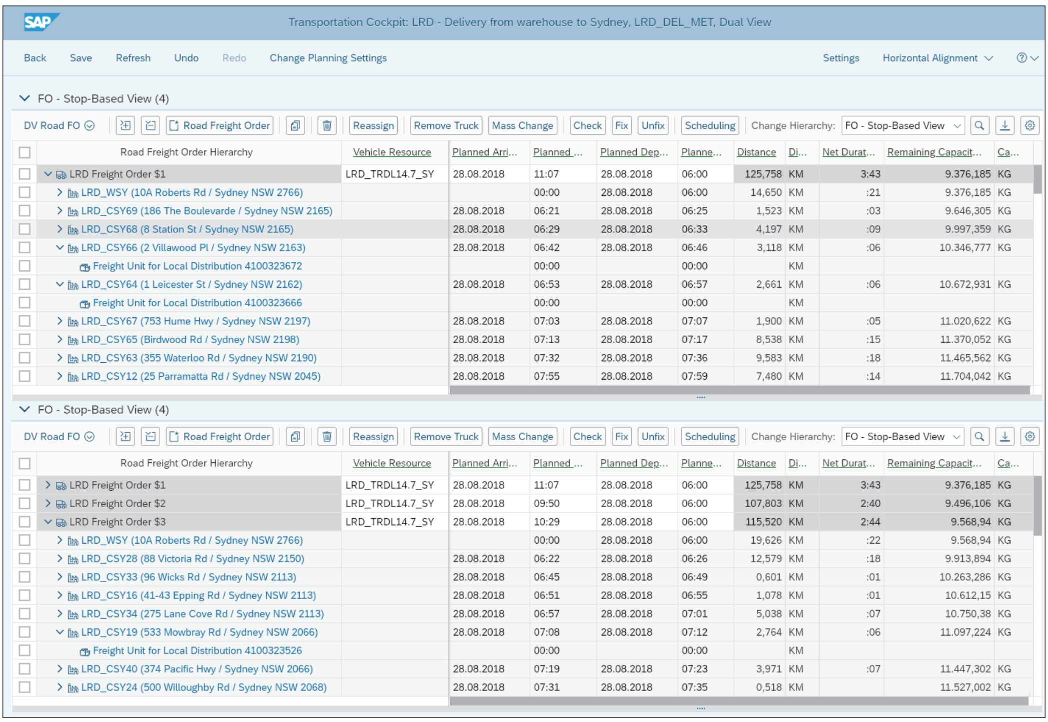


Figure 5.81 Horizontal Dual View for Road Freight Orders

Within the transportation cockpit, the dual view is triggered by the **Dual View** button from a list or hierarchy of capacity documents. If some of the documents in the list or hierarchy are selected, the dual view will only contain the selected documents. Thus, if you want to replan just 3 out of 50 freight documents, you can select the 3 relevant documents and focus on these in the dual view. If no documents are selected in the list or hierarchy, the dual view will contain all documents.

The **Dual View** button can be activated in the page layout definition for the list or hierarchy at hand. Figure 5.82 shows the definition of a dual view for a road freight order hierarchy. In the **Dual View** area below the **Details** area, you can specify the initial alignment of the dual view (either vertical or horizontal) and the hierarchy types for the two hierarchical views in the dual view. If you define only one hierarchical view, it's used for the second hierarchical view too. If your layout is user specific, you can also define the view for the column sets. It's also possible to define the number of rows; the initial value **0** uses the full space available for the page layout.

As the dual view is composed of two hierarchies, our discussed recommendations regarding the size of hierarchies are very relevant for dual views too. The dual view shows only two hierarchical views and can't be combined on one screen with other screen areas, such as resources or freight units. However, you can define a layout with two hierarchical views and other screen areas. If you want to enable an easy switch between the horizontal and vertical views, as is built into the dual view, you can define two layouts: one resembling the horizontal variant and one for the vertical variant.

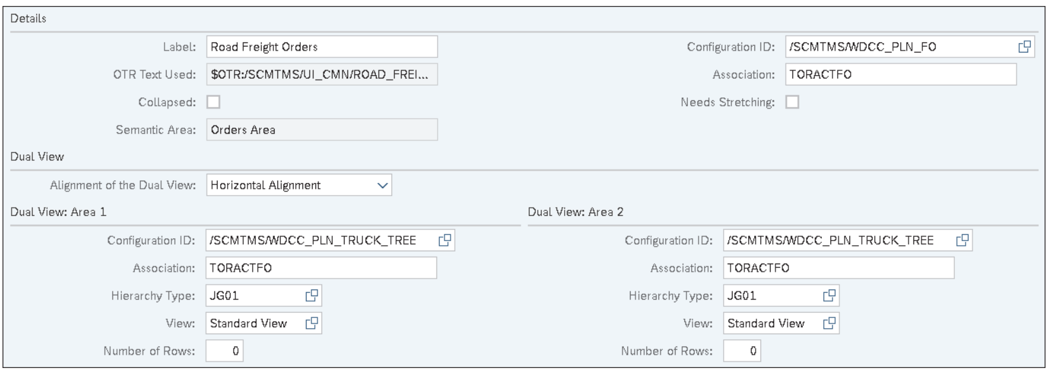


Figure 5.82 Defining a Dual View for Road Freight Order Hierarchy

5.7.4 Map

The map allows the planner to focus on the geographical aspect of the planning scenario, which is particularly important for consolidation decisions and searching demands or capacities nearby. Instead of working with names of objects in lists or hierarchies, the planner can see the objects directly on a geographical map. This enables the planner to judge distances between locations much more intuitively than in a text-based list and therefore supports the planner in making good decisions from a geographical perspective.

Similar to the transportation cockpit in general, the map provides rich configuration capabilities, so that it can be adapted perfectly to the transportation planning scenario at hand. First, we'll motivate the need for configuration on two planning scenarios, and then we'll describe how to work with and configure the map.

Local Distribution Scenario

In a local distribution scenario, for example, the planner needs to see the distribution center and the customers on the map. Figure 5.83 displays a map in which the distribution center is visualized as a square, and the customers are shown as triangles. If customers have the same address, which may be the case if multiple customers are located in the same business complex, they are displayed as a big triangle.

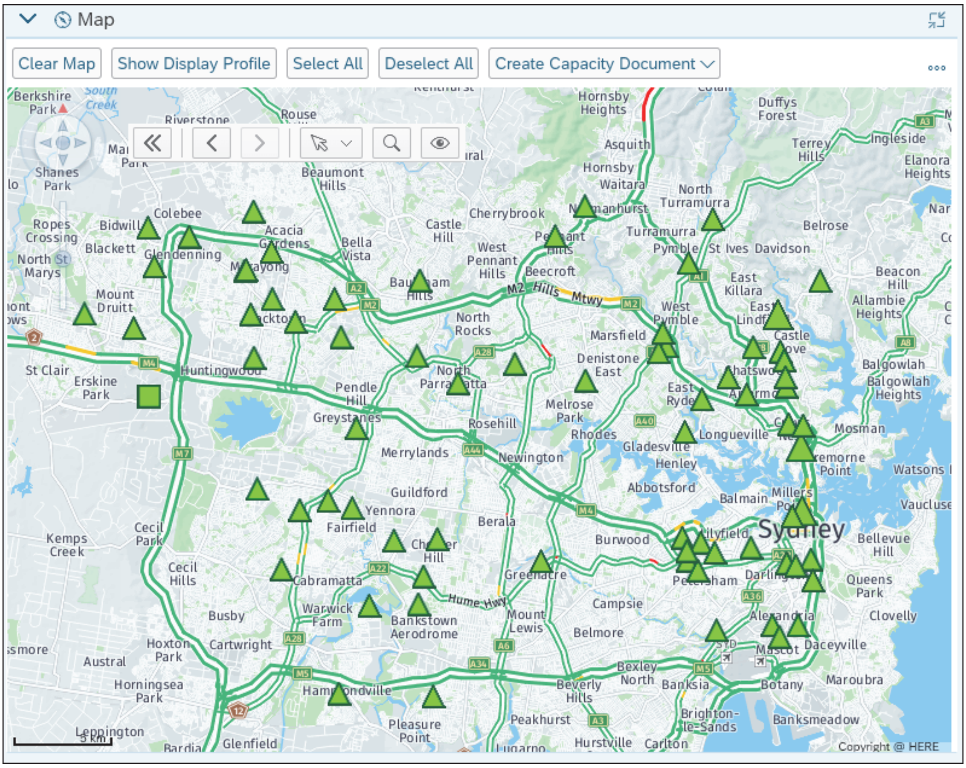


Figure 5.83 Unplanned Freight Unit Stages Displayed on a Map

Using the toolbar in the map scene, you can use a lasso to select certain freight unit stages on the map, as depicted in Figure 5.84. The selected freight unit stages are displayed in a different color than the unselected freight unit stages, as shown in Figure 5.85.

Now, the planner can use automated or manual planning to create a road freight order for the selected freight unit stages. The resulting freight order is immediately displayed on the map as well, as shown in Figure 5.86. The stops of a freight order are displayed as circles to differentiate them from unplanned demands.

This visual representation is very intuitive as all demands have the same source, which the planner can easily identify by its special shape on the map. The demands are mainly differentiated visually by the geographical position of the destination locations.

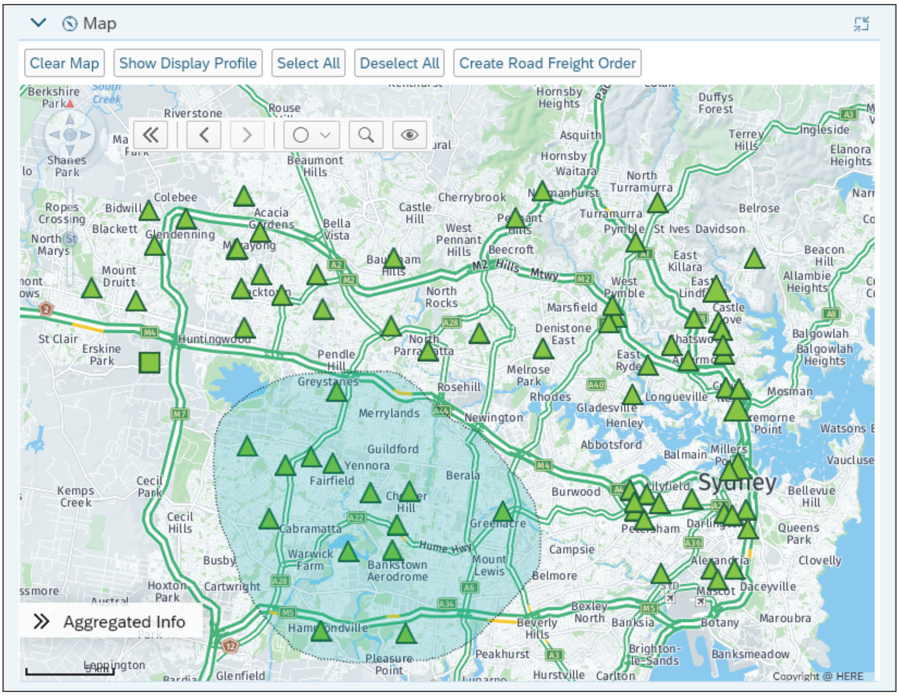


Figure 5.84 Lasso Selection of Unplanned Freight Unit Stages

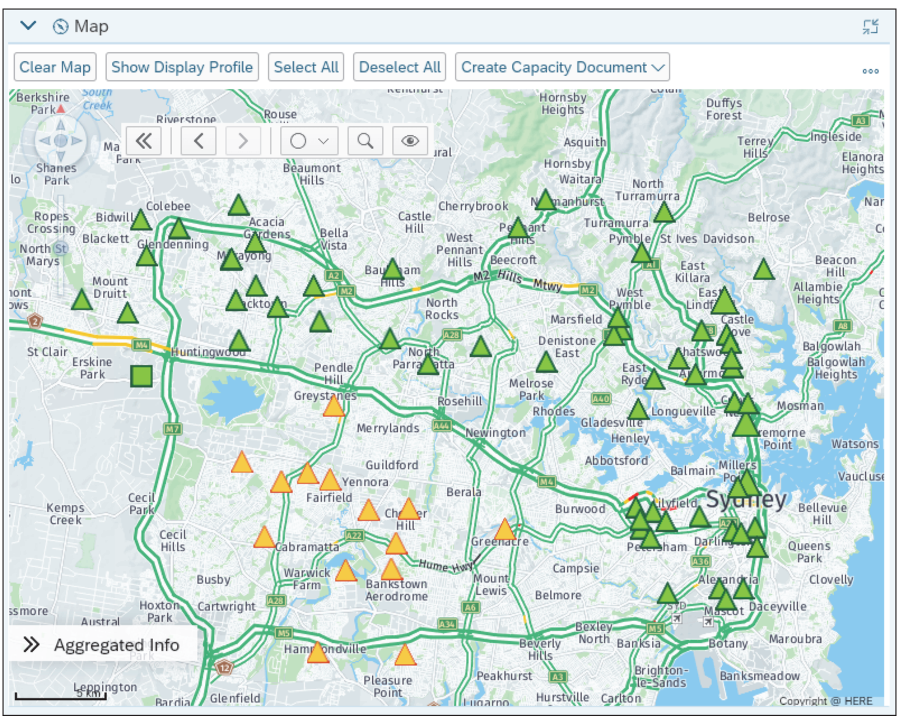


Figure 5.85 Selected Freight Unit Stages on a Map

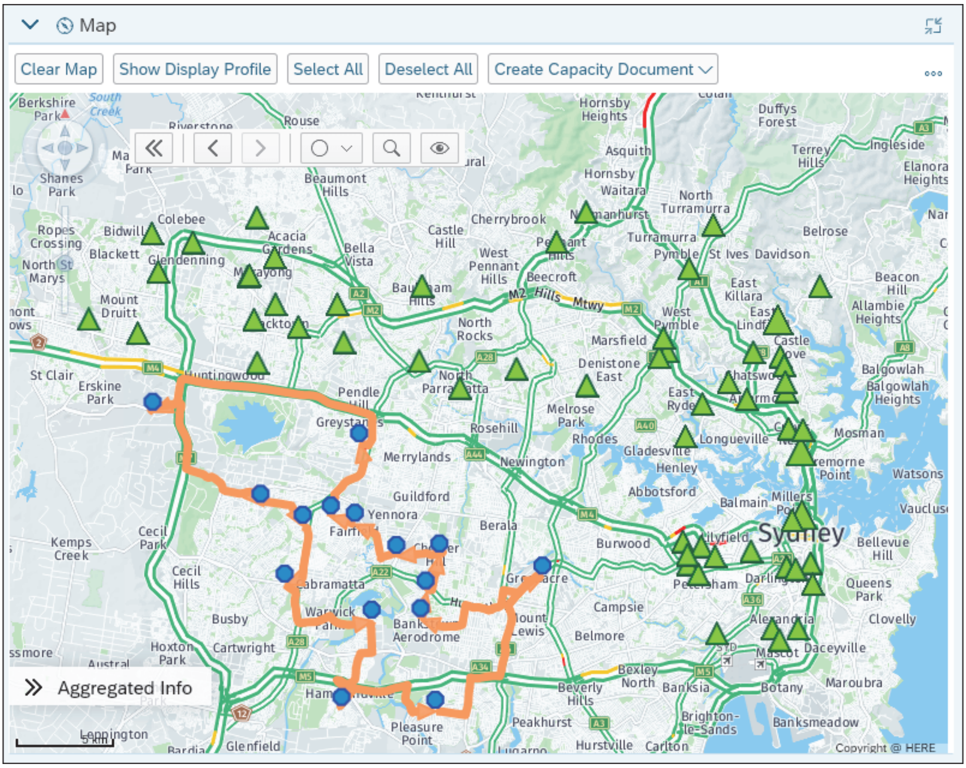


Figure 5.86 Road Freight Order and Unplanned Freight Unit Stages on a Map

Road Carrier Scenario with Full Truckloads

For a road carrier transporting FTLs, it's more natural to visualize unplanned freight unit stages as arcs connecting source and destination per demand, as shown earlier in Figure 5.64. This gives the perfect overview of the flow of transportation demands across the whole country.

In this scenario, you also need to see the last planned location of each truck, that is, the location in which the last freight order scheduled for the truck ends. You can show this and selected freight orders together with the unplanned freight unit stages on the map, as already depicted in Figure 5.64.

Working with the Map

Using the mouse wheel, you can zoom in or out; pressing the mouse button, you can move the displayed region into any direction with the mouse. Alternatively, the navigation and zoom controls in the top-left corner allow zooming in and out and moving the visible area.

The toolbar in the map allows you to go back and forth between recently used zoom levels. You can use three selection modes: single object, rectangle, and lasso. The two rightmost buttons in the toolbar offer rectangular zooming and optimizing the zoom level so that all objects are visible on the map.

You can push objects to the map by corresponding buttons in the global toolbar of the cockpit or buttons in the **Actions** column in a list, a hierarchy, or the Gantt chart. Individual objects can be removed from the map by the context menu, and the whole map can be cleared by a button in the toolbar above the map. In the page layout, you can define the buttons to appear in the toolbar above the map. Basically, you can create any capacity document for the selected documents on the map.

By dragging and dropping demand document stages, you can create new capacity documents (by dropping on a resource) or assign them to existing capacity documents. Dragging one or multiple stops of a capacity document enables reassigning the corresponding demand document stages to another capacity document. You can even drag and drop one freight order to another freight order, leading to a reassignment of all the assigned demand document stages to the target freight order. It's also possible to split a demand document stage into two new stages by dragging and dropping the stage to a location. In the example of a freight unit stage, the location serves as a new intermediate transshipment location, and the stage is split into two stages.

The **Aggregated Info** window (refer to the bottom-left corner in Figure 5.86) can be expanded and collapsed. It shows the total weight and volume as well as the number of sources and destinations for the requirement documents on the map. This information can be shown for selected requirement documents too, and, alternatively, it can be shown for selected documents, which additionally includes freight orders and selected stops of freight orders. In general, this window is useful when making decisions on the map, for example, by dragging and dropping stops or demand document stages to freight orders.

The context menu offers the following features:

- **Insert a stop**
  Insert a new stop into the document at hand.
- **Remove a stop**
  Remove a stop from the document at hand.
- **Editing the stages**
  Edit the stages of a capacity document.
- **Assigning objects to one object**
  Select unplanned demand document stages and start planning via the context menu. The system then offers possible assignments to the resources from which you can choose.
- **Find transportation demands nearby**
  Define a distance threshold and then display all demands within this distance from a given resource on the map. This allows the planner to find efficient potential assignments of demands to the given resource.

- **Find resources nearby**
  Find efficient potential assignments of a resource for a given transportation demand.
- **Find documents**
  For resources on the map, show the assigned documents on the map.
- **Report a resource position**
  Report the current position of a single resource and define the time stamp.
- **Color documents by attribute**
  Color-code documents according to their attributes. This is helpful if many freight orders are displayed at the same time. For example, you can color them by their document number, as shown previously in Figure 5.57, or you can color them by assigned resource, which allows you to identify all freight orders assigned to one specific truck resource.
- **Show details**
  For any object on the map, navigate to its detailed UI.
- **Show delays**
  Show delays, if they have been configured in the planning profile as described in Section 5.6.2.
- **Show events**
  Show events, if they have been configured in the planning profile as described in Section 5.6.2.
- **Remove execution data**
  Remove the execution data such as delays and events from the map.
- **Show transshipment locations**
  Display the relevant transshipment locations for your scenario.
- **Remove**
  Remove all objects of one kind from the map.
- **Show detailed routes**
  Show arcs on the map based on their detailed (street-level) routes.
- **Show straight-line routes**
  Alternatively to the previous option, display arcs on the map as straight lines.
- **Hide freight order stages**
  Hide the first stage, the last stage, the first and last stage, or show all stages. In a local distribution scenario, in which all customers get served from one central distribution center and all trucks start and end their freight orders at the distribution center, displaying the first and last stage per freight order leads to a lot of arcs on the map that don't provide any insight into the planning situation. To get a better overview, you can omit these arcs, which allows focusing on the most relevant part of the freight orders, namely the relative sequence of the visited customers. In other scenarios, it may be beneficial to show the first or last stage, or both. You can dynamically switch between these options in your planning session.

- **Show display profile**
  Show the display profile that includes a legend for the visualized objects and some capabilities to adjust the visual appearance on the fly. For example, the display profile in Figure 5.87 has been used for the visualization of freight units and freight orders in Figure 5.86.

  You can see that planned freight unit stages aren't displayed; unplanned freight unit stages are shown by a square and triangle for source and destination, respectively, but without arc; and freight orders are shown as circles for their stops and arcs between the stops. Labels aren't shown at all. The display profile allows you to show resources at the depot location, the last reported position, or the last planned location. You can also activate clustering to get a quick overview of the unplanned demands, as shown in Figure 5.88.

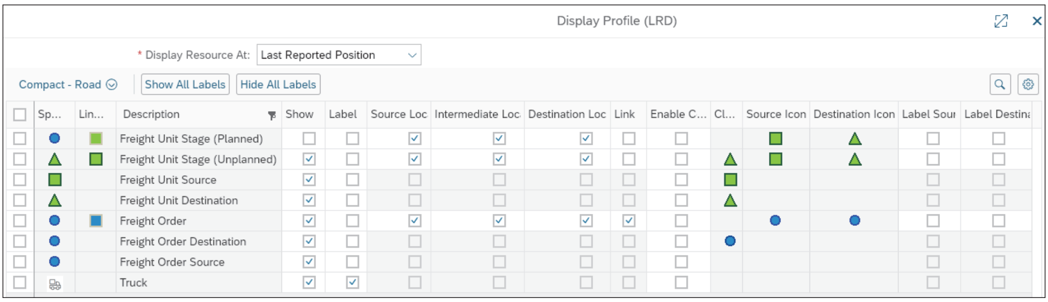


Figure 5.87 Display Profile

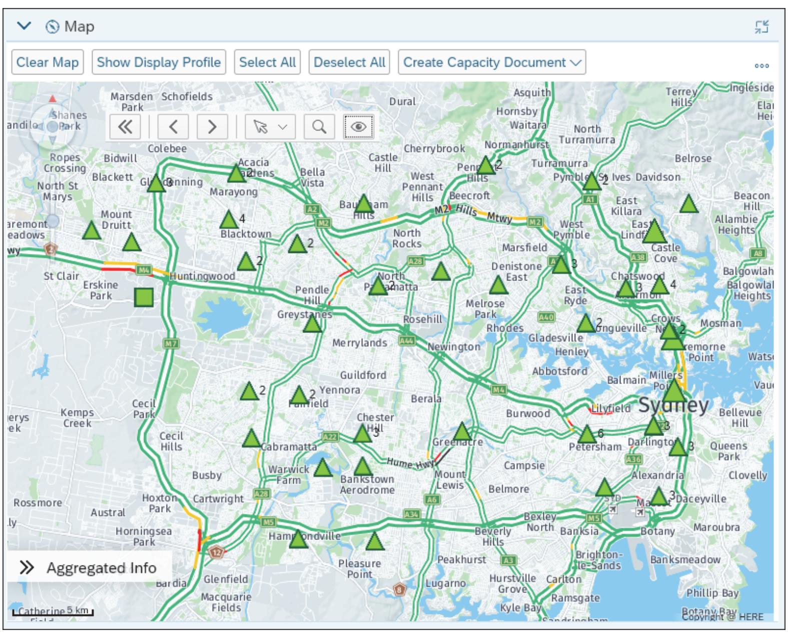


Figure 5.88 Clusters of Demands on the Map

- **Personalize**
  Define the initial map section, for example, the map of Italy if you plan that region most of the time, and choose among available map types configured.
- **Address search**
  Enter an address and show its geographical position on the map. Search results can be cleared afterward.

If multiple objects correspond to one visual object on the map, you can first choose one of these objects in the context menu, and then select one of the actions for it.

Configuration

Map layouts can be defined in Customizing using menu path **Transportation Management • Basic Functions • Geographical Map • Define Layouts for Geographical Map**. You can assign map layouts for one of the following three applications:

- **Map Display Component**
  Displays one single document on the map, in the single document UI or the transportation cockpit.
- **Transportation Network Cockpit**
  Shows the network as already described in Chapter 3, Section 3.2.8.
- **Visual Transportation Cockpit**
  Represents the map in the transportation cockpit that allows displaying many objects at the same time and manual planning. In this section, we'll focus on this application because it's the most powerful one.

For each application, you can define one map layout as the default. The definition of a map layout is based on the following abstract concepts:

- **Icons**
  Icons can represent circles, squares, and triangles of a predefined size, fill color, border color, and border width. An icon can also be a real icon defined by an image, for example, a truck or driver.
- **Spot**
  A spot is a logical object that combines icons for different states, such as single, multi-object, highlighted, and selected spots. In the previously described local distribution example, a destination spot has been defined as a green triangle for the single state, a big green triangle for the multi-spot state, an orange triangle for the selected state, and so on. A spot also specifies properties for a cluster, such as its icon, distance used for clustering, font color, size, and offset, to indicate the number of objects in the cluster.
- **Link**
  A link is a logical object defining the visual appearance for an arc on the map. You can specify the fill and border color for the normal, highlighted, selected, and multi-

link states; determine whether the link, its source and destination, and intermediate stops get displayed; and decide whether detailed street-level routing can be used.

- **Object**
  An object is composed of a spot, a link, and a set of description fields used in the label and tooltip. You can also define the drop type, which can be either stage or document, leading to insertion into the stage or based on the definition in the manual planning settings (Section 5.7.8), respectively. You can drag either a complete freight document or a stage of a demand document such as a freight unit, transportation unit, or consignment order.
- **Object scheme**
  An object scheme defines the object for each document or resource required on the map, its label background color and position, and whether it's shown by default. For simplification purposes, the object scheme also defines a default background color and position of labels and refers to a default link configuration and a default spot configuration.

A map layout combines an object scheme and a context menu, and it defines several global properties, such as the usage of the aggregated information window, whether it considers only requirement documents or any documents, and stopping in its selection section. You can activate the quick add function, which automatically pushes all selected objects to the map. For this function, you can define the selection behavior: either the selection on the map overrules the selection for lists and hierarchies in the cockpit in general, or this overruling principle is applied individually per document category and resource category. Moreover, you can define whether objects get colored; for example, by their ID or assigned resource, the first and last stage of a freight order get shown or hidden. You can specify that objects shown on the map will remain displayed when refreshing the planning session and whether resources get displayed at the depot location, last reported location, or last planned location. The map can automatically focus on objects added to the map. You can define the selection behavior for multi-objects, that is, several objects that appear at the same position. Selection of a multi-object either triggers selection of all contained objects or triggers a popup in which you can choose among the contained objects. You can also define the country or region context, which is useful if different countries or regions get served by different map providers (see Chapter 3, Section 3.2.9, for more details). The context menu contains the menu structure, including submenus, ordering of menu entries, and usage of separators in a menu.

Using menu path **Transportation Management • Basic Functions • Geographical Map • Define Settings for Geographical Map** in Customizing, you can define the routing strategy that is used to determine the individual street segments displayed for a detailed route of an arc on the map. For the configuration of the map itself (e.g., geographical information system [GIS] vendor, etc.), refer to Chapter 3, Section 3.2.9.

5.7.5 Gantt Chart

The Gantt chart allows the planner to focus on the time aspect of the planning scenario at hand. Showing the plan from the time perspective in an intuitive graphical fashion, it creates visibility on the usage of your resources. The planner can easily identify which resource becomes available at which time and check the usage of the resources (i.e., when it's used for which activity), as well as the load utilization (i.e., the free capacity per time period).

The status of documents, activities, and delays causing overlaps with subsequently planned activities are visualized too, allowing monitoring of the execution of the current plan. Moreover, the Gantt chart provides visual warnings for delays, missing empty stages, consecutive empty stages, and incorrect driver assignment. With all these capabilities, the Gantt chart is key to enabling real-time planning, such as adapting the current plan based on progress reported from executing the plan.

The Gantt chart can visualize all planning-relevant documents, equipment types, resources, and drivers, and it offers all buttons available in lists and hierarchies in the cockpit.

Overview

The Gantt chart is a very powerful and flexible interactive graphical UI. Figure 5.89 shows its basic structure and main capabilities. Before describing the functionalities in more detail, we first describe the overall structure of this UI. The global toolbar ❶ contains several buttons. The example contains two views. The view in the top consists of a local toolbar ❷, the selection panel ❸, and the chart ❹. The view in the bottom has the same structure ❺/❻/❼ and offers the same functionalities N–Q, so we focus our explanation on the view in the top.

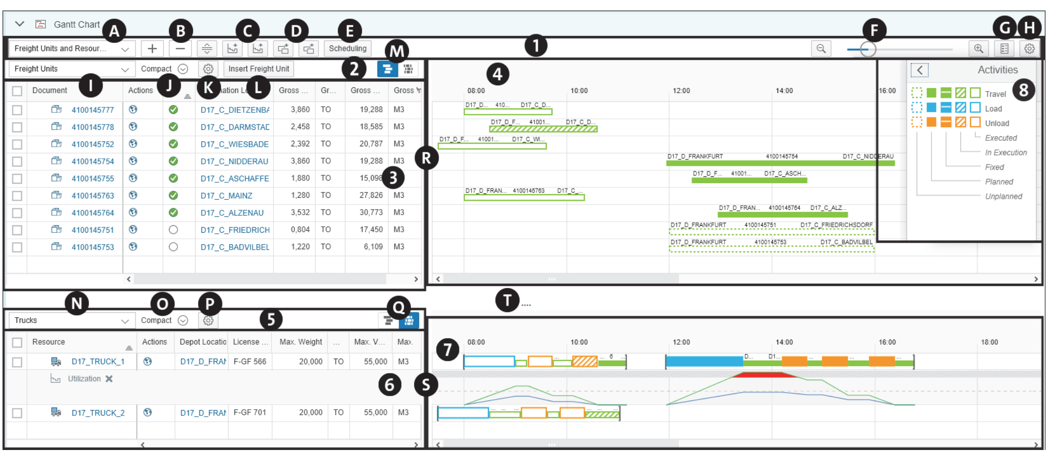


Figure 5.89 Building Blocks and Features of the Gantt Chart

The selection panel displays multiple columns per row and allows you to select and sort rows, which you can scroll horizontally (via the scroll bar in the bottom of the selection panel). Using the button K, you can add or remove columns for the selection panel and reorder them. The button J allows you to store the column personalization, including sorting as a new variant, switching between variants, and managing them, that is, defining a variant as the default or deleting variants.

The selection panel and the chart can be scrolled vertically via scroll bar to the right of the chart (not shown in Figure 5.89 because all objects can be visualized in the available rows), and, of course, they scroll synchronously. The chart area consists of the time axis on top and the rows corresponding to the selection panel. The legend 8 can be shown or hidden using the button G, which contains multiple sections that explain colors and patterns and allows you to show or hide certain aspects of the plan, which we'll describe later.

While the vertical splitters R/S allow the ratio between the selection panels and the charts to be adjusted, the horizontal splitter T enables changing the relative sizes of the top view and the bottom view.

You can use the zoom in and zoom out plus and minus buttons F or drag the zoom level to the left or right. You can also use bird's-eye view zooming (left to the minus button, not shown in the screenshot), which can determine the best zoom rate for the visible rows or all rows at hand. The bird's-eye view can also be triggered for a row via the context menu.

You can dynamically switch between the document and activity view using the view button M. The document view shows a complete document, such as a road freight order or freight unit, as one rectangle. This is particularly helpful if the planner wants to quickly assign a complete document to one resource or reassign it from one resource to another. If the planner needs more details about the documents at hand, the activity view can be used to visualize all individual activities of a document (i.e., travel, load, unload, prepare, finalize, couple, and uncouple) as rectangles. In Figure 5.89, the views in the top and bottom show documents and activities, respectively.

The activity types are distinguished by colors, and the corresponding statuses are differentiated by patterns, as shown in the legend for the activities. The activities' statuses are propagated to the corresponding documents:

- If all activities are planned, but execution hasn't started yet, the corresponding document also has the status **Planned**.
- If at least one activity is already executed or in execution, and at least one activity isn't yet executed, the document is **In Execution**.
- If all activities are executed, the corresponding document also has the status **Executed**.

Moreover, documents can have the status **Fixed** or **Unplanned**.

The combination of color and pattern allows the planner to quickly understand the progress of execution of the current plan. Of course, colors and patterns can be configured, as described later in this section.

While downtimes and nonworking times are displayed for resources, only nonworking times can be maintained and shown for vehicle types. A downtime may represent a planned maintenance period or breakdown, indicating that the resource can't be used during this time period. In the case of a planned maintenance period, the location is shown as text in the downtime rectangle so that the planner can consider moving the truck to the maintenance location and plan its next trip after the downtime from there. Nonworking times can model weekends or public holidays during which a truck isn't supposed to drive. Note that travel activities can be interrupted by such nonworking time to model, for example, weekend breaks during which the truck rests at some parking area along the highway.

You can display the load utilization of a resource by selecting the corresponding row and using the left load utilization button C. In Figure 5.89, you see the time-dependent load utilization for the truck resource **D17_TRUCK_1**. In the truck row running in activity view, you see two freight orders. The corresponding load utilization is shown in the row below the truck resource and displays two curves, one for volume utilization and one for weight utilization. The overcapacity zone has a back-slashed pattern, and any utilization across the capacity is displayed red. In this example, the planner notices that the second freight order contains one loading activity followed by two unloading activities and that the truck capacity is exceeded. In addition, the overcapacity notification bar appears in the top of the corresponding document/activity rectangle. The planner can solve this problem by assigning one of the unloading activities to another truck or a new freight order on the same truck. The planner can hide the load utilization row by either clicking the cross in the selection panel part of the load utilization row or using the right load utilization button C.

Hierarchies and Multiple Views

The user can switch between predefined hierarchies via the local dropdown menus (refer to I and N in Figure 5.89). This dynamic switch allows the user to view the plan from a different angle, such as from the freight unit perspective, freight order perspective, or truck resource perspective. A real hierarchy (with more than one hierarchy level) visualizes the structural relation between different objects (e.g., trucks and their assigned drivers). Using the view dropdown menu A in the global toolbar, you can switch between predefined views.

The view control buttons B allow you to add a new view until the limit of three views is reached (refer to Figure 5.64 for an example), to remove a view, and to switch between horizontal and vertical display. In the horizontal version, the views appear on top of each other; in the vertical version, the views appear side by side. As already discussed in the dual view concept for lists (refer to Section 5.7.3), the horizontal version provides more horizontal space for the chart and selection panel, and the vertical version provides more rows for the charts.

The concepts of multiple views and dynamic hierarchy switching allow planners to quickly adapt the Gantt chart to the decisions they want to make next. For example, if planners want to assign unplanned road freight orders to truck resources, they can use two views with freight orders in the top and truck resources in the bottom. With this setup, planners can now assign the freight orders to trucks via drag and drop.

In general, the multiple view concept is perfect for assignment decisions to be made, such as assigning freight units to trucks. You simply define a dual view with freight units in the top view and trucks in the bottom view, and then you can drag and drop freight units to the trucks, thereby creating new road freight orders, as shown in the dual view in Figure 5.89. Other dual view use cases are assignments of drivers to freight orders, freight units to trailer units, trailer units to trailer resources, trailer units to freight orders, trailer units to truck resources, and so on. Using three views at the same time can be useful if you deal with two-level consolidation decisions, such as assigning container units to trailer units and assigning trailer units to road freight orders.

The dual view also allows you to compare certain aspects of plan or replan documents from one truck resource to another, as depicted in Figure 5.90. Here, truck resources are shown in the top and bottom, so the planner can bring some resource into focus of the upper view and others in the lower view, compare them, and then make reassignment decisions that can be executed by dragging and dropping the relevant documents or activities.

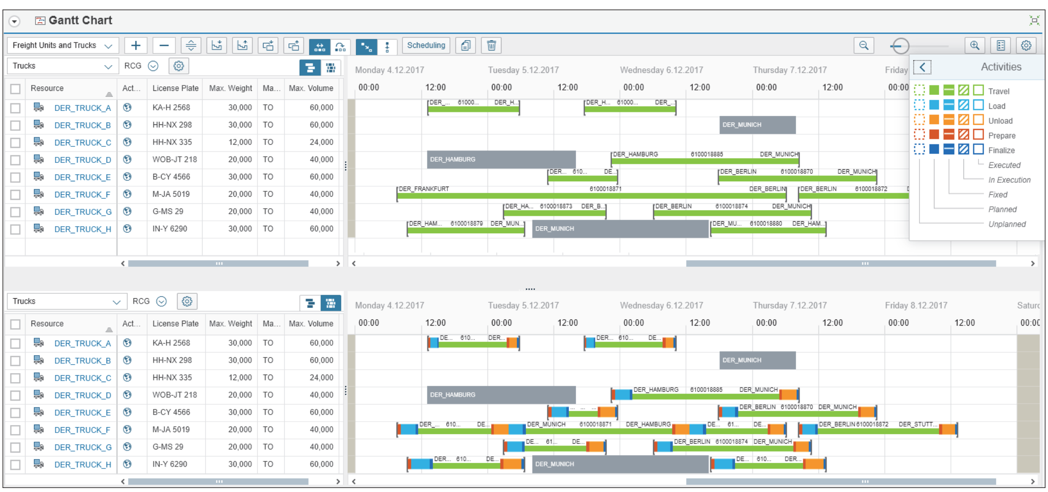


Figure 5.90 Gantt Chart with Two Truck Views

The utilization of handling resources can also be visualized, for example, in a dual view with trucks and handling resources, as shown in Figure 5.91. The visualization of handling resources is useful when there are bottlenecks or the planner wants to balance the utilization or reduce overcapacity situations on a handling resource. The planner can analyze the handling resource utilization, capacity, nonworking times, and downtimes in the upper view and replan the corresponding freight orders and loading or unloading activities in the bottom view. For each handling resource, you can display the detailed activities in the row below the utilization curve by selecting the corresponding handling resource and using the **Show Detail** button (refer to **D** in Figure 5.89).

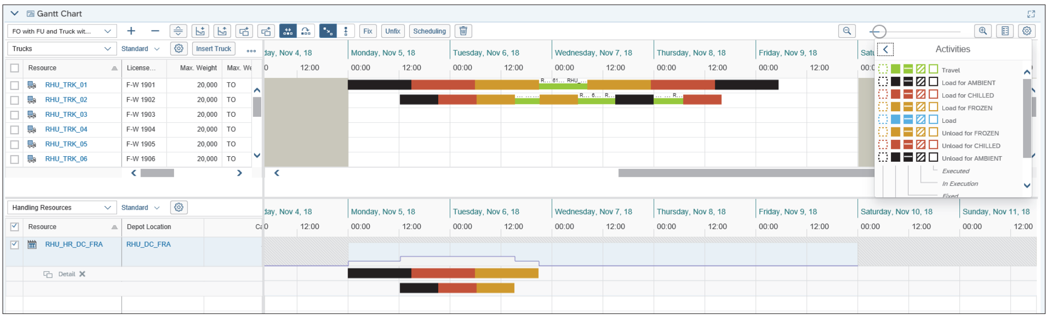


Figure 5.91 Dual View with Handling Resources and Coloring by Attributes

If certain views (single, dual, or triple) are used frequently, they can be preconfigured, allowing the user to switch between them easily, as described previously for the dropdown menu in the global toolbar (refer to **A** in Figure 5.89).

Attribute-Based Planning

In certain industries, such as retail, the planner doesn't want to plan at the individual freight unit level but at the assortment level, for example, ambient, chilled, and frozen. You can define one attribute and colors for different attribute values in the Gantt chart Customizing. Loading and unloading activities then get colored accordingly, as shown previously in Figure 5.91, in which the document label was used as the attribute. For usability reasons, all attribute groups at a stop get the same visual duration (as it otherwise would be difficult to see and drag a small group). Now, the planner can drag and drop attribute groups, which may represent many freight units associated with the same attribute value. In this retail example, you can drag the ambient group from one freight order to another, which is much more efficient than selecting all individual ambient freight units. This general principle to work on the group level can also be used by freight unit hierarchies grouped by an attribute, as described in Section 5.7.3.

Notifications

Notifications are used to visualize certain critical aspects of the current plan, as shown in Figure 5.92. They are shown as lines on the top or in the bottom of rectangles representing documents or activities. A notification bar on the top visualizes important aspects of load utilization:

- **Empty run**
  The truck or trailer doesn't have any load; in other words, it travels empty. Planners for company fleets usually want to avoid or at least minimize empty runs.
- **Low load utilization**
  The planner can specify a certain threshold, such as 70%, and the system then notifies the planner about loads below this percentage. Many companies work with such thresholds and execute freight orders only if they have a utilization above the threshold.
- **Overcapacity**
  The current load in a capacity document exceeds the capacity of the corresponding resource, as shown for truck **DER_TRUCK_C** in Figure 5.92. The planner may temporarily create such a situation, such as when consolidating multiple freight units into one freight order. Of course, the planner should later reduce the load so that the resource capacity isn't violated.

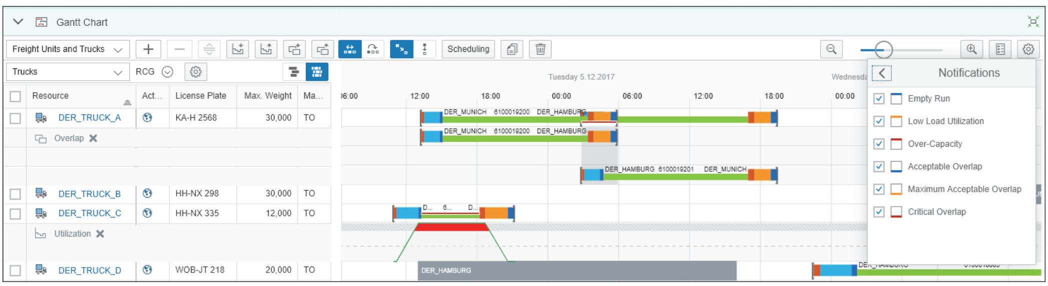


Figure 5.92 Notifications in the Gantt Chart

While a single resource represents an individual truck instance (i.e., a real physical truck with a license plate), equipment types and multiresources, which can also be used to represent equipment types instead of equipment instances, allow scheduling several documents in parallel. For multiresources, you can even define a maximum number of allowed parallel documents. A notification bar in the bottom of a rectangle indicates an overlap situation, such as when more than one freight document or activity is scheduled at the same time. Selecting the corresponding row and using the left overlap button (refer to **D** in Figure 5.89), the planner can show the details of the overlap below the selected row. The system differentiates between three kinds of overlap situations:

- **Acceptable overlap**
  There are at least two overlapping documents, but the number of overlapping documents is below the allowed number of instances.
- **Maximum acceptable overlap**
  The number of overlapping documents equals the allowed number of instances. Although this assignment is still feasible, it's more critical because any new assignment of a document to the resource at hand would lead to exceeding the number of instances.

- **Critical overlap**
  The number of overlapping documents exceeds the allowed number of instances. Thus, the planner has to get additional resources or replan some of the involved documents to meet the original constraint. In the example, truck **DER_TRUCK_A** contains two parallel freight orders, which led to a critical overlap because the truck is a single resource.

While all three overlap situations can occur for multiresources, only acceptable overlaps are relevant for equipment types as these don't allow defining a limit for the document instances. The colors for the different overlap situations help to notify the planner in a visual fashion about the criticality of the overlap situation. You can dynamically show and hide each notification by the checkboxes in the legend.

Warnings

While notifications are used to indicate overlap situations or load utilization issues, warnings are provided for other critical situations. Warnings are visualized with icons and can be switched off via a checkbox in the legend, as depicted in Figure 5.93.

The first warning type refers to missing empty stages. In the example shown in Figure 5.93, two freight orders are assigned consecutively to the single truck resource **DER_TRUCK_D**. The first freight order goes from Hamburg to Munich, and the second goes from Frankfurt to Hamburg. Obviously, the truck needs an empty travel from Munich to Frankfurt, which hasn't yet been planned. This fact is visualized by two icons, one at the end of the first freight order and one at the beginning of the second freight order. Hovering over an icon, the planner gets information about the distance and duration of the missing travel activity. Thus, the planner can decide to insert the empty stage or replan one of the freight orders to another truck, if it's necessary to avoid the empty mileage. By right-clicking to reveal the context menu for the previous or subsequent freight order and choosing **Solve Warnings** and **Solve Missing Stage Warning** in the submenu, the planner can add the missing stage to the corresponding freight order.

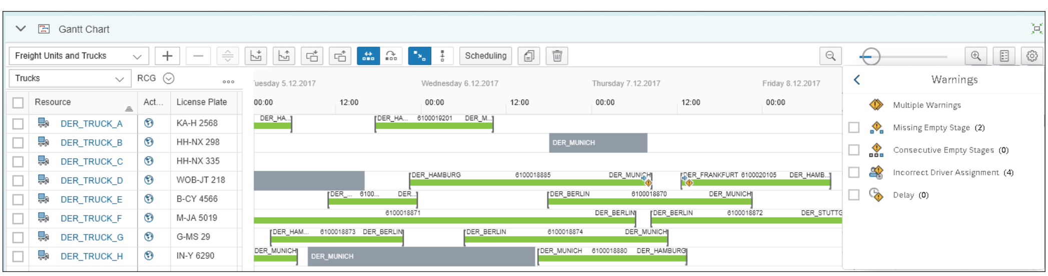


Figure 5.93 Warnings in the Gantt Chart

The second warning type reports consecutive empty stages on a single resource. Suppose that one or multiple consecutive road freight orders on the same truck resource contain multiple consecutive empty stages, which may be the result of previous planning decisions. If it's known that no more freight will get added across these empty stages, the planner wants to reduce these empty stages because that would save mileage, time, and costs. In an example with empty stages forming the stop sequence A, B, C, D, they can be reduced to one single empty stage from A to D. The warning indicates the reduction potential regarding consecutive empty stages. Using the context menu and choosing **Solve Warnings** and **Reduce Consecutive Empty Warnings** in the submenu, the planner can reduce the consecutive empty stages. Note that you can trigger this reduction of empty stages even automatically right after adding missing empty stages via the parameter **Reduce No. of Empty Stages When Solving Missing Stage Warnings** in the manual planning settings, which are described in Section 5.7.8.

The third warning type displays an incorrect driver assignment. If you configured driver planning to be relevant for the road freight order type at hand, the system issues a warning if the current driver assignment isn't correct. This might occur, for example, if the freight order requires a single driver, but you haven't assigned one, or if the freight order requires a driver team (of two drivers), and you've assigned only one or no driver. The warnings are shown on the document and travel activity level, as you may have configured that different drivers can be assigned on each stage of a road freight order.

The fourth warning type displays a delay within a freight order if the delay determination strategy and the corresponding threshold in the **Real-Time Execution Data** section of the planning profile have been configured as described in Section 5.6.2. If the user hovers over this warning, the system displays a tooltip that contains the duration of the delay and the estimated time of arrival.

Document Separators and Time Windows

Using the **More** part of the legend, you can display acceptable and requested time windows for loading and unloading demand documents, as shown in Figure 5.94. This is helpful to verify the current plan from a service level viewpoint, that is, whether the desired and acceptable time windows are met. The legend also allows you to show and hide the document separators, which you can see in Figure 5.90 and Figure 5.93, shown earlier. They help to identify idle times on a resource between consecutive capacity documents, in particular when using the activity view.

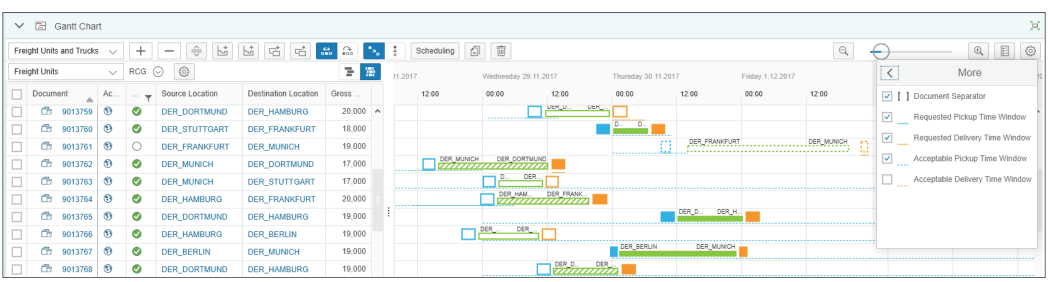


Figure 5.94 Requested and Acceptable Pickup and Delivery Time Windows

Additional Settings

The settings dialog can be triggered by the **Settings** button **H** (refer to Figure 5.89) to allow activation of the following:

- **Indicate current time**
  The current time is shown as a vertical line in the charts.
- **Show cursor time**
  When the planner moves the mouse inside the charts, a vertical line is shown in the charts and following the mouse cursor movements. The line contains a time stamp shown in the time axis area. It allows comparison of the times of documents or activities in different rows or charts, or just getting the time stamp for the current mouse cursor position.
- **Show divider lines**
  You can switch off vertical divider lines in the chart area, as shown previously in Figure 5.93.
- **Synchronize time scroll**
  When using multiple views, all charts have the same time axis by default; in other words, they visualize the same time period and are scrolled (horizontally) synchronously. In some scenarios, the planner may not want to scroll synchronously, such as when replanning a freight document from truck 1 (this week) to truck 2 (next week). The planner may want to do this by keeping truck 1 and this week visible in the view in the top and scrolling in the bottom view to the next week (and keeping the visible area of the other view stable).
- **Display related documents/activities only**
  When showing hierarchies, you can define whether you want the lower hierarchy levels to show only documents and activities that are directly linked to the parent hierarchy level. The trailer swap example depicted earlier in Figure 5.38 shows two views: in the top, you see trailers below trucks, and in the bottom, it's vice versa. Here, the lower levels only show the activities that are linked to the parent level. For example, in the view in the top for trailer **AT_TRAILER1**, only the couple, travel, and uncouple activities are shown because these are performed together with truck **AT_TRACTOR1** on hierarchy level 1. Therefore, that trailer's activities performed together with **AT_TRACTOR2** aren't shown below **AT_TRACTOR1**. If you want to see the full context—that is, all other activities on the lower hierarchy levels as well—you can activate such visualization as depicted in Figure 5.95.
- **Automatically determine drag and drop target**
  If you drag and drop a demand document to a time period on a resource where another capacity document has already been scheduled before, the system will automatically assign the demand document to the capacity document. However, in particular when planning with multiresources, you may want to create a new capacity document on the resource at hand, although this would result in an overlap. You can

switch off the automatic assignment, and when performing a drag and drop that would offer multiple assignment options for the drop target, the system raises a popup window that allows you to choose one of the identified options. For example, if there are already two freight orders in the drop target time period, you can choose between these two freight orders and the third option to create a new freight order.

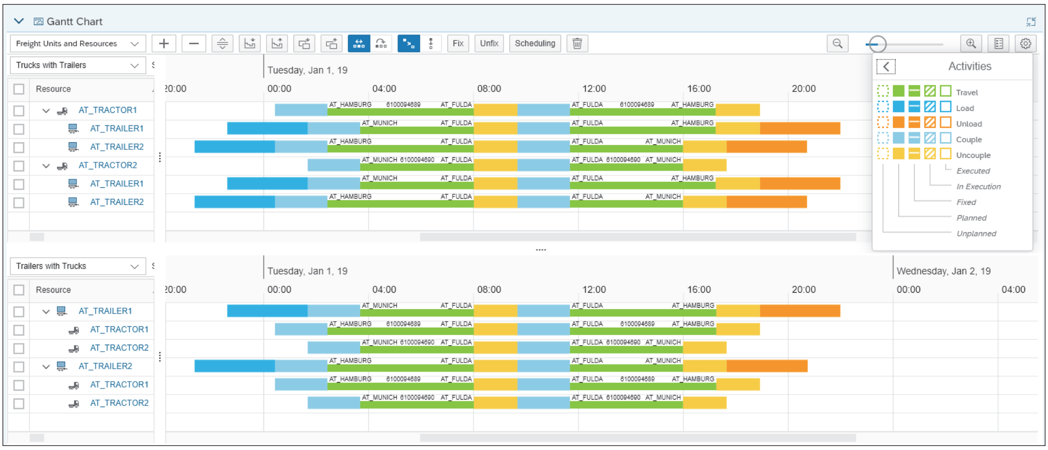


Figure 5.95 Trailer Swap in a Gantt Chart Showing All Activities in the Lower Hierarchy Levels

Drag and Drop Modes

The Gantt chart offers different modes for performing drag and drop:

- **Toggle between the rescheduling and the resequencing mode**
  The two buttons to the right of the overlap button in Figure 5.95 are called **Rescheduling** and **Resequencing**. Basically, rescheduling means that a drag and drop triggers a rescheduling, but the location sequence is kept, while resequencing allows changing the location sequence. Rescheduling is the default mode and behaves as follows. When dragging an activity, this activity serves as an anchor scheduled at the drop position's time, and other activities are scheduled accordingly, starting from the anchor. When dragging a document, its first activity serves as an anchor. Independent of which mode is active, drag and drop of an object from one resource to another resource causes a reassignment and, consequently, rescheduling on the new resource. If an activity is dragged, only the corresponding demands are reassigned, and in the case of a dragged document, the whole document is reassigned. With the resequencing mode active, drag and drop of a loading or unloading activity removes the corresponding demands (freight units) from their current position and inserts them into the new position on the same resource. This could be a new position in the same document, a new position in another document, or a new position on a free space that would result in creating a new document.
- **Drag and drop with scheduling or assigning**
  The two buttons to the right of the **Rescheduling** and **Resequencing** buttons in

Figure 5.95 are the **Drag and Drop Scheduling** and **Drag and Drop Assigning** buttons. If you reassign a document or activity from one row to another, usually you want to specify the desired anchor time for scheduling by the drop position in the target row. However, in some businesses, you may want to preserve the previous times of the document at hand. For example, suppose that you've created road freight orders with the VSR optimizer, considering opening hours and time windows of customers and transportation demands. You may want to preserve this scheduling of the freight order but just assign a driver. Switching to the assigning only option, you can ensure that you drag and drop the freight order to a driver row in the Gantt chart and preserve the freight order's scheduling.

These buttons need to be activated explicitly in the page layout, as mentioned in the **Configuration** section of the Gantt chart.

Context Menu

The context menu is triggered by right-clicking with the mouse and offers additional manual planning features, such as assigning or unassigning resources or drivers, inserting locations, applying the default routing, editing stages, and fixing or canceling the document at hand. Moreover, you can use the context menu to solve warnings. You can also scroll to the first or last activity in a row or to the current time, select all objects in the row at hand, or open the single document UI. By double-clicking on a document in the chart, you can trigger a quick view that lists some extra information. It also provides a hyperlink to the single document or resource UI, which you can also reach by hyperlinks in the selection panel.

Smart Add

While some customers use the Gantt chart as the primary tool to visualize all resources and documents and perform manual planning, other customers want to work in lists and hierarchies and use the Gantt chart as a kind of detailed area in which only selected resources and documents get displayed. The second usage is offered by the *smart add* mode, which can be activated in the Customizing as described in the next subsection. Basically, this mode makes the Gantt chart only display objects selected in lists and hierarchies outside the Gantt chart. If the user didn't select anything, the Gantt chart is empty. If the user selects a resource or a document, the Gantt chart will show it, including its context. Therefore, if the user selects a road freight order, the Gantt chart will show it as well as its assigned resource (if any) and other documents assigned to that resource.

Configuration

Because the Gantt chart is a very visual tool, it's impossible to provide a color and pattern configuration that all planners like or can work with. Some people have difficulties distinguishing red and green, so they need different colors that they can differentiate. Some companies are used to certain colors in their software and may want to use them in the Gantt chart too.

While one planner is mainly interested in the start and end times of a freight order, another planner prefers to see the start and end location as text in the Gantt chart. One company is mainly interested in the number of pallets, while another company needs to see volume and weight information. For all these reasons, the Gantt chart provides sophisticated configuration capabilities so that every company and user can adapt it to their needs.

To configure the Gantt chart, select IMG menu path **Transportation Management • Basic Functions • Gantt Chart**. Note that a lot of Customizing content has been delivered, usually starting with the prefix "SAP." We recommend using that as a starting point and then copying and adjusting it according to your business needs.

Following the **Define Color Schemes and Patterns for Gantt Chart** activity, you can do the following:

- Color schemes for activities serve to define colors and heights (full or half row) of activity types and patterns of activity statuses. For example, you can give full height to location-based activities, such as loading, unloading, preparing, finalizing, coupling, and uncoupling, and half height to travel activities to differentiate traveling from other activities in an easy, visual way. The color scheme also defines an attribute that is used for color loading and unloading activities, and the assigned attribute scheme defines the sequence of attribute values and their colors per activity type.
- Similarly, color schemes for documents define colors, heights, and levels for document types and patterns for document statuses.
- Set colors for visualizing overlaps on resources.
- The color schemes for resources configure colors for downtimes and nonworking times of resources.
- The color schemes for utilization define the load utilization curves for weight, volume, quantity, and normalized quantity. You can also switch off certain loading dimensions, such as if only weight was critical for your business, for example.
- Notification schemes allow you to set percentage intervals, heights, and colors for notifications about load utilization. For example, a utilization below 70% could be marked yellow, a utilization above 100% marked red, and an empty run marked blue. This helps users quickly identify underutilized and overutilized capacity documents as well as empty runs. You can also define heights and colors for notifications about overlaps and enable visualization of document separators and time windows. Note that colors for the time windows can't be configured because the color of the corresponding activity type (loading and unloading) is used. For all these graphical

components except for the time windows, you can define whether they are active when starting the transportation cockpit.

- Warning schemes enable the usage of warnings for missing empty stages, consecutive empty stages, incorrect driver assignments, and delays, as well as whether they are active initially.
- You can define the colors and patterns that are the basis for all the preceding definitions.

If you choose the activity **Define Field Lists and Label Schemes for Gantt Chart**, the system allows you to do the following:

- Define the fields that can be displayed in the selection panel and used in labels for the chart. For each field, you can specify its type (text, hyperlink, image, icon, or label) and content per object type. Using this principle, you could use one column differently per object type. This may be helpful for hierarchies because you would otherwise consume two different columns, and half of the cells would be unused because the field applies to only one object type.
- Specify field lists that are used for the selection panel. A field list is an ordered set of fields. Per field, you can define whether a quick view is offered.
- Define labels that can combine multiple fields and static texts. For example, you can specify a label that combines source location and destination location, resulting in texts such as “Hamburg → Munich”.
- Set label schemes for activity types to define which label is visualized as text in the chart area and which labels are used as tooltips. Using this concept, the source location could always be shown on the left of a travel activity, the destination location shown on the right, and both the start time and end time shown in the tooltip. The configuration can be done per activity type of a document type.
- Define label schemes for document types similar to the label schemes for activity types.

Choosing the **Define Layouts for Gantt Chart** activity, you can define the hierarchies, views, and layouts for the Gantt chart as follows:

- **Hierarchies**
  A hierarchy refers to a field list and consists of multiple hierarchy levels. For example, the hierarchy **SAP_TRK_WITH_DRV** contains trucks on level 1 and drivers on level 2; therefore, the assigned drivers are shown below the truck resource, which is useful if multiple drivers are using the same truck separately and consecutively. All flat lists are modeled as hierarchies with just one hierarchy level, such as the hierarchy **SAP_FO**, which contains only road freight orders (on the first hierarchy level). For all levels in a hierarchy, you can specify whether the level will be expanded initially and overlap details get shown initially when showing or expanding a hierarchy. The latter function is useful particularly for equipment types and multiresources, for which

you expect overlaps being the normal situation and want to avoid the need for manually triggering the display of the overlap details.

- **Views**
  A view can be a single view, a dual view, or a triple view, meaning that it contains one, two, or three Gantt charts, each with its own hierarchy. If it's a dual or triple view, you can specify whether it's initially displayed in its horizontal (charts above each other) or vertical (charts beside each other) version. For the view, you can specify the initial ratio of the selection panel versus the chart part, and if it's a dual or triple view, you can specify the sequence of the hierarchies and ratio between them. Moreover, you can define for each hierarchy in a view whether it's initially shown in the document or activity view.
- **Layouts**
  The layout contains an initial view and a set of additional views that may be used in the planning session (using the dropdown menu in the global toolbar). It also contains a list of additional hierarchies that can be used by the dropdown menu in the local toolbar. The layout refers to color schemes for activities, documents, resources, and utilization; to label schemes for activities and documents; and to schemes for warnings and notifications.

  In the layout, you can also define whether the following are true:
  - The current time is shown as a vertical line.
  - The cursor time is displayed.
  - The horizontal scroll bars are synchronized when using multiple views.
  - Lower levels in hierarchies only show activities and documents related to the parent level.
  - Load utilization can be displayed.
  - Automatic zoom level detection is active; the zoom level is determined so that all documents are visible in the Gantt chart. Alternatively, you can explicitly choose among predefined zoom levels, ranging from 15 minutes to 2 months.
  - Quick views are shown in the selection panel and after which time period they are shown during hovering.
  - Rescheduling or resequencing is taken as default mode for drag and drop in a row.
  - Scheduling or pure assigning is the default mode for dragging and dropping between rows.
  - Bird's-eye view zooming is available for which options are offered (visible or all rows).
  - Automatic target detection during drag and drop is active.
  - The smart add function is activated.

When choosing the Gantt chart screen area in the page layout (of the transportation cockpit), you can refer to a Gantt chart layout as defined in the previous bullet list. In the page layout, you can choose the buttons offered in the global toolbar and the local toolbars of the Gantt chart. For example, you can activate the buttons for the **Re-scheduling or Re-sequencing Mode** and **Drag and Drop with Scheduling or Assigning** in the global toolbar.

5.7.6 Load Plan

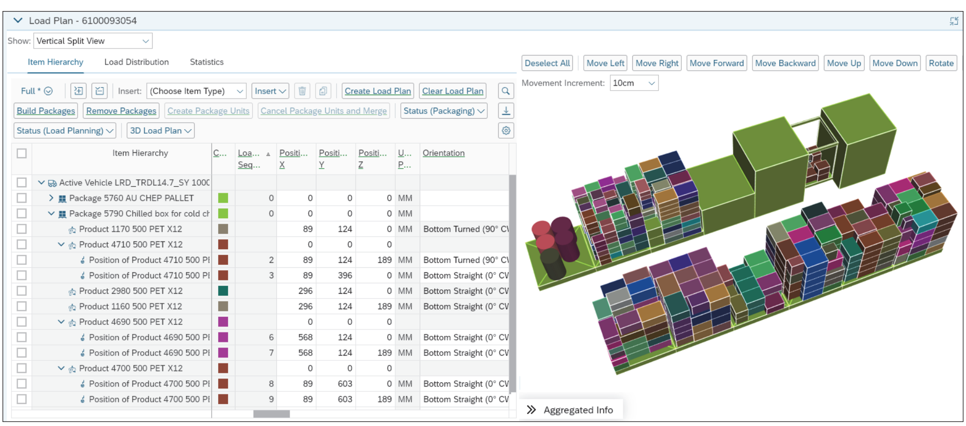
The load plan view serves many purposes. It enables manual and automatic load planning (Section 5.8.8) and displays the corresponding result, that is, the positions and orientations of packages and products loaded into the cargo space represented by a road freight order, trailer unit, or container unit. The load plan view also allows manual and automatic creation of a packaging hierarchy for road freight orders, consignment orders, trailer units, container units, and package units. The automatic creation is done by unified package building (Section 5.3), and the packaging hierarchy can include the positions and orientations of products and cartons positioned in a pallet. You can also manage the status from the load planning and packaging perspective and create package units based on the packaging hierarchy of a road freight order, as described for the integrated delivery and line-haul planning scenario introduced in Section 5.4.5.

In this section, we'll walk through the load plan view types, manual load planning, and configuration.

Three-Dimensional View

The load plan view is composed of a hierarchy and a 3D view, showing the current plan from a tabular and visual viewpoint. In the 3D scene, you can show or hide the assigned resource of the capacity document at hand, and you can show the packaging details or omit them; that is, each package is displayed as one big box without the objects positioned in it.

Figure 5.96 shows the package details in the 3D scene without the assigned truck of the road freight order at hand.



Item Hierarchy	C...	Loa... Seq...	Positi... X	Positi... Y	Positi... Z	U... P...	Orientation
Active Vehicle LRD_TRDL14.7_SY 100(							
Package 5760 AU CHEP PALLET		0	0	0	0	MM	
Package 5790 Chilled box for cold cł		0	0	0	0	MM	
Product 1170 500 PET X12			89	124	0	MM	Bottom Turned (90° C\
Product 4710 500 PET X12			0	0	0		
Position of Product 4710 500 PI		2	89	124	189	MM	Bottom Turned (90° C\
Position of Product 4710 500 PI		3	89	396	0	MM	Bottom Straight (0° CV
Product 2980 500 PET X12			296	124	0	MM	Bottom Straight (0° CV
Product 1160 500 PET X12			296	124	189	MM	Bottom Straight (0° CV
Product 4690 500 PET X12			0	0	0		
Position of Product 4690 500 PI		6	568	124	0	MM	Bottom Straight (0° CV
Position of Product 4690 500 PI		7	568	124	189	MM	Bottom Straight (0° CV
Product 4700 500 PET X12			0	0	0		
Position of Product 4700 500 PI		8	89	603	0	MM	Bottom Straight (0° CV
Position of Product 4700 500 PI		9	89	603	189	MM	Bottom Straight (0° CV

Figure 5.96 Load Plan View with Package Details in 3D View

This view allows you to analyze the result of package building, which includes some kegs on one pallet, some pure product pallets shown as big boxes, many open pallets containing cartons of varying sizes, and a closed package, which resembles a cool pack with some goods in it that require a cooled package. Closed packages represent pallet cages or cool packs, and only their skeleton is displayed so that you can see the positioning of products in it. In this example, the products are colored by the destination location, so most pallets represent mixed pallets for many customers and with many different products.

The detailed positions of products on pallets are only available when using package building as the engine and detailed mixed package building, as described in Section 5.3.5. They aren't available when using packing instructions or packaging specifications as the engine in unified package building.

The package details can be switched off, as depicted in Figure 5.97. The pallets with an X symbol indicate that they aren't stackable. This view indicates the pallets' outer volumes very precisely and therefore shows the package information that is considered as input for load planning. In the previous examples, load planning hasn't yet been performed. The result of load planning is shown in Figure 5.98, again without package details. To verify the result, the truck resource is shown—in the previous two screenshots the truck was hidden. This view is helpful to quickly review the load plan result.

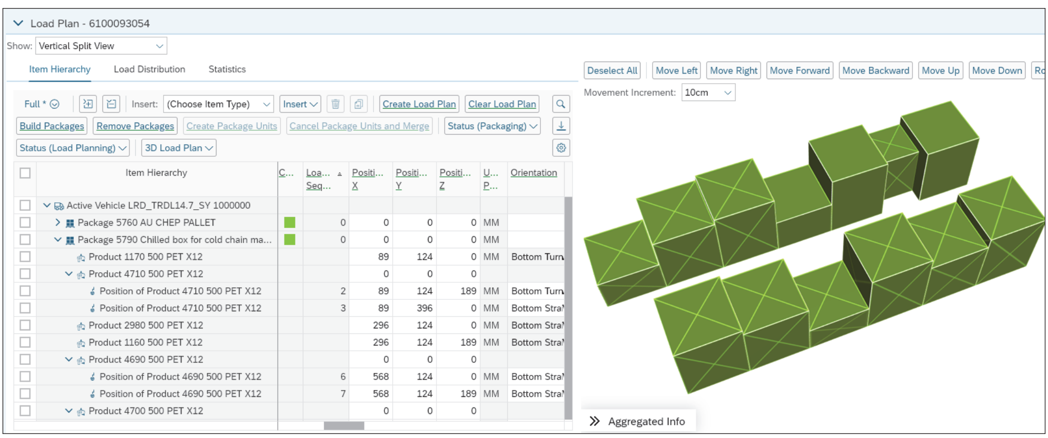


Figure 5.97 Load Plan View without Package Details in 3D View

Of course, you can also show the load plan result by including all packaging details, as depicted in Figure 5.99. This represents the full level of detail determined by package building and load planning.

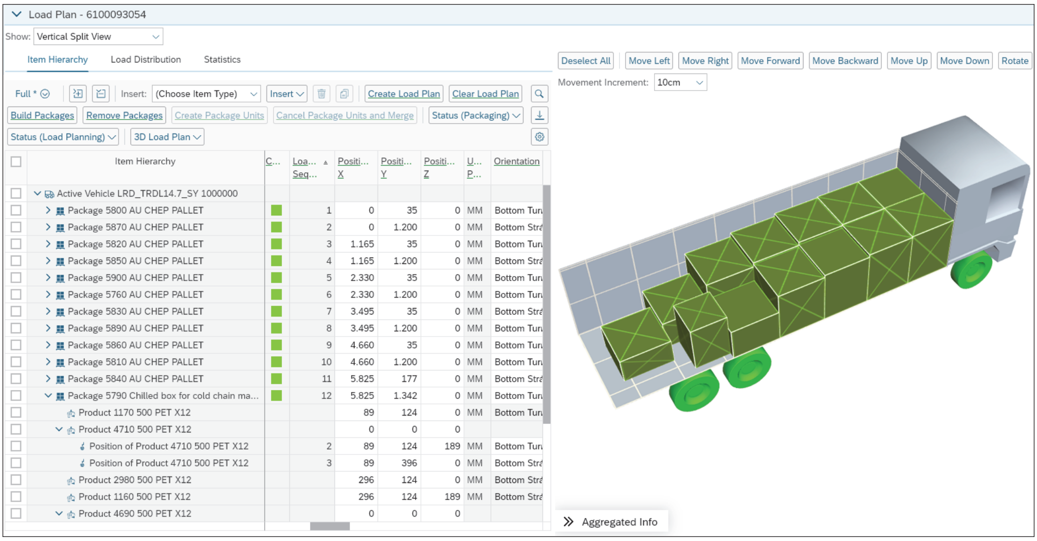


Figure 5.98 Load Plan View with Cargo Space but without Package Details

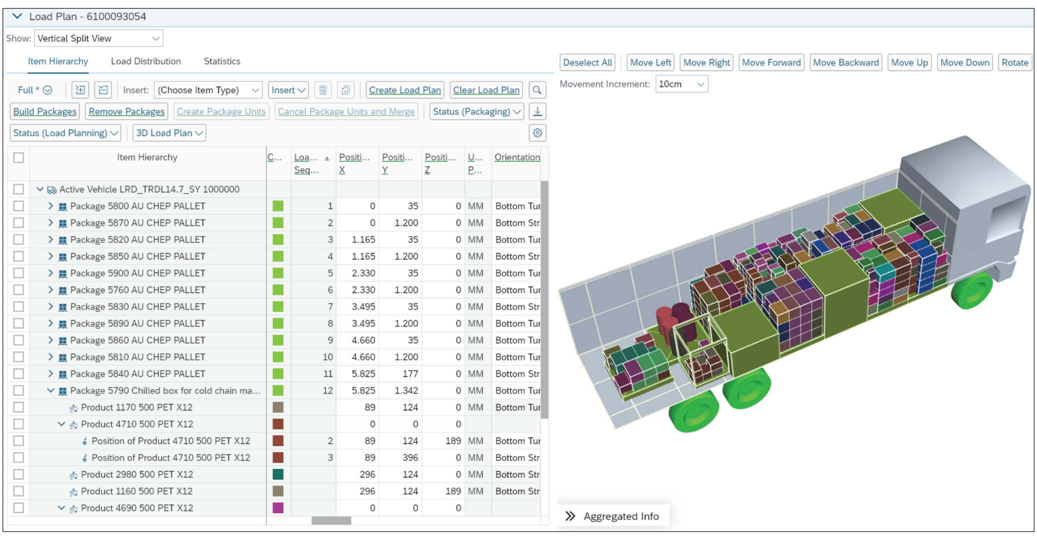


Figure 5.99 Load Plan View with Cargo Space and Package Details

The 3D view allows displaying labels for top-level packages and on the three axes of the cargo space, the center of gravity with respect to length and width of the cargo space, and an aggregated info window, as shown in Figure 5.100. The graphical view allows the planner to rotate the view and zoom in and out using the mouse to verify the plan from any angle. The context menu offers the following features:

- Switch between predefined views (e.g., from back, left, right, or top).
- Color-code the loaded packages and products by freight unit, package unit, destination location, weight, stackability, product, reference product, and orientation.

While coloring by destination is very helpful to verify the last in, first out (LIFO) principle for pallets that serve just one customer, coloring by reference product allows you to verify how products of the same reference product are distributed among the mixed pallets. You can use coloring by freight unit to see how the goods of one freight unit are spread over multiple pallets.

- To analyze the structure of the load plan, hide selected items, stacks, rows, levels, or the upper deck from the visualization.
- Switch off the grid on the cargo area that is used to show the dimensions if not necessary.
- Display a legend that shows the colors used in the 3D scene.
- Display the package details.
- Show the complete load plan or only the selected packages.
- Use the load chart to display the center of gravity and the constraints imposed by the axle weight constraints. This is helpful to identify the degree of freedom for further objects loaded into the cargo space.

The aggregated info window displays the axle weights, as well as the volume, weight, and quantity of the objects (planned and all) in the scene. You can easily expand and collapse the aggregated view and its sections and move the aggregated view by dragging and dropping to a different position in the 3D view.

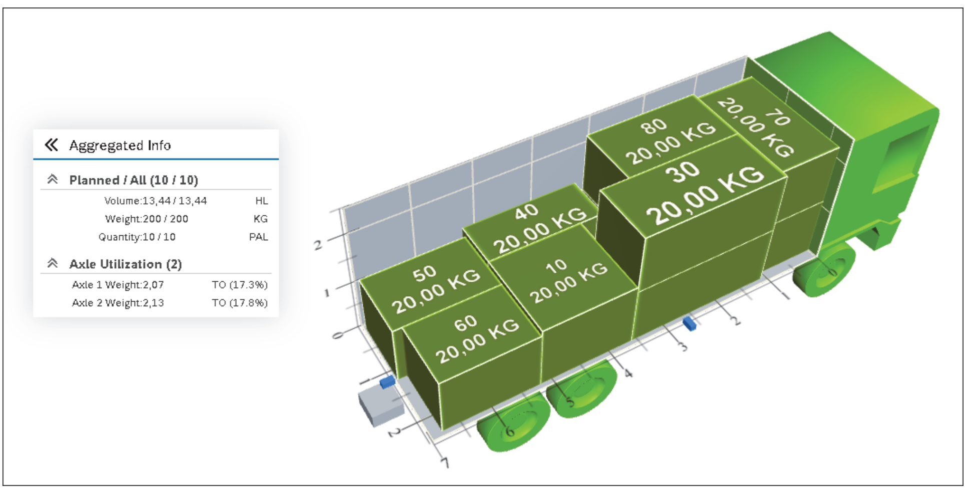


Figure 5.100 Result of Manual Load Planning for Pallets with Varying Sizes

Quick views for objects in the 3D scene can be triggered by double-clicking. Tooltips are provided for all visual elements, so you can check the weight on the axle groups or get additional information about the loaded items or the resource. The axles are colored based on their utilization, so you could use green, yellow, and red to differentiate utilizations close to the limit from two other utilization intervals.

Hierarchical View

The **Item Hierarchy** tab provides the item hierarchy from the load planning and packaging viewpoint, as shown in Figure 5.101.

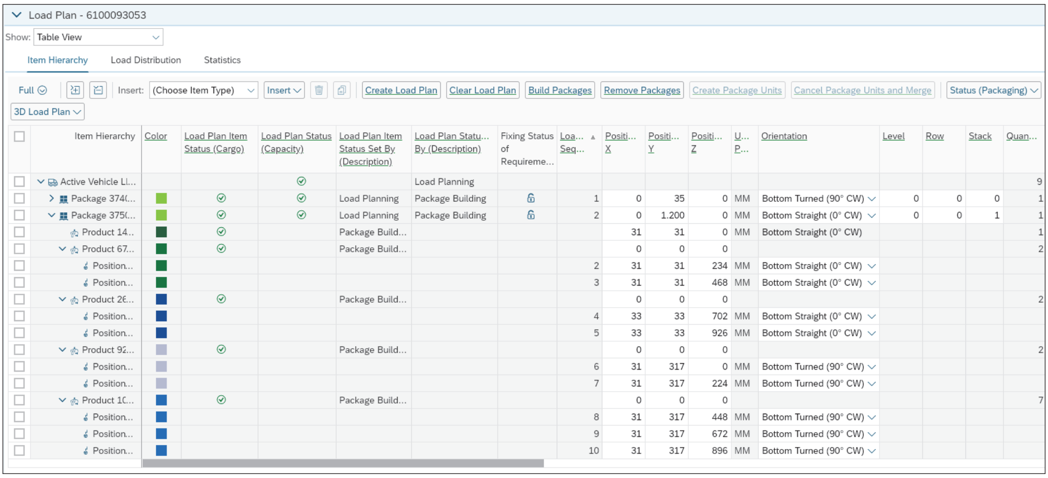


Figure 5.101 Load Plan Hierarchy

This hierarchy provides many useful fields that can be personalized, but we recommend only using the most important fields for your business, as many columns and a huge number of items may become performance-critical, as already discussed in Section 5.7.3. Now, let's review the available fields and their usage:

- **Color** indicates how the item is colored in the graphical scene.
- **Load Plan Item Status (Cargo)** indicates whether the item at hand has been planned into its parent item. **Load Plan Status (Capacity)** informs whether all children of the item have been planned into the item; this status is relevant for packages and resources, but not for products, auxiliary packaging materials, and consignment orders (because they don't represent a capacity). In the shown example, the first status for the top-level packages yields the status from the load planning perspective, while the second status indicates whether all children have been packaged into the top-level package. For both status values, separate fields indicate how the status got set, for example, by load planning, unified package building, or manually. Using the buttons in the local toolbar, the status values can be changed. For example, you can finalize packages to protect them against further changes such as creating or clearing a load plan, or building or removing packages; in this case, the **Fixing Status of Requirement Assignment** is set to **Fixed** too. In general, these fields are very useful to identify the progress in the planning process that consists of unified package building, load planning, and finalizing top-level packages, for example, when required to create package units, as described in Section 5.4.5. Note that the hierarchy displays the status across the complete assigned document chain. Suppose you have a road freight order with assigned trailer units or consignment orders. If the assigned

documents carry a packaging hierarchy each, you see the corresponding status values even in the road freight order.

- **Loading Sequence** specifies the sequence in which the items need to be loaded. This applies to the top-level items being loaded into the cargo space as well as to top-level items loaded into top-level packages (e.g., cartons into mixed pallets). A zero value indicates that the item at hand hasn't been loaded yet into the equipment (truck, trailer, container) at hand.
- **Position X**, **Position Y**, and **Position Z** define the physical position of the item. Top-level items are positioned in the cargo space of the truck, trailer, or container, while their direct children are positioned in the top-level packages.
- **Row**, **Stack**, and **Level** are useful to identify the position when all pallets in the cargo space have the same footprints.
- **Deck** indicates whether the package is loaded into the lower or upper deck. See Figure 5.102 for an example of a truck with a flexible upper deck.
- **Orientation** specifies whether the item is turned, tilted, and so on.
- The **Position Category of Item** indicates whether the item refers to a material, layer, or mixed layer, and the **Layer Definition** provides the unit of measure of the layer at hand.
- **Gross Weight**, **Gross Volume**, **Outer Volume**, **Quantity**, **Normalized Quantity**, **Length**, **Width**, and **Height** define the dimensions of an item. The utilization, total capacity, remaining capacity, and consumed capacity are provided for volume, weight, and normalized quantity.

Figure 5.102 Load Plan for Truck with Flexible Upper Deck Based on Beams

- The **Resource**, **Equipment Group**, and **Equipment Type** are provided, and the **Combination Resource** field indicates whether it represents a combination resource.
- **Product** specifies the loaded product and the packaging material for product items and package items, respectively. For product items, you can also see the **Reference Product for Package Building**. For packaging materials, **Closed Packaging Material** indicates whether it's an open or closed package.
- **Loading Location** and **Unloading Location** are presented, together with the **Hard Group** and the **Soft Group**, which are useful if you use the location hierarchy–based constraints described in Section 5.3.5.
- **Mixed Package** and **Non-Stackable Packages** indicate whether the package item at hand is mixed, that is, contains multiple products, and non-stackable, respectively. **Maximum Top Load** lists how much weight can be stacked on the package at hand.
- You can identify the origin of the item, that is, whether it stems from a freight unit or a transportation unit, and the original requirement document, for example, its forwarding order.
- **Contained In PU** informs you whether the package at hand has already been extracted into a package unit.
- If you want to remove certain items from the next load planning run, you can exclude them via a checkbox in the list and trigger load optimization again.
- **Unified Package Building Profile**, **Unified Package Building Engine**, and **Unified Package Building Rule** indicate which profile and engine have been used by unified package building (Section 5.3), and which rule was used. The rule represents the packing instruction and packaging specification used by the corresponding engine, and it's undefined if package building is used as the engine.

As already mentioned in Section 5.7.3, you can configure the hierarchy to present layers as a dedicated level in the load plan hierarchy, as shown in Figure 5.103. Each layer represents one row in the hierarchy. In case of a mixed layer, its products are shown as children. This layer-oriented view directly corresponds to the 3D scene, in which the layers are visualized as big boxes covering the complete footprint of the pallet.

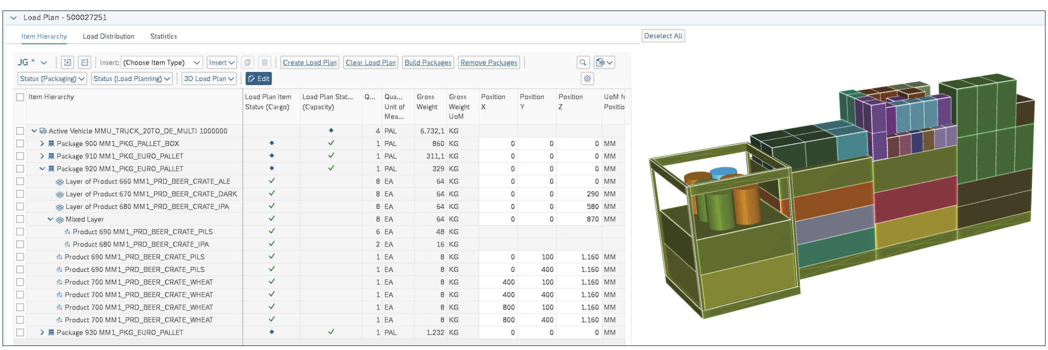


Figure 5.103 Load Plan View with Layers in the Hierarchy

Load Distribution and Statistics

The **Load Distribution** tab displays the utilizations regarding all weight constraints on the axle groups, split deck, trailing load, and total weight, and the **Statistics** tab provides additional information, such as the number of pallet positions, used floor space on the lower and upper decks, used LDMs, used volume, and percentage of items that could be loaded, as shown earlier in Figure 5.65.

Manual Load Planning

While most users prefer automatic load planning, manual load planning may be required to adjust an automatically created plan or to create a load plan from scratch. Figure 5.100 earlier showed a load plan for inhomogeneous pallets of varying sizes, which has been created manually. You can perform manual load planning using the buttons in the toolbar of the 3D scene, keyboard shortcuts, or the editable fields for loading sequence, positions, and orientations in the hierarchy. Note that the **Edit** button to enable editable fields needs to be configured for the hierarchy, as already mentioned in Section 5.7.3. An unplanned object can be put into the cargo space by maintaining a nonzero loading sequence value. For a combination resource with two trailers, you can drag and drop an unplanned object within the hierarchy below the right trailer, and then put it into the trailer by defining its loading sequence value. The movement increment used for manual planning in the graphical view can be chosen in the dropdown menu of the toolbar.

Creating PDF Files

The planner wants to provide the load plan, including a 3D image as a PDF file, to other parties such as the carrier or driver, or just print it. The PDF file can be created from the road freight order or container unit UI in the corresponding lists of the transportation cockpit by using the **Print** button and choosing the (un-)loading instruction action in the popup, or via a report by choosing **Logistics • Transportation Management • Administration • Background Processing • Print Load Plan** in the SAP menu; it can also be stored in the archive. The 3D images included in the PDF file get created by a dedicated service that is part of SAP Enterprise Product Development.

The file contains a headline with document number, date, and page number, as well as multiple sections to cover the following: general data such as carrier, shipper, and ship-to party; stop sequence with locations, addresses, and departure and arrival dates and times; resource and cargo overview with capacity, consumption, and utilization per cargo space; package material overview with statistics on top-level packages and unpackaged products; item list with top-level packages and unpackaged products ordered by their loading sequence; detailed item list representing the complete packaging hierarchy; and load plan images.

Configuration

For the 3D scene and the statistics information, configuration options are offered in IMG menu path **Transportation Management • Basic Functions • Load Planning • Define Layouts for 3D Load Plan**. Here, you have the following options:

- Specify the units of measure to be used for the statistics.
- Define whether the grid, load distribution, not loaded items, package details, and information window will be shown.
- Specify whether the center of gravity will be shown for resources and packages, only for resources, or not at all.
- Set the initial coloring scheme for items, the thresholds for coloring axles, and the colors for loaded items, not loaded items, low loading, medium loading, and high loading.
- Define weight groups and classes that are used for coloring packages by weight.
- Define the content for quick views, tooltips, labels, and context menus.
- Specify whether labels are shown for items and the resource. For the resource, labels are shown across the three axes of the cargo space.
- Activate manual load planning in the 3D scene, which then offers buttons in the toolbar to move and rotate items. For each button, a corresponding default keyboard shortcut is available.
- Define keyboard shortcuts that replace the default and refer to a keyboard layout, which can be defined via path **Transportation Management • Basic Functions • Load Planning • Define Keyboard Layouts** in Customizing, and model, for example, a German or English version. A keyboard shortcut binds operations to move left, right, forward, backward, up, and down, and to rotate to key codes in the keyboard layout.
- Define the movement increments in the scene, which are used during manual load planning based on buttons or keyboard shortcuts.

After you've defined such a load plan layout, you can refer to it in the page layout. You can choose among different configurations, including the hierarchy view, the 3D view, both together arranged horizontally or vertically, or a combination that includes all previous options and the ability to dynamically switch between them.

For the creation of load plan PDF files, choose IMG menu path **Transportation Management • Basic Functions • Load Planning • Printing • Define Load Plan Printing Profile**. The load plan printing profile allows defining the following:

- The **Load Plan Printing Layout** defines which sections are put into the PDF file. For example, you may choose to omit the detailed item list for space reasons.
- The **Layout of 3D Load Plan** specifies the visual appearance of the 3D images.
- The RFC destinations for authentication and the service to provide the 3D images. Refer to SAP Note 3023625 for more details on how to connect the image creation service to TM.

- The **Printing Sequence** defines whether multiple 3D images are required, and if yes, how many top-level cargo objects are added per consecutive 3D image.
- The **Parallel Processing Profile** enables fetching 3D images in parallel.
- The logo to be used in the headline of the file.

Choosing **Transportation Management • Basic Functions • Load Planning • Printing • Assign Load Plan Printing Profile** in Customizing, you can assign the load plan printing profile to a road freight order or container unit document type. Using menu path **Transportation Management • Basic Functions • Load Planning • Printing • Configure Load Plan Printing Layout** in Customizing, you can add or remove the header or any other sections in the load plan PDF file.

5.7.7 Selection Criteria and Profile and Layout Sets

The previous sections mentioned the need for configuring the cockpit's appearance and introduced page layouts, hierarchical views, dual views, the map, the Gantt chart, and the load plan. Let's turn our attention to how to get started in the transportation cockpit.

Choosing **Transportation Cockpit** takes you to the entry screen for the transportation cockpit. You can choose from two entry possibilities in the **Switch Start Screen** choice: one based on selection criteria and one based on profile and layout sets.

In addition to these entry options, the transportation cockpit can be triggered from various POWL queries, such as OTRs, DTRs, road freight orders, and rail freight orders. It's also possible to trigger the transportation cockpit directly out of a business object, such as the forwarding order.

Let's now focus on the most commonly used cockpit entry options, the selection criteria and profile and layout sets.

Selection Criteria

The entry by selection criteria allows you to define ad hoc selection criteria for the various objects or choose from previously defined selection criteria (saved searches, can be private or global, i.e., available for all users), as shown in Figure 5.104. In the **Freight Unit Stages**, **Transportation Units**, **Consignment Orders**, **Freight Orders**, **Freight Bookings**, **Vehicle Resources, Vehicle Types**, **Drivers**, **Container Resources**, **Container Types**, and **Schedules** sections, you can define multiple criteria for the desired object types with each criterion referring to one attribute and one matching criterion. For example, the two criteria for freight unit stages refer to the source and destination location, respectively. Both use the matching criterion **equal to** and together result in selection of freight unit stages that meet both criteria. You can add or remove criteria by clicking the plus and minus buttons. The planning profile, page layout for transportation cockpit, page layout for the planning result screen, and transportation cockpit settings, which will be introduced in Section 5.7.8, can be selected in the **Settings** section. Note that you can suppress the display of the planning result screen via the **Skip Planning Result Screen** checkbox in the transportation cockpit settings. After you've made your choice, click **Continue** to start the cockpit.

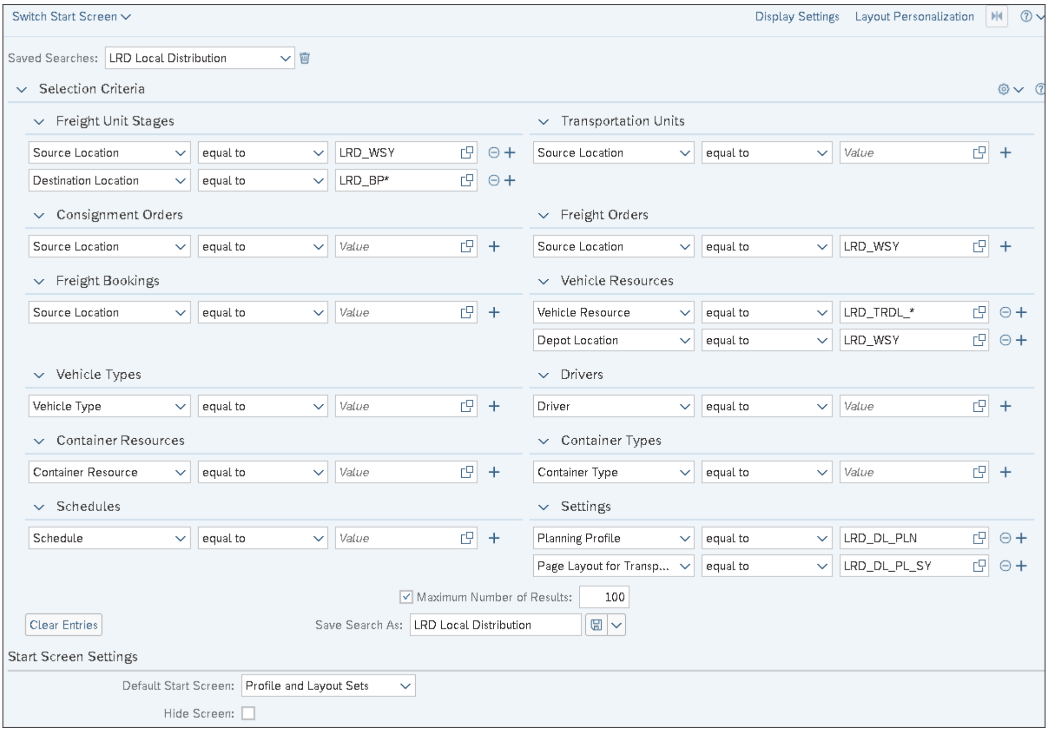


Figure 5.104 Selection Criteria

You can store alternative search criteria, and using the **Settings** button in the **Selection Criteria** row, you're able to do the following:

- Define one of the selection criteria as the default.
- Run the default when opening the selection criteria.
- Collapse the search criteria panel.
- Run the selected search automatically.

Profile and Layout Sets

Figure 5.105 shows the entry by profile and layout sets method. A profile and layout set is defined by a description; selection profiles for freight units, transportation units, consignment orders (not shown in the screenshot), freight orders, and freight bookings; capacity selection settings; incompatibility settings; transportation cockpit settings; planning profiles; and page layouts for the transportation cockpit and the planning result screen (not shown).

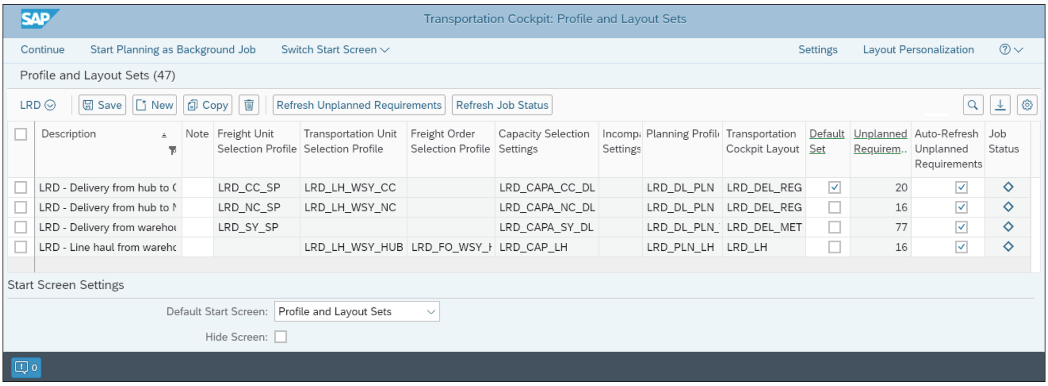


Figure 5.105 User Worklist for Profile and Layout Sets

You can define your own sets but also use predefined sets administrated centrally (see the next section). Working with multiple sets allows you to use the transportation cockpit for different scenarios. You can organize all your sets by maintaining a personal note per set and using the personalization capabilities, including sorting, grouping, filtering, and conditional formatting. If you mainly work with your own sets but occasionally substitute for your colleagues on their sets, you can use the **Substitute Set** field to identify the sets for which you act as substitute.

By selecting one set and clicking **Continue**, you can start the transportation cockpit as defined by the set. If you've defined multiple sets but usually use only one set, you can define it as the default set, which frees you from having to select it every time you start the cockpit. You can trigger a background job for the selected set and check its status in the corresponding column.

The system provides some administrative and statistical information, for example, when the set was created and changed, by whom, the last time it was used, and how many times it was used. Additionally, the system indicates the number of unplanned requirements—that is, freight units, trailer units, railcar units, container units, and package units—which is helpful for comparing the workload for a planner using several sets per day. You can refresh the number of unplanned requirements using the **Refresh Unplanned Requirements** button in the toolbar, or you can activate automatic refreshing when entering this UI. If you deal with several big scenarios, be careful when using the automatic refresh options, as this may be time-consuming.

Comparing the entries via profile and layout sets versus selection criteria, the selection criteria are simpler to maintain and very intuitive, allowing a quick start of the transportation cockpit without having to define several selection profiles. However, the entry with profile and layout sets is much more powerful because the selection profiles provide more sophisticated selections, and the individual selection profiles for the different objects can be combined and reused by multiple users. Moreover, the central administration of profile and layout sets, which will be explained soon, minimizes the overall administration efforts significantly. Especially for big companies with many users and planning scenarios, the profile and layout set approach enables structuring the users' scenarios and roles on a very systematic and fine-grained level.

Using the **Default Start Screen** choice, you can define whether selection criteria or profile and layout sets are used as the default. If you always start the cockpit with the same profile and layout set, you can set it as the default profile and layout set. Then choose the **Hide Screen** option, which suppresses the whole entry screen when you start the transportation cockpit. If you want to see the entry screen again, just start the transportation cockpit, and click the **Change Profile Selection** button. If your layout doesn't permit this, change the layout to activate this button.

Administrating Profile and Layout Sets

The administration of profile and layout sets can be started by choosing the PLS Management for Transportation Cockpit app. Figure 5.106 shows the administration worklist for profile and layout sets, which is similar to the user worklist depicted in Figure 5.105 but offers many useful additional features to simplify maintenance:

- Create, edit, delete, or copy a set, either with or without assigned users.
- Transport selected sets to another system.
- Using the user symbol in the **Actions** column, you can assign explicit users or roles, as well as define them as available for all users. Moreover, you can define individual users as substitutes for the set at hand.
- Use the **Users** button in the toolbar to perform a mass update of users. You can assign all users, remove all users, assign individuals, and remove individuals for the selected sets.
- Show sets assigned to a specific user. Together with the previous mass update function, this is helpful, for example, if you want to remove a user from all of its assigned sets.
- View similar sets in the **Similar Sets** column, which detects similar profile and layout sets. Two sets are considered similar if they have identical entries for selection profiles, capacity selection settings, incompatibility settings, and planning profile.

  If you upgraded from SAP TM 9.4 or an earlier release that didn't offer administration of profile and layout sets and where users had to create their sets completely manually, this field helps to identify equivalent sets after the upgrade. Using grouping or filtering on this column allows you to merge selected similar sets, which may significantly reduce the number of required sets—in particular if many users have been working with similar sets. Alternatively, you can use **Auto-Merge Similar Sets**, but be careful as this performs many changes automatically.

Similarly, you can manage profile and layout sets for carrier selection and delivery creation.

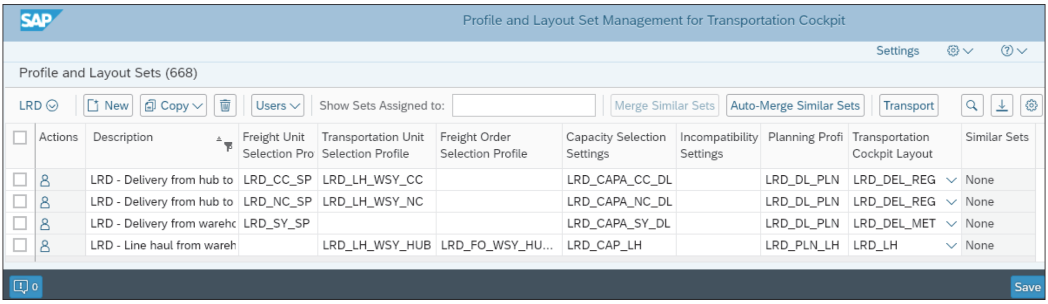


Figure 5.106 Managing Profile and Layout Sets for the Transportation Cockpit

The administration capabilities significantly simplify the usage of profile and layout sets, as the sets can be defined and assigned to users and roles centrally. In addition, this is much less error-prone than the previous approach, in which the sets had to be created individually for each user.

5.7.8 Working in the Transportation Cockpit

All building blocks of the transportation cockpit and entry options have been described in the previous sections. This section presents its functionalities for navigating through the objects, changing the appearance on the fly, manual planning, triggering automatic planning, and performing subcontracting and execution-related tasks. The transportation cockpit offers a rich set of functionalities that can be triggered by selecting objects in lists, hierarchies, the map, or the Gantt chart via buttons or drag and drop.

You can save the results of planning by clicking the **Save** button, and you can refresh the documents in the transportation cockpit session with the **Refresh** button. This may be useful if, for example, execution information from freight documents has been updated outside the transportation cockpit session.

Using the **Undo** and **Redo** buttons in the global toolbar, you can go back to previous planning states or go forward again. This is helpful if you want to compare certain plans or if you're not satisfied with your planning decision. After saving, you can't go back anymore. You can define the maximum number of steps for undo and redo in Customizing by following path **Transportation Management • Basic Functions • General Settings • Define Maximum Number of Consecutive Undo and Redo Actions**.

The main decisions made during manual planning refer to assignments of requirement document (stages) to capacity documents, which can be done explicitly or implicitly by creating a new capacity document for a resource, an equipment type, a driver, or a schedule departure. Such decisions have an impact on the affected stop sequences, and you can decide on the insertion position explicitly by using, for example, drag and drop into a location-based hierarchy, or implicitly, for example, letting the system determine the position.

Let's walk through the main settings and features you'll encounter while working in the transportation cockpit.

Transportation Cockpit Settings

The transportation cockpit settings shown in Figure 5.107 define the behavior of the transportation cockpit by the following parameters, which can be maintained by choosing **Create Transportation Cockpit Settings**:

- **Clear Selection After Successful Action**
  You can define that the selection in the cockpit is cleared after a successful action. This is quite helpful if the user iteratively selects freight unit stages to be consolidated into capacity documents. Without the clearing of the selection, the user would have to do this manually. Thus, this option can save a lot of clicks during the planner's day. However, if planners want to run several operations on the same set of selected freight orders, for example, package building and load planning, they want to keep the selection after successful actions. Therefore, it's also possible to define that the selection is kept after successful actions.
- **Default UoM for Normalized Quantity**
  This parameter allows showing the capacities of resources and equipment types regarding the normalized quantity of the specified unit of measure. Refer to Section 5.5 for planning with normalized quantities.
- **Context Det. f. Def. Drivers and Trucks**
  As mentioned in Chapter 3, Section 3.3.3, you can assign a default driver to a truck resource. In this case, the truck is considered as the default truck resource for the driver at hand. The parameter allows an implicit selection of trucks and drivers based on the explicit selection of trucks and drivers and the default relationship between trucks and drivers. For example, if the explicit selection contained only drivers, the system would pull all assigned default truck resources into the planning session too. Alternatively, if the explicit selection contained only truck resources, all assigned default drivers would be fetched into the session too. This parameter gets processed before the next one.
- **Context Determination for Res. and Docs**
  This parameter enables an automatic implicit selection of the following objects into a transportation cockpit session based on explicitly selected objects: The truck, trailer, locomotive, railcar, and container resources assigned to explicitly selected freight orders and transportation units; drivers of explicitly selected road freight orders; freight documents and transportation units (in the planning horizon) for the resources selected explicitly or implicitly; road freight orders for the drivers selected explicitly or implicitly; freight documents and transportation units (in the planning horizon) assigned to explicitly selected transportation units; and transportation units assigned to explicitly or implicitly selected freight documents. The main pur-

pose of this functionality is to ensure a complete view for the resources and drivers at hand, which is particularly important when you deal with your own fleet and need visibility on the usage of your resources and drivers (e.g., in the Gantt chart). If you run a fleet operating in Europe and want to select all trucks that have been planned to make a stop in France during the planning horizon, you can do so by explicitly selecting freight documents with France as a source or destination zone and using context determination to select the assigned trucks.

- **Skip Planning Result Screen**
  You can skip the planning result screen, which is useful if you always accept the results of the VSR optimizer that is explained in Section 5.8.1.
- **Do Not Create Transp. Prop. Immediately**
  You can control whether the transportation proposals are determined before you enter the proposal UI. Refer to Section 5.7.9 for more details on transportation proposals.
- **Skip Carrier Selection Result Screen**
  You can skip the carrier selection result screen, which is useful if you always accept the results of automatic carrier selection that is explained in Chapter 6, Section 6.5.

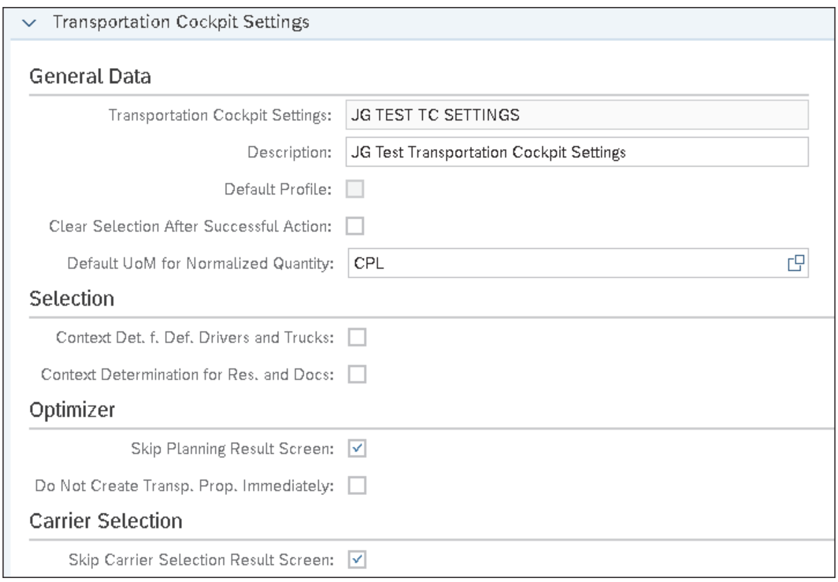


Figure 5.107 Transportation Cockpit Settings

Manual Planning Settings

As different users, businesses, or companies expect a different behavior during manual planning, the *manual planning settings* shown in Figure 5.108 allow you to define the detailed behavior:

- **Manual Planning Strategy**
  Choose from the available strategies (Section 5.6.1). For example, you can choose **VSRI_SCH** and **VSRI_1STEP** to trigger scheduling and carrier selection, respectively, after each manual planning step, or **VSRI_DEF** for the default manual planning operation without any subsequent step. When you use strategy **VSRI_ALP**, load planning is automatically triggered after each manual planning operation, such as drag and drop.
- **Consider Fixing Status**
  Define the reaction of the system to your attempt to change a fixed document in the cockpit. The system either issues a warning (in which case, you can continue planning and save the document) or reports an error (in which case, the planning operation can't be executed).
- **Remove Locations Without Activities**
  Define whether stops without any activity get removed after the manual planning operation. Note that the first and last location aren't removed if they represent the depot location of the vehicle resource.
- **Document Assignment Strategy**
  Specify how to handle the assignment of a requirement document to a capacity document if the relevant locations aren't yet included in both documents. You can insert new locations only into the capacity document or only into the requirement document. Alternatively, the system can first try to insert new locations into the capacity document and then into the requirement document. You can also copy the missing locations from the capacity document to the requirement document, or neither change the capacity document nor the requirement document.
- **Loc. Extn. Strategy of Capacity Doc.**
  Define where to insert a new location into a capacity document. You can insert it to minimize the total distance, as the start or end of the sequence, or based on the date and time of the inserted requirement document.
- **Location Movement Strategy**
  Define the result of a drag and drop. The to-be-inserted location can be inserted before or after the target location.
- **Rule for Creating Capacity Documents**
  Consolidate all selected requirement documents into one capacity document. Alternatively, you can create one capacity document for each selected requirement document stage or for all consecutive selected requirement document stages.
- **Depot Location Handling**
  Define whether the depot location is used as first, last, or first and last location in a new capacity document, or whether it's ignored.

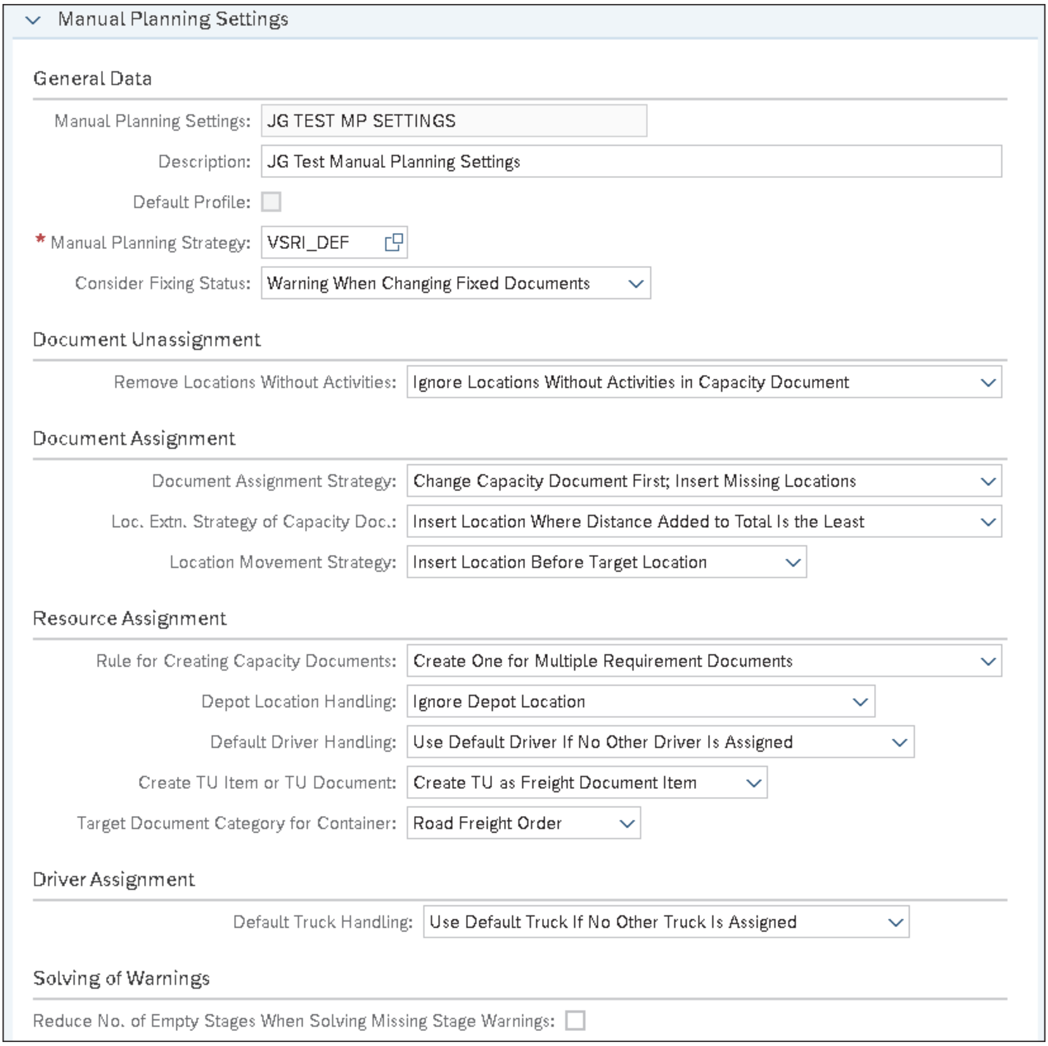


Figure 5.108 Manual Planning Settings

- **Default Driver Handling**
  Define how the default driver of a truck resource is considered when assigning a truck to a road freight order. You can ignore it, always assign the default driver to the freight order at hand, or assign the default driver only if the freight order doesn't yet have an assigned driver.
- **Create TU Item or TU Document**
  Specify whether a transportation unit as separate business document or a local resource item of a freight document is created. For example, when you assign a freight unit stage to a railcar type, the system would create a railcar unit or a local railcar item in a rail freight order.

- **Target Document Category for Container**
  If you've chosen the **Create TU as Freight Document Item** option for the previous parameter, you can specify the target document category for containers, which can be road or rail freight order, or ocean or air freight booking. Specifying the analogous target document category for trailers or railcars isn't necessary because they can only be assigned to road and rail freight orders, respectively.
- **Default Truck Handling**
  Similarly to **Default Driver Handling**, this defines how the default truck of a driver is considered when assigning a driver to a road freight order. You can ignore the default truck or use the default truck if no other truck is assigned to the freight order. Note that a truck is considered the default for a driver if the driver is the default driver for the truck.
- **Reduce No. of Empty Stages When Solving Missing Stage Warnings**
  In the Gantt chart, you can solve warnings regarding missing empty stages, which leads to inserting the required empty stages. This may cause multiple consecutive empty stages, which usually would not get executed in this way. Using this parameter, you can let the system reduce the number of consecutive empty stages. Suppose you have freight order 1 with stops A, B, C, and freight order 2 with stops D, E, F. Solving the warning for missing empty stages leads to adding D as the last stop in freight order 1 or first stop in freight order 2, depending on the setting in the **Handling of Empty Stages** section of the planning profile, as described in Section 5.6.2. If nothing is transported from B to C and from D to E, there are three empty stages B → C, C → D, and D → E, which can be reduced to B → E.

Assignment Decisions and Capacity Documents

You can make assignment decisions and create new capacity documents as follows:

- **Create new capacity documents from scratch**
  You can create a new document in a document list or hierarchy, map, or Gantt chart. Alternatively, you can create it for a resource, equipment type, driver, or schedule (departure)—in this case, the resource, equipment type, driver, or schedule departure is directly assigned to the new document. You have the option to specify the number of desired documents, which allows you to quickly create many capacity documents with just one click.
- **Drag and drop**
  You can make any assignment decision by drag and drop, be it a demand document to a capacity document or vice versa, or any document to resources, equipment types, drivers, schedules, and schedule departures. It's even possible to drag a freight order and drop it to another freight order—in this case, all requirements of the source freight order get reassigned to the target freight order. Drag and drop is supported from any list and hierarchy to any list and hierarchy, within the Gantt chart, and within the map.

- **Assign selected items**
  You can assign the selected objects—in any list, hierarchy, map, or Gantt chart—by clicking the **Assign Selected Items** or **Reassign** button (within a hierarchy).
- **Assign resource, equipment type, driver, or carrier by editable fields**
  You can edit the resource, equipment type, driver, and carrier fields in the capacity document lists.
- **Create new capacity document(s) based on demand document (stage)**
  For any set of selected requirement documents or requirement document stages, you can explicitly create one or multiple capacity documents of the same kind. For example, for a freight unit stage, you can explicitly create a package unit, container unit, railcar unit, trailer unit, consignment order, road freight order, rail freight order, ocean freight booking, or air freight booking. You can also create capacity documents based on groups, as already described in Section 5.6.2.
- **Create package units**
  You can create package units for the top-level package items in a road freight order, as described in Section 5.4.5 for integrated delivery and line-haul planning. Using the **Cancel Package Units and Merge** button for the road freight order, the package units get cancelled and their top-level packages are merged back into the freight order.
- **Create package units based on unified package building**
  You can create package units based on unified package building for the selected freight unit stages, as described in Section 5.4.5.
- **Copy capacity documents**
  You can copy capacity documents, but the document assignments won't be copied. The **Multiple Copies** button allows copying the document at hand many times with just one click.
- **Unassign from capacity document**
  By clicking the **Remove Capacity Document** button, you can revert the assignments to documents.
- **Unassign from resource, equipment type, or driver**
  You can remove the resource or equipment type assignment for capacity documents or the driver assignment from road freight orders.
- **Cancel**
  You can cancel capacity documents, which results in unassigning the assigned demand documents.

Document Stages

You can change the stages of a document as follows:

- **Split and merge stages**
  You can split and merge freight unit stages and transportation unit stages.

- **Remove unplanned stage**
  You can remove an unplanned stage of a freight unit or transportation unit, which leads to removing any unplanned preceding or subsequent stages, too.
- **Remove capacity document and merge**
  You can remove the assigned capacity document from a freight unit stage or a transportation unit stage. The system will then merge preceding and succeeding unplanned stages. This function is useful for intermodal planning, when the planner has already assigned a freight booking to the main leg of a freight unit and wants to restart planning and choose a different port.
- **Apply default route and unassign default route**
  For a freight unit stage or a transportation unit stage, the system determines a matching default route and creates stages accordingly. You can also unassign a default route. See Chapter 3, Section 3.2.6, for more details on default routes.
- **Insert and remove locations**
  Within the hierarchies, you can insert new stops and remove stops from a transportation unit and a freight order.
- **Edit stages popup**
  Using the **Edit Stages** button, you get a popup in which you can maintain the stage sequence and additional information for a capacity document, such as dates and times.
- **Create triangulation and revoke triangulation**
  For an empty container unit stage, you can create a triangulation with another selected matching empty container unit stage. Suppose you have an empty return stage from location A and an empty provisioning stage to location B. You can reduce mileage and costs by performing a triangulation that unifies the two empty stages with one new empty stage from A to B. Using the **Create Triangulation** button, the system offers a popup with available stages among which you can choose to perform the triangulation. Using the **Revoke Triangulation** button, you can go back to the original situation. These functions are offered analogously for a container unit, railcar unit, and railcar unit stage.

Additional Manual Functions

The following additional useful functions are offered:

- **Split and merge quantities**
  You can manually split off or merge partial quantities for product items in freight units, which leads to splitting or merging freight units.
- **Mass change**
  Using the **Mass Change** button, you can change certain properties, such as dates and times, for many capacity documents at the same time.
- **Editable fields**
  Beyond the assignment decisions mentioned previously, you can also change dates

and times of capacity documents, which may trigger rescheduling if configured by the manual planning strategy, and the means of transport. You can also change the source and destination (air-)port, and the movement type of freight bookings. Basically, all fields offered in the create document dialogs of freight documents can also be changed by editable fields in the corresponding lists.

- **Command-line planning**
  You can also use command-line planning, which allows you to enter an assignment command in a text field. For example, the command `5 6 7 – 2` assigns the freight unit stages with indexes 5, 6, and 7 to the vehicle resource with index 2.
- **Interaction with map**
  Using the **Update Map** button, you can add or remove selected objects, add all objects to the map, or clear the map and add selected objects (with all resources, if desired). Using the **Actions** column in lists, hierarchies, and the Gantt chart, you can add or remove the object at hand; the icon indicates whether the object is already on the map.
- **Determine distance and duration**
  You can determine the distance and duration for a freight unit stage, package unit stage, container unit stage, trailer unit stage, or railcar unit stage, based on the configured strategy. This is useful if you're sure that the previously determined values aren't correct.
- **Exclusive package for customer versus standard consolidation**
  For selected freight unit stages, you can define whether a customer-exclusive package is desired or consolidation into packages with other customers is allowed. This property is considered during package building on the freight order level.
- **Load plan status management**
  For selected trailer units, container units, and road freight orders, you can set the load plan status (capacity) to **Planned**, **Not Planned**, and **Finalized**. Additionally, you can also set all top-level packages to **Planned**, **Not Planned**, or **Finalized** for selected package unit stages, container unit stages, trailer unit stages, consignment orders, and road freight orders. Refer to Section 5.7.6 for more details.
- **Last planned location and availability time**
  For manual planning of your own resources and drivers, it's key to know where they are supposed to be according to the current plan and when they are available for new transports after the current plan. The system provides the **Last Planned Location** and **Availability Time** fields, which can be displayed as columns in any list for resources—of course, including the Gantt chart—as described in SAP Notes 2051868 and 2187025. While the Gantt chart itself creates visibility on the availability time in a graphical fashion and can display the location as text in the chart, these two columns allow sorting and filtering, which is particularly important if you deal with lots of resources that can't be displayed at the same time in the corresponding screen area. If you create a new freight order for a truck resource after its current availability time, the two

fields are updated automatically according to the last location and the end time of the last activity in the new freight order.

As described in Section 5.7.4, you can also display a resource on the map at its last planned location.

Local Resource Items

As explained in Section 5.4.2, Section 5.4.3, and Section 5.4.4, trailer units, railcar units, and container units represent self-contained business documents. They can be created by freight unit building or planning, and enable stage-based planning; that is, the transportation unit gets transported by multiple freight documents. It's also possible to represent a trailer, railcar, or container as a local resource item in a freight document, which can be appropriate if it doesn't need to get planned across multiple stages. The transportation cockpit shows local resource items in hierarchies and offers assignment operations, such as drag and drop, editable fields, and assigning selected items, as described previously. In addition, it offers the following operations to plan with local resource items:

- **Insert item**
  Creates a local container item, trailer item, or railcar item, either with or without the defined equipment type. You can define how many such items will be created.
- **Delete item**
  Deletes the selected local container items, trailer items, or railcar items.
- **Remove equipment type**
  Removes the equipment type from the selected local resource items.

While the VSR optimizer and load planning don't consider local resource items, and load consolidation can't create local resource items, unified package building considers the product and package items within local container and trailer items.

Automatic and Semiautomatic Planning

In addition to manual planning, you can also trigger automatic and semiautomatic planning from the transportation cockpit:

- **Scheduling**
  The start and end times for all activities represented by selected freight documents and transportation units are scheduled automatically. As defined in the scheduling settings, the scheduling direction can be forward or backward. Refer to Section 5.7.10 for more details on scheduling.
- **Optimization**
  You can run the VSR optimizer on all the data in the cockpit, only the selected objects, or the selected objects together with all resources in the session. See Section 5.8 for more details on the VSR optimizer.

- **Unified package building**
  Unified package building can be used to create the packaging hierarchy for package units, container units, trailer units, consignment orders, and road freight orders. See Section 5.3 for more details. You can also remove the packages created before.
- **Load planning**
  This triggers load planning for the selected road freight orders, trailer units, or container units. The results are shown in the **Load Plan** detailed view as described in Section 5.7.6. Refer to Section 5.8.8 for more details on load planning. You can also clear the load plan.
- **Load consolidation**
  Load consolidation is run for all data in the cockpit, only the selected objects, or the selected demands with all resources. This process can create road freight orders, trailer units, and container units based on freight unit and package units as input. If its consolidation mode is based on load planning, you can review the results in the **Load Plan** detailed view too. See Section 5.8.7 for details on load consolidation.
- **Transportation proposal**
  The system can determine a set of transportation proposals for the selected freight unit stage, from which you can choose one proposal. See Section 5.7.9 for more details.
- **Explanation – optimizer planning**
  This tool helps you understand the input and output data for automatic planning—that is, for VSR optimization, transportation proposals, load planning, and load consolidation. See Section 5.8.6 for more details on the explanation tool.
- **Explanation – scheduling**
  This tool helps you analyze the result of scheduling and visualizes the considered constraints. Refer to Section 5.7.10 for more details.

User Interface Adaption

You can adapt the UI in the same cockpit session as follows:

- **Maximize**
  Using the **Maximize** button in the top-right corner of each screen area, you can focus on that screen area shown in full window size and then go back to the original layout.
- **Page layout**
  You can switch between alternative page layouts.
- **Resizing columns of the page layout**
  Using the **Enable Column Resizing** button in the top-right corner of the transportation cockpit and a divider between the left and right column, you can adjust the relative width to any other percentage, such as 40% for the left column and 60% for the right column.

- **Skip result screens**
  If you always accept the result of the carrier selection or the VSR optimizer, you can skip the result screen by default, which will always save you one click for accepting it. The result screens can be skipped by parameters in the transportation cockpit settings introduced earlier in this section.
- **Dual view**
  You can trigger the dual view (Section 5.7.3), switch between its horizontal and vertical versions, and then go back to the original page layout. If you've selected objects in the tab from which you trigger the dual view, only these objects are shown in the dual view.
- **Change hierarchy**
  You can switch between alternative hierarchical views.
- **Change (column) view**
  For each list and hierarchy, you can choose which columns are contained, define the ordering of the columns, and define the width (in pixels) for each column. Additionally, you can freeze a selected number of columns so that they remain visible and are protected against horizontal scrolling. You can also define sorting, filtering, and conditional formatting. All this is captured in a personalized view, and you can switch between alternative views that you've defined. The lists also provide a grouping and aggregation functionality, which can be personalized; group objects by predefined criteria; and aggregate columns by determining the maximum, minimum, average, sum value, or distinct count for all entities in a group.

See Figure 5.109 for an example of freight unit stages shown in maximized view and grouped by unloading location. The bottom row provides the total aggregation, and the row above shows the aggregation of selected rows (triggered by the sum icon, highlighted in the top-right corner). Volume and weight are aggregated by sum, while the other aggregations represent the distinct count.

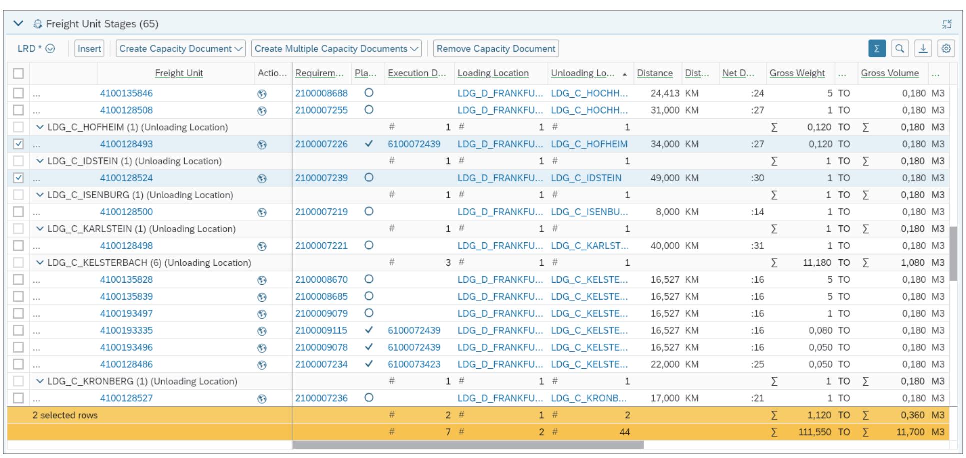


Figure 5.109 Grouped Freight Unit Stage List with Aggregation Rows

Navigation

Navigation through the objects in the various lists and hierarchies is possible as follows:

- **Sorting**
  Sort according to a sequence of columns, and store this information in the personalized view.
- **Filtering**
  Define filters for multiple attributes, and store this in the personalized view.
- **Searching**
  Search by free text field, and iterate through the search results, which get highlighted in the corresponding lists and hierarchies.
- **Expanding and collapsing hierarchies**
  Expand or collapse all nodes or all selected nodes.
- **Hyperlinks**
  Use hyperlinks that are provided for all documents and master data to easily jump to the detailed UI for the object at hand. Such navigation is also offered via context menu, which is particularly helpful for editable fields (e.g., carrier and resource) that don't provide hyperlinks.
- **Quick views**
  Hover over a cell in a list or hierarchy to open a quick view popup, which displays additional information for the object at hand, as shown in Figure 5.110. See SAP Note 2262509 for how to change or enhance the content according to your needs.

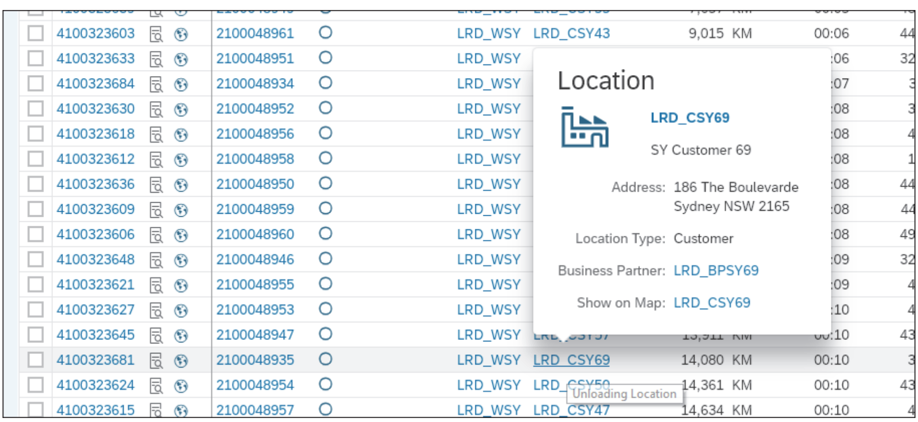


Figure 5.110 Quick View for Location

Usage of Quick Views

We recommend reducing the visible columns in a list or hierarchy to those required for sorting, filtering, grouping, aggregating, conditional formatting, and comparing. Put any extra information into quick views (e.g., street name for a location's address) because you probably won't sort rows by this field. As a consequence, fewer columns are needed in lists, hierarchies, and Gantt charts, leading to performance improvements and less scrolling and searching efforts.

Planning Session Environment

You can adjust the environment for your planning session as follows:

- **Change planning settings**
  Adjust several parameters in the planning session, as shown in Figure 5.111. The initial values stem from the planning profile and its assigned subprofiles.
- **Change profile selection**
  Go back to the selection screen to adjust the selection and restart the cockpit.
- **Insert**
  Insert new resources, equipment types, drivers, schedules, and documents into the cockpit session.
- **Context determination**
  Determine the context of the selected resources and drivers; in other words, additional freight documents or transportation units inside the planning horizon are fetched into the planning session, as explained in Section 5.6.2.
- **Change display settings**
  Using this function in the top-right corner of the transportation cockpit, choose between user or individual time zone, use location-specific time zones, use a short time format, define the format for durations (e.g., hours and minutes, or full days and fraction of days), use the default unit of measure for distances (kilometer) or use an individual one, or disable text wrapping in column headers.

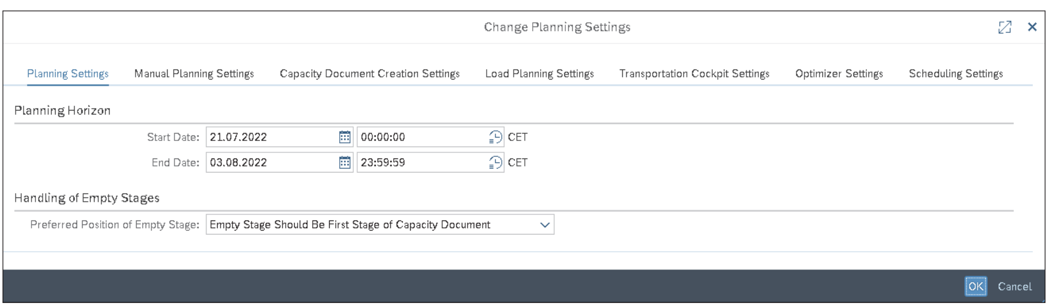


Figure 5.111 Change Planning Settings in the Planning Session

Subcontracting, Execution, and Additional Features

In addition to all its planning capabilities, the cockpit can be used as a work center for subcontracting and execution tasks. You can execute the following subcontracting activities from the cockpit:

- **Carrier selection**
  Start manual or automatic carrier selection, determine the available carriers and store them in the carrier ranking list, remove the carrier assignment, and clear the carrier ranking list.
- **Tendering**
  Start and stop the tendering process, and create requests for quotation.
- **Subcontracting**
  Send a freight document to the carrier.
- **Invoicing carrier per stage**
  Definethat the invoicing carrier can be edited per stage, as allowed by the rail freight order hierarchy.

You can also trigger execution-related activities for the freight documents at hand:

- **Calculate charges**
  Trigger charge calculation for the selected freight documents and consignment orders.
- **Printing**
  Print freight documents or review the print preview first. This covers creating PDF files for the load plan, which is also supported for container units, as described in Section 5.7.6.
- **Insert and change warehouse loading and unloading stops**
  Insert and change warehouse loading stops within hierarchies for freight unit stages, package units, container units, trailer units, consignment orders, and road freight orders. See Chapter 12, Section 12.2, for more details.
- **Status management**
  For freight orders, update their general status (e.g., **In Process**, **In Execution**, or **Completed**), or the specific status regarding advanced shipping and receiving (see Chapter 12, Section 12.3), for example, **Arrived**, **Checked In**, or **Checked Out**. You can also perform more updates, for example, regarding the security status for freight orders or the organization interaction status for freight units, as described in Section 5.2.2.
- **Create delivery proposals**
  The system can create delivery proposals as explained in Chapter 4, Section 4.1.3.
- **Create export declaration**
  Refer to Chapter 8, Section 8.1.4, for more details.

The system provides the following additional features:

- **Check**
  The system performs a check of the selected transportation units, consignment orders, and freight documents.
- **Export to spreadsheet**
  The content of a list or hierarchy can be exported into a spreadsheet file.

Flexibility

The various planning activities don't have to be performed in a predefined sequence. Therefore, you have full flexibility to use the most efficient and effective sequence of planning steps for your scenario. For example, you can use the VSR optimizer to create freight documents and then manually adjust the plan. Alternatively, you can create freight documents before the cockpit session via a nightly VSR optimizer background run that assigns freight units to the freight documents or by systematically creating schedule-based freight documents for a certain time period, as described in Chapter 6, Section 6.4.2, and then manually assigning freight units to them. You can also create new schedule-based freight documents in the cockpit by choosing an appropriate schedule and departure.

Resources can be chosen manually or by the optimizer. You can first create road freight orders, then assign freight units, and select a vehicle resource. Alternatively, you can assign freight units directly to a resource to create a freight document.

In truck and trailer scenarios, you may first determine the stages of the trailer units and then assign appropriate vehicle resources, but you could also first define the stages of the vehicle resources and then assign matching trailer units or let the VSR optimizer determine the whole plan.

5.7.9 Transportation Proposal

The transportation proposal engine automatically determines a set of alternative proposals for one requirement document stage or for multiple requirement document stages from the same original requirement document (e.g., sales order or forwarding order), thereby considering the complete transportation network definition and all the other constraints for automatic planning, as described in Section 5.8. The alternatives are presented to you for making your choice, as shown in Figure 5.112.

Alternatively, you can refine your preferences or change some parameters and let the system again determine new transportation proposals according to your preferences and parameters. Because the transportation proposal combines automatic planning—for determining the alternatives—and manual interaction choosing from those alternatives, this planning process can be called semiautomatic.

Similar to the transportation cockpit, there are multiple entry options for the transportation proposal UI. You can trigger it directly from a forwarding order by defining the actual route, as described in Chapter 4, Section 4.2.1, or from the forwarding order POWL query by defining the route for a selected forwarding order via the follow-up button. The forwarding order type Customizing allows you to declare the planning profile and page layout for the transportation proposal. There, you can also define how the selected proposal is copied into the forwarding order, considering either only its route or its whole plan, including start and end times.

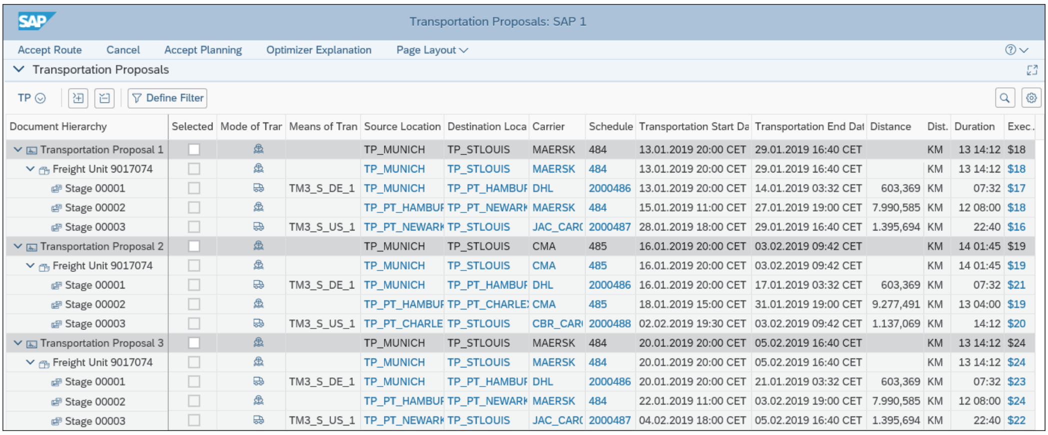


Figure 5.112 Proposal Layout: Only Results

In the transportation cockpit, you can select a freight unit stage, container unit stage, package unit stage, or railcar unit stage, and click the corresponding button to trigger the transportation proposal UI. The manually chosen result is directly applied to the selected demand document stage in the cockpit. If multiple consecutive stages of the same document have been selected, the corresponding transshipment locations are preserved; however, additional transshipment locations could be inserted. Only one alternative is provided for the distribution stage of a package unit of the linear with distribution type.

The transportation proposal UI employs the page layout concept, as already mentioned in Section 5.7.2. The page layout for transportation proposals (see Figure 5.113) offers the following screen areas:

- **Transportation Proposals**
  This screen area contains a hierarchical display of the transportation proposals, structured with proposals on the first level, demand documents on the second level (omitted if you call the proposal for one document only), and stages on the third level. This screen area allows you to choose from the proposals, so it should be activated in the page layout. You can sort the transportation proposals via the available columns or use the filter in the toolbar. Collapsing and expanding the hierarchy allows you to compare the proposals on an aggregated level and analyze the stages of the proposals in greater detail, respectively. Personalization of the hierarchy's columns is supported too, as in the transportation cockpit.
- **Map Display**
  This area shows a geographical map, enabling comparison of the proposals on the map. You can add and remove proposals from the map using the button in the **Actions** column or add all proposals by using the **Show All on Map** button.

- **Transportation Proposal Preferences**
  This area, as shown in Figure 5.114, allows you to define preferences that are considered by the automatic transportation proposal determination.

Like the page layout for the transportation cockpit, one to three of these alternative screen areas can be placed on a grid with three rows and two columns, with each screen area covering either two columns or only one column. Figure 5.113 shows an example of the results area on top and the map on the bottom.

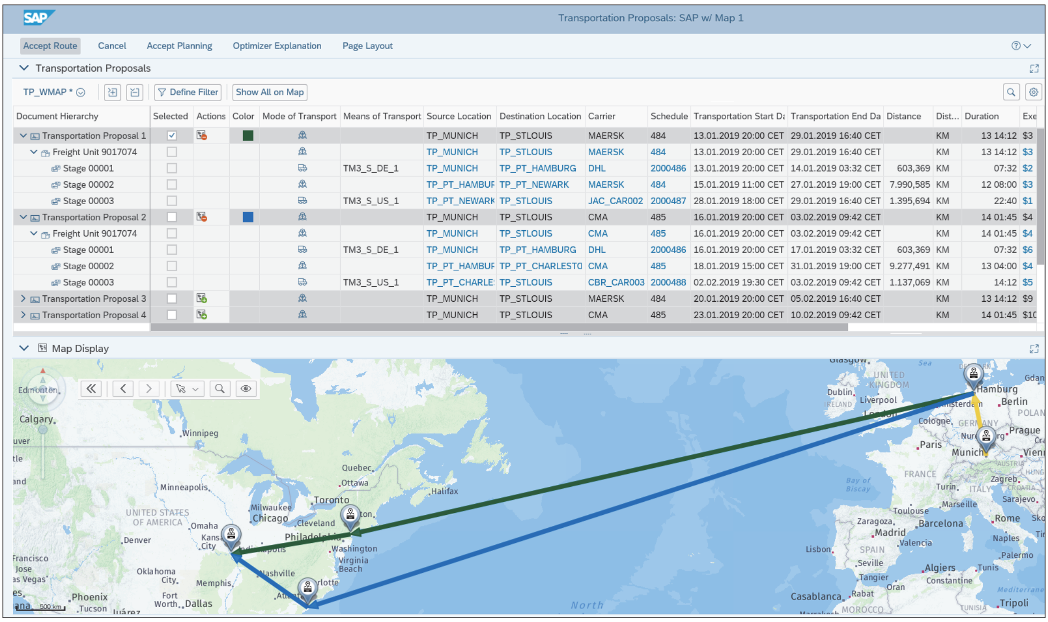


Figure 5.113 Proposal Layout: Results and Map

The preferences can be entered before triggering a new transportation proposal determination. (See Figure 5.114 for a layout that has preferences on the top and results and map on the bottom.) Suppose that you transport goods from Germany to the United States, and you want them to go via ocean and the port in Hamburg. You can use the **Stages** area in the **Transportation Proposal Preferences** area to define that the transport must contain a stage from the port in Hamburg to the destination location and that ocean is used as the mode of transport for this stage. Note that the system would still be allowed to split this stage into one main stage and a subsequent stage, which would then result in an ocean main stage and a subsequent stage that could be handled by road or rail, but not the air mode of transport. You can also predefine a sequence of transshipment locations (e.g., to force the system to determine only transportation proposals going via the ports in Hamburg and Newark).

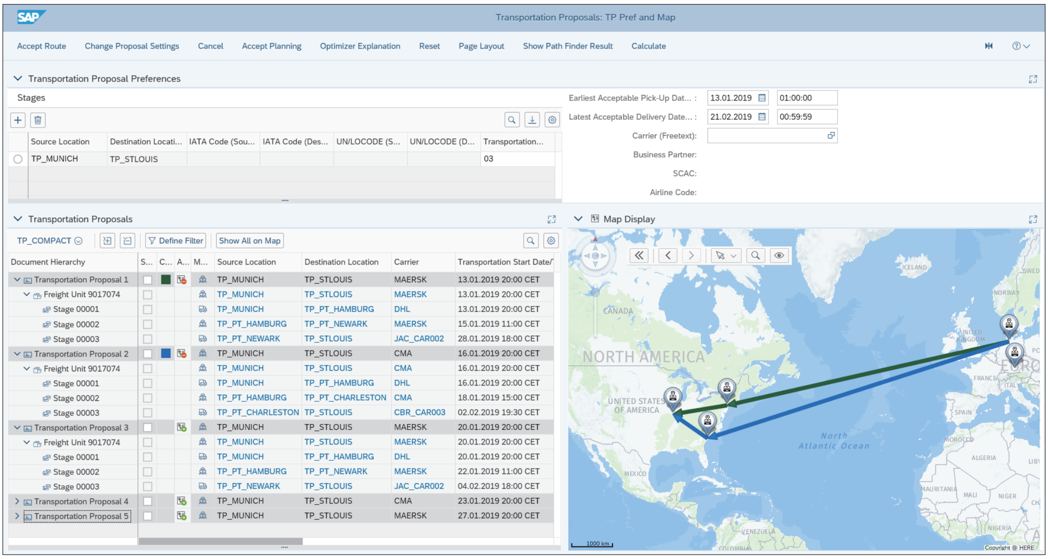


Figure 5.114 Proposal Layout: Preferences Results Map

Besides the preferences for transshipment locations and mode of transport per stage, you can also predefine a carrier and dates and times for loading at the source and unloading at the destination. The system determines proposals that have at least one stage covered by the predefined carrier, and loading and unloading doesn't take place earlier or later than the corresponding preferences.

Analogously to the transportation cockpit, you can define alternative page layouts in the **Page Layout Switch** section of the page layout for the transportation proposal. If you've maintained at least one alternative page layout, the **Page Layout** button in the transportation proposal UI allows you to switch between the defined alternative page layouts.

The **Pushbuttons for Application Toolbar** section in the page layout for transportation proposals offers the following buttons:

- **Accept Route**
  Allows acceptance of only the route of the result; that is, only the stages for the forwarding order or demand document at hand are stored according to the proposal.
- **Accept Planning**
  Stores the complete plan of the proposal, including start and end times.
- **Calculate**
  Triggers a new transportation proposal determination.
- **Change Proposal Settings**
  Opens a popup with parameters, which you can change for this transportation proposal session. Initially, these parameters are defined as in the planning profile. Overruling these may be useful, for example, if you're used to considering the capacities

of air freight bookings, but no satisfactory proposal is found. Then you can relax the booking capacity check to find better proposals, knowing that you can increase the corresponding capacity as necessary later.

- **Reset**
  Resets the preferences and allows restarting the transportation proposal determination, which may be required if you tried several preferences but didn't find a satisfactory transportation proposal.
- **Show Path Finder Result**
  Allows you to search for connections and display them on the map, which is helpful for analyzing your network definition. This functionality is also available in the transportation network cockpit and is described in detail in Chapter 3, Section 3.2.8.
- **Optimizer Explanation**
  Helps decipher the input and output data of the transportation proposal determination. It's described in more detail in Section 5.8.6.

The optimizer settings contain two groups of parameters dedicated to the transportation proposal. The **Transportation Proposal Settings** section offers the following parameters:

- **Accept Transportation Proposal**
  You can predefine whether only the route of the selected proposal result is stored or the corresponding freight documents are considered too. Alternatively, you can keep this parameter undefined, letting the user choose between these two options in the transportation proposal UI.
- **Planning Strategy for Transportation Proposal**
  This allows you to define whether only the transportation proposals are determined (strategy **VSR_DEF**) or carrier selection is performed for each transportation proposal (**VSR_1STEP**), as already mentioned in Section 5.6.1.
- **Maximum Number of Transportation Proposals**
  This parameter defines how many alternative proposals are shown in the UI. Note that automatic planning may yield fewer proposals (e.g., if the network or capacity situation doesn't allow offering the defined number of proposals).

The **Transportation Proposal Preferences** section, visible after clicking the **Advanced Settings** button in the optimizer settings, contains parameters to control the diversity of the determined transportation proposals. For each diversity criterion, you can define the relevance to be high, medium, or low; set it as not relevant; or rely on the default behavior in the transportation proposal algorithm. The following parameters are offered:

- **Route Variation**
  This determines the relevance of how the demand document is routed through the network. If this aspect is relevant, the system searches for transportation proposals

differing in their used transshipment locations, modes of transport, and means of transport.

- **Carrier Variation**
  This parameter controls whether the system searches for proposals differing in their carriers. For example, if this parameter is relevant, but the previous parameter isn't, the system would determine the best routing through the network and search for alternative proposals along this routing that use different carriers.
- **Departure Date Variation**
  Defining this parameter as relevant, the system searches for proposals with alternative departure and arrival dates and times. For example, if the previous two parameters are irrelevant, the system would determine the best routing and carrier and search for alternative departure and arrival dates and times.
- **Time Relevance**
  In the trade-off of timely delivery versus transportation costs, this parameter defines the relevance of timely delivery. If time relevance is high, but cost relevance isn't applicable, the system focuses on transportation proposals that meet the demand document's time windows as closely as possible; if no time windows have been specified, it delivers the goods as early as possible.
- **Cost Relevance**
  In the trade-off of timely delivery versus costs, this parameter defines the relevance of transportation costs. If cost relevance is high, but time relevance isn't applicable, the system searches for minimum cost proposals, and compromises on timely delivery are allowed (within the hard time windows of the freight units).

As mentioned in Section 5.7.8, the transportation cockpit settings offer the **Don't Create Transp. Prop. Immediately** parameter, which controls whether the proposals are determined before you enter the proposal UI. If you want to maintain preferences first, you can activate this parameter so that proposals are calculated only after you click the **Calculate** button.

Note that the transportation proposal determination is performed by a special operating mode of the VSR optimizer; its technical details are described in Section 5.8.2.

5.7.10 Scheduling

Scheduling determines the start and end times for a set of activities while considering multiple constraints, such as a predefined relative ordering among the activities, time windows for the activities, and the availability of vehicle types and resources. Scheduling can be triggered for one or more selected freight documents. The Gantt chart is the best tool to visualize and explain scheduling. Let's review the example shown in Figure 5.115.

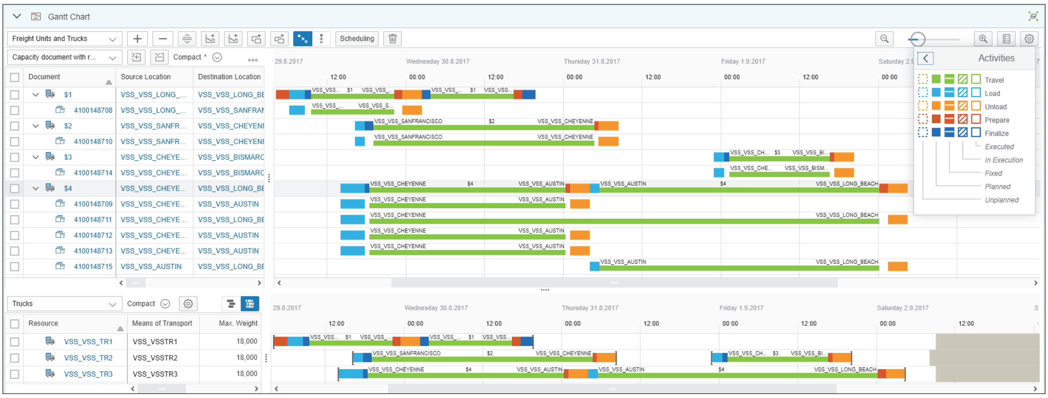


Figure 5.115 Gantt Chart with Freight Order/Freight Unit Hierarchy and Trucks

A freight order represents a sequence of activities. While a travel activity is a movement between two locations, all other activities take place at a location. A loading activity can represent one or multiple freight units being loaded, and the start and end time of the loading activity at the freight order stop is propagated to the assigned freight units, in this example, for freight order **$3**. Unloading activities are handled similarly. Preparing and finalizing are activities independent of the transported cargo and may represent check-in or check-out activities. Coupling and uncoupling activities (not shown in Figure 5.115) refer to a truck and trailer and are used in scenarios with dynamic recoupling, such as trailer swaps, as described in Section 5.4.2 and shown earlier in Figure 5.38.

The durations for loading, unloading, preparing, finalizing, coupling, and uncoupling can be defined in the scheduling settings, which are explained in Section 5.8.4, and the duration for traveling is determined based on the distance, as explained in Chapter 3, Section 3.2.3.

There is a natural ordering of the different activity types during one stop:

1. Prepare
2. Uncouple
3. Unload
4. Load
5. Couple
6. Finalize

As you would expect, prepare and finalize are the first and last activity types. Uncoupling takes place as early as possible, and coupling takes place as late as possible to maximize the flexibility of handling trailers and not restricting them by the bottleneck—the truck. Unloading takes place before loading because loading could not be possible otherwise, due to the capacity constraint of the resource at hand.

The freight order **$3** represents the stop sequence Cheyenne, Austin, and Long Beach. The stop sequence can be defined by manual or automated planning. Scheduling respects the given stop sequence and doesn't change it—the only purpose of scheduling is to assign start and end times to the activities of the capacity document at hand. If you prefer the stop sequence Cheyenne, Long Beach, and Austin, you can do so by manually changing it and then scheduling it again. The scheduling algorithm can be run forward or backward, which can be set in the scheduling settings described in Section 5.8.4. Forward scheduling uses the first activity to be scheduled as the anchor, defines its start and end times, and then iterates through the whole activity sequence until the last activity is reached, assigning start and end times for each activity. Backward scheduling uses the last activity to be scheduled as the anchor, defines its start and end times, and then iterates through the activity sequence until the first activity is reached, assigning start and end times for each activity. For both directions, the algorithm tries to schedule the activities as compactly as possible to avoid idle times between the activities. However, time windows and other constraints may make it impossible to avoid idle times entirely.

Forward scheduling is useful if you want to push the goods out of a depot to minimize your inventory. Backward scheduling aims at meeting the delivery time window as closely as possible, and your transportation happens "just in time" before the delivery.

You can trigger scheduling by buttons, or by a drag and drop in the Gantt chart. Using the parameter `/SCMTMS/SCH_FORCE` in the user's master data, you can configure the system to perform scheduling for a freight order when you've entered the departure date. The values `X` and `T` for this parameter activate this behavior for all UIs offering scheduling and only the transportation cockpit, respectively.

Scheduling can be triggered for freight orders in execution, which allows adapting the dates and times based on reported progress or delays in execution. If a travel, loading, or unloading activity is in execution or already executed, all its logical predecessor activities are considered executed too, and thus their dates and times aren't changed. In general, scheduling doesn't change a fixed date and time, for example, a fixed departure time.

While scheduling can be triggered for freight orders, it's also supported for unplanned demand documents, such as freight units, trailer units, railcar units, container units, and package units. The latter requires activating the distance and duration determination in the corresponding requirement document type, and it can be triggered during freight unit building or by applying a default route. Scheduling unplanned demand documents is useful because it already indicates the expected transportation duration before planning the document at hand.

Scheduling considers the following constraints:

- Planning horizon defined in the planning profile as described in Section 5.6.2
- Time windows for loading and unloading activities, as specified for the corresponding freight units and other demand documents, as described in Section 5.2.2

- Availability of active vehicle types and resources, as defined in the capacity availability settings, as explained in Section 5.8.4
- Availability of single resources based on already assigned and scheduled documents, which haven't been selected for scheduling
- Operating times and handling resources' calendars and capacities for loading and unloading activities, as described in Chapter 3, Section 3.3.5
- Minimum and maximum goods wait times defined for transshipment locations, as described in Chapter 3, Section 3.2.1
- Scheduling constraints to reflect driving time regulations, as described in Section 5.8.4

The scheduling settings define how scheduling will consider the time windows of freight units: either both hard and soft time windows are considered, only soft time windows are considered, or time windows are ignored. Considering all time windows is the most restrictive version and may cause the scheduler to fail if your time windows make it too hard to find a feasible scheduling for the activities at hand. However, not considering the time windows at all may lead to extreme solutions that fully exploit the boundaries of the planning horizon. Therefore, you should carefully specify these parameters and consider the interplay with the planning horizon to ensure that scheduling can produce the desired results. Refer to SAP Note 1908165 for handling time windows in the scheduling algorithm and the VSR optimizer.

Since the SAP S/4HANA 2020 release, *embedded scheduling* is the default and represented by the scheduling strategy `VSS_EMBED` that you can maintain in the scheduling settings (Section 5.8.4). In earlier releases, scheduling was performed by a special operating mode of the VSR optimizer, which can still be used by the scheduling strategy `VSS_DEF` but requires an optimizer server (Section 5.8.2 for technical details). The two scheduling strategies don't necessarily create the same result, but both deliver a correct result regarding the involved data and constraints. Embedded scheduling considers requested dates in a cost-based approach that can be activated by the **Cost-Based Requested Dates/Times** parameter in the scheduling settings. This option isn't supported by strategy `VSS_DEF`. Note that scheduling constraints are supported by `VSS_DEF` but not by embedded scheduling.

Choosing **Explain Scheduling Results** allows you to review the latest embedded scheduling runs in a list. Per run, you can see its status and which action triggered scheduling, which is very useful information if you want to analyze why scheduling was called at all. In the list, you can choose one run and review its result in more detail, as shown in Figure 5.116.

With the dropdown menu in the top-left corner, you can choose among alternative activity groups, which is useful if scheduling was run on different, independent resources and you want to focus only on the activities of one resource. Similar to the Gantt chart, you can use two views and choose the content per view, which can be the activity view and truck view, or the handling resource view. In the example, freight order activities are shown on the first level of the hierarchy, and freight unit activities appear in the second level of the hierarchy. As the scheduling algorithm performs multiple phases, you can choose the phase you would like to review. In the depicted example, the final solution is shown in both views, from different perspectives, but you could also compare the initial or any intermediate solution with the final one via the dropdown menu in the local toolbar. This allows you to iterate through the different steps of the algorithm. Using the legend menu in the top-right corner, you can choose whether time windows and relationships between activities get shown. While this visual tool doesn't explain the result verbally, it enables a thorough analysis of the scheduling results, which helps to identify the root cause of unexpected results, for example, missing or unexpected constraints such as time windows or relationships.

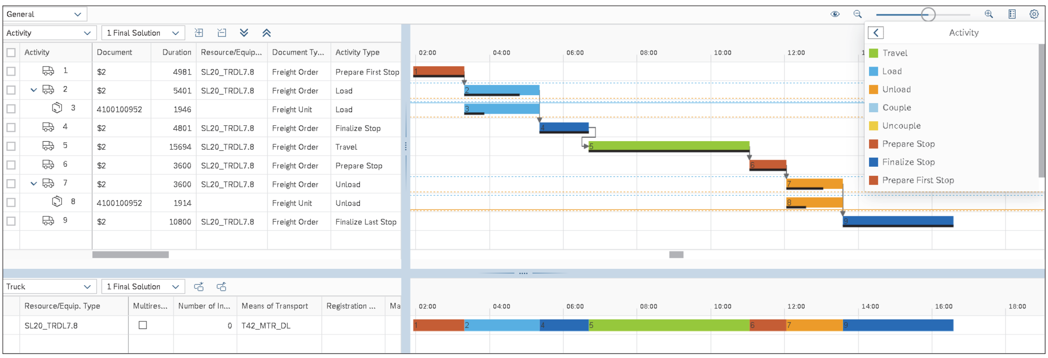


Figure 5.116 Explain Scheduling Results

Note that the color settings are taken from the default Gantt chart layout, and you need to set the parameter /SCMTMS/EXP in the user's master data to X to save the scheduling run for this tool.

5.8 Automated Planning

In contrast to the previous section, our focus now is on planning processes that don't require user interaction. One way of limiting user interaction is to omit it completely, as in the zero-click process described in Section 5.2.3. Freight orders are created automatically instead of freight units upon the creation of their predecessor business documents, and subsequent planning steps such as carrier selection and tendering are triggered either by background jobs or process controller strategies. Thus, planning in the background is the first topic here.

In the zero-click process, freight orders are actually rule based (i.e., created using freight unit building rules). This way, the planning process of creating freight orders (i.e., choosing the right vehicle resource, choosing the shortest path for the vehicle resource, and choosing the best possible time schedule for loading and unloading) is omitted. These tasks can be done manually or interactively, as described in the previous section, by using the VSR optimizer (as standard functionality) or defining custom planning strategies. How the VSR optimizer creates transportation plans in a structured way is the main topic of this section.

Finally, automated planning is also supported in other transactions outside the planning domain. The route functionality to create stages based on default routes directly in the forwarding order (as described in Chapter 4, Section 4.2) or the transportation proposal functionality (as described in Section 5.7.9) are examples of automated planning that requires some user interaction. The DSO (Section 5.2) is a means of using "real" costs in the automated planning step.

When we elaborate on planning in the remainder of this chapter, only the first planning step that creates the freight order is addressed. Subsequent planning steps, such as carrier selection and tendering, are discussed in detail in Chapter 6.

5.8.1 Background Planning and Vehicle Scheduling and Routing

You can initiate background planning in the backend by starting Transaction /SCMTMS/BACKGRD_PLAN from menu path **Logistics • Transportation Management • Administration • Background Processing • Run Planning**, scheduling the report /SCMTMS/VSR_OPT_BGD, or clicking the **Start Planning in Background** button in the transportation cockpit. Figure 5.117 shows the configuration options of this report. The **FU/CO/TU/FO/FB Selection Profile** fields determine the *scope*, that is, which documents (stages) are selected for planning in the background. In the **Additional Order Selection** section, additional documents can be added to the selection. The **Planning Profile** field determines the *method*, that is, the planning strategy (e.g., whether carrier selection should be included with planning strategy VSR_1STEP), available capacities, planning costs, and constraints.

Background planning is used when limited or no user expertise is required or even desired for creating a reasonable transportation plan. Thus, it can be used in simple planning scenarios (e.g., to group freight units by temperature requirements and assign them to a suitable resource). Both grouping of freight units with similar temperature requirements and their resource assignment can be expressed by the definition of incompatibilities, which then implies that freight units are sorted and assigned properly. In this type of scenario, automated planning takes the burden of manual assignments from the transportation planner, and a high volume of freight units and freight orders can be processed in a short amount of time.

However, background planning can also be used in rather complex scenarios (e.g., if the consolidation of freight units into freight orders involves complex routing and scheduling decisions) because many freight units with different delivery windows based on fixed appointments have to be delivered to many destination locations with a limited number of vehicle resources. In this case, the decision situation is rather complex because of the combinatorial nature of the planning problem; the VSR optimizer can explore many more alternatives to find the best possible solution than a human planner can in the same amount of time. For this kind of scenario, background planning can be scheduled overnight, and the transportation planner can check and adapt the results in the morning upon arriving to work.

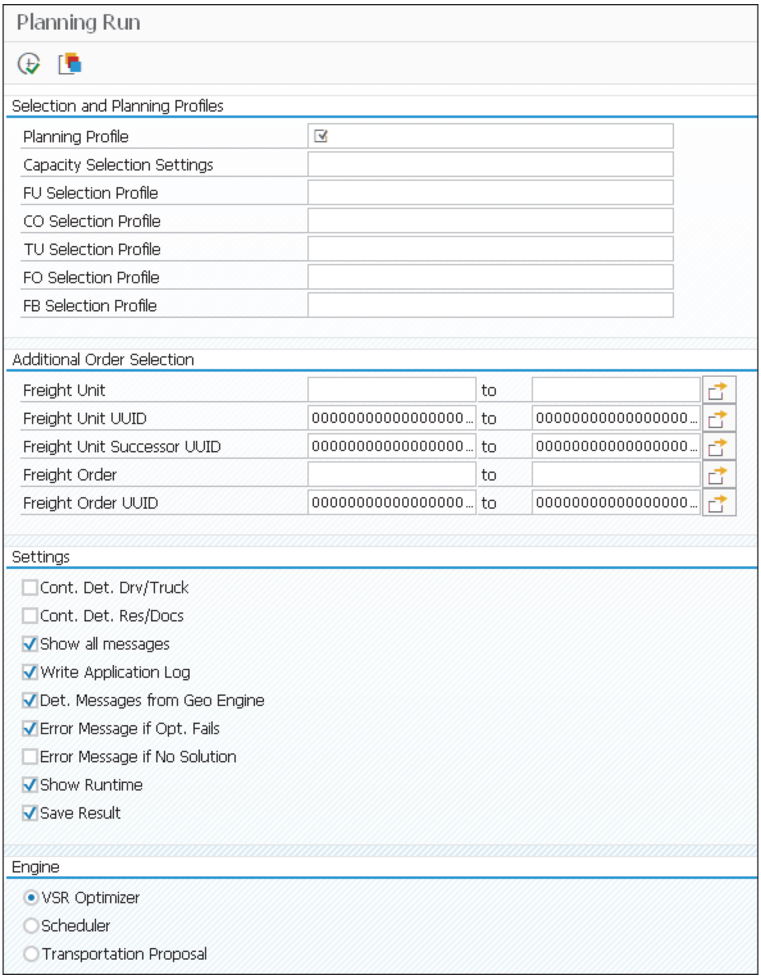


Figure 5.117 Background Planning

Using the background job scheduler (report /SCMTMS/BGD_JOB_SCHEDULER, see Figure 5.118), you can define a sequence of background planning reports to run consecutively, for example, if you want to plan the different transportation stages of your freight units separately and want to take the planning result of one stage into account while planning the next stage. You can control whether the successor job should run after the failure of a predecessor job via the **Cancel Run After a Job Failed** flag. The background job scheduler report can be executed directly or in the background. In the latter case, the results can be found in the job overview of Transaction SM37.

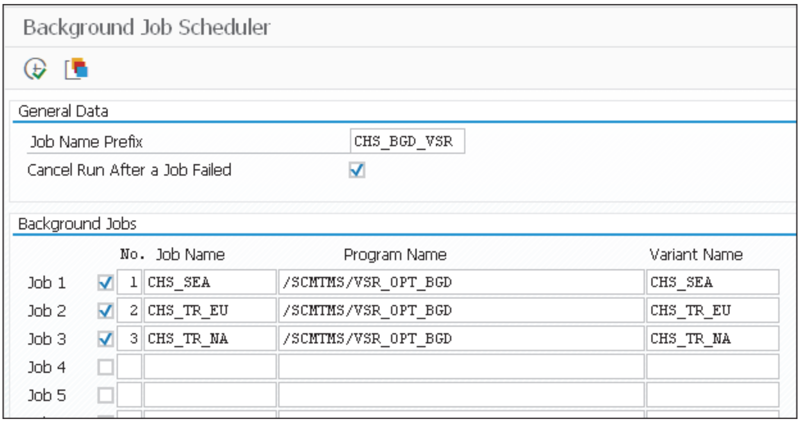


Figure 5.118 Background Job Scheduler

To enable the automatic creation of a systematic transportation plan, a suitable framework needs to be defined that allows the maintenance of the objectives, rules, and constraints to which the planning result should adhere. The VSR optimizer engine provides this framework. For this purpose, the VSR optimizer requires all relevant data for this task:

- **Freight units**
  Freight units (precisely, freight unit stages, because the different stages of a freight unit can be planned independently of each other in a transportation chain) are selected directly via the selection profile.
- **Transportation capacities**
  Transportation capacities are selected via the planning profile and can be vehicle resources, vehicle types, container resources, container types or schedules (selected via capacity selection settings), existing freight orders (selected via the selection profile for freight orders), transportation units (selected via the selection profile for transportation units), or freight bookings (selected via the selection profile for freight bookings).
- **Master data**
  Finally, the relevant master data (i.e., the transportation network consisting of information about locations, transportation zones, transportation lanes, and transshipment hierarchies) is retrieved based on the selected freight units and transportation capacities.

During automated planning, the system has to consider dependent objects to keep all objects consistent and at the same time consider the effects of parallel processing (e.g., if other users or reports try to change the same objects in parallel).

The selection of dependent objects is called *context determination*. It's relevant, for example, in a scenario in which new freight units are assigned to existing freight orders. In this case, the existing freight orders (created either manually or automatically) already have freight units assigned. These freight units are also relevant because their constraints (i.e., pickup and delivery windows) or properties (i.e., required temperature conditions in transportation) need to be respected if the freight order is adapted. The same is valid in the opposite case. If a freight unit needs to be transported via several stages, some of these stages may already have been planned, so existing freight orders for some stages can apply relevant context information for the current planning scope. Finally, the context information for vehicle resources is determined to limit the timely and geographical availability of a fleet based on already-scheduled freight orders.

Objects that haven't been explicitly selected but have been retrieved via context determination are only for information purposes; that is, they aren't changed by the VSR optimizer but only impose additional side constraints.

To keep planning data consistent while several users work in parallel, a locking concept is imposed to allow parallel planning. If different users or processes of the same user try to access the same object (e.g., a vehicle resource) in manual planning or in VSR optimization, a message that the object is locked is issued. Only the user or process that locked the object is allowed to change it. Subsequent processes can't change the locked object until the lock is released. Freight bookings are exempt from this locking concept. The VSR optimizer or a transportation proposal can both access the freight booking in parallel, with both processes being able to use the remaining capacity of the freight booking. Because saving is done in an asynchronous mode, this can result in overbooking the freight booking.

Locking of Multiresources

Recall from Chapter 3, Section 3.3, that multiresources are often used to represent external vehicle resources in subcontracting scenarios. If these are available only in a limited number for certain means of transport, you can specify in Customizing (via **Transportation Management • Master Data • Resources • Means of Transport and Compartment • Define Means of Transport**) whether these multiresources are locked. However, the lock applies to all copies of the multiresources at once.

5.8.2 Configuring Optimizer Settings

The configuration of the VSR optimizer is primarily done in the Edit Optimizer Settings app (see Figure 5.119), and the optimizer settings are subsequently assigned to the planning profile.

Defining a **Planning Strategy** is mandatory because the system needs to know whether only the VSR optimizer should be used (**VSR_DEF**) or another process step should be triggered subsequently, such as carrier selection (**VSR_1STEP**) or load planning (**VSR_ALP**). The freight order building rule (**FO Building Rule**) decides how freight orders are structured. If the same vehicle resource is scheduled to pick up freight units from several locations and deliver to several locations, different freight orders can be created either based on the load of the vehicle (**New Freight Order when Resource is Empty**) or whenever it returns to its depot location (**New FO when Resource is Empty and Depot Location Reached**).

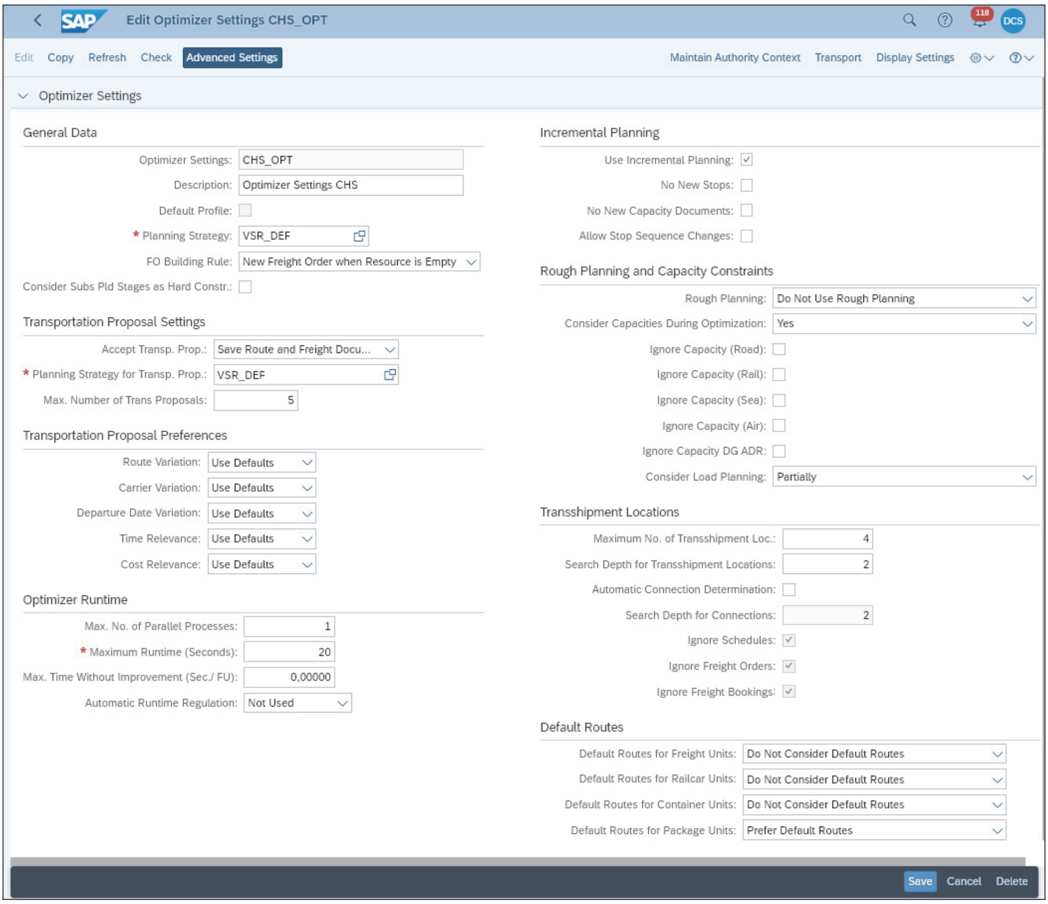


Figure 5.119 Optimizer Settings

Use Incremental Planning is an option to keep parts of an existing transportation plan and only add new freight units to it. While the standard behavior of the VSR optimizer is to delete existing freight orders and create new freight orders, incremental planning allows certain information to be retained from an existing plan. Use cases include adding freight units to freight orders that are already in execution or changing freight orders that have already been published to carriers. In these cases, you can't delete the existing freight orders and replace them with new ones, but you need to retain certain attributes of the freight order (e.g., freight order number, location sequence, and existing assignment of freight units). If incremental planning is selected, the VSR optimizer will keep the existing assignment of freight units to freight orders. In addition, you can choose from three additional options or a combination thereof:

- **No New Stops**
  The VSR optimizer can only add additional freight units to existing freight orders if there is remaining capacity and corresponding stops exist. The stop sequence of existing freight orders is fixed, but new freight orders can be created.
- **No New Capacity Documents**
  The VSR optimizer can add new freight units to existing freight orders but isn't allowed to create new freight orders. This option may be used if you've defined empty default tours that may be changed by the VSR optimizer, but no additional tours should be created.
- **Allow Stop Sequence Changes**
  The VSR optimizer can change the stop sequence of existing freight orders, except for the first and last location. A use case for this option is a scenario in which a planner has manually created freight orders, but you want the system to optimize their routing.

Business Add-In for Incremental Planning

If you use a business add-in (BAdI) implementation, more sophisticated limitations can be specified for incremental planning, for example, that new stops in a freight order can only be created for a predefined subset of locations or that a tour may be extended but shouldn't exceed a certain duration. SAP Note 1866364 explains how this is achieved.

You have to define a **Maximum Runtime (Seconds)** to specify the amount of time the algorithm uses to calculate the best possible result. The required runtime depends on many factors (e.g., number of freight units to be planned, number of available vehicle resources, and complexity of the transportation network) and has to be determined during testing. It's possible to define a second termination criterion for the VSR optimizer: **Max. Time Without Improvement (Sec./ FU)**. If the VSR optimizer doesn't improve the best solution found for the defined amount of time per freight unit, then it's automatically terminated prior to the defined maximum runtime. A third option is to leave the decision regarding when to stop with the VSR optimizer by using **Automatic Runtime Regulation**. You can choose from **Not Used**, **Fastest**, **Fast**, **Balanced**, **Good Quality**, **High Quality**, and **Highest Quality** options depending on whether you want to fully use the maximum runtime to compute the highest quality solution or whether you want to sacrifice speed versus quality.

Modern hardware can parallelize processes. The **Max. No. of Parallel Processes** field allows you to define how many parallel processes the VSR optimizer is allowed to start. Each process requires one CPU core, so this setting needs to take into account the available hardware as well as the number of parallel users that can run the VSR optimizer at the same time.

The transportation proposal settings and transportation proposal preferences refer to the use of the VSR optimizer for creating transportation proposals, as explained in Section 5.7.9.

Rough Planning and Capacity Constraints deal with exact or rough duration determination in planning (**Rough Planning**) and whether vehicle capacities should impose a constraint for planning with the VSR optimizer. For many business processes, it isn't important to plan complete, end-to-end transportation in detail. For example, it may be important to find the right flights, but it's known that the airport can be reached within a predefined time interval (e.g., eight hours), and planning for this stage of the journey doesn't require the same degree of precision. The assignment of a transshipment location to a transportation zone (i.e., an entry or exit point into a transportation network) can be used to allow planners to specify a duration that can be used for *rough planning* instead of the exact distance and duration determined based on transportation lanes. This means that a detailed transportation network (transportation lanes) isn't required for the pre-carriage/on-carriage in this kind of scenario. Furthermore, capacities of certain transportation modes may be ignored as well as the calculation of European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) points for the transportation of dangerous goods.

While load planning will be a separate topic and covered in detail in Section 5.8.8, in some scenarios, aspects of load planning should be considered already during VSR optimization because, otherwise, freight orders will be created that can't be executed. For this purpose, the VSR optimizer essentially generates additional internal dimensions for floor space and upper deck capacity to respect packages' footprints, stackability (e.g., some packages may not be stacked on each other), and positions (e.g., some packages may be loaded to the lower deck only). Because the consideration of load-planning constraints has a performance impact on the VSR optimizer, the **Consider Load Planning** option can be switched on (**Partially**) or off (**No**).

The parameters for **Transshipment Locations** influence the complexity of the transportation network and therefore have a significant impact on the amount of time required to calculate a reasonable planning result. The **Maximum No. of Transshipment Loc.** field defines the number of transshipment locations any freight unit is allowed to be routed through between its source and destination. It should be as small as possible to limit the number of paths in the transportation network that the VSR optimizer has to consider as possible alternatives.

To ease maintenance of the transportation network, you don't need to define transshipment locations that are part of a schedule explicitly as transshipment locations, but **Automatic Connection Determination** can be activated in the optimizer settings. This implies that all possible connection points (stops of flight or carrier schedules) are implicitly considered transshipment locations (see Chapter 3, Section 3.2.5).

Default Routes (see Chapter 3, Section 3.2.6) can be considered for freight units, container units, railcar units, and package units in the VSR optimizer. You have four options for whether default routes will influence the planning result:

- **Only Consider Default Routes**
  The VSR optimizer considers only default routes as possible routing alternatives.
- **Prefer Default Routes**
  The VSR optimizer chooses a default route if it represents a feasible routing alternative but searches for alternatives if no feasible default route exists.
- **Also Consider Default Routes**
  The VSR optimizer returns the lowest cost routing, independently of whether it has been defined as a default route.
- **Do Not Consider Default Routes**
  The VSR optimizer doesn't consider any default routes.

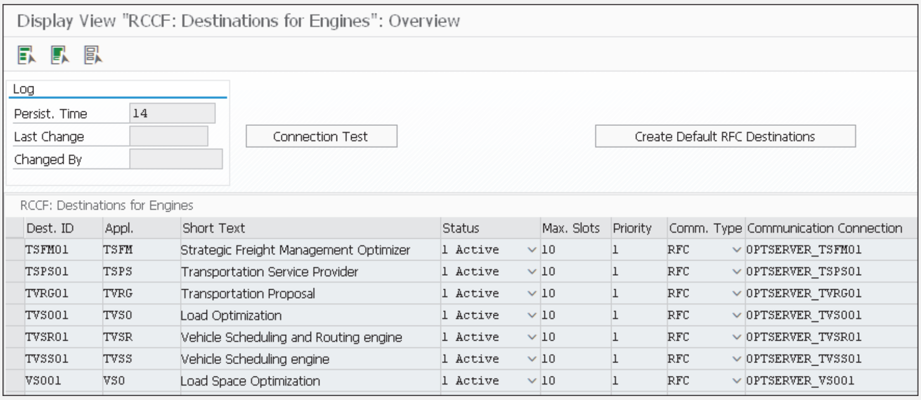
Technical Configuration of the VSR Optimizer

The VSR optimizer is a separate piece of software that has been developed for performance reasons in C++ and not in ABAP. Technically, the optimizer is called via the *remote control and communication framework* (RCCF) using a remote function call (RFC). You'll find relevant transactions for the technical configuration in the backend system at **Cross-Application-Components • Processes and Tools for Enterprise Applications • Remote Control and Communication Framework**.

In the Edit Destinations transaction, Transaction RCC_CUST (see Figure 5.120), you can define which hardware you have available for the VSR optimizer and the other external engines and how these can be reached. The following applications are other external engines that use the same framework:

- **TSPS**: Carrier selection
- **TVRG**: Transportation proposal
- **TVSR**: VSR optimizer
- **TVSS**: Manual scheduling
- **TVSO**: Load optimization
- **TSFM**: Strategic freight management

The **Communication Connection** column defines the RFC connection and is defined in Transaction SM59 (TCP/IP Connections). The **Max. Slots** column refers to the number of CPU cores available at the destination server. If these are already in use, and an additional optimization run is started, it's canceled immediately because no hardware is available to process the request. If several destinations (**Dest. ID**) are defined for the same application (**Appl.**), the **Priority** column determines the sequence that the VSR optimizer tries to use for these servers.

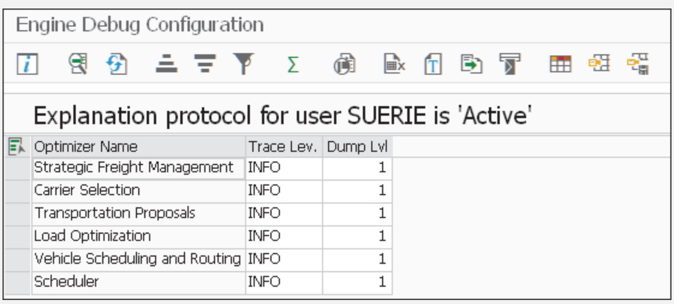


Dest. ID	Appl.	Short Text	Status	Max. Slots	Priority	Comm. Type	Communication Connection
TSFM01	TSFM	Strategic Freight Management Optimizer	1 Active	10	1	RFC	OPTSERVER_TSFM01
TSPS01	TSPS	Transportation Service Provider	1 Active	10	1	RFC	OPTSERVER_TSPS01
TVRG01	TVRG	Transportation Proposal	1 Active	10	1	RFC	OPTSERVER_TVRG01
TVS001	TVSO	Load Optimization	1 Active	10	1	RFC	OPTSERVER_TVS001
TVSR01	TVSR	Vehicle Scheduling and Routing engine	1 Active	10	1	RFC	OPTSERVER_TVSR01
TVSS01	TVSS	Vehicle Scheduling engine	1 Active	10	1	RFC	OPTSERVER_TVSS01
VS001	VSO	Load Space Optimization	1 Active	10	1	RFC	OPTSERVER_VS001

Figure 5.120 RCCF: Edit Destinations

The **Persist. Time** field specifies how many days the planning logs are kept in the system before they are deleted. The logs can help you analyze the planning result and are explained in Section 5.8.6 in more detail. The logs are also required for SAP Support to reproduce VSR optimizer behavior in the case of an error in any of these engines. For this purpose, set the optimizer **Trace Lev.** to **INFO** and the optimizer **Dump Lvl** to **1** in Transaction /SCMTMS/OPT10 (Engine Debug Configuration), as shown in Figure 5.121.

The correct installation and technical setup of all destinations can be checked in the Version Display transaction. If a version is displayed as **Version Information**, then everything is fine. Note that the engines are downward-compatible and therefore have to be of the same or a newer version and support pack than the application.



Optimizer Name	Trace Lev.	Dump Lvl
Strategic Freight Management	INFO	1
Carrier Selection	INFO	1
Transportation Proposals	INFO	1
Load Optimization	INFO	1
Vehicle Scheduling and Routing	INFO	1
Scheduler	INFO	1

Figure 5.121 RCCF: Engine Debug Configuration

The Display Active Sessions transaction, Transaction RCC_SESSION, provides a monitoring tool for currently running sessions of all engines using the RCCF. This transaction can also be used to terminate background runs.

Finally, the optimization data can be manipulated prior to the engine run, when the relevant data is sent to the optimizer (e.g., to add additional constraints on the fly) and after the engine run (to adapt the results). This is done in BAdI `/SCMTMS/PLN_PRE_PROC` to preprocess the optimization data and in BAdI `/SCMTMS/PLN_POST_PROC` to postprocess the planning result.

5.8.3 Vehicle Scheduling and Routing: Planning Objectives

For the VSR optimizer engine to create a reasonable transportation plan, you need to define an objective. Individual objectives may be different in different implementation projects or even for different planning situations in the same implementation. This can be illustrated by a simple example.

Assume this is a simple planning situation with only one source location (plant) and only one delivery location (customer). The customer orders the equivalent of half a truck of goods every day. In this situation, there are two possible solutions from a transportation planning point of view:

- Every day, a truck delivers the goods from the plant to the customer. However, this truck is only half full (or half empty). Although this solution isn't very efficient because of the low truck utilization, it provides a high service level because the customer is served exactly as needed.
- The customer is served every other day with a full truckload. This solution is very efficient from a transportation perspective (100% truck utilization), but the customer service level is poor because the customer is provided 50% of the orders either one day early or one day late based on the delivery pattern.

Which solution is better and will be created from the VSR engine? The answer depends on the individual situation; either one may be preferred. The first solution may be preferred if there are inventory/warehousing constraints at the customer location or if the shelf-life of goods doesn't allow their storage but forces daily deliveries. The second solution is preferred in competitive situations if cost is the driving decision criterion. The VSR engine can create both solutions, and which one is returned depends on the defined objective. Thus, the relation between different cost elements must reflect the user's business objectives to make it possible to calculate the right solution.

The VSR optimizer is governed by a cost minimization objective. The cost elements depend on the freight units as well as on the transportation capacities. Freight unit-dependent cost elements influence the service level (timely pickup and delivery), whereas transportation capacity–related cost elements influence their efficient usage. In the previous example, the first solution is returned if the freight unit-dependent costs for earliness and lateness are high compared to the transportation capacity-related cost because, in that case, it would be expensive to violate the delivery window for half of the goods. The second solution is returned if the transportation capacity–related costs are higher.

Let's look at which cost elements are considered. Most of them are defined in the Create Constraints and Costs Settings app (see Figure 5.122 and Figure 5.123).

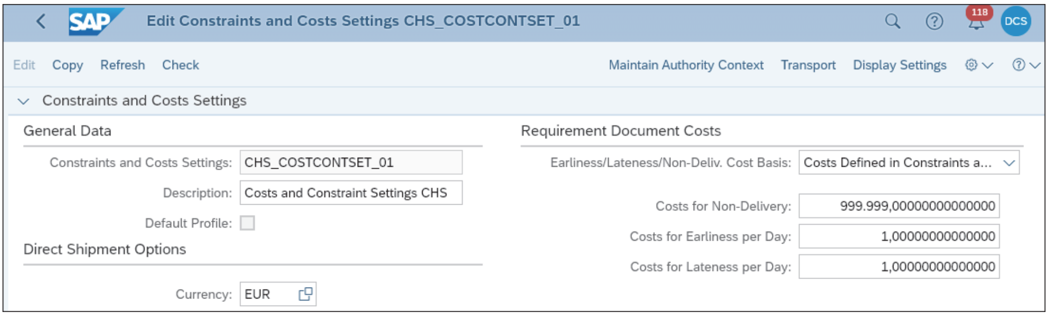


Figure 5.122 Constraints and Cost Settings: Requirement Document Costs

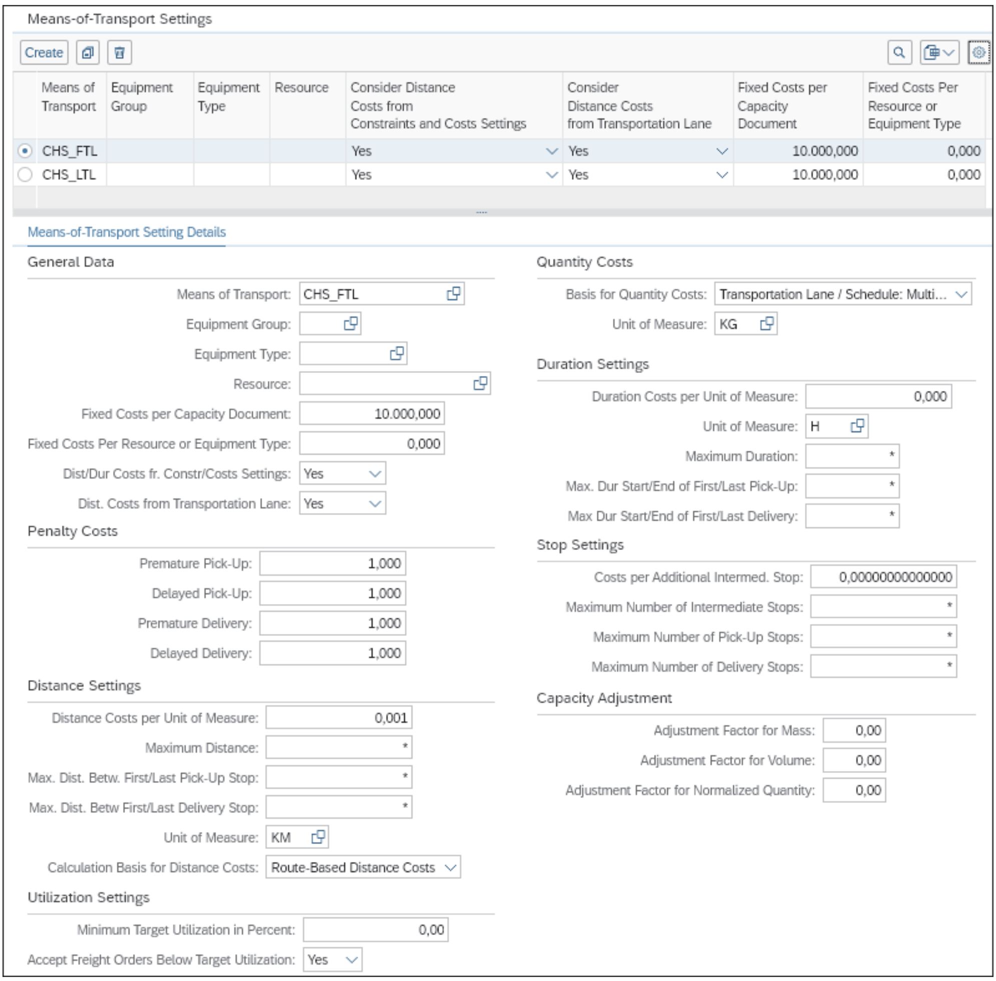


Figure 5.123 Constraints and Costs Settings: Means-of-Transport Settings Details

Freight unit costs can be defined either directly in the Constraints and Costs Settings app or via a condition (type /SCMTMS/FU_PNLT_COST) that is assigned in that screen. If a condition is used, different costs can be defined based on the characteristics of each freight unit (e.g., different lateness penalties depending on customer priority) or based on whether pickup or delivery windows are violated:

- Costs for nondelivery are incurred in the cost objective if a freight unit isn't transported. By default, they are set very high to force the VSR optimizer to find a solution because nondelivery isn't usually a valid option.
- Costs for earliness per day apply to both early pickup and early delivery of a freight unit. The duration of the earliness is calculated as the interval between the scheduled time of the pickup/delivery and the requested date to start. Whether the start or end of the loading/unloading activity counts toward this calculation is defined in the condition for pickup/delivery time window determination (Section 5.2.2).
- Costs for lateness per day also apply to both late pickup and late delivery of a freight unit. The duration of the lateness is calculated as the interval between the scheduled time of the pickup/delivery and the requested date to end. Whether the start or end of the loading/unloading activity counts toward this calculation is defined in the condition for pickup/delivery time window determination (Section 5.2.2).

Means-of-transport costs define the transportation capacity costs and can be maintained directly in the Constraints and Costs Settings app (see Figure 5.123) and, to some extent, in transportation lane master data (see Chapter 3, Section 3.2.3). These costs can relate to means of transports, vehicle/equipment types, or individual vehicle resources.

Means-of-transport costs can be defined differently for all means of transport or even for particular vehicle resources in the scope of the planning scenario:

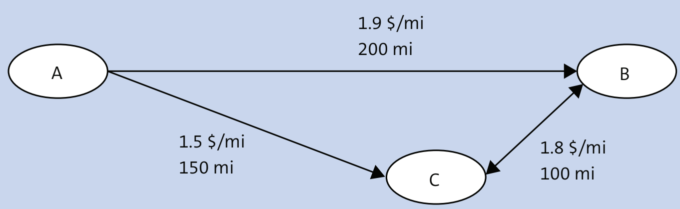
- **Fixed costs**
  These costs are incurred in the objective function either per freight order or per vehicle resource. Therefore, fixed costs can be used to minimize the number of vehicle resources used or to select between different available vehicle resources.
- **Penalty costs**
  These costs are factors that apply to freight unit–dependent earliness and lateness costs. These factors can be used to distinguish earliness and lateness based on the means of transport. For example, violating a pickup window for an ocean transport is much more expensive than for a truck transport.
- **Distance-dependent costs**
  These costs per means of transport can be maintained in the Create Constraints and Costs Settings app or in the transportation lane (**Mns of Trsp. Costs** field). The actual distance of the freight order is multiplied by the costs per distance unit (see Chapter 3, Section 3.2.3, for the determination of transportation distances). In North America and other parts of the world, different concepts for calculating distance-dependent

costs exist. In North America, these are known as *destination-based distance costs*; in Europe, they are *route-based distance costs*.

Figure 5.124 provides an example that illustrates the different calculation concepts, which can even result in different optimal solutions. Destination-based distance costs are calculated by multiplying the actual distance of the complete freight order with the distance cost from the transportation lane between the source and the destination. Route-based distance costs are calculated by multiplying the actual distance of each stage with the cost of the transportation lane for this stage and summing up the costs for the individual stages.

Finally, a *minimum cost* can be defined that applies to distance costs calculated for a freight order. A typical example is a scenario in which freight costs are usually variable based on the distance (e.g., $2/mi), but a minimum of $300 applies because short trips less than 150 miles aren't economical with only variable rates. The minimum cost can be defined in the transportation lane master data (**Min. MTr Costs** field).

Distance costs are usually minimized to lower fuel consumption or reduce operating times of the vehicle resources.



Destination-based cost:
Freight order (A→B→C) = Distance (A→B→C) * Cost (A→C) = 300 * 1.5 = 450 $
Freight order (A→C→B) = Distance (A→C→B) * Cost (A→B) = 250 * 1.9 = 475 $

Route-based cost:
Freight order (A→B→C) = Distance (A→B) * Cost (A→B) + Distance (B→C) * Cost (B→C) = 200 * 1.9 + 100 * 1.8 = 560 $
Freight order (A→C→B) = Distance (A→C) * Cost (A→C) + Distance (C→B) * Cost (C→B) = 150 * 1.5 + 100 * 1.8 = 405 $

Figure 5.124 Destination-Based Cost versus Route-Based Cost Calculation

- **Duration costs**
  These costs refer to the actual use of vehicle resources. They are incurred from its first use (loading) until its last use (unloading). The duration is multiplied with the cost per duration unit. Duration costs can be used to minimize operating times, perhaps to create a compact transportation plan with limited idle time.
- **Quantity costs**
  These costs based on a unit of measure (e.g., kilogram or cubic meter) can be incurred into the objective function or not (**No Costs** selected in the **Basis for Quantity Costs**

dropdown box). If quantity costs are considered, they can be distance independent or distance dependent. For distance-dependent quantity costs, the freight order quantity is multiplied by the actual distance. This calculation is done stage by stage. Additionally, you can define quantity costs universally in the Create Constraints and Costs Settings app or based on the geography in the transportation lane.

Transported quantities can have an impact on fuel consumption and may therefore be considered distance-dependent cost elements in the objective.

- **Additional stop costs**
  These costs can be used to minimize the number of stops in a freight order. The costs per additional intermediary stop are incurred for each stop that isn't the source or destination of the freight order. For example, in a freight order from A via B to C, the costs per additional intermediary stop would be incurred once for the intermediary stop at B.

Cost Functions

In addition, you can define *cost functions* using a BAdI implementation in `/SCMTMS/PLN_PRE_PROC` and assign them to the means of transport for one loading dimension. A cost function is a stepwise linear function that is referenced to a unit of measure when assigned to a means of transport (see Figure 5.125). The cost function is intended to load vehicles in a more efficient way by associating a cost with the vehicle resource that is dependent on the load of the resource in the referenced unit of measure.

In the example in Figure 5.125, a load cost of 10,000 is defined if the vehicle is loaded with less than 15,000 kg. From 15,000 kg, the load cost is 500 and decreasing linearly to 0 at the vehicle capacity of 20,000 kg. With this cost pattern, the VSR optimizer would try to load a vehicle resource with at least 15,000 kg.

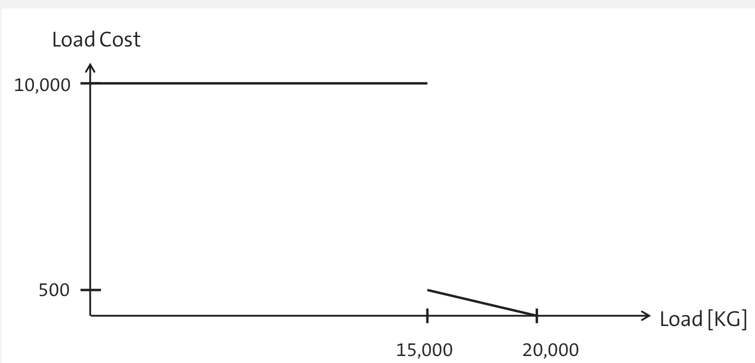


Figure 5.125 Cost Function

Cost functions are sometimes used to achieve a minimum utilization of freight orders. However, keep in mind that sacrificing a good routing for a better utilization is rarely a reasonable choice. More options to deal with a minimum utilization objective are dealt with in the next section.

5.8.4 Vehicle Scheduling and Routing: Planning Constraints

The VSR optimizer tries to minimize all different cost elements introduced in Section 5.8.3. The creation of a minimal cost transportation plan also must adhere to certain constraints. These planning constraints model the physical or execution-related restrictions of the real world in the planning system. For example, because of physical or legal restrictions, trucks can transport only a certain load, which is expressed as a maximum mass, maximum volume, and/or maximum number of pallets, that needs to be considered as a capacity constraint in the freight order. Many constraints are available in the VSR optimizer, which we'll discuss. However, it's important to note that good modeling practice isn't to constrain a planning problem too much; instead, use only those constraints that influence the planning decision.

Capacity Constraints

Capacity constraints are important in transportation planning and are considered hard constraints; that is, the VSR optimizer doesn't create any solution that violates capacity constraints. The VSR optimizer would rather decide not to transport a freight unit (and incur a high nondelivery cost) than violate a capacity constraint. Capacity constraints can be expressed in vehicle resource master data (see Chapter 3, Section 3.3) or in Customizing for vehicle types (**Transportation Management • Master Data • Resources • General Settings • Define Equipment Groups and Equipment Types**). Vehicle resources are required if you need to consider each physical vehicle individually during planning, for example, if vehicle resources represent trucks of your own fleet. If you regularly subcontract freight orders to carriers, you can either use vehicle resources flagged as multiresources to avoid individual maintenance or plan based on vehicle/equipment types.

For each vehicle resource, the VSR optimizer can consider up to eight different capacity dimensions. The prevailing dimensions are mass, volume, and floor space (number of pallets). Only those dimensions that have also been defined as capacity requirements in the freight unit (i.e., those that have been defined as planning quantities in the freight unit building rule; see Section 5.2.3) are considered in planning. In addition to capacity constraints, the temporal availability defined in the resource master data is considered a hard constraint by the VSR optimizer.

Capacity constraints are observed on several levels, as illustrated in Figure 5.126. The lowest level is the compartment level. In Figure 5.126, both the vehicle resource and the trailer are physically structured into four compartments (e.g., tanks, C1 to C8).

You may need to take this property of the vehicle into consideration, for example, if different liquids that can't be mixed have to be transported. Each compartment provides a capacity constraint. In addition, each vehicle resource (the vehicle and the trailer) provides a capacity constraint, and finally the vehicle combination can also have a capacity constraint. Capacity constraints on different levels can be defined independently from each other and are considered independently from each other during planning. They aren't derived from the other levels.

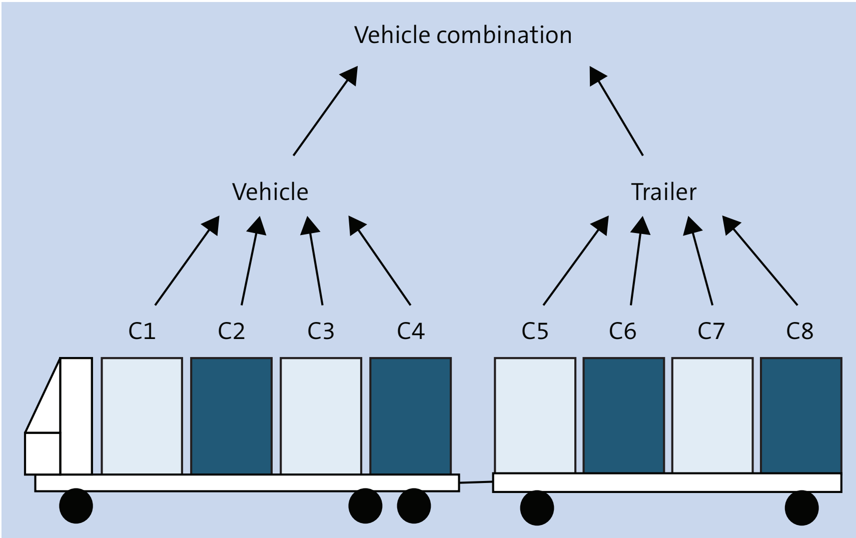


Figure 5.126 Capacity Constraints: Compartment, Vehicle Resource, and Vehicle Combination

Compartments are defined in Customizing via menu path **Transportation Management • Master Data • Resources • Means of Transport and Compartment • Define Compartment Types** in the following way:

1. A compartment type is defined by its capacity (in several dimensions) and attributes. Attributes can be used in conjunction with incompatibilities to control whether only liquids or goods that require special temperature conditions can be loaded into the compartment. In Figure 5.126, different colors indicate that the vehicle consists of four compartments with two different compartment types.
2. In the same Customizing transaction, compartment profiles are defined to combine the compartment types with a vehicle configuration. In Figure 5.126, the compartment profile indicates that the vehicle has two compartments of compartment type 1 and two compartments of compartment type 2.
3. Finally, the compartment profile is assigned to the means of transport (in the same Customizing transaction). In the example in Figure 5.126, the same compartment profile can be assigned to the means of transport representing the vehicle resource and to the means of transport representing the trailer. Alternatively, you can assign compartment profiles to individual vehicles resources in master data.

Compartments are frequently used in planning scenarios that involve liquids or, in retail distribution, to meet the temperature conditions of transported goods.

Vehicle combinations are defined in Customizing via menu path **Transportation Management • Master Data • Resources • Means of Transport and Compartment • Define Means-of-Transport Combination** in the following way:

1. Means-of-transport combinations consist of exactly one means of transport that is *not* defined as passive (**Transportation Management • Master Data • Resources • Means of Transport and Compartment • Define Means of Transport**) and any number of means of transport that have been defined as passive. Any means of transport that is used in a means-of-transport combination can't be defined as a multiresource because planning requires tracking individual resources in these scenarios.
2. Like compartments, a means-of-transport combination is assigned capacities (in different dimensions) and attributes.

As a result of planning with the VSR optimizer, each vehicle resource with a means of transport used in a means-of-transport combination can be used in a vehicle combination and be coupled to and uncoupled from other vehicle resources based on any defined means-of-transport combination. Coupling and uncoupling durations are defined in the **Scheduling Settings**.

In the location master data (**Master Data • Transportation Network • Locations • Define Location • TM**), you can define how coupling and uncoupling of trailers is to be handled at a location. A few options are available: to allow coupling/uncoupling activities at the location, *not* to allow these activities, to allow them only if freight units are picked up from or delivered to the location at the same time, or to allow only trailer swaps at this location. The VSR optimizer supports these scenarios and the creation of trailer units as part of the automated planning process.

Planning with vehicle combinations is used if trailers are frequently exchanged between tractors or the number of tractors and trailers deviates because loading and unloading takes a significant amount of time compared to driving, and a tractor can pull other trailers while one is being loaded or unloaded. However, the use of means-of-transport combinations introduces a lot of complexity into the planning scenario because tractors and trailers have to be planned independently from each other. Therefore, modeling this constraint should be avoided if possible. Note that this feature is limited to truck and trailer scenarios (e.g., one tractor and one or a few passive resources) and isn't intended for building trains in a railway scenario.

An alternative to planning with vehicle combinations is the use of combination resources. The use of combination resources avoids the complexity of modeling and planning individual trucks and trailers by the definition of a fixed combination. For this combination, multiresources can be used. Therefore, the VSR algorithm doesn't have to deal with coupling/uncoupling of the individual components of a combination resource. Planning happens on the level of the combination resource instead, which is recommended if you don't need to plan a company's own fleet.

Capacity constraints aren't limited to compartments, vehicle resources, and vehicle combinations. Schedules and freight bookings can also provide capacity in planning.

Decreasing capacity is a capacity constraint that sometimes exists in retail scenarios. If a truck delivers goods to several stores, the goods in the truck are loaded sequentially per store and a separator (thin wall) is used to separate the goods for each store from each other. However, because of the separator, some loading space can't be used and is lost. How much space is lost depends on the number of separators—that is, on the number of stores planned to be delivered to with the vehicle. Thus, the available vehicle capacity isn't a fixed value but depends dynamically on the transportation plan. Decreasing capacity is a planning constraint that addresses this situation and defines how much the vehicle capacity is decreased based on the number of stops on the freight order. Decreasing capacity is defined per means of transport via menu path **Profiles and Settings • Create Decreasing Capacity Settings**.

In Section 5.8.3, you learned about the load cost function as a means of introducing a utilization objective into the objective function of the VSR optimization algorithm. This can be counterproductive because it may force the VSR optimizer to send a truck on a large detour by adding a freight unit that needs to be delivered in the opposite direction than everything else to fill the truck. To avoid the creation of such tours, you can define a **Minimum Target Utilization in Percent** in the Create Constraints and Cost Settings app (refer to Figure 5.123) instead of defining a cost function. That way, the optimization algorithm isn't misguided by an ambiguous objective, but you can still control what should happen if a utilization objective isn't met for a freight order. Based on whether you choose **Accept Freight Orders Below Target Utilization**, the VSR optimizer will either leave some freight units unplanned or issue a warning for freight orders below target utilization. However, it's important to note that, with this setting, the VSR optimization algorithm doesn't actively seek a defined minimum utilization, but rather only checks planned freight orders at the end of the algorithm to determine whether they meet the desired criteria or not.

Time Constraints

To represent time constraints, you can define a calendar resource in master data (**Master Data • Define Resource**) and assign it to the location in location master data (**Master Data • Define Location • Resources**). You can assign different calendar resources as operating times for inbound (unloading) and outbound (loading) activities. In addition, you can assign operating times that are specific to a means of transport. If the number of parallel loading and unloading activities is restricted, you define handling resources in master data (**Master Data • Define Resource**) and assign them to the location in the location master data (**Master Data • Define Location • Resources**). Similar to opening times, you can distinguish between inbound and outbound and define these constraints as being specific to a means of transport (see Chapter 3, Section 3.2.1 and Section 3.3, for the definition of master data).

The availability of vehicle resources is defined in master data (**Master Data • Define Resource**). In addition, the capacity availability settings (Figure 5.127) provide a central place to define availability for both master data resources and vehicle types. You can assign a **Factory Calendar**, **Shift Sequence**, and **Time Zone** to resources and vehicle types. The rules defined in the capacity availability settings get processed according to the processing sequence, and the first matching rule is applied. You define whether to **Use Availability from Master Data** or consider the vehicle resources/vehicle types as **Always Available**. Deviating from the master data in these settings allows you to easily switch between different availabilities for simulation/evaluation purposes.

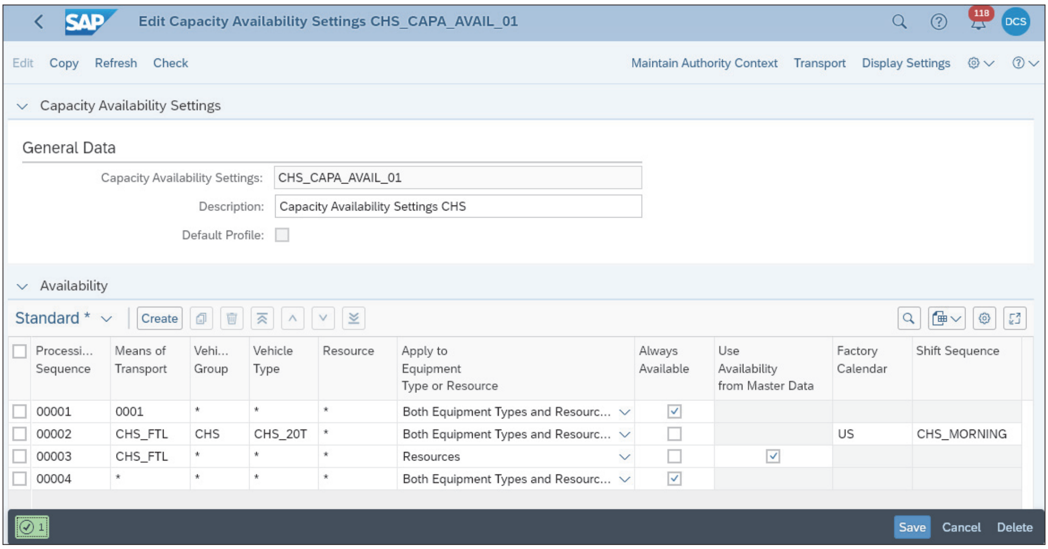


Figure 5.127 Capacity Availability Settings

We introduced pickup and delivery time windows in Section 5.2.2. The acceptable start and end dates of both the pickup and delivery time window are hard constraints for the VSR optimizer and are never violated. The requested dates express preferences (soft constraints) and are considered in the objective of the VSR optimizer to incur earliness and lateness costs for freight units (Section 5.8.3).

Pickup and delivery imply that the freight units must be loaded onto and unloaded from transportation capacities. These activities imply additional constraints for planning. Loading and unloading are activities that require not only the vehicle resource but may also require availability at the location. Some locations may be open only at certain times (e.g., weekdays from 9 a.m. to 5 p.m.). Other locations may limit the number of parallel loading/unloading activities because of limited ramps or personnel available to load and/or unload vehicles. Furthermore, additional activities, such as "gating in" at large locations, some time to do paperwork for the driver, and so on, may require explicit scheduling to obtain a reasonable freight order schedule. The scheduling concept is based on seven basic activity types (loading, unloading, traveling, coupling, uncoupling, preparing, and finalizing) and the combination of freight unit-specific activities (loading and unloading) into freight order/location-specific activities (preparing, loading, unloading, and finalizing). In Figure 5.128, the scheduling concept is explained, and Figure 5.129 shows its configuration.

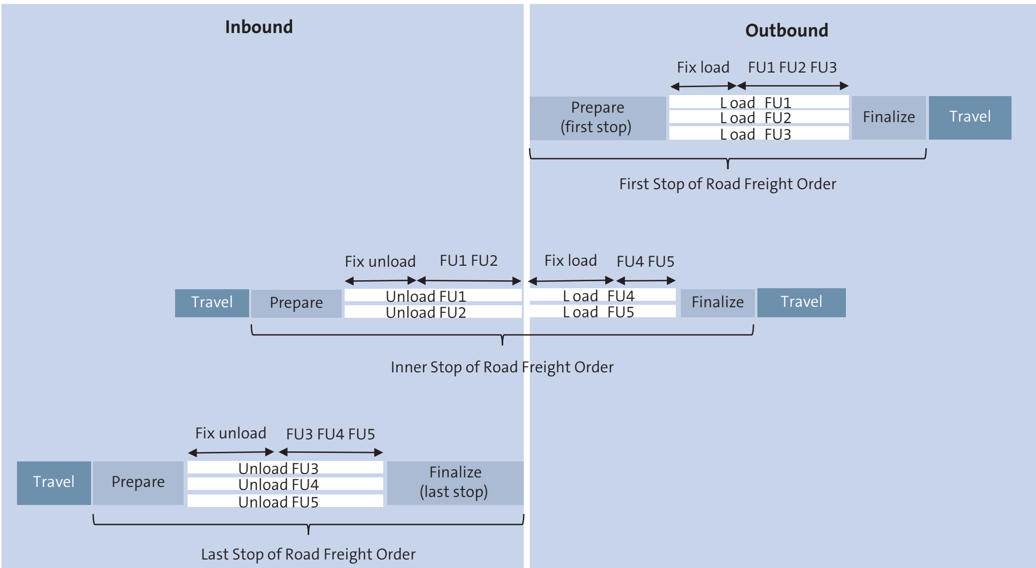


Figure 5.128 Scheduling Concept for Road Freight Orders

A freight order can have pure outbound stops (first stop and first line in Figure 5.128), combined inbound and outbound stops (second stop and second line), and pure inbound stops (third stop and third line in). Each stop consists of one to four activities:

1. Prepare
2. Unload
3. Load
4. Finalize

Their duration can be independently defined based on locations, means of transport, a document attribute, and the loading/unloading quantity. Let's take a closer look at each:

- **Preparation activity**
  Preparation activities are always the first activities in a stop. They are defined on the **Outbound** tab (if it's the first stop of the freight order; in Figure 5.129, it's defined as 30 minutes in the **Prepare First Stop and Finalize Stop** area of the screen) or on the **Inbound** tab for all other stops. Preparation activities can represent "gating in" activities in a location, and a calendar resource can be assigned to allow these activities only during the availability time of this calendar resource.

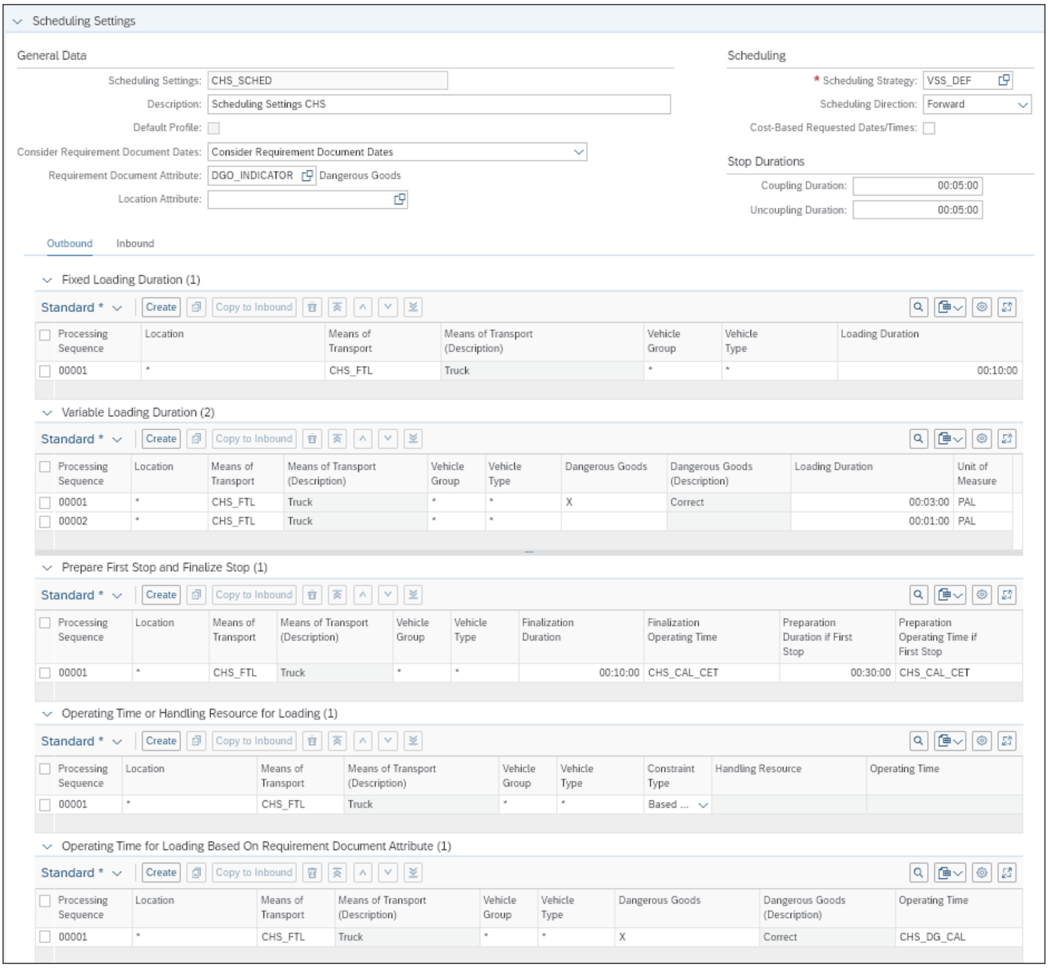


Figure 5.129 Scheduling Settings

- **Loading activity**

  The loading activity is also defined on the **Outbound** tab. One common duration is calculated for all freight units that are loaded at the location. This common duration is used for scheduling instead of the individual loading durations of each freight unit to avoid that different freight unit composition caused by freight unit building leads to different results in the calculation of loading durations. As shown in in Figure 5.129, the calculation of the common loading duration consists of a fixed part (**Fixed Loading Duration**) plus a variable part (**Variable Loading Duration**), where the variable part may be dependent on an attribute of the requirement document.

  In Figure 5.129, the **Dangerous Goods** indicator has been used to define a loading time of 3 minutes per pallet with dangerous goods and 1 minute per pallet without dangerous goods. In addition to the duration, **Scheduling Settings** allow you to define whether these durations have to consider an operating time (calendar resource), handling resource, or none, as well as whether these resources are **Based on Location Master Data** or defined in the **Scheduling Settings**.

- **Unloading activity**
  The unloading activity is similarly defined as the loading activity on the **Inbound** tab. One common duration is calculated for all freight units that are unloaded at the location. This common duration is used for scheduling. Similarly, the calculation of the common unloading duration consists of a fixed part plus a variable part, where the variable part may be dependent on the same attribute of the requirement document as the loading activity. In addition to the duration, **Scheduling Settings** allow you to define whether these durations have to consider an operating time (calendar resource), handling resource, or none, as well as where these resources are defined.
- **Finalization activity**
  The finalization activities are always the last activities in a stop. They are defined on the **Outbound** tab (for all stops other than the last in a freight order; in Figure 5.129, it's defined as 10 minutes in the **Prepare First Stop and Finalize Stop** area of the screen) or on the **Inbound** tab only for the last stop. Finalization activities can represent "gating out" activities or paperwork in a location, and a calendar resource can be assigned to allow these activities only during the availability time of this calendar resource.

Note that for the calculation of durations, the first matching row in each area of the screen will be used. Furthermore, because freight units aren't scheduled individually, for the determination of the pickup and delivery time window, the system will use the intersection of all freight units' individual time windows. As a consequence, a prerequisite for successful scheduling is that the acceptable time windows of the individual freight units overlap, which also means that there can't be gaps between individual loading/unloading activities.

Routing Constraints

Section 5.8.2 introduced the maximum number of transshipment locations in a transportation chain as a constraint that drives complexity. Transshipment locations are defined in the Transshipment Assignment Definition app (see also Chapter 3, Section 3.2.5). This constraint helps the VSR optimizer limit the number of possible alternatives to transport a freight unit from its source to its destination. However, if the constraint maintained is too low, no feasible alternative may be found. Using transshipment locations (e.g., ports or airports) often implies a second constraint that is the cutoff time at the transshipment location. If a flight takes off at 2:15 p.m., it's usually too late to deliver freight to the airport at 2:10 p.m. Thus, a minimum cutoff time should be respected. On the other hand, delivering freight to the airport one week in advance also isn't an option because this may incur additional costs or not be accepted at all. Therefore, minimum and maximum cutoff times can be defined in either the location master data via **Master Data • Define Location • TM** or schedules via **Master Data • Create Schedule**.

If a fleet is in the scope of transportation planning, then depot or home locations of vehicle resources may be in the scope. If trucks are parked in depot D overnight and need to transport a freight unit from A to B the next day, then the freight order must include the empty runs from D to A and from B back to D because these stages also require time and incur cost.

Depot locations are maintained in the resource master data (**Master Data • Define Resource**) for each vehicle resource. They are considered as a constraint only for means of transport that are flagged as **Your Own MTr** and aren't flagged as **Multiresource** in Customizing (**Transportation Management • Master Data • Resource • Means of Transport and Compartment • Define Means of Transport**).

If planning local delivery tours from a depot is in the scope of the planning scenario, there may be an additional constraint in place that each tour should last, at most, eight hours, reflecting the working times of drivers. This type of constraint can also be considered by the VSR optimizer. Essentially, the optimizer is allowed to impose limits on one, a subset, or all of the following:

- Total duration of a freight order
- Maximum duration between first and last pickup stop of a freight order
- Maximum duration between first and last delivery stop of a freight order
- Total distance of a freight order
- Maximum distance between first and last pickup stop of a freight order
- Maximum distance between first and last delivery stop of a freight order
- Maximum number of intermediate stops of a freight order
- Maximum number of pickup stops of a freight order
- Maximum number of delivery stops of a freight order

These limits are separate constraints and can be used independently from defining depot locations. For each means of transport, these limits can be maintained in the means-of-transport settings of the Constraints and Cost Settings app (refer to Figure 5.123).

Scheduling Constraints

Chapter 3, Section 3.2, explained how transportation duration is calculated based on the transportation distance. However, this isn't a very precise calculation and can't be used universally, which is obvious from even a simple example.

To calculate the transport duration for a container ship from Rotterdam to Boston, you can take the distance (3,200 nautical miles) and divide it by the speed (20 knots/hour) to calculate the expected duration to be 160 hours (approximately one week). The same calculation logic fails for a truck going from Boston to Los Angeles. The distance (3,000 miles) divided by the truck speed (50 miles/hour) would indicate that the truck would arrive after 60 hours (2.5 days) at its destination.

However, in contrast to the ship, which sails day and night, the truck (driver) has to take some breaks that prolong the transportation duration. If the driver were allowed to drive 10 hours per day, the trip from Boston to Los Angeles would take 6 days instead of 2.5 days. Scheduling constraints can be defined to take those breaks into account. As shown in Figure 5.130, scheduling constraints are defined in Customizing (**Transportation Management • Planning • General Settings • Define Scheduling Constraints**) in the following way:

❶ Define an activity group.

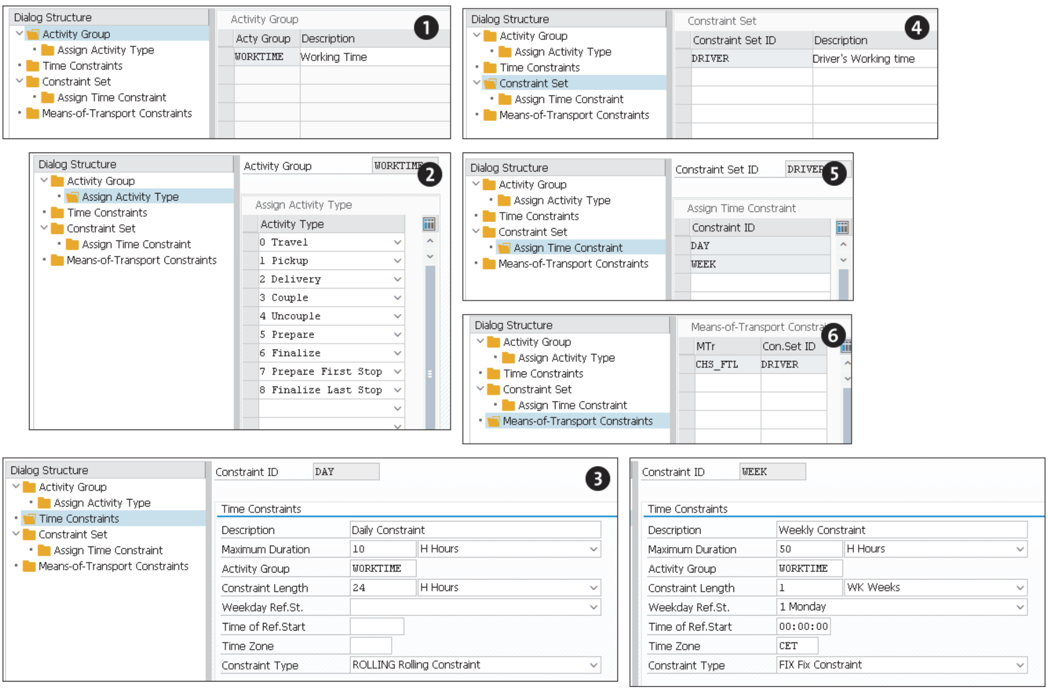


Figure 5.130 Scheduling Constraints

❷ Assign activity types to the activity group. The available activity types include **Travel**, **Pickup** (loading), **Delivery** (unloading), **Couple** (vehicle combination), **Uncouple** (vehicle combination), **Prepare**, **Finalize**, **Prepare First Stop**, and **Finalize Last Stop**. Depending on the origin or purpose of this planning constraint in a specific scenario, either all activity types or just a subset may be relevant for the scheduling constraint. This step maintains the relevant activity types.

❸ Several **Time Constraints** can be maintained in the third step. In the example shown in Figure 5.130, two time constraints are defined. **Constraint ID**: **DAY** represents a constraint in which the maximum duration of activities of activity group **WORKTIME**, defined in step ❷, is 10 hours in any 24-hour time interval (constraint length). The constraint type is defined as a rolling constraint; that is, it doesn't apply per workday but applies to any 24-hour period. If it were defined as a fixed constraint, it would be possible to schedule activities during the last 10 hours of day 1 and during the first 10 hours of day 2, which would allow 20 hours of uninterrupted driving. The second **Constraint ID**, **WEEK**, allows 50 hours of activities within one calendar week.

❹ Because both constraint IDs should be considered together, a **Constraint Set** is defined in this step.

❺ Both constraints, **DAY** and **WEEK**, are assigned to the constraint set in this step.

❻ Finally, the constraint set is assigned to a means of transport.

Driving Time and Working Hours Constraints

While scheduling constraints are sufficient to estimate the duration of subcontracted road freight orders, they aren't sufficient to fulfill legal driving time and working hours regulations. The main functional deficit of scheduling constraints is that the break or idle time can be split arbitrarily across the freight order. The **DAY** constraint in Figure 5.130 could result in a freight order alternating between one hour of driving and one hour of break time for 20 hours. However, legal requirements typically ask for an uninterrupted rest to allow drivers to sleep.

The VSR optimizer supports driving time and working hours constraints that fulfill this requirement. In EU law, the following regulations apply (Regulation (EC) No 561/2006):

- EU 1 (Daily Rest): Within each period of 24 hours after the end of the previous daily rest period, a driver shall have taken a new daily rest period of at least 11 hours. A rest is any uninterrupted period during which a driver may freely dispose of his or her time.
- EU 2 (9h Driving Time): The accumulated driving time between two rests of 11 hours shall not exceed 9 hours.
- EU 3 (4.5h Driving Time): After a driving period of 4.5 hours a driver shall take an uninterrupted break of not less than 45 minutes unless he or she takes a rest period. A break is any period during which a driver may not carry out any driving or any other work and which is used exclusively for recuperation.
- EU 4 (6h Work Time): The driver needs to take a break of at least 30 min after at most 6 hours work time (not only driving time).

All of these constraints consist of the following: a limit (e.g., 9h of driving), activity restriction after exceeding that limit (no more driving), and a reset period to reset the limit (rest time of 11h). The VSR optimization algorithm can consider EU regulations by defining expert parameter **HOSRULESET** as **EU** in Transaction RCC_PARAM, as shown in Figure 5.131.

Similar constraints exist in the United States and are activated by setting the parameter value to **USA** instead of **EU**. Additional constraints to complement the existing ones or assigning certain constraints only to a subset of vehicle resources/vehicle types is possible by means of a BAdI implementation. SAP Note 3231830 includes a detailed guide on the available options and constraints, and SAP Note 3248876 provides some sample code.

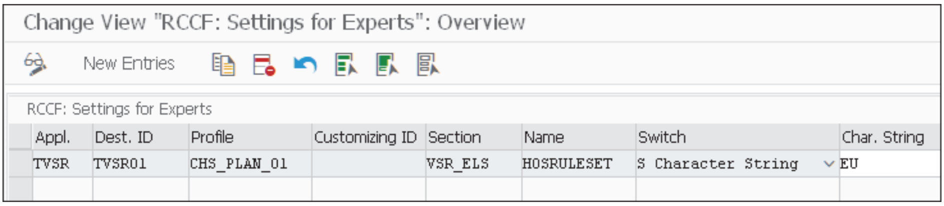


Figure 5.131 Driving Time and Working Hours Constraints

Incompatibilities

We've already mentioned incompatibilities as constraints because they are used in several areas of the application (Section 5.2.3; Chapter 4, Section 4.1.3; and Chapter 6, Section 6.5):

- Freight unit building
- Automatic planning and manual planning
- Carrier selection
- Delivery proposal

Incompatibilities define which two objects aren't compatible with each other. In VSR planning, the following incompatibility types exist:

- **Freight unit—freight unit (vehicle level)**
  Two freight units aren't allowed on the same vehicle (e.g., they may be explosive if mixed in an accident).
- **Freight unit—freight unit (compartment level)**
  Two freight units aren't allowed in the same compartment (e.g., chemicals shouldn't be mixed with milk in a tank).
- **Freight unit—freight unit (means-of-transport combination)**
  Two freight units aren't allowed on the same vehicle combination (e.g., they may be explosive if mixed in an accident).
- **Freight unit—freight unit (consignment order level)**
  Two freight units aren't allowed to be grouped into the same consignment order.
- **Freight unit—vehicle resource/vehicle type**
  A freight unit isn't allowed on a specific vehicle or vehicle type (e.g., chemicals aren't allowed in a truck intended for food transport).
- **Freight unit—transshipment location**
  A freight unit isn't allowed to be routed via a transshipment location (e.g., a heavy turbine can't be routed through ports that don't have cranes to lift it).

- **Freight unit—vehicle compartment**
  A freight unit isn't allowed on a vehicle compartment (e.g., chemicals aren't allowed in a milk tank).
- **Freight unit—driver**
  A driver isn't allowed to transport a specific freight unit (e.g., certain chemicals aren't allowed for the driver). Because drivers aren't supported by automatic planning, the driver-related incompatibilities are mapped to the vehicle resource, if the driver is maintained as the default driver in vehicle resource master data.
- **Vehicle resource/vehicle type—vehicle resource/vehicle type**
  Two vehicle resources/vehicle types can't be coupled, although in general it would be allowed by the means-of-transport combination definition.
- **Vehicle resource/vehicle type—location (stay level)**
  A long vehicle resource/vehicle type can't visit certain locations (e.g., because of maneuvering limitations) on its route.
- **Vehicle resource/vehicle type—location (loading/unloading level)**
  Locations that don't have loading and unloading equipment must not be visited by vehicle resources/vehicle types that don't carry their unloading equipment (e.g., crane, forklift) themselves.
- **Vehicle MTR combination—location**
  A long vehicle combination must not visit certain locations (e.g., because of maneuvering limitations) on its route.
- **Freight unit—freight booking**
  A freight unit containing hazardous goods can't be booked on some freight bookings.
- **Freight unit—schedule**
  A freight unit containing hazardous goods can't be booked on some schedules.
- **Freight unit—transportation unit resource**
  A freight unit containing hazardous goods can't be loaded into a food grade container.
- **Container unit—container unit (vehicle level)**
  Two container units aren't allowed on the same vehicle.
- **Container unit—vehicle resource/vehicle type**
  A container unit isn't allowed on a vehicle resource/vehicle type (e.g., an equipment type isn't allowed on a certain truck type).
- **Container unit—transshipment location**
  A container unit isn't allowed to be routed via a transshipment location (e.g., because of storage constraints).
- **Container unit—freight booking**
  A container unit containing hazardous goods can't be booked on some freight bookings.

- **Container unit—schedule**
  A container unit containing hazardous goods can't be booked on some schedules.

As shown in Figure 5.132, incompatibilities are defined in the Create Incompatibility app. The incompatibility definition determines the incompatibility area and incompatibility type. It also defines whether violations of the incompatibility are allowed, will result in a warning, or are forbidden. This decision can be made separately for manual planning and automated planning—perhaps to forbid violations in automated planning but to allow a manual override of the decision, resulting in a warning only. The comparison of the evaluation result of two conditions that are evaluated for the two objects defined in the incompatibility type determines whether these two objects are compatible with each other.

In Figure 5.132, an incompatibility between a freight unit and a vehicle resource is defined. Those freight units for which the first condition **CHS_TEMP_FU** returns the result **FROZEN** are incompatible to those vehicle resources or vehicle types for which the second condition **CHS_TEMP_VEH** returns the result **AMBIENT**.

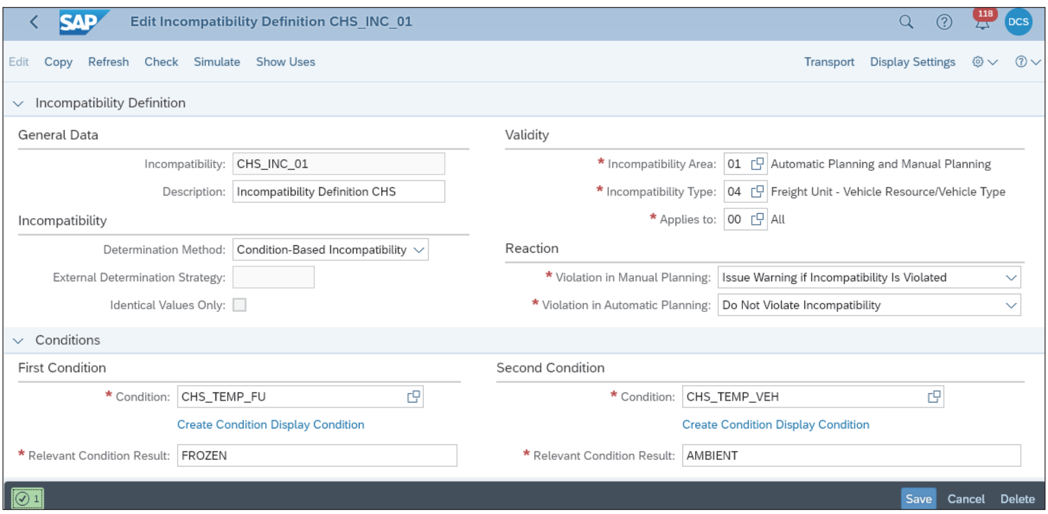


Figure 5.132 Incompatibility Definition

Incompatibility settings (**Profiles and Settings • Create Incompatibility Settings**) are a list of incompatibility definitions that are grouped together because all of them should be considered in a specific planning scenario. The incompatibility settings are assigned to the planning profile. Loading direction constraints as well as attached equipment constraints that are explained later in this chapter (Section 5.8.7) are also considered by the VSR optimizer.

An overview of all defined incompatibility definitions and incompatibility settings is available in a worklist via one of the queries for profiles and settings (**Profiles and Settings • Profiles and Settings Worklist**).

Ship with Constraints

Sometimes, the requirement isn't to transport two freight units separate from each other, which is represented by an incompatibility, but the requirement is to specifically transport two (or more) freight units together. On first sight, you could ask, why two (or more) freight units have been created in such a scenario in the beginning of the process, but looking closer, there may be valid reasons for not having consolidated everything into one freight unit:

- The freight units that should be transported together originate from two different deliveries (one representing frozen products and the other one ambient products).
- The two freight units originate from different source locations, but should be delivered together at the destination location (e.g., a machine and some spare parts).

The VSR optimization algorithm allows you to define these types of constraints via a BAdI implementation as part of the preprocessing of optimization data (`/SCMTMS/PLN_PRE_PROC`, enhancement spot `/SCMTMS/PLN_OPT`). In both cases, you define correlation groups (ship with groups). These represent groups of freight units that should be one of the following:

- Picked up together
- Delivered together
- Transported completely together (i.e., picked up and delivered together)

The correlation groups will then be considered a soft constraint, meaning the VSR optimizer will try to adhere to this constraint but can violate this constraint if, for example, only five freight units out of a correlation group of six freight units can be delivered together. If the requirement is to completely transport those freight units together, the constraint can even be made a hard constraint.

SAP Note 1900800 includes a modeling guide and explains in detail which tables have to be modified to introduce ship with constraints.

5.8.5 Vehicle Scheduling and Routing: Optimization Algorithm

The VSR optimizer combines the ideas of several metaheuristics in a population-based optimization algorithm that tries to determine reasonable transportation plans within an acceptable runtime. The algorithm is based on the basic principle of evolutionary local search, so a population of candidate solutions is subject to an evolutionary search process by iterative selection and variation. The initial population is created by several insertion heuristics that iteratively assign all freight units to transportation capacities. In the improvement phase, different variation operators reassign freight units to other transportation capacities, change the routes of freight orders, or adapt the scheduling of activities. In this process, the VSR optimizer tries to minimize total costs defined as the objective (Section 5.8.3) while respecting all active constraints (Section 5.8.4). The best solution found within the maximum runtime (Section 5.8.2) is returned. Figure 5.133 shows how the solution evolves over time.

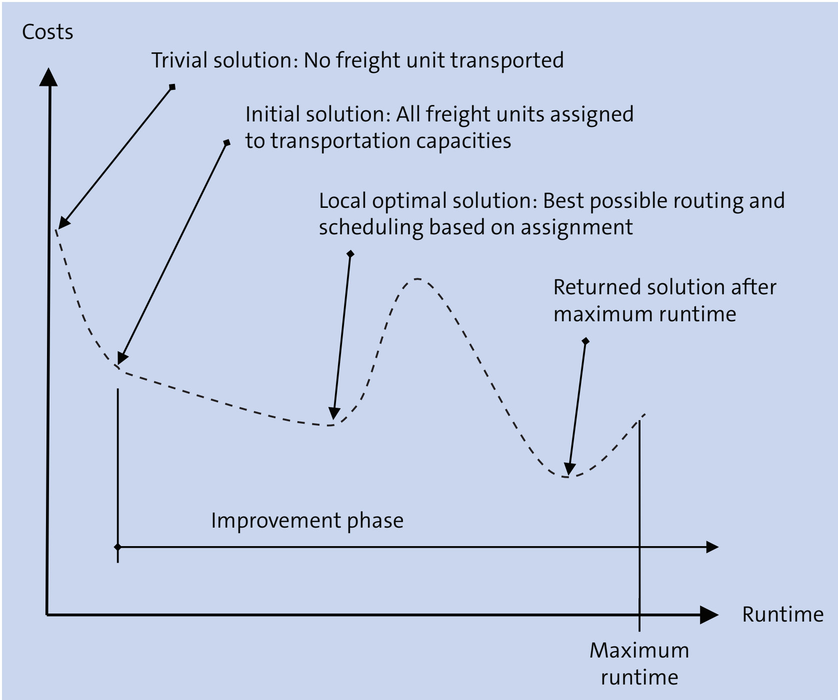


Figure 5.133 VSR Optimizer Runtime Behavior

Complexity of VSR Problems

The VSR optimizer is based on an optimization algorithm for the *vehicle scheduling and routing problem* (VSRP). The VSRP is a combinatorial optimization problem that is NP-complete—meaning that, based on current research, no polynomial time algorithm is known that solves the problem exactly.

In practical terms, NP-completeness means that an exact procedure for large problem instances would require computing time that would be too high to determine the global optimum. That is why the VSR optimizer relies on approximation procedures that achieve an acceptable solution quality in an acceptable computing time.

In the process of generating solutions, the algorithm has to make the following decisions:

- For each freight unit, it decides whether it's transported.
- If the decision is made to transport the freight unit, the path (direct or via which transshipment locations) in the transportation network needs to be chosen.

- Each stage of the freight unit has to be assigned to a transportation capacity (e.g., vehicle resource, schedule, freight booking).
- For each vehicle assignment, the compartment assignment (if defined) needs to be made.
- For each transportation capacity, the sequence of activities (e.g., loading, traveling, unloading, coupling, uncoupling) needs to be determined.
- A date and time need to be determined for each activity according to its sequence.

5.8.6 Explanation Tool

From the previous section, you can see that the VSR optimizer is based on a very powerful algorithm; however, to some extent, it isn't transparent to the user how the VSR optimizer created a specific result and why. Therefore, an explanation tool is provided to help the user understand and analyze the optimization results. To activate logging of the optimizer data for optimization runs, a prerequisite is that the user parameter `/SCMTMS/EXP` is set to `X` for the specific user. You can access the explanation tool interactively by clicking the **Optimizer Explanation** button either while working in the transportation cockpit or directly after any interactive optimizer run prior to accepting or canceling the result. Both actions take you to the explanation of your last optimizer run.

Another way of accessing the explanation tool, which is also applicable for background runs, is the Log Display transaction in the backend system (**Cross-Application Components • Processes and Tools for Enterprise Applications • Remote Control and Communication Framework • Log Display**). This transaction lists and identifies the logs of all engine calls (optimizer, transportation proposal, and scheduling; see also Section 5.8.2) via the user that triggered the engine run, planning profile used, and date and time of this activity. You can access the explanation tool from here for each engine call by clicking the **Explanation Tool** button for the specific run (row of the table).

Explanation Tool: Cleanup

Note that the persistence time for engine logs mentioned in Section 5.8.2 doesn't relate to the explanation tool. For performance reasons, old explanation data should be deleted regularly with report /SCMTMS/PLN_EXP_DELETE.

The explanation tool displays all data that is sent to or retrieved from the engine. Let's walk through Figure 5.134, which shows the input data for the optimizer.

On the left side of the screen, it's possible to browse in a folder structure through all the tables, which are organized based on the data origin (e.g., freight unit data, transportation network data, etc.). The right side of the screen displays the content of the tables selected on the left. Often, not all tables contain entries because not all planning constraints mentioned in Section 5.8.4 are present in each optimization problem. You can click the **Show/Hide Empty Tables** button to toggle between the display of all tables or only tables that have at least one entry. Figure 5.134 shows how the scheduling constraints created previously in Figure 5.130 are transferred to the VSR optimizer. Note that for entries in dimension time (**Max. Duratn** and **ConstrLng** columns in the **Bucket Constraints** table), no unit of measure is transferred, but the seconds unit of measure is always used (10 hours corresponds to 36,000 seconds).

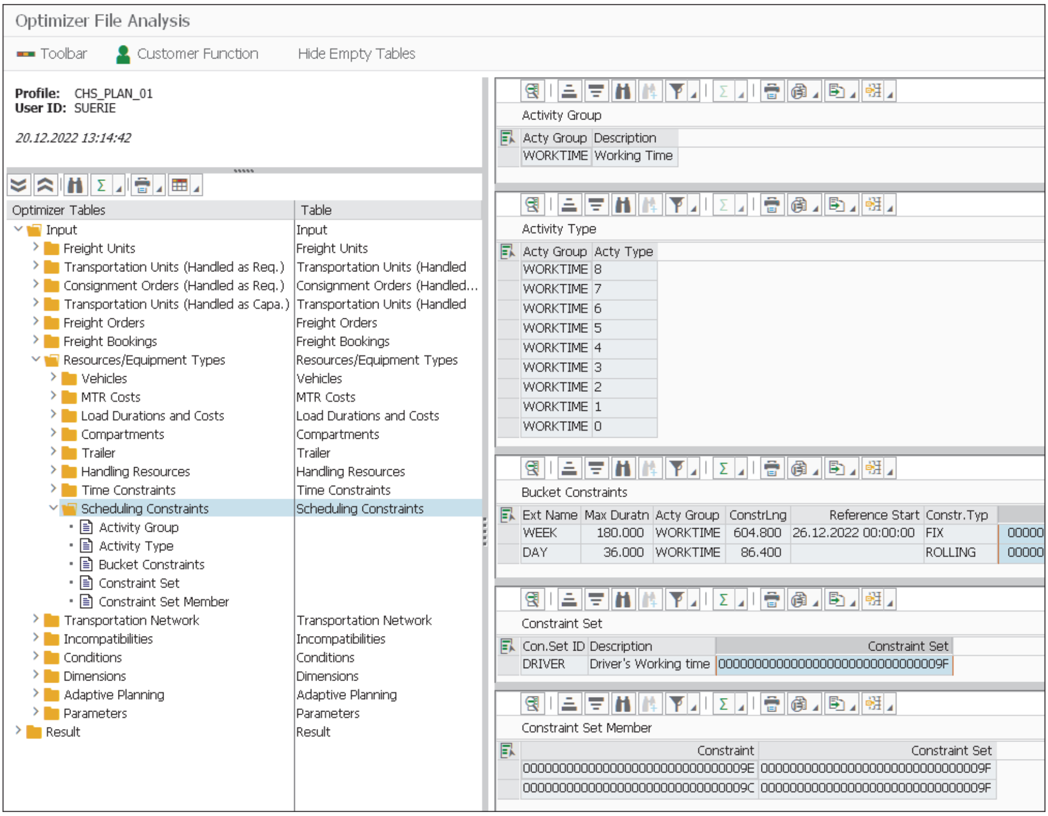


Figure 5.134 Optimizer File Analysis Input Data

Figure 5.135 shows how the planning result is displayed in the explanation tool. Again, the available tables are displayed in a folder structure on the left, with the table contents displayed on the right. If freight units couldn't be planned as shown in this example (freight unit **4100176501**, **Planning Status Not Planned**), an explanation would be displayed as **Messages for Freight Units**. In this case, the explanation **No valid connection to destination location** for location **CHS_SAP_3** indicates that transportation lane information was missing for the optimizer. This is only a hint to the user because the system can't know the real root cause. Other possible root causes for this scenario include the following:

- The resources that have been selected for this planning run are defined for a means of transport that isn't assigned to the existing transportation lane.
- A freight booking or schedule should have been used but wasn't selected, so the missing transportation lane wasn't relevant.

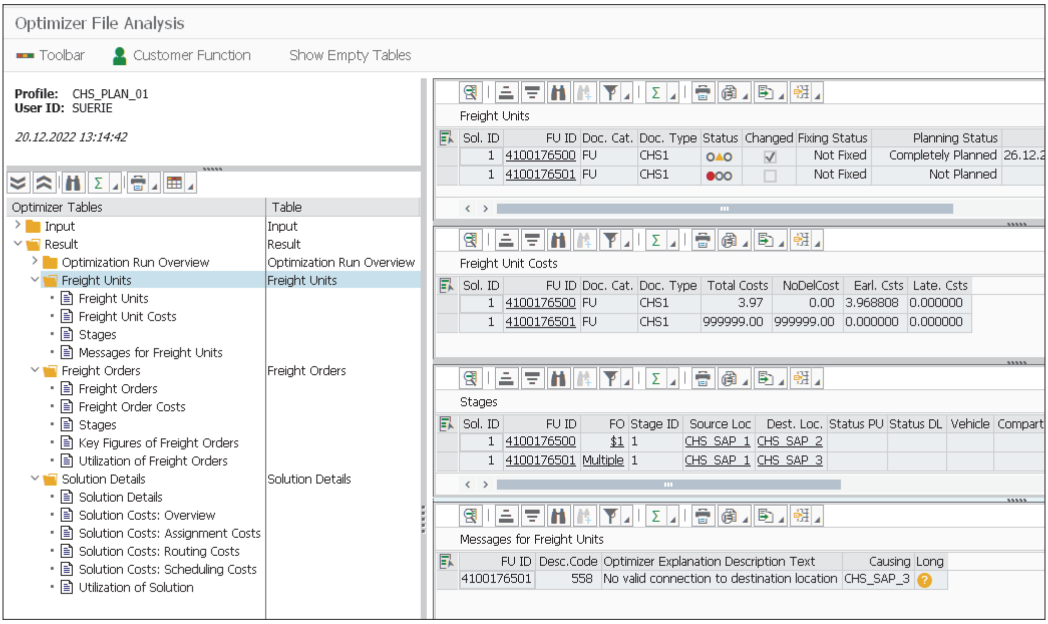


Figure 5.135 Optimizer File Analysis Results Data

5.8.7 Load Consolidation

The load consolidation process supports the planner in the decision to order the correct amount of equipment in case large quantities have to be transported between two locations. In contrast to VSR, no route determination is required in this case, but it has to be done subsequently. Figure 5.136 shows how load consolidation is embedded into a planning process. In this example, freight has to be transported from Mannheim to Chicago. In the package building step, the decision is made regarding which products should be grouped into packages and how many packages and which types are required (Section 5.3 for details on the package building process). The decision regarding how many containers are required as well as which types are needed is made in load consolidation. Furthermore, load consolidation determines the assignment of packages to containers. Finally, VSR determines the routing and scheduling of the individual containers.

The load consolidation isn't limited to containers but can also be used with trucks and trailers as capacity. The result of load consolidation is the assignment of freight units, package units, or consignment orders to resource types to create freight orders, container units, or trailer units. The assignment to actual resources is done subsequently in the VSR step.

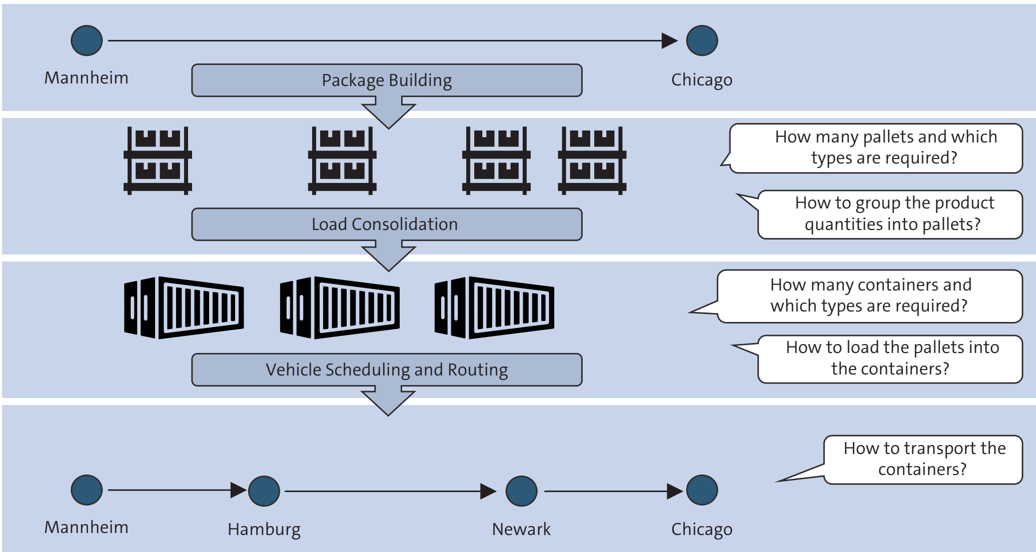


Figure 5.136 Load Consolidation Process

The load consolidation process can be initiated from the transportation cockpit interactively or in the background using report /SCMTMS/PLN_LOAD_CONS_BGD, as shown in Figure 5.137. It's an optimization process that minimizes the fixed costs of the equipment chosen in the process. The fixed cost per equipment type is defined in the Edit Constraints and Cost Settings app (refer to Figure 5.123). The number of available equipment items per equipment type can be limited for multiresources in a popup window if the **Change No. of Individual Resources** checkbox is checked in the Edit Load Planning Settings app (see Figure 5.141 later in this chapter). The load planning settings control the behavior of the load consolidation process. Load planning settings are assigned to the planning profile but can also be changed interactively in the transportation cockpit via the **Change Planning Settings** button (Section 5.7.8).

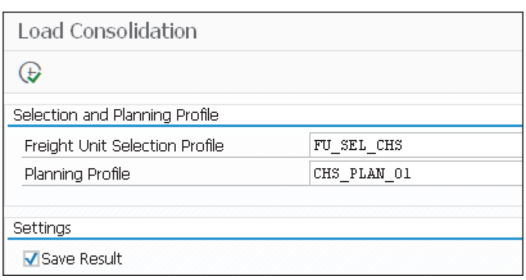


Figure 5.137 Background Report for Load Consolidation

The load consolidation process considers loading direction constraints, attached equipment constraints, and generic vehicle-location incompatibilities. Figure 5.138 shows how loading direction constraints and attached equipment constraints can be defined and assigned to vehicle resources (vehicle types) and locations:

❶ You define the loading direction profile in Customizing (**Transportation Management • Master Data • Resources • General Settings • Define Loading Direction Profile**). The profile indicates the direction (e.g., left, right, back, top) from which loading or unloading is possible and preferred.

❷ The loading direction profile can be assigned to a location loading profile and a vehicle loading profile. In Customizing of the location loading profile (**Transportation Management • Master Data • Transportation Network • Location • Define Location Loading Profile**), you can define specific loading constraints for a location, for example, the loading direction profile or whether loading equipment is required at this location.

❸ In Customizing of the vehicle loading profile (**Transportation Management • Master Data • Resources • General Settings • Define Vehicle Loading Profile**), you can define specific loading constraints for a vehicle, for example, the loading direction profile or whether loading equipment is attached to the vehicle for every transport. If the equipment isn't fixed, it can be removed to gain additional loading space. You can also define that the loading equipment is attached to the vehicle resource outside the cargo space.

❹ The attached equipment profile can describe both a requirement for equipment if assigned to a location, and the availability of equipment if assigned to a vehicle resource. You can assign multiple equipment categories to an attached equipment profile. Each equipment category defined in the profile represents one piece of attached equipment. The attached equipment profile is defined in Customizing (**Transportation Management • Master Data • Resources • General Settings • Define Attached Equipment Profile**).

❺ The location loading profile and the attached equipment profile can be assigned to a location on the **TM** tab.

❻ The vehicle loading profile and the attached equipment profile are assigned to a vehicle resource on the **Transportation** tab or to vehicle types in Customizing (**Transportation Management • Master Data • Resources • General Settings • Define Equipment Groups and Equipment Types**).

In the Edit Incompatibility Settings app in Figure 5.139, you can define generic vehicle-location incompatibilities as well as activate loading direction constraints and attached equipment constraints. The incompatibility settings must be assigned to the corresponding planning profile.

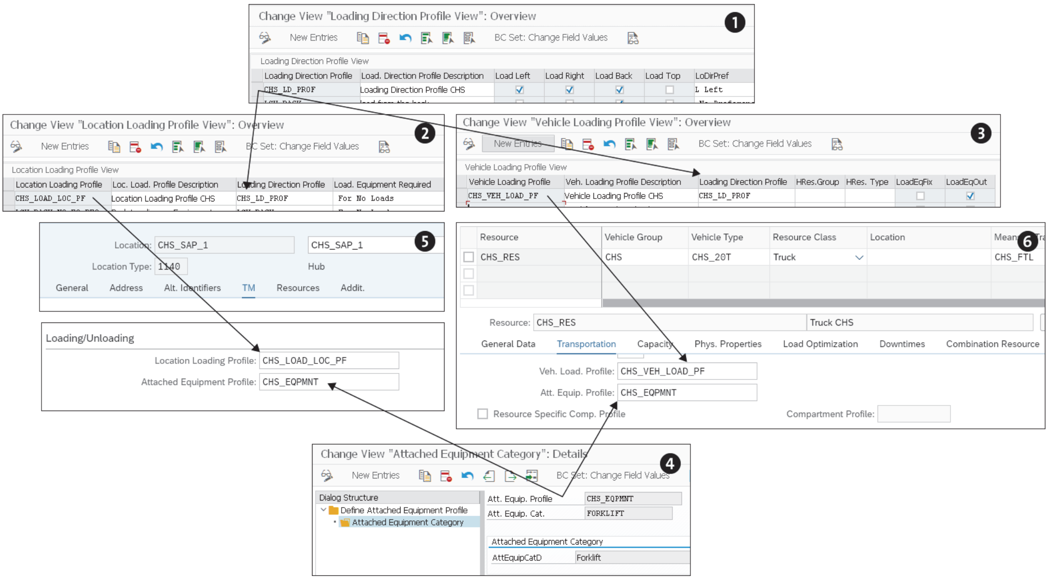


Figure 5.138 Loading Direction Constraints and Attached Equipment Constraints

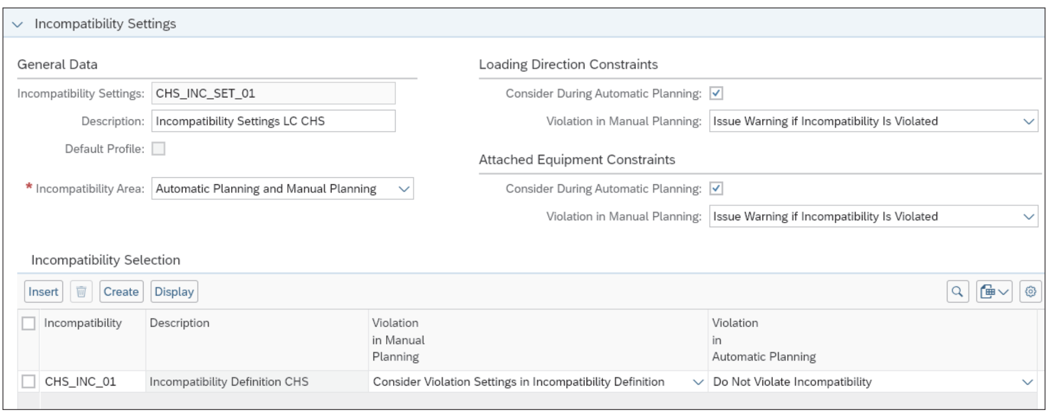


Figure 5.139 Constraints for Load Consolidation

The load consolidation optimizer will select among the available equipment the cheapest set considering capacity constraints and incompatibilities between freight units (e.g., certain dangerous goods must not be in the same container) as well as freight units and capacity types (e.g., reefer cargo requires a reefer container). The capacity check can be defined as **Capacity-Based** or **Load Planning-Based** according to the choice in the Load Planning Settings app (see Figure 5.141 later in this chapter). If the capacity check is based on load planning, the load consolidation process will provide an exact load plan as in load planning, which is described in the next section.

5.8.8 Load Planning

Load planning deals with the creation of a load plan, primarily for loading trucks with pallets. For that reason, master data for vehicle resources and dimensions of freight units needs to be available in more detail. Load planning can be triggered in three ways:

- Manually from the transportation cockpit (refer to Section 5.7.6), freight order, trailer unit, or container unit
- Interactively as part of a planning strategy (e.g., manual planning strategy VSRI_ALP or optimizer planning strategy VSR_ALP)
- By scheduling the report /SCMTMS/PLN_LOAD_PLANNING_BGD in the background or from menu path **Logistics • Transportation Management • Administration • Background Processing • Run Load Planning** in the backend system

Load planning is done by a rule-based optimization engine. The optimization engine is provided with information from the freight order, package information from the items of the freight order, and resource information (number of axles and their specification; interior dimensions, e.g., length, width, and height; etc.). The result of load planning is the exact position of each item of the freight order on the resource. The optimization engine is based on metaheuristics. It runs for a maximum runtime defined in the load planning settings and returns the best-found solution within this runtime.

Load planning is limited to box-shaped items (e.g., pallets and cartons) and cylinder-shaped items (e.g., drums) to be loaded onto box-shaped resources (e.g., trucks, trailers, and containers). Other geometries (e.g., odd-shaped objects) to be loaded on planes or ships aren't within the scope of the solution because either specific equipment exists for their load planning (e.g., ULDs in air freight) or special trim software exists (for balancing the load on large container ships).

In addition to determining the exact position of each package in the resource, the load planning algorithm also supports determining the best configuration (height position) of a split deck, if this has been defined as flexible for a specific resource. Prerequisites for this case are that the details of the split deck (size and range of movement) have been defined in the resource viewer and that all packages have the same footprint (length and width). Figure 5.140 shows an example with packages that can't be stacked. Without a split deck, the resource can carry only half of the packages (left picture). With a fixed split deck, most of the packages fit onto the truck (middle), and when the beams of the split deck can be adjusted, everything is successfully loaded (right picture).

Depending on the goods to be transported, load planning can become important because legal restrictions and safety considerations may require that the load be distributed inside the vehicle resource based on certain rules. For example, in the United States, the US federal bridge formula establishes the maximum weight any set of axles on a vehicle resource may carry on the interstate highway system. These rules must be observed when loading a vehicle.

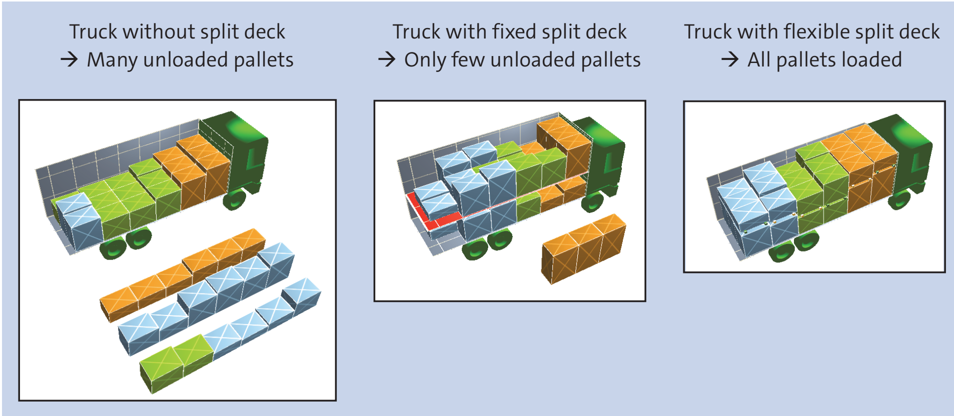


Figure 5.140 Load Planning with Split Decks

The load optimizer is based on an objective function that is to be minimized and some hard constraints that need to be met. Hard constraints relate to the physical attributes of the resource (maximum gross weight, maximum weight on a split deck, maximum weight on an axle group, etc.) and the physical attributes of the load (pallet dimensions, pallet gross weight, stackability, etc.). The objective is to find a suitable assignment of freight order items to the positions in the resource that meets all hard constraints and minimizes the other objective criteria:

- All freight order items should be loaded onto the resource. Not loading an item results in a penalty cost, which is considered very high because this situation needs to be avoided first.
- All load planning rules must be met according to their priority.

The load planning settings (**Profiles and Settings • Create Load Planning Settings**) control the behavior of the load optimizer. Load planning settings are assigned to the planning profile but can also be changed interactively in the transportation cockpit via the **Change Planning Settings** button. Load planning settings allow you to define which load planning rules you want to consider and how these different rules will be prioritized (from 1 = highest to 10 = lowest). In addition to priorities, the applicability of load planning rules can be limited to certain equipment groups and types. For some load planning rules, additional parameters can be defined (e.g., maximum height difference of adjacent stacks; see Figure 5.141).

More than 45 different load planning rules are available. Available load planning rules can be grouped into the following areas:

- **Stability of load**
  Motivation for this set of rules is to minimize movement of goods during transport to reduce damages. Examples are ascending or descending stack heights in driving direction or weight balancing regarding load on left/right wheels.

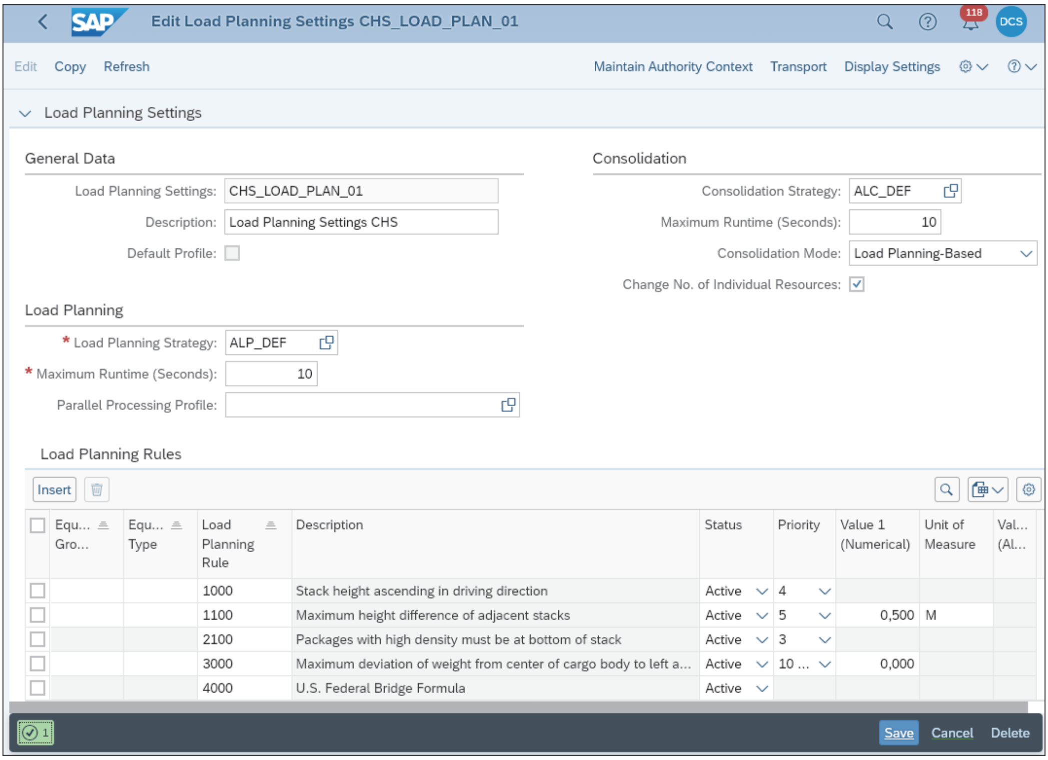


Figure 5.141 Load Planning Settings

- **Positioning of packages**
  Motivation for this set of rules is related to ease of handling (keeping items for the same unloading location together) or the stability of stacks. Examples are maximum weight per stack, density-based sorting from bottom to top of each stack, and consideration of the LIFO principle for trucks/containers that can be loaded from only one end.
- **Double deck-specific rules**
  These rules aim to respect the physical limitations of double-deck equipment and reduce the risk of damages during transportation. Examples are maximum weights per stack or row of the upper deck.
- **Unplanned packages**
  Because not all items assigned to the freight order may physically (based on geometry or maximum [axle] weight considerations) fit onto the assigned resource, these rules allow you to specify preferences for which items will be loaded and which won't. Criteria used to calculate a penalty for any item not loaded can be chosen among weight, volume, or weight × volume.
- **Legal regulations**
  A load planning rule representing the US federal bridge formula allows you to consider legal limitations on axle weights for trucks.

- **Loading patterns**
  Motivations for this set of rules are better weight distribution, load stability, and floor space utilization for customized trucks. More than 20 different rules allow you to define the position and orientation of items. These load-planning rules can be defined as vehicle-specific or deck-specific rules. Examples are specific loading patterns, such as straight loading, turned loading, or pinwheel loading.

The result of load planning is a list of all loaded items, the sequence of loading, the orientation for each item (straight or turned), and the exact position with stack and row number defining the position on the floor and level in the stacking sequence. The result can be displayed both in list format and as a 3D visualization.

5.9 Integration to an External Transportation Management System

In addition to the planning capabilities inside TM, you can plan your freight demands with an external transportation management system (TMS). In Figure 5.142, you can see that TM is able to send out freight units to an external system, for example, from a logistic service provider, and then receive the planned freight orders. The communication between the two systems is based on the business to business (B2B) web service `TransportationOrderGenericRequest_Out/In`, which supports the replication of freight units, as well as freight orders (as already introduced in Chapter 2, Section 2.4).

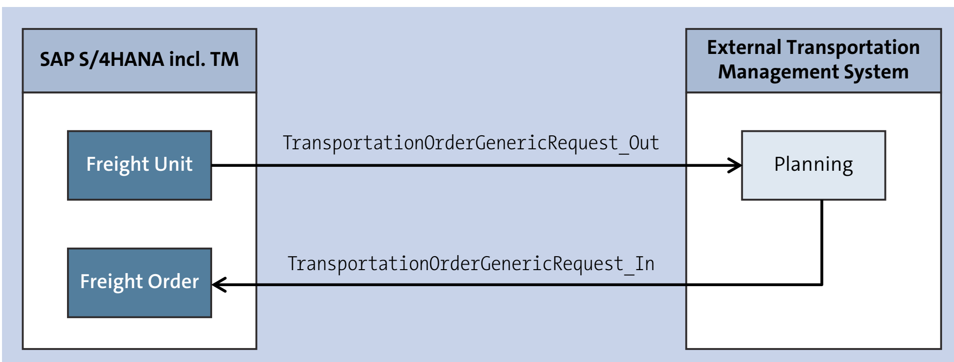


Figure 5.142 External Planning Scenario Based on TransportationOrderGenericRequest_Out/In

The freight unit web service is activated, like most of the other EDI communications, with the help of an action profile that is assigned to a freight unit type. The action profile `/SCMTMS/TOR` contains the standard action `TOR_TPNOR_FU` to send the freight unit replication message. You can check the action profile via Customizing path **Cross-Application Components • Processes and Tools for Enterprise Applications • Reusable Objects and Functions for BOPF Environment • PPF Adapter for Output Management • Maintain PPF**. If you want to use the standard action, you only have to assign the profile to the freight unit type via Customizing path **Transportation Management • Planning • Freight Unit • Define Freight Unit Types** (see Figure 5.143).

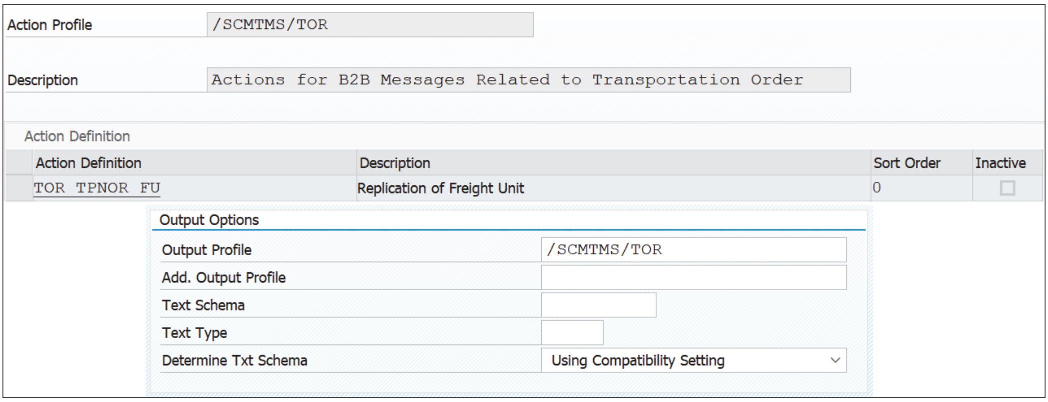


Figure 5.143 Assignment of Action Profile /SCMTMS/TOR to Freight Unit Type Customizing

In standard, the web service message will be sent automatically after the completion of the **Warehouse Processing Status** of the freight unit. This status is an ASR-specific status (see more details in Chapter 12, Section 12.3). In other words, if you want to use the external scenario without ASR or use another schedule condition, you have to adapt it during the project. An explanation of the output management and the concept of the schedule condition can be found in Chapter 2, Section 2.3.

You can see the replication web service in the freight unit by following menu path **Planning • Edit Freight Unit**, on the **Communication History** tab in the SAP Fiori launchpad (see Figure 5.144).

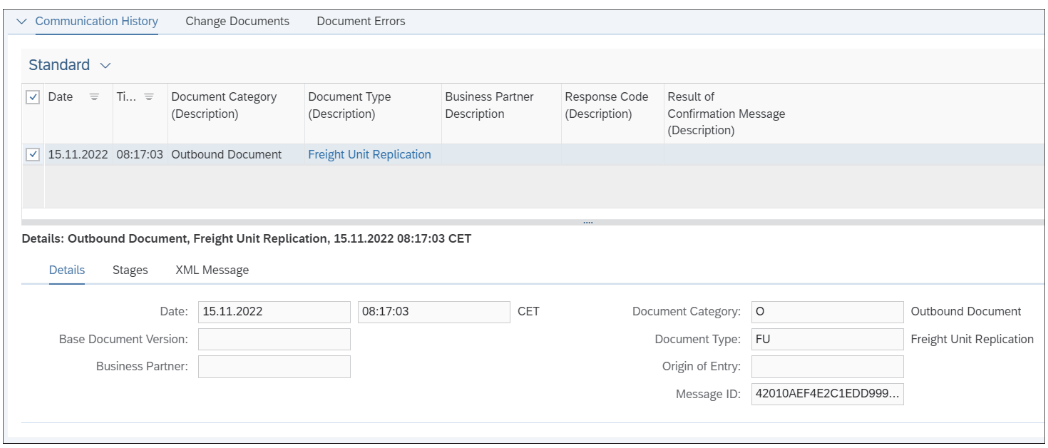


Figure 5.144 Freight Unit Replication Web Service in the Communication History Tab

The freight order creation based on `TransportationOrderGenericRequest_In` (refer to Figure 5.142) works without any additional Customizing. The external planning system has to fill the structure of the web service with the right information, and TM will handle the inbound communication in the correct way. But what kind of information is needed? Let's take a deeper look into the structure of the web service.

In Figure 5.145, you can see that the web service can serve different purposes. At first, different scenarios are supported (as discussed in Chapter 2, Section 2.4). In this case, the web service should be used for the external planning scenario. This is indicated by business scope = "EXTERNAL_PLANNING". Additionally, the category, either "FU" or "FO", describes which transfer of requirements (TOR) object is included in the message. Based on the category, the message has different information. The freight unit replication message contains information about the different parties, such as customer, consignee, or shipper, and the stage information with locations and times. On the item level, the item hierarchy is described with package and product information. This level also contains information about the base document such as the delivery ID. Looking now on the freight order message, we can see that the structure is the same, and most of the information is similar such as involved parties and stage information. The main difference is on the item level. Here, the message again contains a hierarchy, but now freight unit IDs are assigned to a vehicle. Based on this information, TM finds the corresponding freight units for the assignment to the freight order.

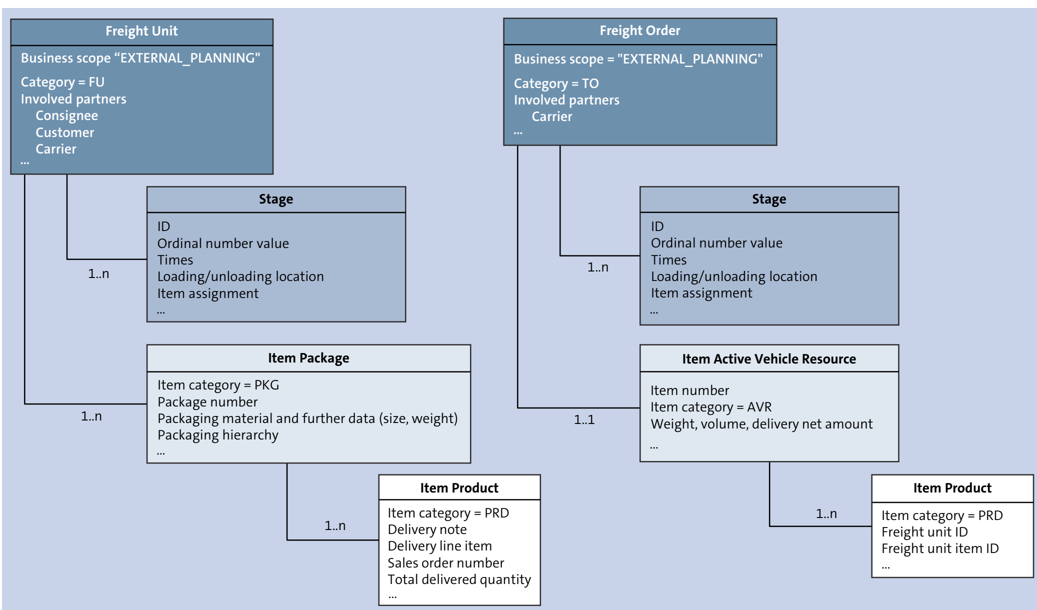


Figure 5.145 Structure of TransportationOrderGenericRequest with Category FU and FO

TM in SAP S/4HANA versus LE-TRA in SAP ERP

Many customers are currently implementing TM in SAP S/4HANA as LE-TRA (the old transport module in SAP ERP) won't be supported in the future by SAP. A classic business scenario in LE-TRA is the external planning scenario based on the shipment via IDoc communication. `TransportationOrderGenericRequest_Out/In` is the replacement of the shipment IDoc in TM, and customers must adapt to the web service when using TM to enable the business scenario.

As these customers are working mostly based on the delivery ID, it's also possible to use the delivery ID as reference in the `TransportationOrderGenericRequest_In` message to create the freight order and find the corresponding freight units. The delivery ID is included on the item level of the outbound communication.

Additionally, SAP provides a consulting note to map the current mandatory fields of the GLOBAL DESADV/VDA4987 standard with `TransportationOrderGenericRequest` (SAP Note 3236759) to support the transition to TM.

On the freight order itself, the communication history contains, as in the freight unit, a reference to the inbound communication. Additionally, you can see on the **General Data** tab in the **General Information** area that the freight order is created via the web service in the **Origin of Freight Document** field (see Figure 5.146).

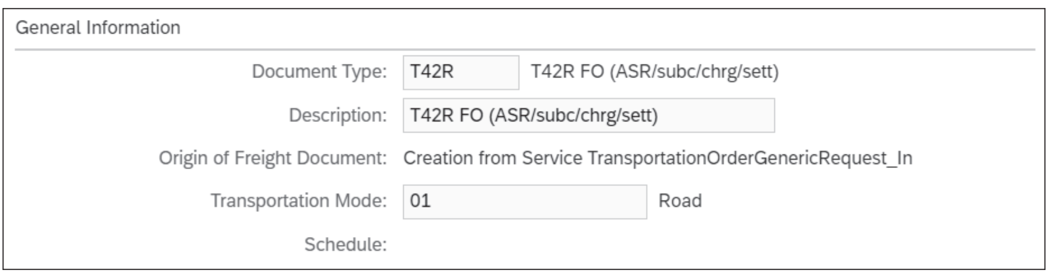


Figure 5.146 Freight Order Origin in the External Planning Scenario.

The `TransportationOrderGenericRequest_Out/In` message supports delete and change processes. Adaptions of the message can be done in two BAdIs via Customizing menu path **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management • Integration • Enterprise Services • Freight Order Management • Freight Order • BAdI for TransportationOrderGenericRequest_Out/In**.

5.10 Summary

This chapter explored the depths of planning in TM. We started by reviewing the different documents involved in this process and exploring the decisions to be made in this process. The definition and creation of freight units transformed the various transportation requirements into plannable objects. Package units have been defined to create a package hierarchy from pure products and quantities.

Multiple manual planning options from textual command-line planning to visually supported planning in the map or Gantt chart have been explained. However, we focused not only on interactive planning but also on automatic planning options that can be executed in the background or even externally.

No matter which planning method is used, all of them produce freight orders, freight bookings, or transportation units. The next chapter focuses on freight orders and how they are subcontracted, tendered, or both.

Chapter 6

Freight Order Management and Subcontracting

Transportation execution can be outsourced to logistics service providers (LSPs) or carriers. Subcontracting leaves the supervision of the transportation process in the control of the company while outsourcing its physical execution. Capacity management allows you to plan consumption of your carriers' transportation capacities on a long-term, mid-term, and short-term basis. Freight order management encompasses the documents required for these processes.

In the previous chapter, we discussed transportation planning as a planning task that deals with the assignment of freight units to available transportation capacities. However, we haven't yet discussed the topic of who will provide these transportation capacities: whether they represent an organization's own fleet of vehicle resources or whether the objective is to subcontract the execution of freight orders.

The focus of this chapter is threefold. The first focus is freight order management, the second focus is capacity management, and the last focus is choosing the best possible carrier through carrier selection and/or tendering processes.

Freight order management deals with the documents that are either used for transportation execution or for subcontracting processes (or both). Depending on the mode of transport these documents are either called freight orders (road or rail) or freight bookings (air or sea). Consignment orders are a third category in this context. However, consignment orders typically don't represent a physical process such as a freight order or freight booking, but rather a logical grouping frequently used in communication between shippers and consignees. On the other hand, subcontracting can also be based on consignment orders.

Transportation capacity management is the process of defining and using your carriers' transportation capacities on different time horizons and geographies. It starts with the long-term contractual part covered by freight agreements and associated capacities, which are represented by freight agreement allocations. Mid-term capacity planning considers gateway schedules based on carrier schedules and schedule-based allocations to plan the capacities for these gateway schedules. The short-term, operative part is the creation of freight documents according to the previously defined mid-term capacities. These operative freight documents are used in daily business, which assigns incoming new freight to freight documents.

The objective of carrier selection is to provide a ranking list of carriers that are available to execute a planned freight order. A broad list of options and constraints is available to streamline the selection of the best possible carrier. These options include expected freight order costs, priorities, incompatibilities, transportation allocations, and business shares representing various contractual obligations. You can perform carrier selection manually, by using an optimization algorithm, or by using an auctioning mechanism as part of the tendering process. The tendering process can itself be used as part of the carrier selection process or as a separate process. In the tendering process, individual freight orders can be tendered to one carrier (peer-to-peer tendering) or to several carriers (broadcast tendering) in parallel. The tendering process involves communication with the carrier in which the carrier can quote prices for the tendered freight order (broadcast tendering) or inform about acceptance or rejection of the freight order (peer-to-peer tendering).

This chapter is structured in the following way: Section 6.1 deals with freight order management, freight order configuration, freight order types, and usage, mainly in land transportation. This section also talks about special processes using freight orders, such as pickup and delivery freight orders in sea and air transportation, customer self-delivery and pickup, and service orders.

Section 6.2 presents freight bookings, which are the freight documents that cover ocean freight and air freight transportation. Basically, these freight bookings can be used to reserve capacity from your carriers. After the carrier has confirmed the freight booking, you can add freight to it. When you've completed your planning and want to execute the freight booking, you can send the content of the freight booking to your carrier, representing the legal document accompanying the execution of the transportation.

Consignment orders are the main topic of Section 6.3. You can group several transportation requirements into a consignment order and use it as a basis for communication between shipper and consignee. Several consignment orders can be grouped into a freight order, and the subcontracting and charge calculation process can be either based on the consignment orders or on the freight order.

In Section 6.4, the capacity management process is presented, including the interplay of the business documents covering the strategic, tactical, and operative aspects; systematic creation of freight documents; and change management that enables you to react to changes in carrier schedules, which are the basis of your business. This section also introduces allocations, which are used to plan consumption of carriers' capacities on various geographical and time levels. The geographical levels range from location-to-location to zone-to-zone levels, and the time levels contain schedule departures as well as daily, monthly, and yearly perspectives. Allocations can be used to create freight documents with corresponding capacities. They are also used by automatic carrier selection to avoid exceeding planned capacities. Finally, business shares are presented, which manage the distribution of freight to carriers according to predefined target shares among the carriers for a specific trade lane and are considered during automatic carrier selection.

Finally, Section 6.5 explains the carrier selection process, objectives, and constraints, as well as the available configuration options, while Section 6.6 focuses on freight tendering and tendering process configuration options.

6.1 Freight Orders

For the most part, freight orders are created as the result of planning, especially in land transportation, whereas freight bookings are used in sea or air transportation. In this section, we focus on the role of the freight order and its automatic or manual creation from a planning perspective; the next chapter covers the view on freight orders from the execution perspective, including the printing of freight documents.

6.1.1 Configuration and User Interface

You can create a freight order either manually or automatically. Choose the manual process if you already know what to order because you regularly create similar freight orders for a carrier. In this case, you manually enter the relevant information (logistical data, e.g., source and destination locations, as well as dates/times and items to be transported) in the freight order user interface (UI), or you copy an existing freight order and change the required fields in your version. You can also create a freight order based on a freight agreement if you want to link it directly to a specific contract for settlement purposes.

On the other hand, there are several options for automatic creation of freight orders:

- **Result of planning**
  Freight orders can be created as a result of two kinds of planning: manual planning in the transportation cockpit and automatic planning using either the vehicle scheduling and routing (VSR) optimizer or transportation proposal functionality.
- **Creation from a freight unit worklist**
  Freight orders are created automatically based on freight units by selecting freight units in a worklist and triggering the corresponding action via a button.
- **Direct creation via a background process**
  Freight orders can be created directly from the freight unit building rule (shortcut planning process; see Chapter 5, Section 5.2.3) or as a result of a direct shipment option (DSO; see and Section 6.1.3 and Chapter 5, Section 5.2.2).
- **Creation via an inbound message**
  Freight orders can be created from outside transportation management (TM) via the inbound message `Transportation Generic Ordering In`.

- **Creation based on a schedule**
  Report /SCMTMS/MP_SCHED_CREATE allows you to create freight orders based on schedule departures.

We'll explain the configuration settings for freight orders in the following sections, starting with freight order types and then continuing with the main freight order UI.

Define Freight Order Types

The most important settings for the freight order are defined in the Customizing activity of the freight order type, which you can access by following menu path **Transportation Management • Freight Order Management • Freight Order • Define Freight Order Types**. Figure 6.1 and Figure 6.2 show the freight order type Customizing with all of its options.

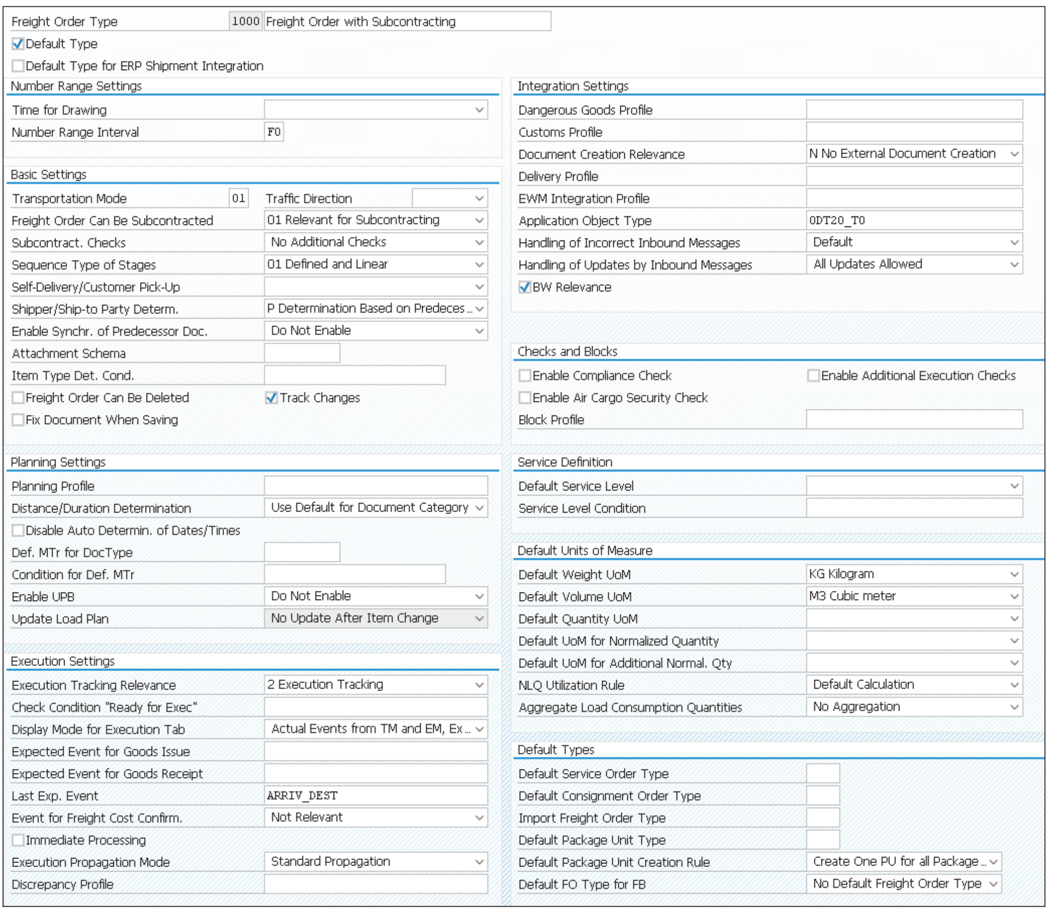


Figure 6.1 Freight Order Type Customizing (1/2)

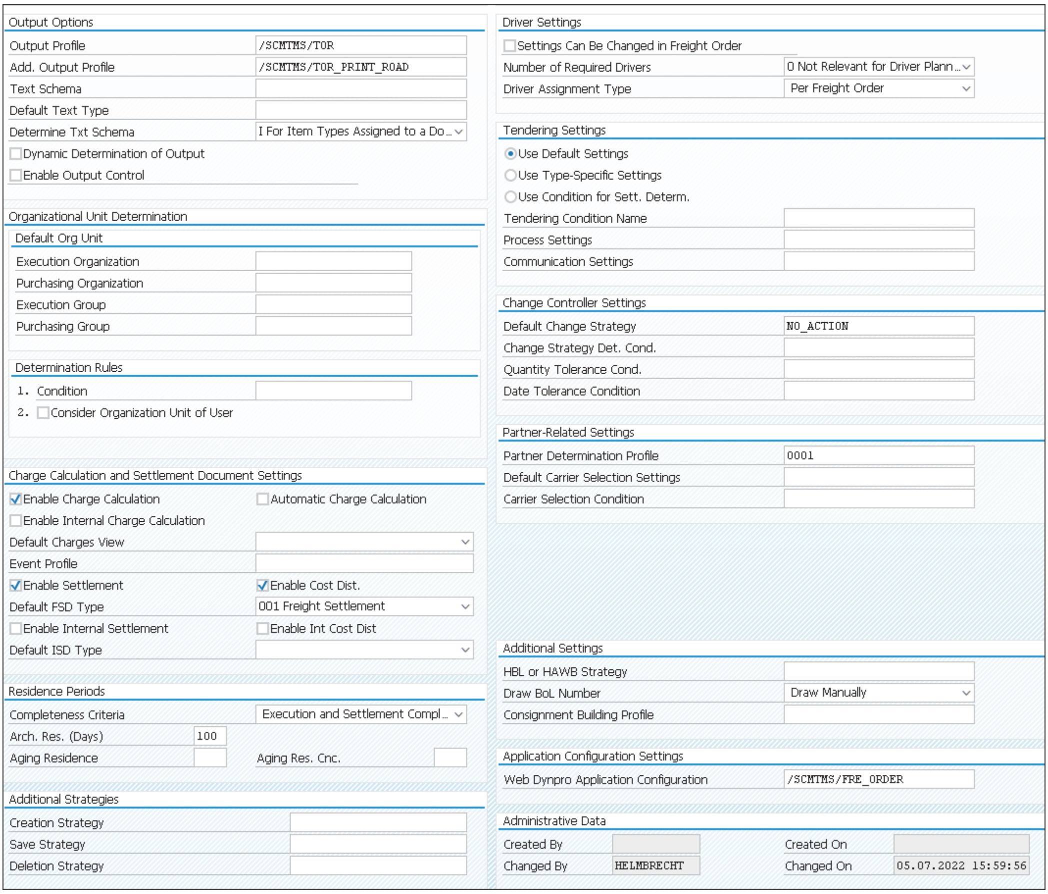


Figure 6.2 Freight Order Type Customizing (2/2)

Let's walk through the most important settings:

- **Freight Order Type**
  The freight order type has to be unique with respect to freight unit types, freight booking types, transportation unit types, consignment order types, and service order types because all of these objects technically originate from the same business object: /SCMTMS/TOR.
- **Default Type**
  Depending on how a freight order is created, the freight order type is manually entered, determined by a condition, determined from the planning profile, or determined from Customizing.

  If the freight order is created during planning, the freight order type is determined from the planning profile (either directly or from a condition maintained there), or the default freight order type is used if the determination from the planning profile has failed. If the freight order is created via the shortcut planning process (see

Chapter 5, Section 5.2.3), the freight order type is determined from the freight unit building rule either directly or from a condition maintained there. If the freight order is created via the DSO process (Section 6.1.3 and Chapter 5, Section 5.2.2), the freight order type is determined from the freight unit type Customizing (either directly or from a condition maintained there). Other processes in which the freight order type is derived from Customizing include the following:

- Freight orders for pickup and delivery: Freight order type is derived from freight booking type Customizing or from the freight order type Customizing (**Default Types**).
- Freight order creation from forwarding order stages: Freight order type is derived from Customizing via menu path **Transportation Management • Forwarding Order Management • Forwarding Order • Define Default Capacity Document Types for Stages**.
- Freight order creation with reference to a schedule: Freight order type is derived from the schedule type Customizing.

- **Number Range Settings**
  The number range settings specify a number range interval and whether a number is drawn immediately or only when the business document is saved.

- **Basic Settings**
  The basic settings define whether the freight order is relevant for subcontracting and whether additional checks are performed before you can subcontract a freight order to a carrier. The basic additional checks make sure that a purchasing organization, purchasing group, and procuring company code are defined in the freight order.

  Sequence Type of Stages determines the structural design of the stages of the freight order. Freight orders created via planning have a **Defined and Linear** stop sequence because the stages of the freight order represent the route that the assigned vehicle resource is expected to drive (e.g., from A to B, from B to C). However, other stop sequences can be defined, such as **Nonlinear Star-Shaped** (from A to B, from A to C) or **Disconnected** (from A to B, from C to D). Figure 6.3 illustrates the different sequence types of stages. These stop sequences, which physically can't be executed as such, may be used in freight orders that are relevant only for charge calculation and can be created using customer-specific functions. No planning activities are allowed for these freight orders. Freight orders created from the parcel process using DSOs may be created with the **Star-Shaped Based on FU Stages** option because all freight units would have the same origin but different destinations.

  In **Basic Settings**, you also define how the shipper and ship-to party are determined. Furthermore, you define whether changes are tracked, whether freight orders are fixed when saving, and whether freight orders of this type can be deleted.

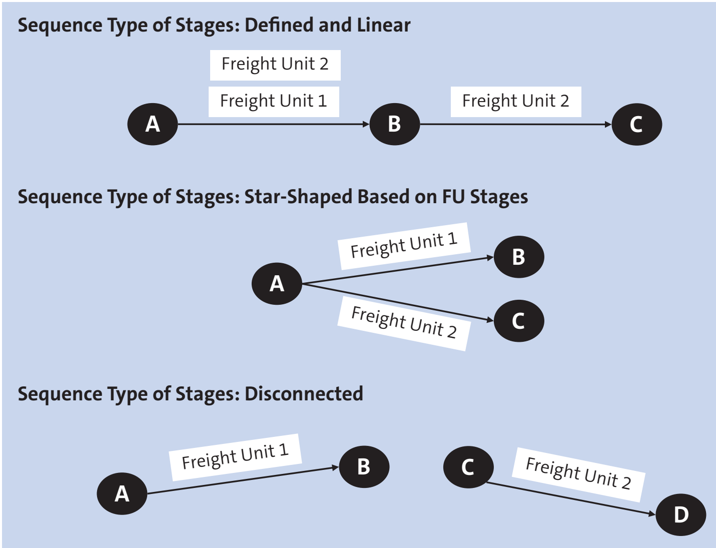


Figure 6.3 Sequence Type of Stages

- **Planning Settings**
  The means of transport of a freight order is usually determined from the vehicle resource assigned to the freight order. However, if the freight order isn't created from planning (e.g., in the shortcut planning process), the means of transport can be determined from the default value defined here or using the specified condition. Similarly, the planning profile can be defaulted here, which may be required for scheduling activities, for example, if these are triggered from the freight order directly and not from the transportation cockpit. Furthermore, you can enable or disable the automatic determination of distances and durations for the freight order. Finally, the Planning Settings allow you to enable or disable unified package building (see Chapter 5, Section 5.3).
- **Execution Settings**
  The execution settings deal with the execution tracking relevance of the freight order type. Tracking and tracing is done with SAP Event Management or SAP Business Network Global Track and Trace, which are described in Chapter 7. The discrepancy profile defines the settings for handling discrepancies (general and quantity discrepancies). A discrepancy profile can contain several discrepancy types. Discrepancies are explained in detail in Chapter 7, Section 7.1.2.
- **Output Options**
  Two output profiles can be assigned to the freight order type. The output options are explained in detail in Chapter 7.
- **Organizational Unit Determination**
  For a freight order, the purchasing organization is relevant in subcontracting scenarios because, in this case, transportation services are purchased from an external

vendor or carrier. Alternatively, the execution organization may be relevant if the freight order isn't subcontracted. The relevant organizational unit for a freight order is first determined from the condition maintained here, second based on the assignment of the user who creates the freight order to an organizational unit, and third from the default values.

- **Charge Calculation and Settlement Document Settings**
  You can enable or disable whether freight orders of this type are relevant for charge calculation, settlement, internal charge calculation, internal settlement, and/or cost distribution, as well as default views and default settlement document types for these options.
- **Residence Periods**
  The residence period defines the minimum time between completion of a document and archiving. Completeness of a freight document is based on the completion of execution, settlement, and, optionally, discrepancies.
- **Additional Strategies**
  Similar to the change controller strategy executed for document changes, additional strategies can be defined to be executed at document creation, save, and deletion. Similar to change strategies, some of these strategies are available in the SAP standard offering, and custom strategies can be defined using the process controller framework (see Chapter 2, Section 2.3.6). Standard save strategies include `CALC_CHARG` to calculate charges at each save or `TOR_CANCEL` to cancel the freight order at save if no transportation requirements are assigned to it. Typical creation strategies are `CARR_SEL` to trigger carrier selection upon creation of the freight order, `TEND_START` to trigger the tendering process upon creation of the freight order, or `CHARG_TEND` to trigger charge calculation and the tendering process upon creation of the freight order.
- **Integration Settings**
  You can define a delivery profile to control creation of delivery proposals based on freight orders. Furthermore, the **Document Creation Relevance** and **EWM Integration Profile** control the integration to extended warehouse management (EWM) in SAP S/4HANA. The **Dangerous Goods Profile** field relates to processing of dangerous goods (DG) content, and the **Customs Profile** field relates to global trade integration.
- **Checks and Blocks**
  Compliance checks, air cargo security (ACS) checks, and additional execution checks can be enabled or disabled. Additional execution checks limit the execution of activities related to cargo management in the freight order based on the handling execution status of the items. Furthermore, you can assign a block profile to your freight order type. With **Block Profile**, you can define initial and delta tolerances for time conflicts that arise during planning and define tolerances within which the time conflict is ignored. The block profile also allows you to define which blocks are propagated to successor business documents. Block profiles are defined in Customizing via menu path **Transportation Management • Freight Order Management • Define Block Profile**.

- **Service Definition**
  The service level for the freight order is determined based on the default setting or retrieved via a condition.
- **Default Units of Measure**
  You can specify a default unit of measure for weight, volume, and quantity. The settings relating to normalized quantities are explained in Chapter 5, Section 5.5.1.
- **Default Types**
  You can specify the default service order type for service orders created from the freight document and default the import freight order type. Furthermore, you can default the consignment order type, package unit type, and the rule according to which package units are built (**Default Package Unit Creation Rule**).
- **Driver Settings**
  The driver settings define whether freight orders of this type are relevant for driver determination, the relevant number of drivers (one or two), and the driver assignment type (per stage or per freight order).
- **Tendering Settings**
  Settings related to the tendering process are defined here. These settings are explained alongside the freight tendering process in Section 6.6.1.
- **Change Controller Settings**
  The change controller settings specify which change controller strategy is used for freight orders of this type or which conditions are used to determine the change controller strategy. The change controller allows you to identify whether a freight order has changed and how you want the system to react to this change. **Quantity Tolerance Cond.** allows you to classify quantity changes into those that don't require a reaction (e.g., rounding differences) or those that require a reaction (e.g., missing quantities). **Date Tolerance Condition** does the same for date/time changes. If the consignee tells you to arrive an hour later, you may only want to inform the carrier, whereas if the consignee requests you to deliver a week later, you may want to replan your freight order. **Change Strategy Det. Cond.** allows you to define a logic with which change strategy you want to react to a combination of quantity changes, date/time changes, location changes, service level changes, and others. You can define your own change strategies using the process controller framework (see Chapter 2, Section 2.3.6) or use standard strategies. Standard strategies are, for example, available to do the following:
  - Remove corresponding freight units from the transportation plan (`REM_CANC`)
  - Stop the current associated tendering process (`STOP_TEND`)
  - Stop and restart the current associated tendering process (`START_TEND`)
- **Partner-Related Settings**
  In the partner determination profile, you can define which business partner roles are relevant to the document and how corresponding business partners are retrieved. The carrier selection condition can be used to derive the carrier selection settings, for example, in a shortcut planning process when carrier selection

is initiated by creation strategy `CARR_SEL`. If the condition doesn't return a result or hasn't been defined, default carrier selection settings as defined here are used.

- **Additional Settings**
  The additional settings deal with house bill of lading (HBL) or house air waybill (HAWB) creation. Furthermore, the **Consignment Building Profile** is defined here (Section 6.3).
- **Application Configuration Settings**
  Finally, the **Web Dynpro Application Configuration** assigned to this document type can be specified. The Web Dynpro application configuration allows you to define the layout of the UI of freight documents of this type. You can define your own Web Dynpro application configuration or use standard ones.

User Interface

Freight orders can be accessed for editing or displaying via worklists (**Order Management • Freight Orders (Worklist)**), from the document flow of predecessor or successor documents, from the transportation cockpit (**Planning • Transportation Cockpit**), or directly via **Order Management • Edit Road Freight Order**. Figure 6.4 shows the UI for the freight order.

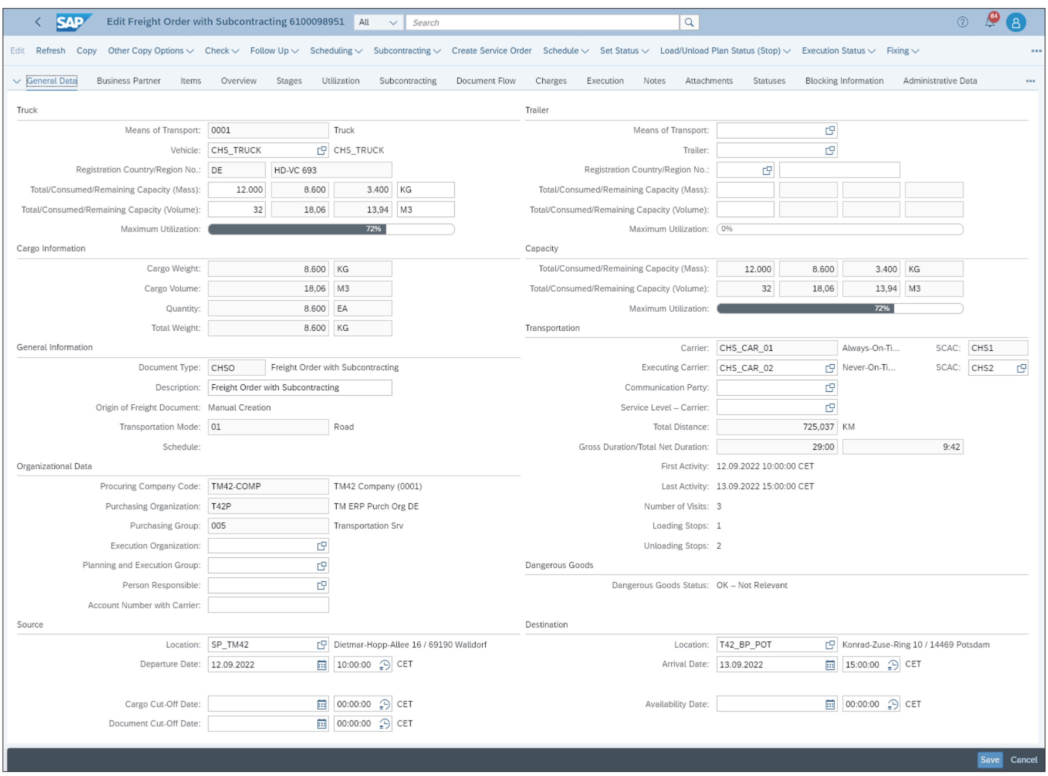


Figure 6.4 Freight Order UI: General Data Tab

The information stored in the freight order is organized into the following tabs:

- **General Data**
  The content of the **General Data** tab is depicted in Figure 6.4. It gives an overview of the freight order. The **General Data** tab shows the freight order type, the origin of its creation, and its transportation mode. Furthermore, it displays geographical information (source and destination location), temporal information (departure and arrival dates and times), cumulative quantities for the cargo assigned to the freight order in different dimensions (weight, volume, pieces), dangerous goods status, assigned capacities (vehicle resources), and carrier and organizational assignments (responsible purchasing organization or planning and execution organization, carrier service level).
- **Business Partner**
  The business partners for the relevant business partner functions are displayed here. The most important business partner functions for the freight order are carrier, shipper, consignee, executing carrier, and communication party. Which business partner functions are mandatory, optional, and/or available for maintenance here depends on the business partner determination profile, which you've defined in Customizing (see Chapter 3, Section 3.1.2) and is assigned to the freight order type. You can update the business partner address that has been retrieved from the master data by maintaining a document-specific address. Deviating business partner addresses can be defined on the document header and item level.
- **Items**
  All items assigned to any stage of the freight order are displayed on the **Items** tab. Figure 6.5 shows the quantities of one of the products assigned to the corresponding freight order. Planned and actual quantities are displayed in different dimensions (gross weight, gross volume, length, width, and height). Planned quantities are retrieved from predecessor documents, whereas actual quantities are filled manually, filled automatically by setting the status **Quantity Received as Planned**, or retrieved from integration with SAP Event Management or EWM in SAP S/4HANA.

  All other information related to cargo is also available here: product details, dangerous goods information, content identification information, customs information, and notes. From this tab, discrepancies can be reported, documented via attachments, and resolved. Different views are available for the **Items** tab. Figure 6.5 shows **All Items**, which displays all items (capacity items such as the vehicle resource as well as requirement items such as the assigned freight units) in a hierarchical format. Another view is the **Status Management** view, which allows you to display the various statuses (**Load Plan** status, **Unload Plan** status, **Handling Execution** status, etc.) for each requirement item. You can also show and create the load plan for the freight order in the **Load Plan** view. The load plan is displayed in tabular format and as a 3D visualization (see also Chapter 5, Section 5.7.6).

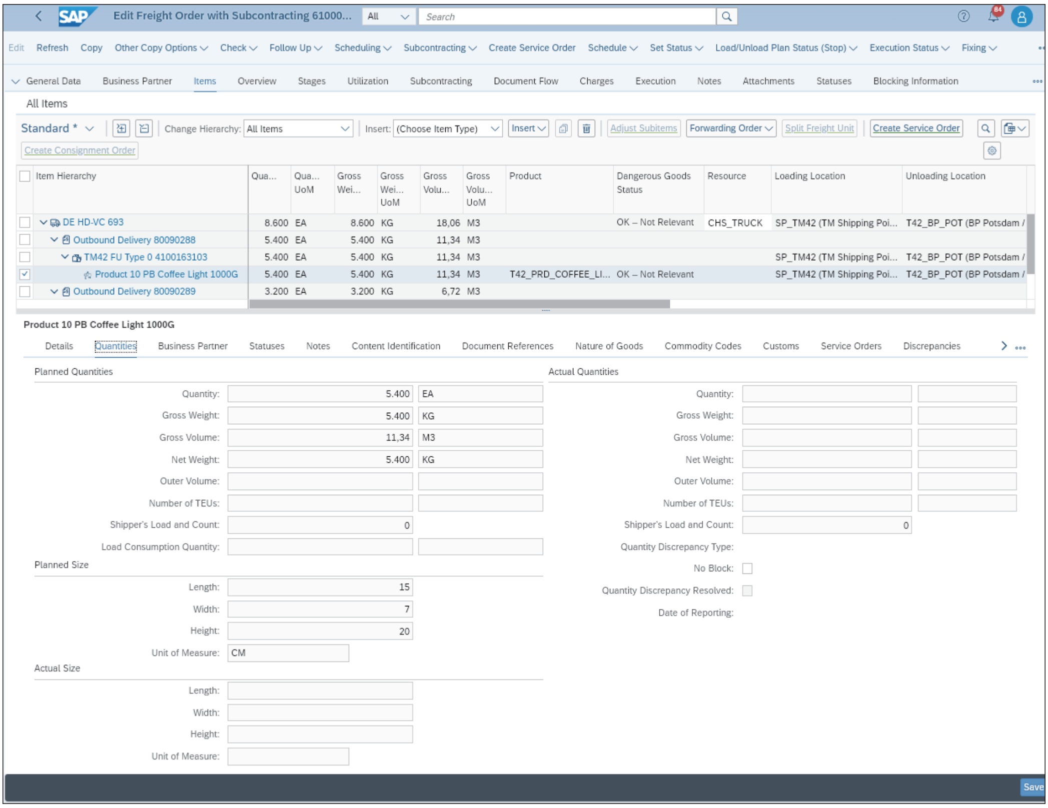


Figure 6.5 Freight Order UI: Items Tab

- **Overview**
  The **Overview** tab displays the logistical information about the freight order in a hierarchical view similar to the freight order details in the transportation cockpit (see also Chapter 5, Section 5.3). As shown in Figure 6.6, the displayed hierarchy consists of the following levels: vehicle resource, involved locations, assigned freight units, and their activities (loading or unloading). You can define appointment times for each stop in the **Overview** tab and the **Stages** tab. The appointment times are hard constraints for scheduling. If the appointment times don't match with the acceptable time windows of the assigned freight units, the system generates an error message. Note that for loading activities, the acceptable start time must match, whereas for unloading activities, the acceptable end time is relevant for the check.

- **Stages**
  The **Stages** tab displays the logistical information about the freight order. For each stage, the distance, duration, planned dates and times, and assigned requirements (freight units) are shown. Stage-dependent block statuses—one for planning and one for execution of the stage—can be checked on this tab.

- **Utilization**
  The utilization of the freight order is visualized on this tab. To calculate the utilization, both planned and actual quantities are considered at each stage. The maximum utilization is calculated for the most critical quantity of the most critical stage and also displayed on the **General Data** tab.

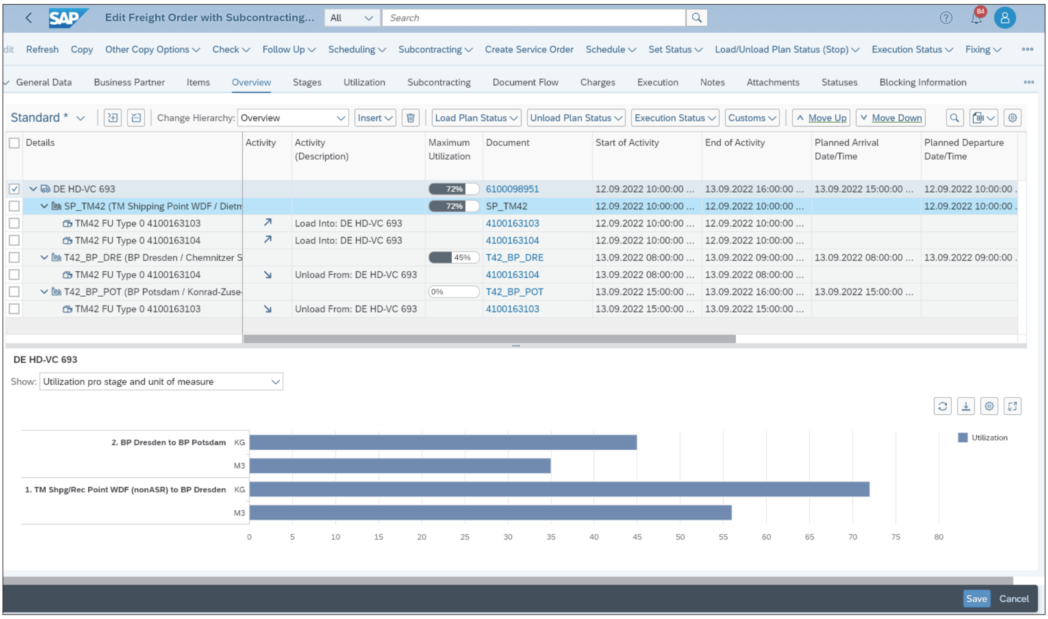


Figure 6.6 Freight Order UI: Overview Tab

- **Subcontracting**
  The **Subcontracting** tab shows all information related to the subcontracting process. This includes the carrier ranking, continuous move information (Section 6.5), and tendering process documentation (Section 6.6). Its content is explained in the respective sections.
- **Document Flow**
  The document flow lists all business documents that have a direct or indirect relationship to the freight order. Figure 6.7 shows an example. Predecessor documents of freight orders that are linked here include the following:
  - Freight units
  - Order-based transportation requirements (OTRs)
  - Delivery-based transportation requirements (DTRs)
  - Forwarding orders
  - Deliveries
  - Sales orders, purchase orders, stock transfer orders, and scheduling agreements (from the sales and distribution functionality and the materials management functionality)

A successor document would be the freight settlement document. Both predecessor and successor documents are displayed in a hierarchical structure.

- **Charges**
  This tab shows the calculation result and all individual charges for external (carrier) settlement. How the charges are determined is the focus of Chapter 9.
- **Execution**
  On the **Execution** tab, you can compare expected and actual dates and times of the events for this freight order, as well as report events. SAP Event Management integration is explained in Chapter 7, Section 7.2.
- **Notes**
  This tab allows the display of freight order texts in different languages.

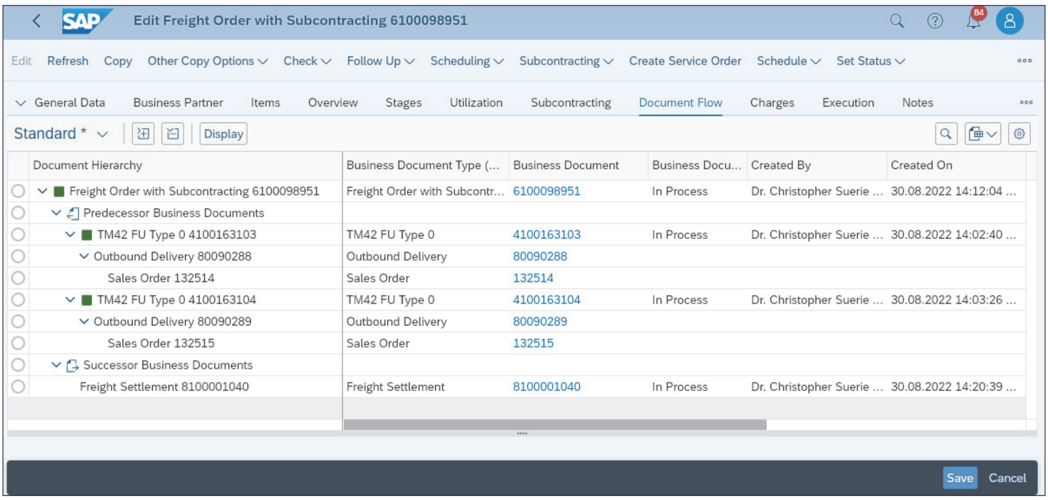


Figure 6.7 Freight Order UI: Document Flow Tab

- **Attachments**
  This tab allows you to link files and URLs to the freight order.
- **Statuses**
  The freight order can be monitored using various statuses:
  – The **Life Cycle Status** shows whether the business document is new, in process, completed, or canceled.
  – The **Fixing Status** prevents changing existing planning results (e.g., you're not allowed to add additional freight units to a fixed freight order). The reason can be that the freight order has been subcontracted and the carrier has confirmed the requested quantities. Adding freight units at this point could lead to situations in which the carrier can't transport the additional (unconfirmed) freight units. For manual planning activities, you can specify to ignore the fixing status in the manual planning settings of the planning profile.

  - The **Subcontracting** status deals with the current status of the subcontracting process (e.g., whether a carrier has already been assigned), and the corresponding **Confirmation Status** shows whether the carrier has confirmed this assignment. Additionally, the **Invoicing Status** shows whether an invoice has been received for the freight order, and the **Dispute Case Status** shows whether a dispute has been created.
  - The **Execution Status** and **Logistical Execution Status** are adapted based on the execution information.
  - The **Manifest Status** shows whether a manifest has been created for the freight order.
  - The **Customs Status** is set based on information from SAP Global Trade Services (SAP GTS) (see Chapter 8, Section 8.1).
  - **Consistency Check** statuses (for the document and cross-document) report the integrity of the business document data.

  Statuses in freight order management relating to the execution of freight documents are explained in detail in Chapter 7, Section 7.1.4.

- **Blocking Information**
  A freight order can be blocked for planning, execution, and invoicing. This is controlled with three separate blocking statuses available on the **Blocking Information** tab. Blocks can be set and removed manually and automatically. Manual blocks can be defined for an entire business document or only for individual document items or stages.

  You can set multiple planning or execution blocks and choose from different block reasons. If blocks were set in a predecessor document, blocks are set by the system automatically. In this case, the information displayed includes which predecessor document caused the block, the type and reason for the block, the date on which the block was created, and the person responsible. When overriding a block, a comment can be entered that is stored along with the information regarding which user has removed the block and when.

  The invoicing block is set automatically or manually but can't be propagated from a predecessor document.

- **Administrative Data**
  The administrative data shows information about the creation and latest change date/time and user.

- **Transportation Dependencies**
  The **Transportation Dependencies** tab shows logistical information from dependent freight order management documents (e.g., freight booking for the main carriage of a freight unit assigned to the freight order, if the freight order represents the pre-carriage).

- **Output Management**
  Print documents or electronic messages can be the result of the output process and are listed here based on their action status (**Unprocessed**, **Successfully Processed**, and **Processed with Errors**). Output actions can be generated and triggered from here. More details about this topic are provided in Chapter 7.
- **Customs**
  The **Customs** tab displays customs-relevant information (see Chapter 8, Section 8.1, for details).
- **Document References**
  The **Document References** tab shows additional external references.
- **Service Orders**
  Service orders related to the freight order are displayed on this tab. Service orders are listed here and on the item level in the **Items** tab depending on whether they relate to the complete document or only to individual items. Service orders will be explained in Section 6.1.4.
- **Drivers**
  If the driver settings can be changed in the freight order (based on Customizing **Transportation Management • Freight Order Management • Freight Order • Define Freight Order Types**), you change the number of required drivers (**Single Driver**, **Driver Team**, **Not Relevant**) and driver assignment type (**Per Stage**, **Per FO**) here. Correspondingly, drivers can be displayed and assigned/removed on the **Drivers** tab, on the **Overview** tab, and on the **General Data** tab. Drivers are defined as business partners (see Chapter 3, Section 3.1.2), but you can also enter a driver who you haven't defined as master data by selecting the **No Master Data Defined** checkbox.
- **Internal Charges**
  The **Internal Charges** tab shows the calculation result and all individual charges for internal settlement. Internal settlement is covered in Chapter 11, Section 11.3.5.
- **Terms and Conditions**
  Terms and conditions include information about the Incoterms for the freight order and about the value of goods (for customs and insurance).
- **Cost Distribution**
  The **Cost Distribution** tab shows how the charges (from the **Charges** tab) are distributed among the cargo transported by the freight order. If goods for two customers (and therefore originating from two sales orders/deliveries) are transported together, the transportation cost has to be borne by these two accounting objects. How the costs are split is shown here (see also Chapter 10, Section 10.2).
- **Change Documents**
  If change tracking has been activated in the corresponding freight order type, the change documents allow you to keep track of who changed what in the freight order.

- **Handling Codes**
  This tab is invisible if not personalized and available only for freight orders and air freight bookings. Handling codes are used to model certain properties of the freight (e.g., whether a unit load device [ULD] can be loaded only on the lower deck).
- **Document Errors**
  If the freight order has been created via an inbound message, the freight order may have been created with errors. In this case, the freight order is still saved, but the errors are displayed on this tab and can be corrected here.
- **Map**
  On this tab, the exact route of the freight order is shown on a map.
- **Communication History**
  The communication with carriers is listed here. This includes inbound and outbound messages, carrier's document number, and stage information from the XML messages.

Rail Freight Orders

Compared to road freight orders, which have been the focus of this chapter, freight orders for rail have some specific differences. Rail freight orders must have a defined and linear sequence of stages. They can represent a train with one or more locomotives and one or more railcars. If several locomotives need to be assigned, they have to be modeled as multi-items. Only one locomotive can be assigned on the header level, which is relevant for scheduling and incompatibilities. The other locomotives can be assigned as subitems of the multi-item. Railcar items can come from railcar units that are assigned to the rail freight orders (similar to trailer units assigned to road freight orders) or can be created directly in the rail freight order as local items. Cargo items are then assigned to railcars. Multi-items can also be used to assign railcars of the same category instead of assigning each individual railcar.

For the most part, the rail freight order UI (**Order Management • Edit Rail Freight Order**) is similar to the UI for road freight orders. For rail freight orders, the **General Data** tab shows the source and destination rail location, the number of railcars, and whether there are multiple executing carriers.

On the **Stages** tab, you can specify the invoicing carrier, which invoices the shipper for the corresponding stages. This is commonly referred to as "rule 11" in rail scenarios in North America. In these rail scenarios, the electronic bill of lading (B/L) is sent to just one carrier. This carrier then forwards the routing instructions to all the invoicing and executing carriers involved. This carrier is usually the carrier responsible for the first or last main stage. In rule 11 scenarios, one carrier accepts the actual rail freight order, but the invoices for the individual stages are submitted by all involved carriers assigned to the different stages.

The **Items** tab indicates the position of the railcar in the train, equipment groups and types, and railcar details, such as whether the railcar is owned by the shipper or carrier.

On this tab, you can change the handling execution status of your cargo and the cargo execution status of your railcars. Any change of one status adjusts the other. For example, if you set the cargo item to **Loaded**, the system also changes the cargo execution status of the corresponding railcar to **Loaded**.

The **Routing** button in the rail freight order UI initiates the following steps to determine possible routing options from the source to the destination rail location:

1. Determine all default routes for which the first and last location (or transportation zone) matches the source and destination rail locations.
2. For each default route, determine freight agreement items for each executing carrier in the default route filtering by trade lane and commodity code.
3. For each default route, determine rates from the freight agreement items for all location combinations within the default route.
4. Show a list of routing options and rating alternatives. A rating alternative includes any combination of rates from different executing carriers from the source to the destination rail location.
5. Based on the selection of a routing option from the list, the system generates the stages of the rail freight order.

For further details on rail freight orders specific to planning, see Chapter 5, Section 5.4.

Many actions can be triggered from the freight order UI. The user can change statuses on the document header level and on the item level for the cargo included in the freight order. In addition, planning activities (scheduling the freight order, starting the transportation cockpit, assigning or unassigning a schedule, and creating a load plan) and actions related to subcontracting (e.g., carrier selection, tendering, and document transfer to the carrier) can be initiated here. Charge calculation and the creation of a freight settlement document, creation and printing of freight documents, and actions related to the logistical integration (creating deliveries, sending and canceling loading/unloading instructions) can be started via buttons on the freight order UI.

In freight order management, a set of checks are available that can be initiated manually from the freight order UI under the **Checks** dropdown at the top of the screen. The document check runs automatically when the freight order is saved, but it can also be started manually. The document check includes the following:

- **Incompatibility check**
  The freight order is checked for incompatible data.
- **Dangerous goods (DG) check**
  The freight order is checked for DG.
- **Check for cross-document time conflicts**
  Time conflicts between the freight order and predecessor or successor documents are checked, for example, if a freight booking arrives too late for the subsequent freight orders or transportation times are outside pickup or delivery time windows.

- **Capacity check**
  The content of the freight order is checked for capacity violations.
- **Resource check**
  The system checks the validity, downtimes, and planning locks for the resources assigned in the freight order and whether they are used by other freight documents at the same time.

  Note that the resource check is also triggered automatically when you enter a resource in the freight order, and it's even triggered automatically in the background when you change the resource availability in master data.

Many of these actions can also be triggered from the freight order worklist (**Order Management • Freight Order (Worklist)**). There you can also mass-change many freight orders at the same time. Data to be changed en masse include transportation data (e.g., means of transport, resource), carrier data (e.g., Standard Carrier Alpha Code [SCAC], executing carrier), and source and destination data (e.g., locations, dates, and times). Other mass actions include the creation and update of notes or mass output.

Planning Profile

The planning profile includes some important information for the freight order, such as whether capacity violations result in an error or warning and which incompatibility settings need to be watched. Therefore, a planning profile needs to be associated with the freight order even when the freight order needs to be changed in transactions that aren't planning related, such as the freight order UI.

For that purpose, a planning profile is stored in the `Plan_Prof_Key` field of the root node of business object `/SCMTMS/TOR`. This field is populated with the planning profile that has been used to create the freight order (e.g., in the transportation cockpit or via a background planning run) or via evaluation of a condition with condition type `/SCMTMS/TOR_PLN_PROF`. If no planning profile can be determined, then the defaults are applied (e.g., no incompatibility check).

6.1.2 Freight Order Items

Items in freight order management documents can represent either capacity or demand (with the exception being containers, which can represent both). Local freight order management items that haven't been transferred from predecessor documents can be changed in the freight order or freight booking.

The following items represent capacity:

- Vehicle resources (active)
- Passive vehicle resources (e.g., trailers and railcars)
- Containers

The following items represent demand:

- Containers
- Packages (e.g., pallets or cartons)
- Packaging materials
- Auxiliary packaging materials
- Products

In addition, nonphysical items (services) can be assigned to items of the freight document. Capacity items are displayed on the **General Data** tab, while both, capacity and demand items, are displayed on the **Items** tab of the freight order UI.

Except for railcar units, each freight order management business document can have only one main item and any number of subitems. Railcar units can have several main items. The item hierarchy defines which items can be loaded into which other items; for example, a product is loaded onto a pallet, which is loaded into a container, which is loaded onto a trailer. You can define item types in Customizing by following menu path **Transportation Management • Freight Order Management • Define Item Types for Freight Order Management** and defining which item types are valid for a document type by assigning the item type to the freight document type (e.g., for freight orders, **Transportation Management • Freight Order Management • Freight Order • Define Freight Order Type**). In the item type shown in Figure 6.8, you can define whether the item is a multi-item. Multi-items can be defined for passive vehicle resources, containers, packages, and products. For a multi-item, you decide in the item type whether subitems are created automatically for multi-items (expansion) or whether the item represent a multi-item (no expansion). This controls whether you'll find in the item hierarchy 1 line item for 10 containers, for example, or whether this multi-item is automatically expanded to 10 line items, each representing 1 container.

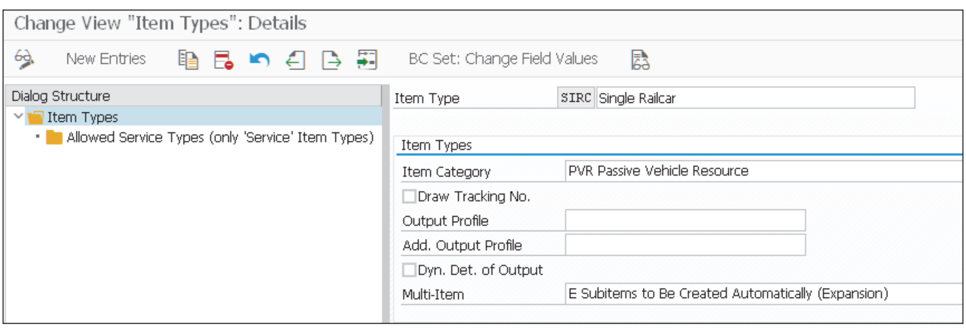


Figure 6.8 Freight Order Management Item Type Customizing

Auxiliary packaging materials include lining in cartons, foil, protective paper, or wooden bars and pallets used to secure the load. Auxiliary packaging materials can be added manually in the item hierarchy of a freight order, or they can be created automatically under a package as part of the package-building process. They are included in messages, such as an advanced shipping notification (ASN).

6.1.3 Special Processes with Freight Orders

This section summarizes some special scenarios that can be represented by freight orders. First, freight orders for pickup and delivery are focused on allowing you to model the transfer between, for example, a gateway and a port, in an ocean freight booking. Then we discuss customer self-delivery and pickup, which are two nontransport-relevant stages in the transportation chain. Finally, we examine the parcel process.

Freight Order for Pickup and Freight Order for Delivery

Freight orders for pickup and freight orders for delivery can be used in an ocean freight process or an air freight process. In an ocean freight process, they are created out of the freight booking for the transfer of containers from the export gateway to the port of loading (freight order for pickup) and/or for the transfer from the port of destination to the import gateway (freight order for delivery), as shown in Figure 6.9. Whether these stages become part of the freight booking depends on the service definition, which determines if consolidation at the source or destination location is required. In an air freight process, these orders are created similarly between the gateways and the airline's delivery/pickup address to transport either ULDs or loose cargo.

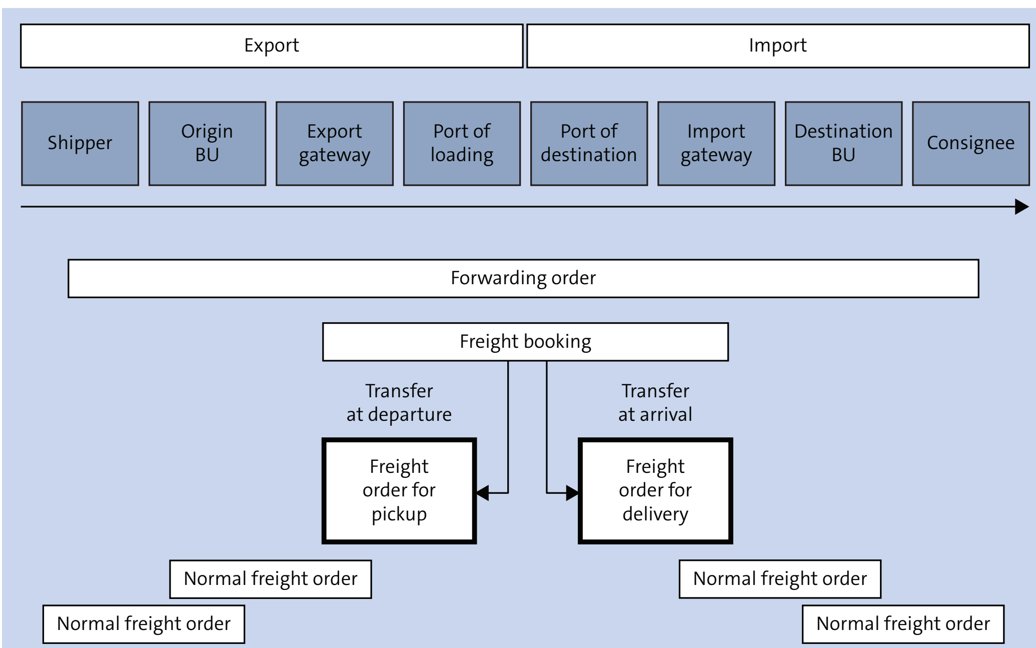


Figure 6.9 Freight Order for Pickup and Freight Order for Delivery

A prerequisite for this process is that the freight booking (ocean or air) has been created from the export gateway to the import gateway. In this situation, the freight orders for pickup and delivery can be created from the freight booking UI (**Items** tab) or from a freight booking worklist (**Order Management • Freight Bookings (Worklist)**). The freight order type used for the creation of these freight orders is defined in the Customizing of the freight booking type (**Transportation Management • Freight Order Management • Freight Booking • Define Freight Booking Types**). You can create one or several freight orders for pickup and delivery from each freight booking, but you can also consolidate freight from several freight bookings into one freight order for pickup and delivery.

The advantage of tight integration between the freight booking and its freight orders for pickup and delivery is that changes in one document automatically update the other document. The following information is copied from the freight booking to the freight orders for pickup and delivery:

- Seal information and changes to seals
- Item changes
- Location changes
- Date/time changes
- Adjustment of handling execution status

The following information is copied from the freight orders for pickup and delivery to the corresponding freight booking:

- Change of cargo receipt status
- Reporting/resolution of discrepancies

Customer Self-Delivery or Pickup

Freight orders for customer self-delivery and pickup are only used for documentation purposes. They offer limited functionality compared to normal freight orders and aren't relevant for planning or charge calculation and settlement. This is indicated in the Customizing of the freight order type (**Transportation Management • Freight Order Management • Freight Order • Define Freight Order Types**), which is marked as a freight order for **Self-Delivery/Customer Pickup** (refer to Figure 6.1), and the use of a "light version" of the freight order UI by defining Web Dynpro application configuration `/SCMTMS/FRE_ORDER_SDCP` in the freight order type Customizing.

Freight orders for customer self-delivery and pickup can be created directly from the forwarding order UI (**Actual Route** tab) or a forwarding order worklist (**Order Management • Forwarding Orders (Worklist)**) in an air or ocean process. If these freight orders are created based on the forwarding order, it's a prerequisite that the corresponding stages are defined based on a stage type with either category **Customer Self-Delivery** or **Customer Pick-Up** (in Customizing: **Transportation Management • Forwarding Order Management • Define Stage Types**). In addition, these stages need to be set to **Never Relevant for Planning** in the stage type sequence of the movement type used in the forwarding order (in Customizing: **Transportation Management • Forwarding Order Management • Define Stage Type Sequence for Movement Types**) or in the corresponding stage profile (in Customizing:

Transportation Management • Forwarding Order Management • Define Stage Profiles). However, the process can also be reversed. In this case, the freight order for customer self-delivery is created only upon arrival of the truck in the yard. When the truck is unloaded, the freight order and its items are created. Using the **Create Forwarding Order** pushbutton on the **Items** tab of the freight order, the forwarding order, its freight unit(s), and the link between the first transportation stage of the freight unit(s) and the freight order for customer self-delivery are created.

Parcel Process

The parcel shipment process deals with transporting parcels from one shipping point to several consignees by an external carrier. The objective of the parcel shipment process is to select a carrier with relevant transportation services while taking into account the applicable freight charges. A parcel shipment process is represented in TM by freight orders from one shipping point to several consignees based on deliveries (or DTRs) using DSOs and includes the following steps:

1. **Creation of parcel shipments**
   A parcel shipment is a freight unit. For each delivery, exactly one freight unit must be created.
2. **Determination of DSOs**
   Determination of DSOs can be triggered manually from the freight unit UI or automatically upon the creation of the freight unit by configuring **Automatic Determination of Direct Shipment Options** in the Customizing of the freight unit type (**Transportation Management • Planning • Define Freight Unit Type**; see Figure 6.10). The determination of DSOs takes into account transportation lanes and incompatibilities based on the capacity selection settings (see Figure 6.11). It checks for freight agreements with the carriers and service products defined therein that meet the requirements of the parcel shipment (e.g., pickup and delivery times or service level). The transit duration is determined based on the duration determination type defined in the freight agreement of the carrier, which defines a transit duration and a calendar. Based on the transit duration and calendar, the freight unit is scheduled to determine eligible DSOs. The eligible DSOs for different carrier and service-level combinations are displayed on the **Direct Shipment Options** tab of the freight unit. Automatically, the cheapest DSO is selected, but a user can deviate from this selection manually.
3. **Assignment of parcel shipment to a parcel freight order**
   The assignment of the parcel shipment to a parcel freight order is governed by the **Direct Shipment Strategy** (see Figure 6.10). Strategy `DSO_RESULT` assigns the freight units automatically to an existing freight order or creates a new freight order and assigns the freight unit. Strategy `DSO_DEF` only creates the DSOs and leaves the assignment to a freight order to a user or background report /SCMTMS/DIRECT_SHIPMENT_BATCH.

   Suitable freight orders must have matching source location, pickup date, and carrier.

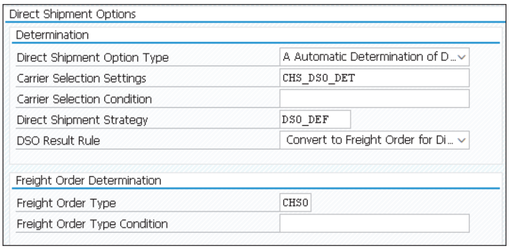


Figure 6.10 Direct Shipment Options

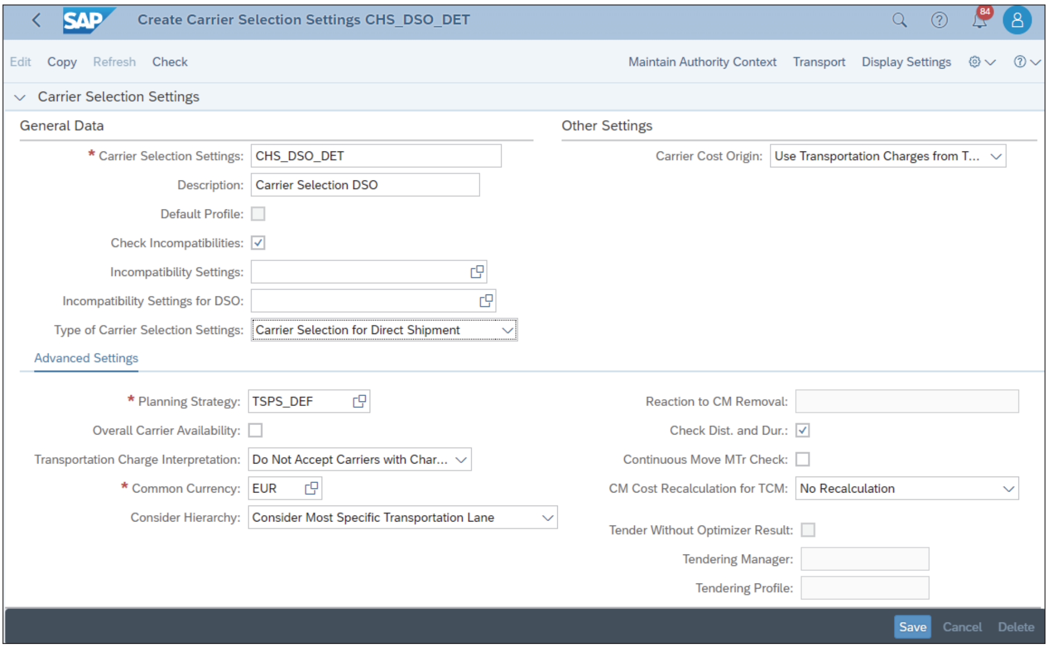


Figure 6.11 Carrier Selection Settings for Direct Shipment

4. **Editing the parcel freight order**
   Parcel freight orders require specific Customizing settings in the freight order type (**Transportation Management • Freight Order Management • Freight Order • Define Freight Order Types**). The default setting for the **Sequence Type of Stages** in the parcel process (refer to Figure 6.3) is **Star-Shaped Based on FU-Stages**. To allow for printing of parcel manifests and labels, you can use /SCMTMS/TOR_PRINT_PARCEL_ROOT as an additional output profile, and to adapt the UI for parcel requirements, you can use /SCMTMS/FRE_ORDER_MANIFEST as Web Dynpro application configuration. To automatically derive B/L numbers (shipment numbers), the freight order type needs to draw B/L numbers automatically with HBL building strategy PRCL_SHP.
5. **Sending and confirmation from carrier**
   The freight order is sent to the carrier and confirmed or rejected by the carrier.

6. **Document printing and execution**
   The parcel manifest and labels can be printed from the **Output Management** tab of the freight order UI. After the **Cargo Ready for Loading** status has been set to start execution and tracking, no automatic assignment of additional freight units to the freight order is allowed, and the parcel freight order is processed like any other freight order.

6.1.4 Service Orders

Cleaning containers, fumigating, and performing security services or documentation are typical examples of services that can occur for items of a freight order or freight booking. These services can be added to freight orders/freight bookings as local service items in the item hierarchy, if the service provider is the same as the carrier of the corresponding freight order/freight booking. However, if these services are provided by a third party, a separate document is required. The *service order* is used to account for and track services, calculate charges, and enable settlement of the charges for services that have been provided for individual items in a freight order/freight booking or for the entire freight order/freight booking by a business partner other than the carrier.

Service orders are created from the freight order/freight booking UI or as standalone service orders without reference to any freight order/freight booking. The **Service Order** tab in the freight order/freight booking UI displays an overview of the service orders created for the freight order/freight booking, while similar information for items is provided on the **Items** tab of the freight order/freight booking UI. The service order UI (see Figure 6.12) provides the following information:

- **General Data**
  The **General Data** tab shows the involved parties (purchasing organization and service provider), as well as the service order type and status information. The service order type is defined in Customizing (**Transportation Management • Freight Order Management • Service Order • Define Service Order Types**). In the service order type Customizing, you define options similar to those in the freight order type Customizing. That is, you can enable charge calculation and settlement, define number range settings, define output options, define how organizational units are determined for service orders of this type, and define change controller and execution tracking settings.
- **Services**
  Under **Services**, the link to the freight order/freight booking or freight order/freight booking items is displayed, as well as the service types that have been or will be provided for the freight order/freight booking or freight order/freight booking items, their location, and the execution time per service type. Service types are defined in Customizing (**Transportation Management • Basic Functions • General Settings • Define Service Types**). Service types can be assigned to item types (**Transportation Management • Freight Order Management • Define Item Types for Freight Order**

Management), which are then linked to service order types (**Transportation Management • Freight Order Management • Service Order • Define Service Order Types**).

The **Charges**, **Document Flow**, **Notes**, **Attachments**, **Change Documents**, **Output Management**, and **Administrative Data** tabs of the service order UI provide similar information as the corresponding tabs on the freight order UI covered in Section 6.1.1.

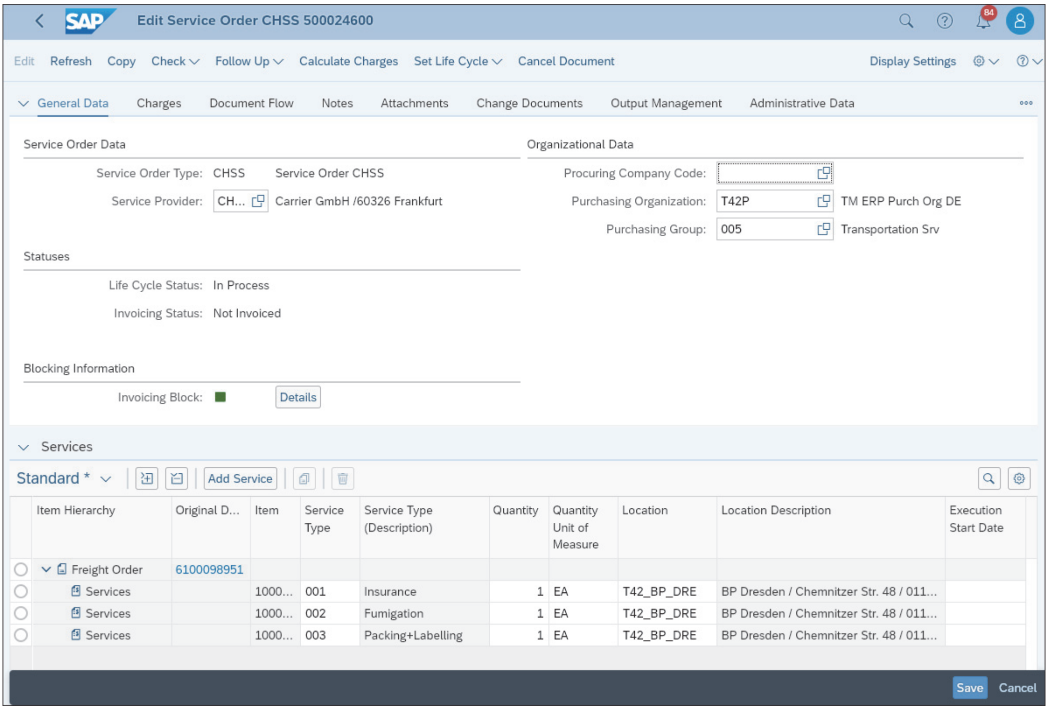


Figure 6.12 Service Order UI

You can edit or display the service order by following menu path **Order Management • Edit Service Order**, by selecting the service order from a worklist (**Order Management • Service Order (Worklist)**), or via the document flow of a related document (e.g., freight booking). In the next section, we expand the view of freight order management to ocean and air transports by introducing ocean and air freight bookings.

6.2 Freight Bookings

Freight bookings are used to reserve freight space on a vessel or in an airplane. The corresponding mode-specific freight documents—called ocean freight bookings and air freight bookings, respectively—provide mode-specific information, such as the vessel name or flight number, on their UIs. The space reserved by freight bookings is consumed by assigning freight units or container units to the freight bookings.

An ocean freight booking represents ocean transportation from a port of loading to a port of discharge, and an air freight booking represents air transportation from an airport of departure to an airport of destination. Freight bookings can cover a consolidation location before the source (air-)port and a deconsolidation location after the destination (air-)port, as illustrated in Figure 6.13. These consolidation and deconsolidation locations are called container freight stations (CFSs) in the ocean case and gateways for the air case. Because the term *gateway* is also used in ocean scenarios, we use the term in the general sense. It's possible to omit the source gateway, the destination gateway, or both gateways, analogously as for schedules as described in Chapter 3, Section 3.2.4. Note that the main leg can consist of multiple stages to model connection flights or multistop voyages. For the pickup leg and delivery leg, freight orders for pickup and freight orders for delivery can be created out of the freight booking (Section 6.1.3).

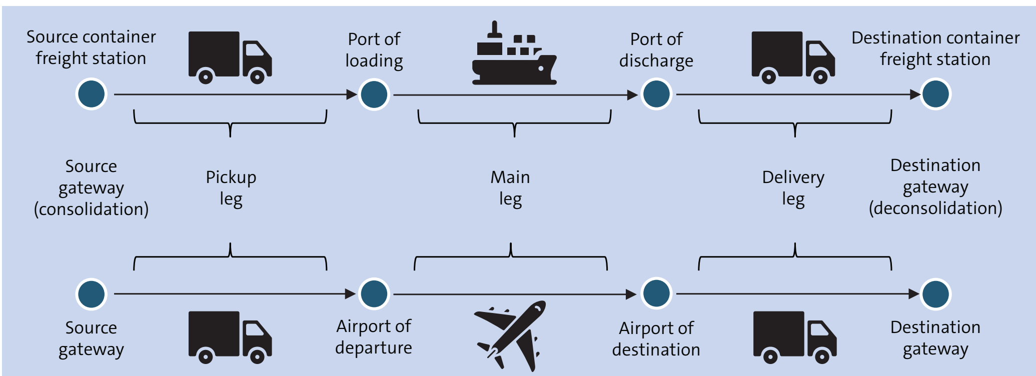


Figure 6.13 Structure of Locations and Stages of Ocean Freight Bookings and Air Freight Bookings

Freight bookings can be generated based on schedules, or they can capture the results of planning (e.g., the assigned freight units). They are typically subcontracted to a carrier. To define the carrier of a freight booking, you can directly assign a carrier, use the carrier selection process described in Section 6.5, or the carrier is taken over from the schedule that is referenced by the freight booking. Once the carrier is assigned, you can send the freight booking to your carrier and explicitly set the response by the carrier, who can confirm, confirm with deviations, or reject the freight booking.

Similar to freight orders, charges can be calculated, freight settlement documents can be created, and costs can be distributed among the involved parties. Freight bookings also serve for transportation execution processes, such as printing, tracking, and tracing the progress of transportation.

Let's examine both kinds of freight bookings. Section 6.2.1 presents ocean freight bookings, reviewing the different functional areas in the UI and the customization of freight booking types. Section 6.2.2 describes air freight bookings, focusing on how they differ from ocean freight bookings and additional air freight specifics.

6.2.1 Ocean Freight Bookings

There are many ways to create ocean freight bookings. You can follow menu path **Order Management • Create Ocean Freight Booking** and manually create an ocean freight booking. You can also create ocean freight bookings from the corresponding worklist, which is available via menu path **Order Management • Freight Bookings Worklist**. Alternatively, it's possible to copy ocean freight bookings, which means that the header and logistical data of the original freight booking but no assignments (e.g., to freight units) are copied. You can also create ocean freight bookings by manual planning (see Chapter 5, Section 5.7), automatic planning (see Chapter 5, Section 5.8), or capacity management, using the report to create schedule-based freight documents, as explained in Section 6.4.2. Manual and automatic planning can also change the freight unit assignments to freight bookings. It's also possible to create freight bookings from an ocean forwarding order for the stages of the actual route, as described in Chapter 4, Section 4.2.

The following sections will explain the ocean freight booking UI and the freight booking types Customizing.

Define Freight Booking Types

You can define freight booking types via the Customizing menu path **Transportation Management • Freight Order Management • Freight Booking • Define Freight Booking Types**, as shown in Figure 6.14 and Figure 6.15.

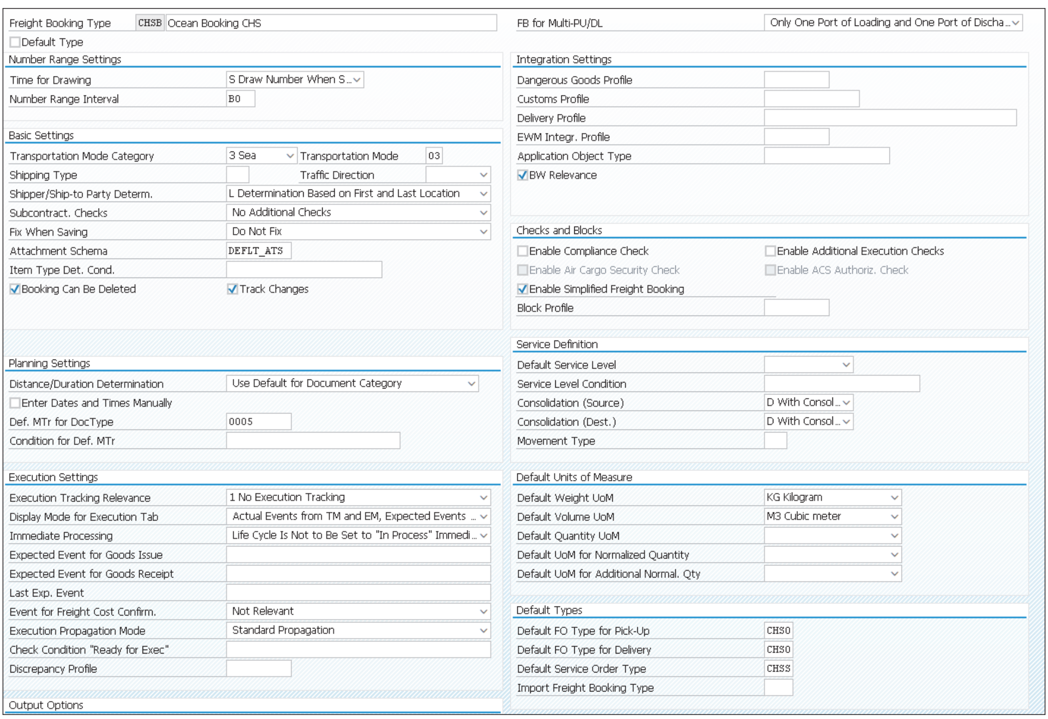


Figure 6.14 Freight Booking Type Customizing (1/2)

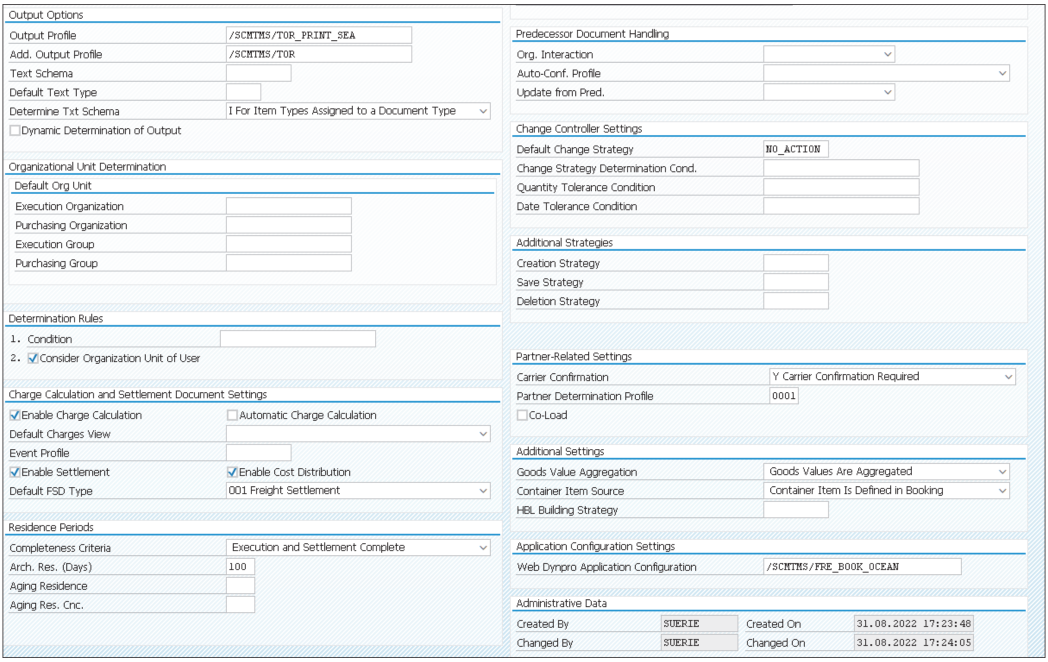


Figure 6.15 Freight Booking Type Customizing (2/2)

When you compare the Customizing of freight order types (refer to Figure 6.1 and Figure 6.2) and freight booking types, you can spot many similarities. Both contain sections such as **Number Range Settings**, **Execution Settings**, **Output Options**, **Organizational Unit Determination**, **Residence Periods**, **Additional Strategies**, **Default Units of Measure**, **Change Controller Settings**, and **Application Configuration Settings** that are almost identical and serve the same purpose for freight orders and freight bookings. Therefore, let's focus on those Customizing settings that are different between freight orders and freight bookings:

- Usually, an ocean freight booking transports goods along a port-to-port connection. In some ocean transportation businesses, it's common to have ocean freight bookings transporting goods along a port sequence. Freight can be loaded in all but the last port, and freight can be unloaded in all but the first port. Using the **FB for Multi-PU/DL** (freight booking with multiple ports of loading and ports of discharge) setting, you can enable ocean freight bookings with a port sequence that has more than two stops. Such ocean freight bookings can only be created manually, and this functionality is offered only for ocean scenarios.
- The differences in the **Basic Settings** relate to subcontracting, the sequence type of stages, and self-delivery/customer pickup scenarios. All freight booking types can be subcontracted, in contrast to freight order types, which can forbid subcontracting to cover transportation businesses fully relying on their own fleets. Although carrier selection and tendering are offered for freight orders, only carrier selection

is possible for freight bookings. In most scenarios, the carrier is already known at the time of freight booking creation because the carrier is assigned to the schedule referenced by the freight booking. With respect to the sequence type of stages, freight bookings allow only sequential stages. Finally, self-delivery/customer-pickup scenarios aren't relevant for freight bookings.

- Within the **Service Definition** section, in addition to the default service level and service level condition, you can define the movement type and whether a consolidation location and a deconsolidation location, respectively, are involved. Using the last two parameters regarding consolidation and deconsolidation locations, you can create port-to-port, port-to-gateway, gateway-to-port, and gateway-to-gateway ocean freight bookings and their air freight booking counterparts.
- You can create pickup and delivery freight orders for the stages from consolidation location to source (air-)port and from destination (air-)port to deconsolidation location, respectively. The freight booking type can define the pickup freight order type and delivery freight order type (**Default Types**).
- Within the **Predecessor Document Handling** section, the sales organization in a forwarding company can access freight bookings and assign forwarding orders and their freight units, but the final decision about the assignment is made in the planning and execution organization. The organization interaction status of the corresponding freight unit stages can request confirmation from the planning and execution organization where the capacity manager works. After a forwarding order is assigned to the freight booking, the capacity manager has to check and confirm the assignment. The manager may accept or reject the assignment; in the second case, an alternative freight booking needs to be identified to ensure that the sold forwarding order can be executed. In the transportation cockpit, the fields for the organization interaction model aren't visible in the standard lists, so you have to activate them in the corresponding views. Refer to Chapter 5, Section 5.2.2, which discusses the organization interaction model from the freight unit stage perspective.

  The **Org. Interaction** parameter activates the organization interaction processing for freight bookings. If active, you have to define an auto-confirmation profile.

  The auto-confirmation profile allows you to confirm freight unit stages automatically, which means that they don't have to be checked manually by the planning and execution organization. Define these profiles using the Create Auto-Confirmation Profile app. For example, you can define that all assignments of quantities below 50 kg are confirmed automatically, which means that all assignments above 50 kg have to be confirmed manually by the planning and execution organization. The **Update from Pred.** parameter specifies whether the assignment of freight unit stages to a freight booking is processed asynchronously or synchronously. If you use the organizational interaction process, we recommend the asynchronous processing, which doesn't lock the freight booking and may therefore lead to exceeding the booking capacity. The assignment of the freight unit stage can then be confirmed automatically or manually.

- You can choose between manually entering the value of goods on the header level and automatically aggregating it via the values of the items' goods (**Additional Settings**).
- The **Container Item Source** from the **Additional Settings** section determines whether container items are taken from the predecessor document or manually defined in the freight booking. In the first case, the item structure of the predecessor document is copied directly into the freight booking. In the second case, if you enter a number of containers, an equipment group, and an equipment type in the **Capacity Requirements** area of the freight booking, corresponding container items are created automatically in the **Items** area. The assigned freight units become subitems of these container items.
- Depending on the process that you want to model with ocean freight bookings, different **Web Dynpro Application Configurations** are available. Use `/SCMTMS/FRE_BOOK_OCEAN_BULK` if you want to create ocean freight bookings for multi-pickups and/or multi-deliveries, or use `/SCMTMS/FRE_BOOK_OCEAN_LOOSE` if you need to transport loose cargo.
- You can't assign drivers to freight bookings.
- Internal charge calculation, internal settlement, and internal cost distribution aren't supported for freight bookings.
- The **Document Creation Relevance** (**Integration Settings**) isn't relevant for freight bookings, but only for freight orders.
- The **Co-Load** and **Air Cargo Security Check** parameters and the corresponding authorization check are described next in the context of air freight bookings.

HBLs and HAWBs can be created for the ocean freight booking and air freight booking, respectively. They are created using the corresponding follow-up action on the freight booking UI and displayed on the **Items** tab (ocean freight booking) or **Capacity and Cargo** tab (air freight booking). The creation happens according to the strategy defined in Customizing of the freight booking type. The default strategy `HBL_SHPCNS` groups together all items that have the same shipper and consignee. Use strategy `HBL_TRQID` to group items originating from the same forwarding order together; use strategy `HBL_SCCONT` to group items that have the same shipper, have the same consignee, and are transported in the same container; and use `HBL_SHPCNA` if you want to group items for which the shipper's and consignee's addresses are identical.

Most of the described customization options as well as the process of managing freight bookings doesn't differ between ocean and air freight bookings. However, there are some specific air freight aspects, as discussed in Section 6.2.2.

User Interface

Ocean freight bookings contain a lot of information that is structured on the UI in multiple areas. Because the basic technical object of freight orders and freight bookings is

/SCMTMS/TOR, the UIs of freight orders and freight bookings bear many similarities. The differences compared to the freight order UI (Section 6.1.1) are the following:

- **General Data**
  The **General Data** tab in Figure 6.16 displays information about carriers, goods information, capacity requirements, organizational data, and transportation distance and duration. The key difference to the **General Data** tab of the freight order is the voyage information. It references the voyage, vessel, IMO ship identification number, and schedule. However, it's also possible to maintain an ocean freight booking without reference to a schedule.

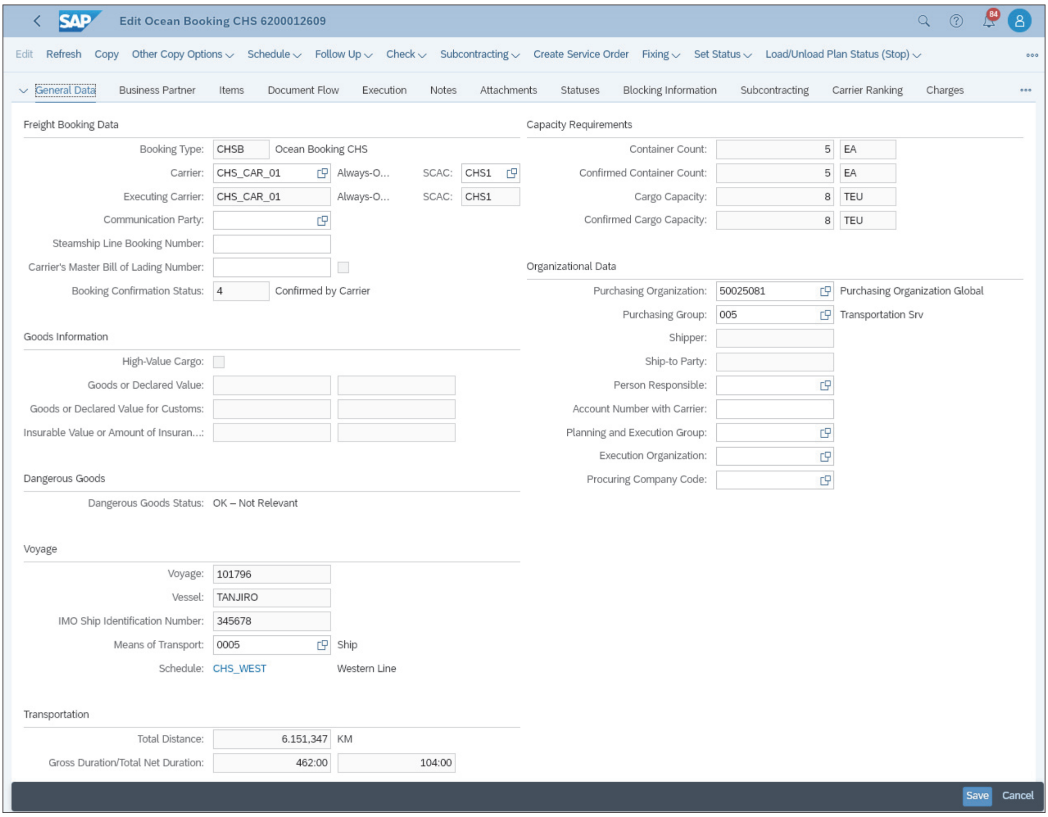


Figure 6.16 Ocean Freight Booking UI: General Data Tab

- **Capacity Requirements**
  The **Capacity Requirements** tab lists the required and confirmed capacities and determines the corresponding cargo capacity, as shown in Figure 6.17. In this example, one equipment type refers to a 20-foot container (**20G0**), and the other equipment type refers to a 40-foot container (**42G0**), which is reflected in the corresponding cargo capacity that is measured in 20-foot equivalent units (TEUs). For each container in the capacity requirements, a corresponding container item is created

on the **Items** tab. In this example, the **Items** tab (shown in Figure 6.18) will show five container items (two from the capacity requirement of **20G0** and three from **42G0**).

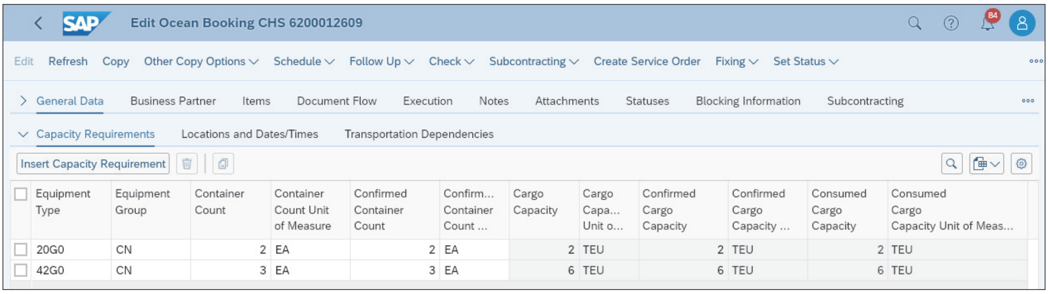


Figure 6.17 Ocean Freight Booking UI: Capacity Requirements Tab

- **Items**
  The **Items** tab allows you to display and maintain information about the loaded cargo and its structure consisting of containers, freight units, packages, and products, as shown in Figure 6.18.

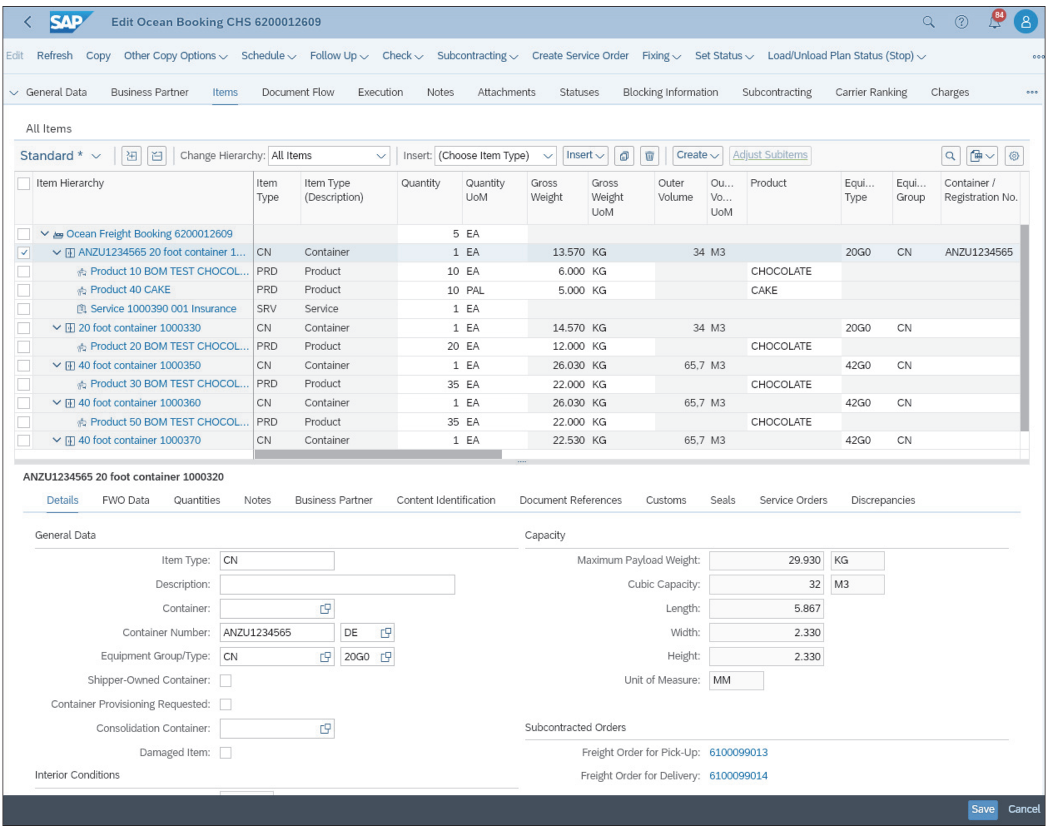


Figure 6.18 Ocean Freight Booking UI: Items Tab

Along with inserting new containers, packages, and products, you can also insert service items and assign freight units to containers by dragging and dropping them. It's also possible to insert new freight units selected according to their identifiers, forwarding orders, or arbitrary attributes. You can also distribute the items of an already-assigned freight unit over several containers. The freight unit's quantities can be split and distributed over multiple containers. You can also report discrepancies if the actually loaded goods differ from the planned and expected freight. This process is described in detail in Chapter 7, Section 7.1.2.

You can define your own hierarchical view to display the cargo structure according to your needs, as explained in Chapter 5, Section 5.7.3. As in the transportation cockpit, you can dynamically switch between alternative hierarchical views.

If you've created freight orders for pickup or freight orders for delivery, as explained in Section 6.1.3, these are referenced here on the container item level, as shown earlier in Figure 6.18, as well as on the **Document Flow** tab, as shown later in Figure 6.22.

Verified Gross Mass

It's a legal requirement based on the International Convention for the Safety of Live at Sea (SOLAS) to record the verified gross mass (VGM) and send it to your business partners before a container can be loaded onto a vessel.

The VGM data, as shown in Figure 6.19, is recorded on the **Items** tab of the ocean freight booking for each individual container item.

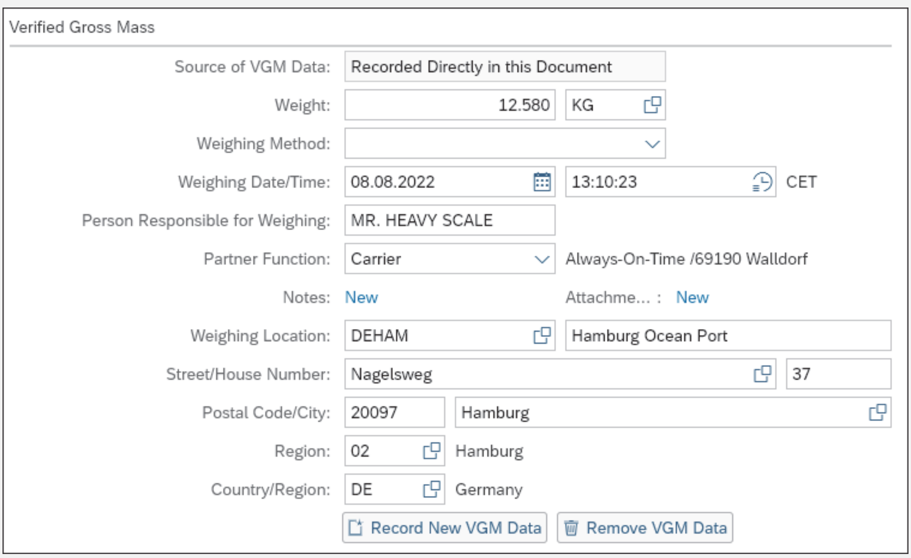


Figure 6.19 Ocean Freight Booking UI: Verified Gross Mass

In addition to the VGM, the person responsible for weighing, the business partner, the weighing date and location, notes, and attachments can be captured. Two weighing methods, packed container (weighing the full container) or container content plus tare weight (weighing the content you put in the container and adding the tare weight) are allowed. If the weight changes or the container is weighed again, the history of recorded VGM data is kept, and the latest information displayed.

- **Location and Dates/Times**
  The **Location and Dates/Times** tab contains all relevant data about the pickup location, port of loading, port of discharge, and delivery location, as well as the corresponding departure date and time, cutoff dates and times for cargo, customs, dangerous goods, documents, and expected arrival date and time, as shown together with the stages in Figure 6.20.

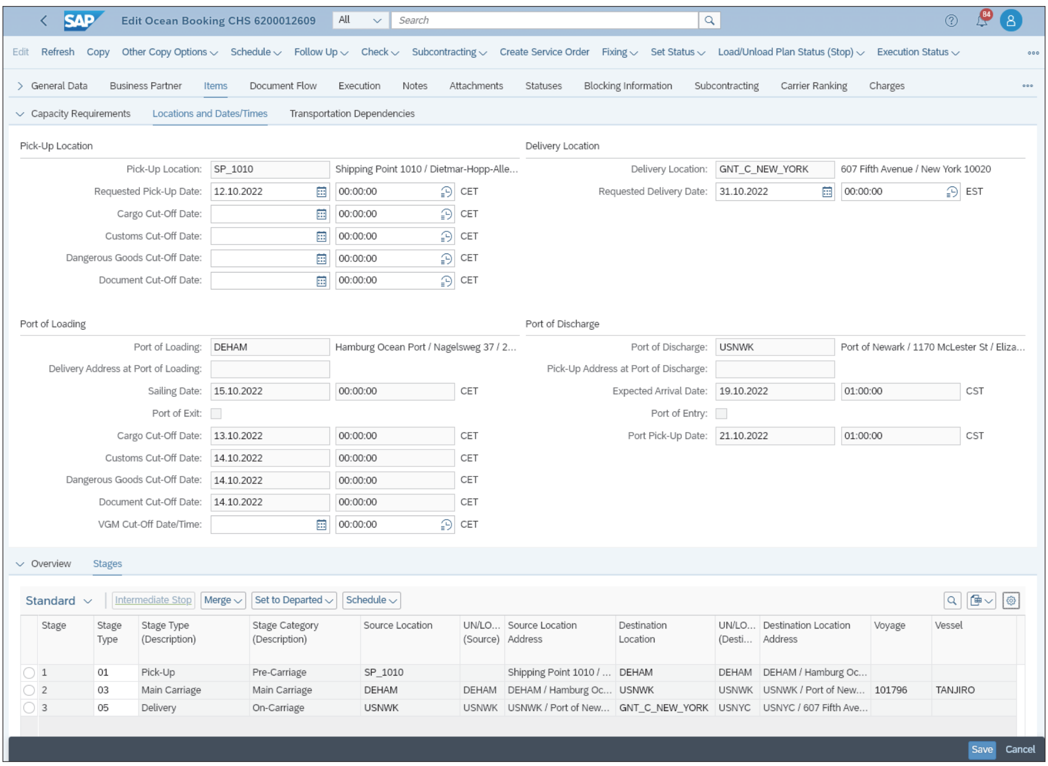


Figure 6.20 Ocean Freight Booking UI: Locations and Dates/Times Tab and Stages Tab

- **Stages**
  The **Stages** area shows the same information from the stage perspective, which is particularly helpful if the freight booking refers to schedules for which the references are displayed or contains more than three stages. More than three stages appear in ocean connection bookings that refer to multiple underlying ocean carrier schedules or in multistop bookings, which we discuss later. By clicking the **Schedule** button, you can assign a schedule to the stage, unassign a schedule, or update the

stage's data per the schedule's data, as will be explained in Section 6.4.3. If you manually create an ocean freight booking for a connection voyage without reference to a connection sailing schedule, you create multiple stages and assign a different ocean carrier schedule to each stage.

- **Overview**
  The **Overview** tab provides a quick overview of the stages and items in a hierarchical view, as depicted in Figure 6.21. You can expand the stages and see the items below, including the substructure of the involved containers. The planned start and end times for each stage are also shown. This area is useful if you want to see the most important information at a glance without having to gather the details that are spread over multiple tabs.

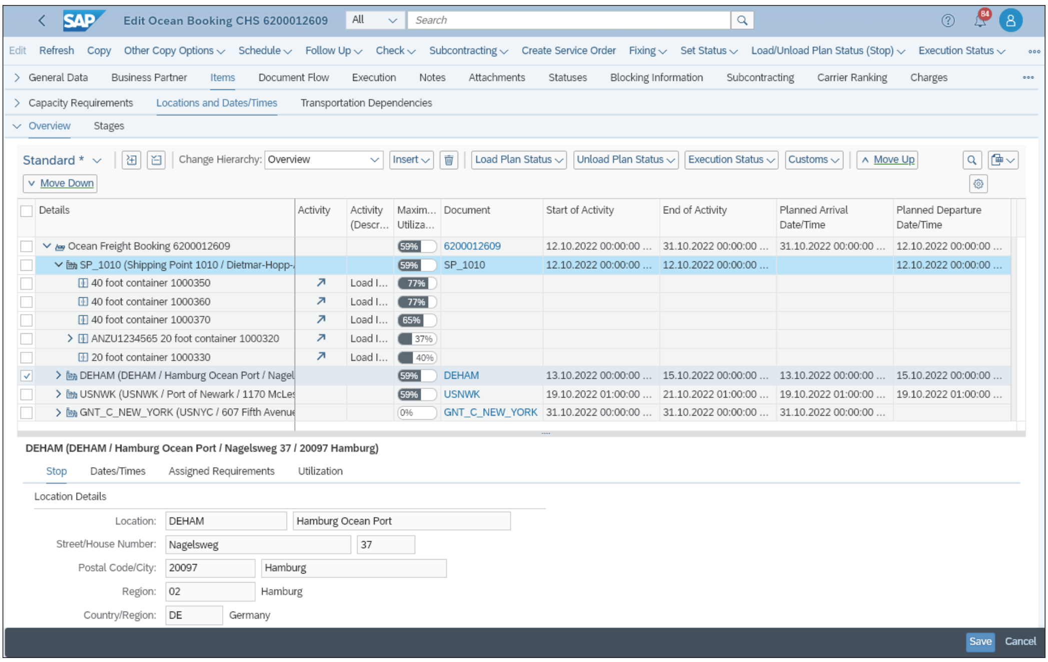


Figure 6.21 Ocean Freight Booking UI: Overview Tab

- **Subcontracting**
  In contrast to the **Subcontracting** tab for freight orders, this tab in freight bookings only displays the carrier, the order date, the partner reference number, and the freight agreement reference.

- **Carrier Ranking**
  The **Carrier Ranking** is displayed on a separate tab in ocean freight bookings. It shows the results of carrier selection, which is a ranked list of the available carriers. If the carrier has been assigned based on the referenced schedule, this tab isn't relevant.

- **Document Flow**
  The **Document Flow** tab shows all related predecessor and successor business documents. In Figure 6.22, you can find documents for the pre-leg (freight orders for pickup) or subsequent leg, (freight orders for delivery), which is helpful for analyzing time conflicts or assessing the effects of potential delays in the transportation chain. In addition, a service order is shown as a successor business document. By clicking the hyperlinks, you can navigate directly to the involved documents.

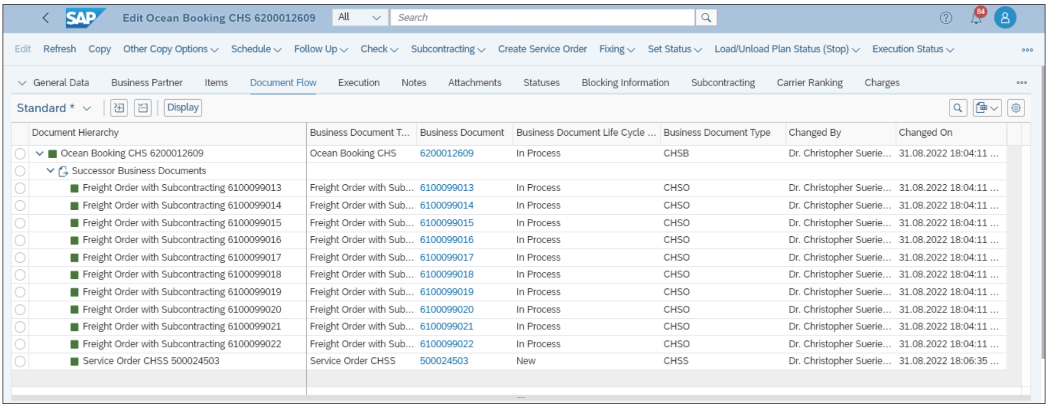


Figure 6.22 Ocean Freight Booking UI: Document Flow Tab

- **Statuses**
  The **Statuses** tab captures all kinds of status values, including **Life Cycle Status**; **Fixing Status**; **Fixing Status of Requirement Assignment**; **Archiving Status**; and more values for subcontracting, confirmation, invoicing, dispute cases, execution, customs, and consistency. The document status and item status can be set by the corresponding buttons in the freight booking's toolbar. Refer to Chapter 7, Section 7.1.4, for a detailed description of execution-related status management.

- **Customs**
  The **Customs** tab displays information relevant for customs handling, such as the customs status, border crossing information, a list of customs activities, and item groups. You can trigger creation of export declaration, request security filing, and perform other customs-related activities. Refer to Chapter 8, Section 8.1, for more details on customs handling.

- **Terms and Conditions**
  The **Terms and Conditions** tab specifies the Incoterm, the Incoterm location, and whether it's a controlled or uncontrolled transport. You can also define the freight term, which can be prepaid or collected, and, together with the traffic direction (import or export), determines how freight settlement documents are created. Additionally, it's possible to define the movement type, the shipping type used for subcontracting, and whether consolidation at the source location and/or destination

location is intended. If no consolidation is chosen, the corresponding location isn't made available for input on the **Locations and Dates/Times** tab.

The remaining tabs (**Charges**, **Cost Distribution**, **Change Documents**, **Attachments**, **Notes**, **Document References**, **Administrative Data**, **Business Partner**, **Communication History**, **Transportation Dependencies**, **Blocking Information**, **Execution**, **Service Orders**, **Output Management**) show similar content and serve similar purposes as the corresponding tabs on the freight order UI explained in Section 6.1.1.

6.2.2 Air Freight Bookings

Air freight bookings are created in a similar fashion as ocean freight bookings. You can follow menu path **Order Management • Create Air Freight Booking** and manually create an air freight booking. You can also create air freight bookings from the corresponding worklist, which is available via menu path **Order Management • Freight Bookings Worklist**. Alternatively, it's possible to copy existing air freight bookings.

There is no separate air freight booking type, but whether a freight booking type is used for air or ocean freight depends on the **Transportation Mode Category** and **Transportation Mode** defined in the freight booking type (refer to Figure 6.14). Air freight bookings have many functional similarities to ocean freight bookings, which is also reflected on the UI. The following tabs are more or less identical to ocean freight bookings: **Overview**, **Business Partner**, **Blocking Information**, **Customs**, **Cost Distribution**, **Service Orders**, **Output Management**, **Communication History**, **Document Flow**, **Statuses**, **Attachments**, **Notes**, **Document References**, **Execution**, and **Administrative Data**.

However, you'll also notice some differences in the following screen areas:

- **Locations**
  The **Locations** tab is more compact than the **Locations and Dates/Times** tab for ocean freight bookings and provides information about the airports of departure and destination and the expected departure and arrival dates and times. The cargo cutoff and availability times are also shown.
- **Booking**
  The **Booking** tab shown in Figure 6.23 replaces the **General Data** tab of the ocean freight booking. It contains a lot of general data, such as the freight booking type, issuing carrier, master air waybill (MAWB) number (see Chapter 7, Section 7.1.1, for more details), airport of departure and destination, as well as expected departure and arrival dates and times.

  Source and destination gateway information and the corresponding cutoff dates and times are displayed too. Organizational data, such as the origin organization and the destination organization, can be maintained. The capacity requirements, ULD information, and handling codes with their constraint modes are shown as well. Refer to Section 6.4.4 for more details on the use of handling codes.

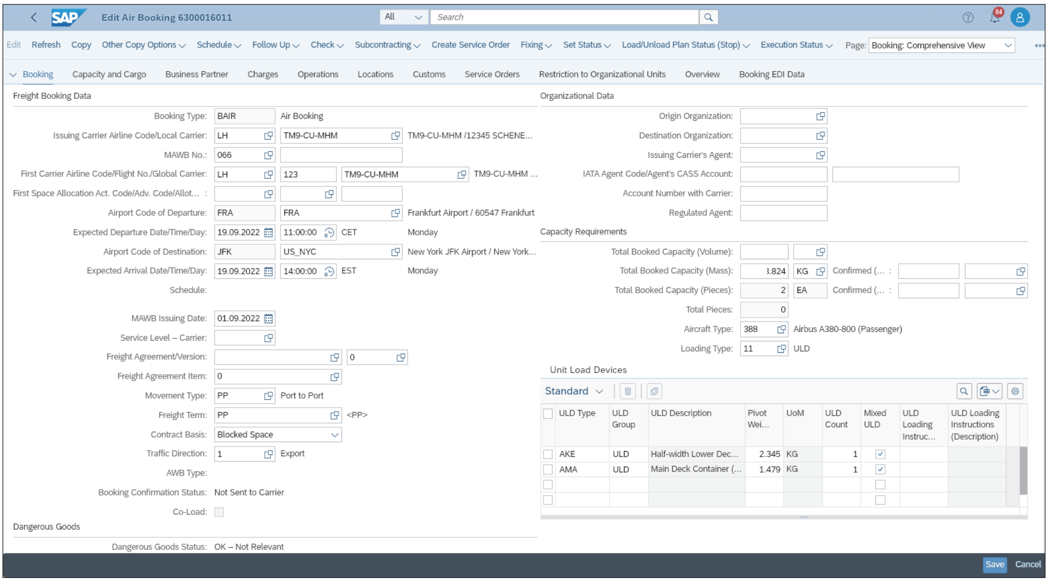


Figure 6.23 Air Freight Booking UI: Booking Tab

The **Contract Basis** is also contained in the **Booking** tab and can be selected from the values defined in Customizing. To do so, follow menu path **Transportation Management • Freight Order Management • Freight Booking • Define Contract Basis**. The contract basis entries **Allotment**, **Blocked Space**, **Charter**, and **Ad Hoc** are delivered by default and reflect different levels of contractual commitment to the carrier of the air freight booking. The higher the commitment is, the higher the cost of the cancellation. For example, if you cancel an allotment, only low costs, if any, are incurred. If you cancel a blocked space booking, however, you usually have to pay the full freight amount to the carrier.

The **Booking** tab also displays the **Carrier Routing** section, shown in Figure 6.24, which provides the stages' information, similar to the **Stages** area of ocean freight bookings. The example in the figure shows a direct flight from Frankfurt (**FRA**) to New York (**JFK**) by Lufthansa (**LH**) with flight number LH123 (**123**) using an Airbus A380-800 Passenger aircraft (**388**). For each stage, you see the referenced schedule and reference data status, which are explained in Section 6.4.3.

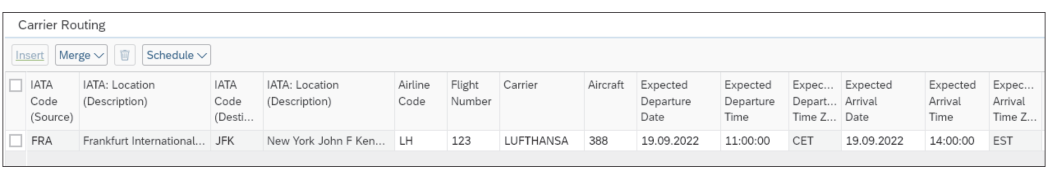


Figure 6.24 Air Freight Booking UI: Carrier Routing

- **Charges**
  The **Charges** tab contains the same settlement content as for ocean freight bookings but adds some air waybill-specific information. It's also possible to activate printing of other charges in the HAWB and the MAWB.
- **Capacity and Cargo**
  The **Capacity and Cargo** tab contains cargo management, just as for the ocean freight bookings' **Items** tab, and provides capacity information, such as the booked volume and weight, remaining capacity for volume and weight, and utilization as a percentage. For air freight bookings, the cost efficiency is determined mainly by the density factor, which characterizes the ratio of volume to weight and is shown as well. Another thing specific to air freight is that the tare weight of a ULD doesn't count toward the gross weight. That means in an air freight booking, the total gross weight doesn't include the tare weight of ULDs, whereas in ocean freight bookings and freight orders, the gross weight adds up the tare weight of the container and its content.

  You can also create mixed ULDs. A mixed ULD carries freight from several air freight bookings, if the quantities from one air freight booking don't fill the ULD completely and you don't want to ship as loose cargo. Mixed ULDs are identified by the **Mixed ULD** indicator, as shown earlier in Figure 6.23, and must all use the same ULD number and same flight. They are displayed with their full quantity in all assigned air freight bookings.
- **Operations**
  The **Operations** area contains general data, such as the air waybill type and issuing date of the MAWB, as well as additional goods information about declared value, insurable value, and handling instructions.
- **Booking EDI Data**
  The **Booking EDI Data** area contains information to be communicated to the airline such as a a high-level description of the cargo, special service requests, and other service information.

By default, there are three different page layouts available, which you can choose from in the air freight booking UI: **Booking: Comprehensive View**, **Cargo Management**, and **Operations Outbound**. These different layouts cater to the needs of the various processors of an air freight booking.

Usually, a special department is responsible for creating air freight bookings. The capacity managers in this department may already create freight bookings in advance, but these freight bookings should become visible to planners and sales agents only after they have explicitly been published. To do so, the capacity manager can set the status to **Published**. The **Immediate Processing** parameter in the **Execution Settings** section of the Customizing allows you to define whether newly created freight bookings get the status **Unpublished** or **Published**. Unpublished freight bookings get a planning block status and therefore can't be consumed or seen by other departments.

Publishing removes this planning block status. A published freight booking can be unpublished.

It's also possible to restrict the visibility of the air freight bookings further to certain organizational units within your company. The capacity manager can maintain several organizational units, together with their functions (sales, company, or forwarding house) in the **Restriction to Organizational Units** tab of the air freight booking UI. With the **Set to Published with Restrictions** button, the capacity manager can publish the freight booking only to the maintained organizational units. Authority checks for displaying and changing the air freight booking are executed, according to the user's role and organization. Note that the organizational units can already be maintained in a master flight schedule and are then copied into the air freight bookings created for the master flight schedule.

Together, the publish concept, restricted visibility concept, and organization interaction model described earlier enable fine-grained access control for the air freight bookings in your company.

The nature of goods is only relevant in business documents for air freight. The nature of goods is a short and meaningful description of the cargo to be transported and is entered as free text on the **Operations** tab of the air freight booking (a maximum of 12 lines with 20 characters per line). This information is synchronized with the air waybill view on the **Charges** tab and printed in HAWBs and MAWBs. In addition, you can enter nature of goods information for use in a manifest on the item level in the **Capacity and Cargo** tab. Here you can enter up to 9 lines with a maximum of 65 characters per line. The nature of goods of the items is automatically copied from the predecessor documents, whereas the nature of goods on the header needs to be entered manually or triggered with the **Copy from Requirement Documents** action. In the latter case, only the first 2 lines from the first six requirement documents are copied due to the space limitation.

Special security requirements arise for air cargo and are covered by air cargo security (ACS) checks and statuses. These can be activated in the freight booking type Customizing by the **Enable Air Cargo Security Check** and **Enable ACS Authoriz. Check** parameters in the **Additional Settings** section. The required ACS status is captured in forwarding orders and propagated to freight units. The available ACS status can be maintained in air freight bookings. It can also be defined in a master flight schedule and is copied into air freight bookings created from the master flight schedule.

The following standard ACS status values are available, ordered from highest to lowest security: **Secure for Passenger Aircraft** (high risk cargo) (**SHR**), **Secure for Passenger Aircraft** (**SPX**), **Secure for Cargo Aircraft** (**SCO**), and **Not Secure** (**NSC**). The ACS check determines whether the **ACS** status of a freight unit is compatible with the assigned air freight booking. Freight units with the status **SPX** can be assigned to air freight bookings with the status **SPX** or **SCO**, whereas freight units with the status **SCO** can only be assigned to freight bookings with the status **SCO**. A freight unit with the status **NSC** gets the planning block status and therefore can't be assigned at all. In this case, the corresponding forwarding order has to be processed according to security guidelines until it becomes secure. Then the status can be changed, and the document can be planned.

System Behavior for Automatic and Manual Planning

Automatic planning ensures that only compatible assignments are made. Depending on your user's authority, manual planning yields either a warning or an error message for an incompatible assignment.

You can maintain country-specific ACS status values in Customizing by following menu path **Transportation Management • Basic Functions • Security • Define Air Cargo Security Statuses** and assigning the country-specific values to the standard ACS status values (**SHR**, **SPX**, **SCO**, and **NSC**).

In some countries, such as the United States, the air forwarder must have known the shipper for a certain period of time, which can be defined in Customizing via menu path **Transportation Management • Basic Functions • Security • Define Offsets for Calculating Known Shipper Status**. If the forwarder knows the shipper for more than half a year, for example, the shipper's goods can be shipped via air freight. Otherwise, the forwarding order gets the status **NSC**, which means that the forwarder has to check the goods very carefully before transporting them by airplane. The known shipper status can be maintained in the business partner or the corresponding location, and it's automatically copied into a newly created forwarding order if the **Copy Air Cargo Security Data** parameter is active in the forwarding order type.

In the co-load process, you transport goods on a flight and use the air waybill stock and contract of another forwarder, the consolidator. This scenario is relevant if you don't have a contract with a carrier for a certain destination or if you don't have enough freight for the destination. Co-loading is a purely manual process, in which you maintain the consolidator and the MAWB number received from the consolidator in your air freight booking. This process is enabled by the **Co-Load** parameter in the air freight booking type.

Now that we've introduced freight documents for all available modes of transportation, the focus will change to a logical grouping of freight within a freight document that is required in various processes for communication purposes. The document representing this logical grouping is called a consignment order.

6.3 Consignment Orders

Consignment orders introduce a new business document level in TM inserted between freight units and freight orders. Consignment orders are used to group several freight units/transportation requirements based on criteria that can be defined in grouping rules. Typical criteria are source location, destination location, delivery date, and business partner. These criteria must match in a consignment order. Consignment orders are primarily used for communication, but they can also be the basis for subcontracting, charge calculation, and carrier settlement. This is a conceptual distinction and doesn't represent a specific capacity or physical restriction.

How consignment orders are linked to other business documents is shown in Figure 6.25 based on an inbound freight order. In this example, the inbound freight order represents a transport from two suppliers to a plant with several unloading points. The freight order consists of two deliveries (1 and 2) from supplier 1 and two deliveries (3 and 4) from supplier 2. For each delivery, one or more freight units have been created. The consignment orders represent the grouping of deliveries for each supplier. Consignment order 1 contains the freight units originating from the deliveries of supplier 1, whereas consignment order 2 contains the freight units originating from the deliveries of supplier 2. Ultimately, the consignment orders are linked to the freight order. The consignment order doesn't have to be linked to the freight order directly, but can also be linked to a transportation unit, which is then assigned to the freight order. As illustrated in the example, a freight order can include multiple consignment orders. However, a consignment order can only be assigned to one freight order (or transportation unit), and it must be assigned completely.

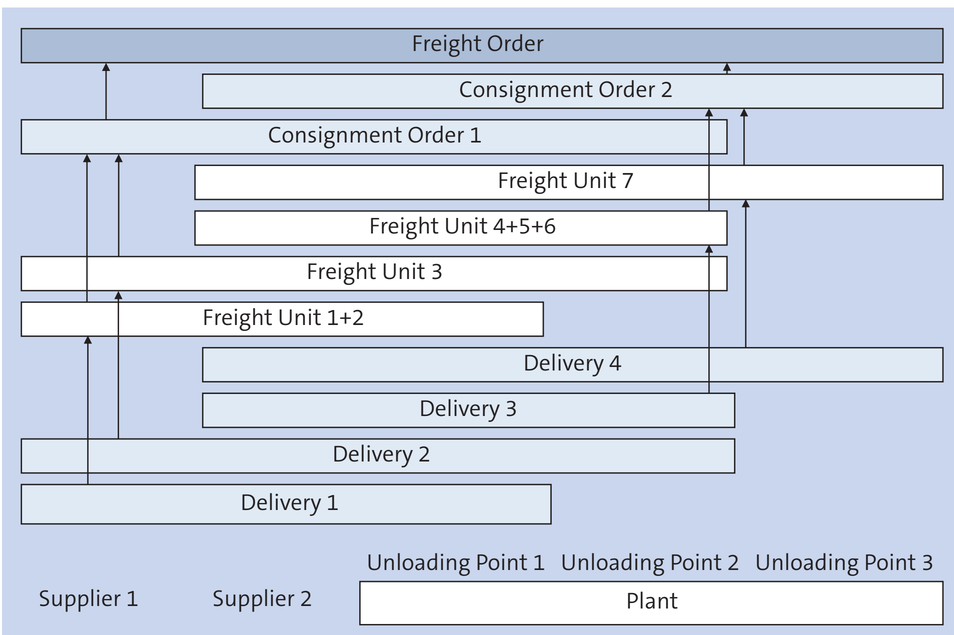


Figure 6.25 Consignment Order: Link to Other Business Documents

Each consignment order has only one shipper and one consignee and must have only one transportation stage from the source to the destination location.

Section 6.3.1 describes the process that consignment orders are used in and the different methods to create consignment orders. Then, Section 6.3.2 reviews the different functional areas in the UI and the customization of consignment order types.

6.3.1 Process and Creation

The consignment order is primarily used for communication. It allows you (as a supplier) to communicate to your customer regarding what products you'll deliver to a specific destination on a specific date together, irrespective of whether these originate from one or multiple transportation requirements (deliveries). The consignment order (number) can serve as a reference and be used for tracking purposes.

Consignment orders are primarily used as part of the advanced shipping and receiving (ASR) process, which is explained in detail in Chapter 12, Section 12.3. As part of this process, consignment orders are typically created via an inbound message using service interface `TransportationOrderGenericRequest_In`. Two scenarios are supported here:

- **Consignment-based freight order**
  In this scenario, as shown in Figure 6.26, you'll receive separate inbound messages for freight orders and consignment orders.

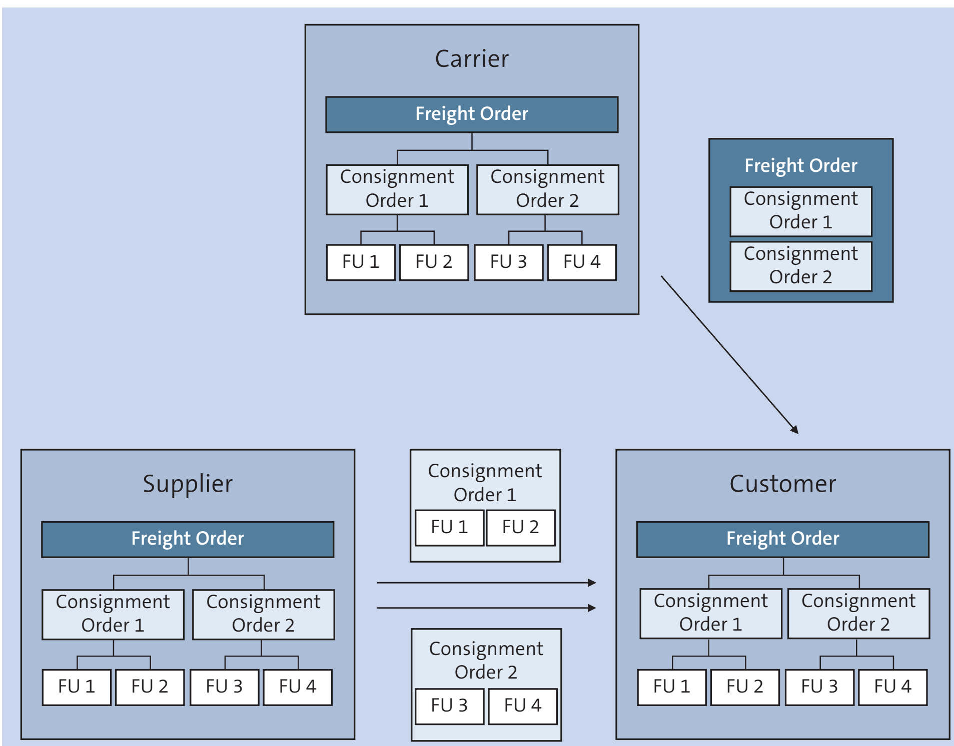


Figure 6.26 Consignment-Based Freight Order

The consignment orders are referenced in the freight order. This scenario can be used if you receive the information from different parties.

The supplier informs the customer about the consignments and which products will be delivered together in which consignments. On the other hand, the carrier will inform the same customer regarding which consignments will be delivered together on one truck (freight order). Based on both messages, the customer can create the link between the incoming freight order and the materials being delivered.

- **Transport-based freight order**
  In this scenario, you'll receive one combined inbound message. The combined inbound message will contain the freight order header information and the full item structure (vehicle information, consignment, and requirement document references).

In both scenarios, freight orders and consignment orders may also be created with document errors if you've allowed this in Customizing of the respective document types. Errors can be related to master data (wrong product, resource, location, or business partner) or to references (wrong reference to predecessor document, such as delivery or purchasing scheduling agreement). Those errors can be corrected automatically or manually; then, the relevant freight units are determined and assigned to the consignment order.

There are multiple ways to create consignment orders either manually or automatically. To create a consignment order manually, you can go to **Order Management • Create Consignment Order** to open the Consignment Order app. You can also create consignment orders during manual planning in the transportation cockpit or by copying an existing consignment order. Automatically, consignment orders can be created via an inbound message (ASN using service interface `TransportationOrderGenericRequest_In`) or when a freight order is created or saved based on the consignment order building profile, which is assigned in the freight order type Customizing.

The consignment order building profile is defined in the Consignment Order Building Profile app, which you can open by going to **Profiles and Settings • Create Consignment Order Building Profile**. In the consignment order building profile shown in Figure 6.27, you can define **Incompatibility Settings** if you want to consider incompatibilities between transportation requirement items that should not be combined into one consignment order. The **Automatic Building** options only define whether and when *local* consignment orders are built within the freight order. This can be done automatically or can be manually triggered from the freight order UI. Furthermore, the **Create Consignment Documents** options allow you to define whether and when *separate* consignment orders are created based on the local consignment orders within the freight order. Automatic document creation can be triggered by either saving the freight order, transportation execution status **Ready for Transportation Execution**, or an event.

Generate Consignment Orders

You shouldn't create separate consignment orders too early in this process because consignment orders aren't automatically updated from local consignment orders. The advantage of having local consignment orders first is that changes can still be made to the freight order such as adding new freight units and retriggering the consignment building process. These changes are afterward taken into account when consignment order documents are created.

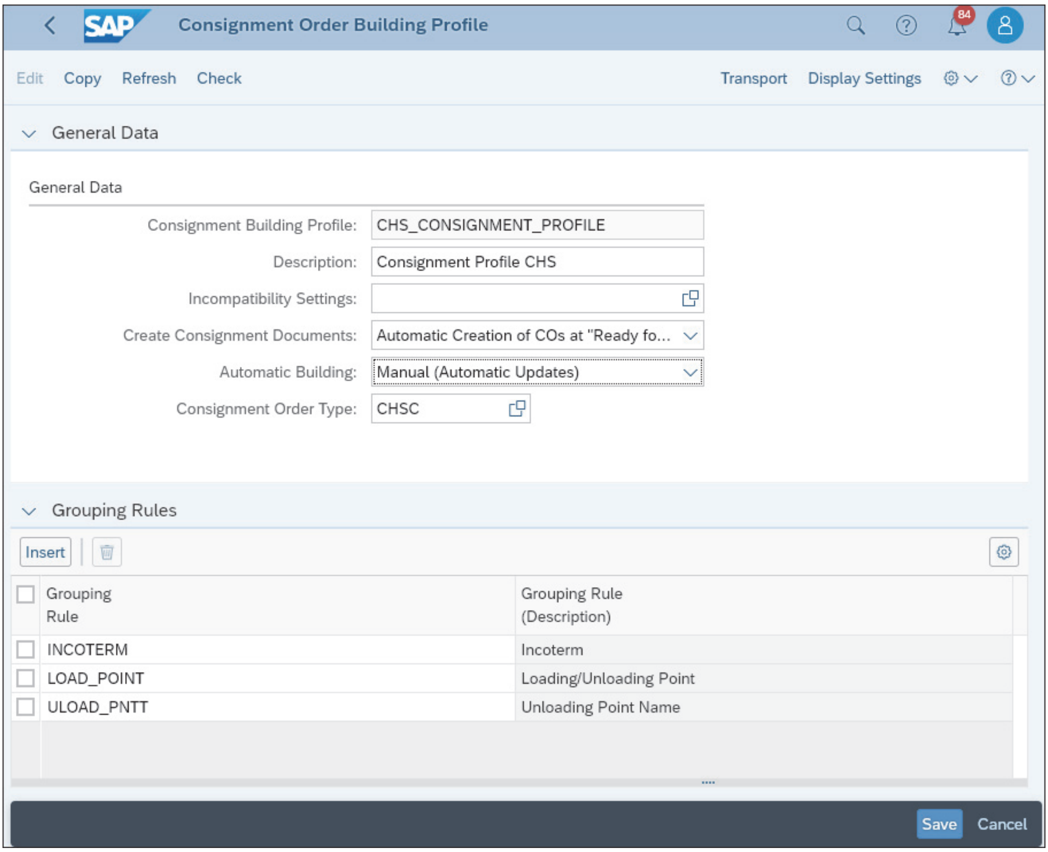


Figure 6.27 Consignment Order Building Profile

The **Grouping Rules** define the criteria that are relevant for the transportation requirements grouped into a consignment order. The grouping rules are defined in Customizing by following menu path **Transportation Management • Freight Order Management •**

Consignment Order • Define Grouping Rules for Automatic Consignment Building. Multiple grouping rules can be combined. Only those freight units that correspond to all of these rules are combined into a consignment order.

After you've created a consignment order, you have similar functions available as in a freight order. You can build packages in the consignment order, subcontract the consignment order to a carrier, calculate charges, and settle the consignment order by creating a corresponding freight settlement document. You can send the consignment order to your carrier and print documents. If you assign the consignment order to a freight order, you have to decide whether you want to use these functions on the consignment order level or on the freight order level. You can't perform subcontracting, charge calculation, and carrier settlement on both levels at the same time. You have to do this either for your consignment orders or freight orders.

6.3.2 Configuration and User Interface

In the following sections, we'll provide the configuration details for consignment orders. We'll start with the consignment order type Customizing and continue with the consignment order UI.

Define Consignment Order Types

Similar to other business document types, in the consignment order type, you define parameters that influence how the system processes this business document, for example, whether you can perform subcontracting, charge calculation, or carrier settlement. The consignment order type is defined in Customizing by following menu path **Transportation Management • Freight Order Management • Consignment Order • Define Consignment Order Types**.

If you create the consignment order from a freight order, the consignment order type is determined from the freight order type. If no consignment order type is defined in the freight order type, the system checks the consignment order building profile, checks the planning profile, or uses the default type defined in Customizing in this sequence.

The consignment order type Customizing is shown in Figure 6.28 and Figure 6.29. It combines elements from freight unit types such as a condition or rule for pickup and delivery window determination with characteristics known from freight order types such as the subcontracting relevance and checks. In general, consignment orders resemble freight orders more closely, which means that most settings are similar to freight order types.

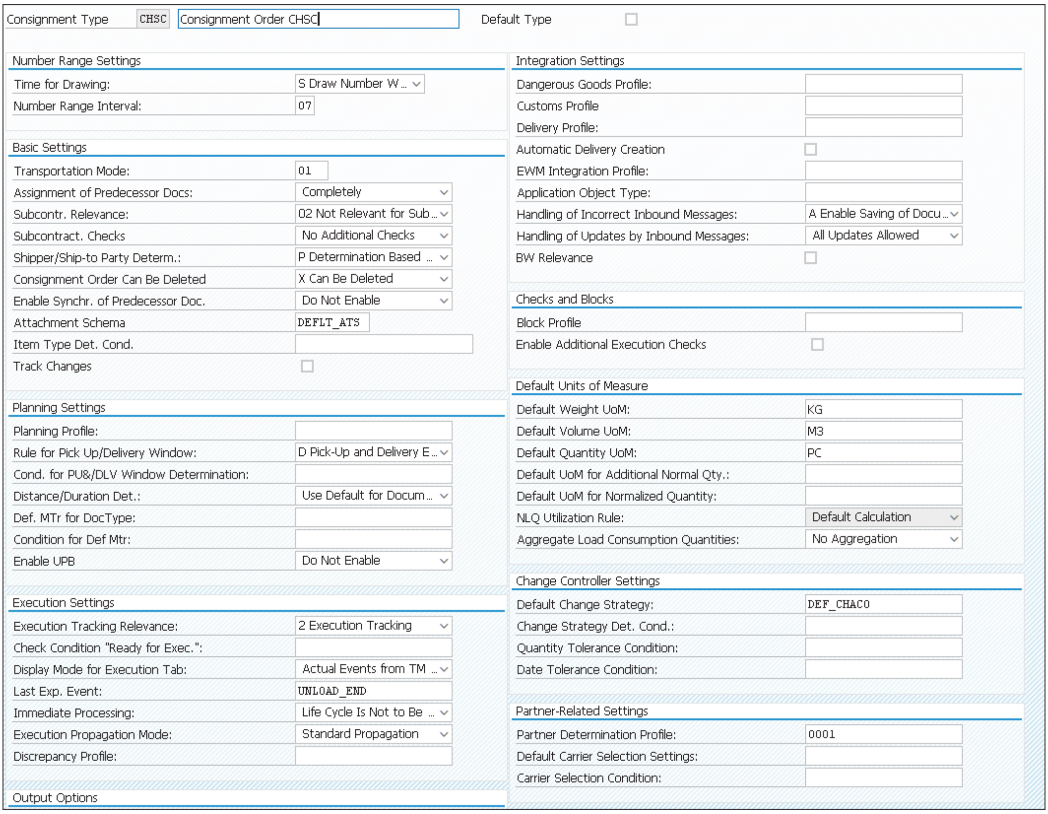


Figure 6.28 Consignment Order Type Customizing (1/2)

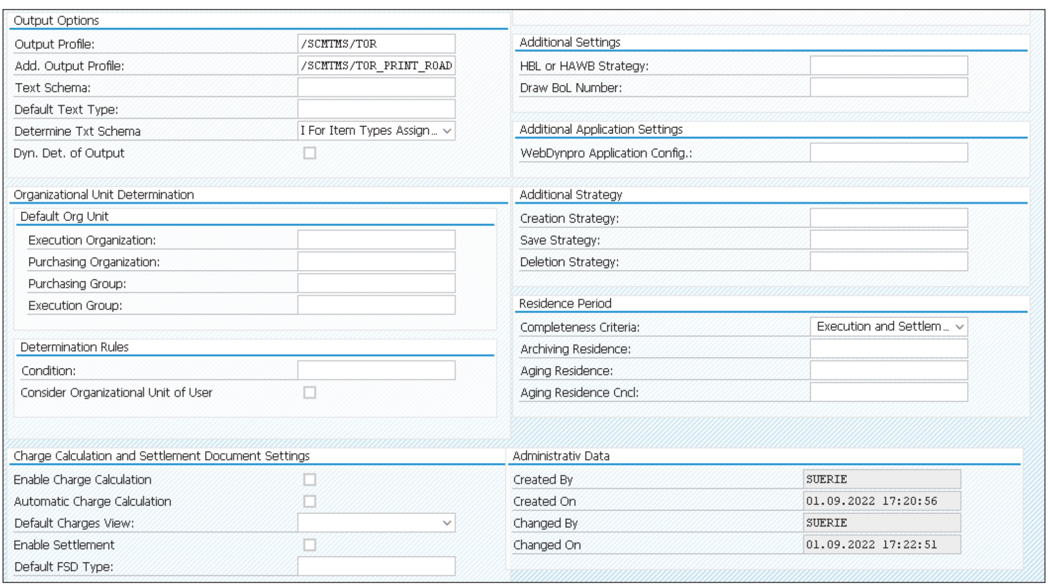


Figure 6.29 Consignment Order Type Customizing (2/2)

Let's focus on those Customizing settings that are different between freight orders and consignment orders:

- **Assignment of Predecessor Docs.**
  A few settings are unique to consignment orders and are mentioned in more detail here. The **Assignment of Predecessor Docs.** can be either **Completely** or **Partially and Completely**. In the first case the predecessor document must be assigned completely to the consignment order. That means all cargo items of the assigned predecessor document are transported as part of the consignment order. If the predecessor document can be assigned partially or completely to the consignment order, this means that only some or all cargo items of the assigned predecessor document are transported as part of the consignment, but other cargo items of the predecessor document can be assigned to one or more different consignment orders.
- **Item Type Det. Cond.**
  This allows you to select a condition to define which item types are assigned to which items in a consignment order. For example, you can create a condition to define that item type `PKG` is used for the topmost package in a consignment order, and item type `PKG2` is used for a child package. The selected condition must use the condition type `/SCMTMS/TOR_ITM_TY`.
- **Automatic Delivery Creation**
  If the consignment order has been created based on an inbound message, the corresponding deliveries, to which the freight units would have to be assigned and from which they originate, may not have been created. Activating the **Automatic Delivery Creation** checkbox will create inbound deliveries automatically upon saving the consignment order.
- **Handling of Incorrect Inbound Messages/Handling of Updates by Inbound Messages**
  Whether the system only creates error-free consignment orders or also allows you to create documents with errors is based on how you've configured **Handling of Incorrect Inbound Messages**. How the system handles updates by inbound messages is configured with **Handling of Updates by Inbound Messages**. You can allow all updates or prevent updates after manual changes have taken place.

You can assign allowed item types and allowed event codes to a consignment order type. On the contrary, consignment order types don't offer tendering settings, internal charge calculation, cost distribution, compliance, and ACS checks.

User Interface

The consignment order UI looks similar to the freight order UI. The **General Data** tab in Figure 6.30 shows the basic information of the consignment order such as the document type, planning status, cargo information, source and destination location, planned departure and arrival times, organizational data, and carrier. The **Origin of Consignment Order** references how the consignment order was created, for example, as a copy from another consignment order or through manual creation.

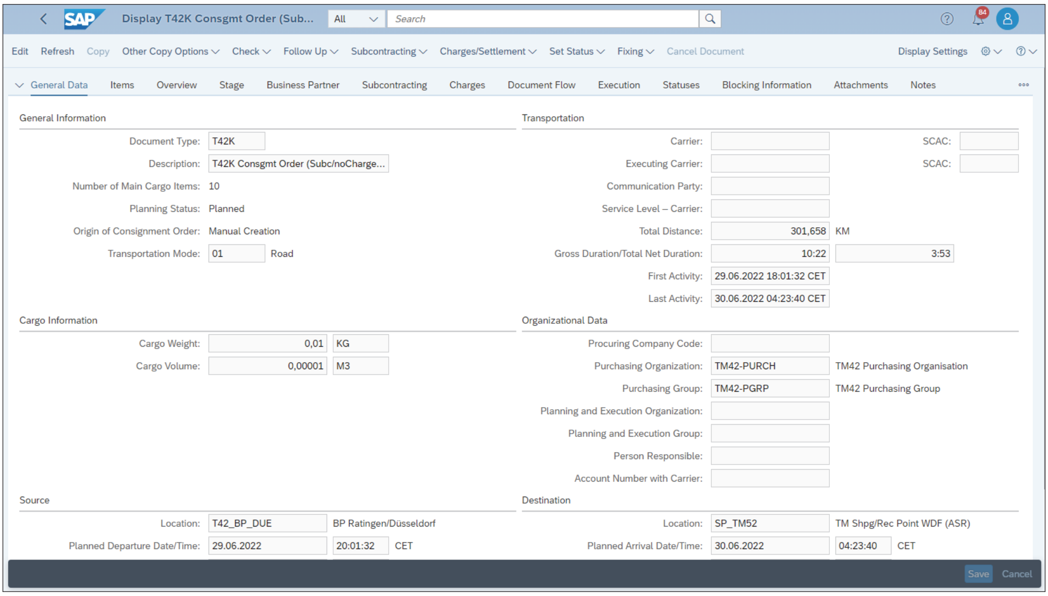


Figure 6.30 Consignment Order UI: General Data

The **Overview** tab displayed in Figure 6.31 shows the involved locations, (un)loading points, and assigned freight units in a hierarchical view. The consignment order in Figure 6.31 is loaded in location **T42_BP_DUE** and unloaded at warehouse number **W042** in location **SP_TM52**. The warehouse is an embedded EWM warehouse, and the information is derived from the unloaded item (via the freight unit from the associated inbound delivery).

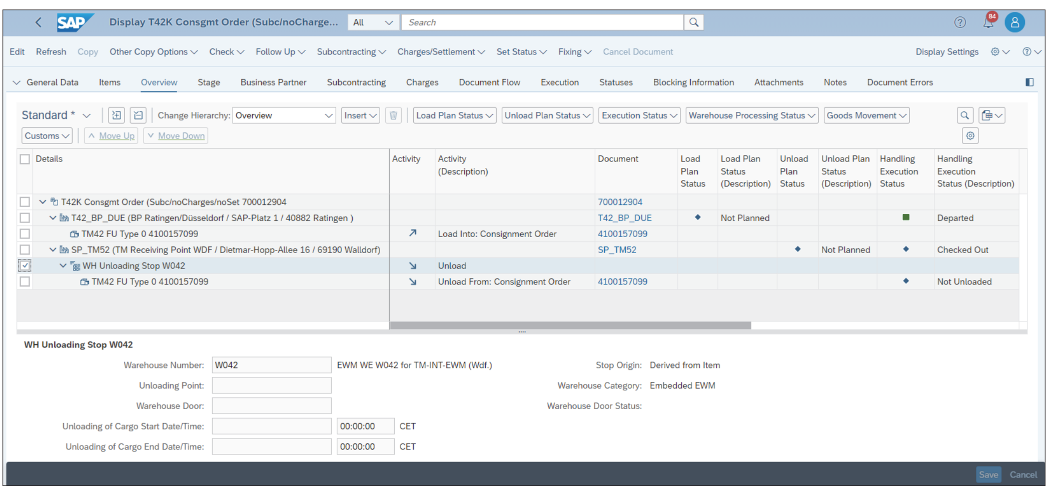


Figure 6.31 Consignment Order UI: Overview

Figure 6.32 shows the same from the perspective of the freight order. On the **Items** tab of the freight order, you can identify the assigned consignment orders (two in this example). Each consignment order is based on one inbound delivery for one product and has created one freight unit.

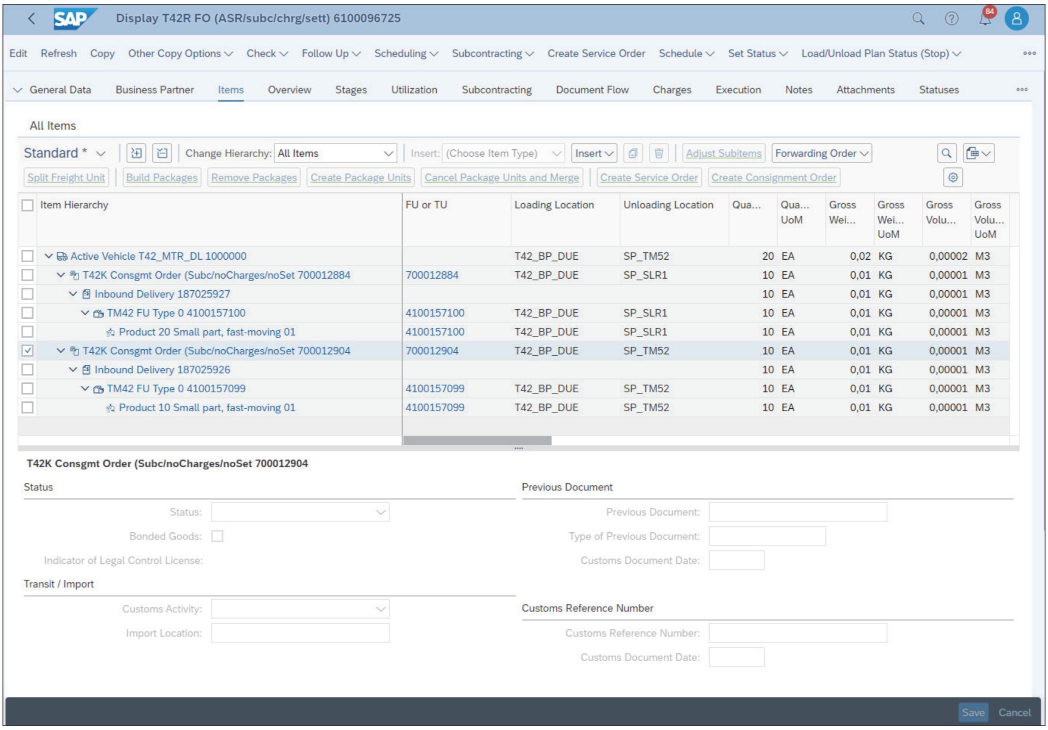


Figure 6.32 Freight Order UI: Items with Consignment Orders

In the next section, we focus on the management of transportation capacities and how this is supported within freight order management.

6.4 Capacity Management

Capacity management involves planning the transportation capacities that your carriers offer to you. The capacity management process involves various business documents that represent the long-term contractual aspect, mid-term capacity planning perspective, and short-term view on capacities that can be used in daily business.

Let's begin in Section 6.4.1 with an overview of the capacity management process and interplay of the involved business documents that reflect these perspectives. Section 6.4.2 describes how the (operative) freight documents can be systematically created based on the mid-term capacity planning. Section 6.4.3 presents the change management capabilities that help you to react to changes in your carriers' schedules.

Allocations and business shares represent capacities per carrier and the desired distribution across carriers, and they are discussed in Section 6.4.4 and Section 6.4.5.

6.4.1 Process

The capacity management process aims to define and plan the transportation capacities that carriers offer you and that you want to use for your transportation demands. We present the process from the perspective of a global air forwarding company, but the process or parts of it can also be used for ocean forwarding or shippers that systematically reserve and use their carriers' capacities for any mode of transport. Capacity management has the following main goals:

- To secure sufficient transportation capacity and avoid bottleneck situations in which you can't transport what you need to transport
- To reduce transportation costs by using planned capacity to negotiate good long-term contracts and by avoiding expensive ad hoc bookings
- To ensure stable, reliable, and long-term relationships with your carriers

Capacity management involves the objects and logical sequence of creating these objects, as depicted in Figure 6.33 using an air freight perspective. Negotiations with your carriers result in freight agreements, which specify the freight rates per trade lane and are explained in detail in Chapter 9, Section 9.1.1. You can define freight agreement allocations, which are assigned in the freight agreements and represent long-term capacity reservations per trade lane. The freight agreement and assigned allocations resemble the contractual perspective on capacity management.

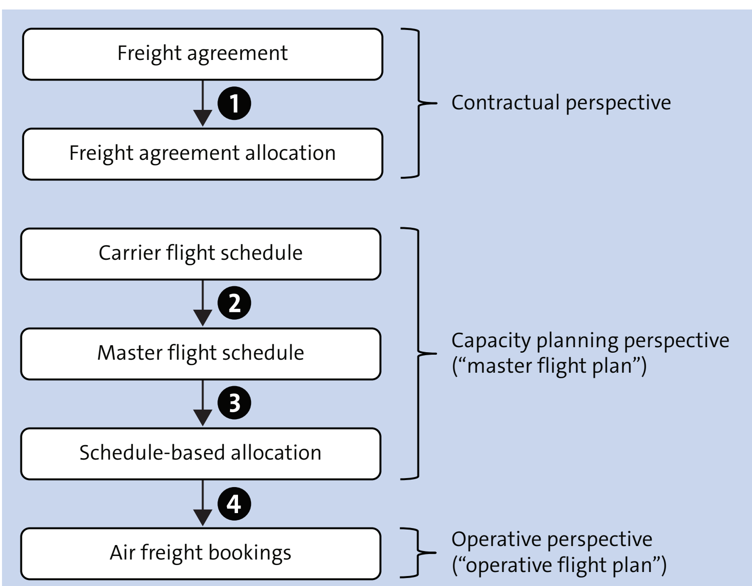


Figure 6.33 Overview of the Capacity Management Process

Carrier flight schedules can be uploaded automatically into the system, as described in Chapter 3, Section 3.2.4; they represent the regular departures that you may want to use in your daily transportation business. You can define master flight schedules, which connect a source gateway with a destination gateway and can refer to one carrier flight schedule or, in the case of a connection flight, multiple carrier flight schedules offered by different airlines. In the master flight schedule, you can trigger creation of schedule-based allocations with buckets referencing the departures of the master flight schedule. This allows you to define capacities for the departures.

In the air freight business, it's common to define the schedule-based allocations for the next 6 to 12 months, and this plan is frequently called a *master flight plan*. In TM, the master flight plan is represented by three objects: the carrier flight schedule to define the departures offered by the carrier; the master flight schedule to define cutoff times, source, and destination gateway; and the schedule-based allocation to define the capacities among the departures.

When you reach the operative management of capacities, it's important to firmly reserve the planned capacities from the carriers; otherwise, the carrier may use them for other customers. These reservations are made by creating air freight bookings based on the master flight plan; for example, the departure date, time, and capacity are taken out of the master flight plan and put into the newly created booking. The air freight bookings are sent to the carrier and, once confirmed by the carrier, represent the operative flight plan that secures the short-term capacities. Usually, the air freight bookings are systematically created each week for the next six weeks. Whereas the master flight plan is used mainly internally and usually not communicated to the carrier, the operative flight plan is the basis for daily business and is therefore aligned with your carrier.

Planning freight is done based on the operational flight plan. New freight units can be assigned to the air freight bookings, iteratively consuming the capacity reserved by the bookings. If bookings were created only when the required freight units appear, there would be a high risk of not getting the carrier's confirmations or having to change the bookings' quantities each time new freight shows up.

You can manually perform steps ❶, ❷, and ❸ in Figure 6.33. Step ❹ can also be done manually but is usually performed automatically by the report to systematically create freight documents out of schedules, which we describe in Section 6.4.2.

The capacity management process secures capacities on the long-term level with the freight agreement allocations and allows capacity planning on the mid-term level with the master flight plan, which is then used to secure capacities on the short-term level with the operative flight plan. This kind of hierarchical planning is common in business areas other than transportation (e.g., in supply chain management and production planning), where planning can take place on strategic, tactical, and operative levels.

Let's illustrate the capacity management process with typical examples for direct flights, multistop flights, and connection flights. Figure 6.34 shows an example of a direct flight from Frankfurt (FRA) to New York (JFK). The carrier flight schedule with flight number LH-400 offers weekly departures, starting on Thursday, June 1, 2023, at 9:00. The master flight schedule connects gateways in Frankfurt and New York and references the carrier flight schedule's departures. The schedule-based allocation references the master flight schedule's departures and assigns a capacity to each departure. The air freight bookings have been created based on the master flight schedule and schedule-based allocation, with one booking per departure and taking the capacity of the allocation and departure date from the master flight schedule.

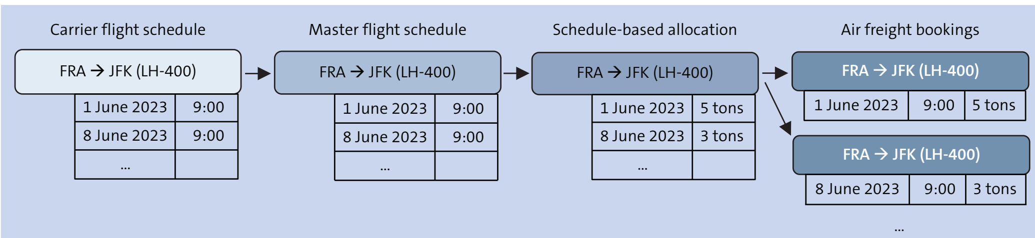


Figure 6.34 Example of Direct Flight

Figure 6.35 shows an example of a multistop flight from Addis Ababa (ADD) to Kilimanjaro (JRO) and then to Mombasa (MBA). The carrier flight schedule with flight number LH-9664 offers weekly departures, starting on Thursday, June 1, 2023, at 10:20 in ADD and 13:40 in JRO. Assuming there are gateways in ADD, JRO, and MBA, you can create three master flight schedules: the first from ADD via intermediate airport JRO to MBA, the second from ADD to JRO, and the third from JRO to MBA. These master flight schedules reference the carrier flight schedule's departures and consume both stages—the first stage and the last stage, respectively—of the underlying carrier flight schedule. Each master flight schedule is referenced by one schedule-based allocation that assigns capacities to each departure.

The air freight bookings are created based on the master flight schedules and their schedule-based allocations. Although the three bookings on June 1 refer to the same physical flight from ADD to JRO to MBA, they are treated as independent bookings from the capacity perspective. The bookings from ADD to MBA, from ADD to JRO, and from JRO to MBA contain 2 tons, 1 ton, and 2 tons, respectively. Thus, the carrier receives two bookings that cover the first stage and have a joint capacity of 3 tons, and two bookings that cover the second stage and have a joint capacity of 4 tons.

Figure 6.36 shows an example of a connection flight from Frankfurt (FRA) to Caracas (CCS) to Bogota (BOG).

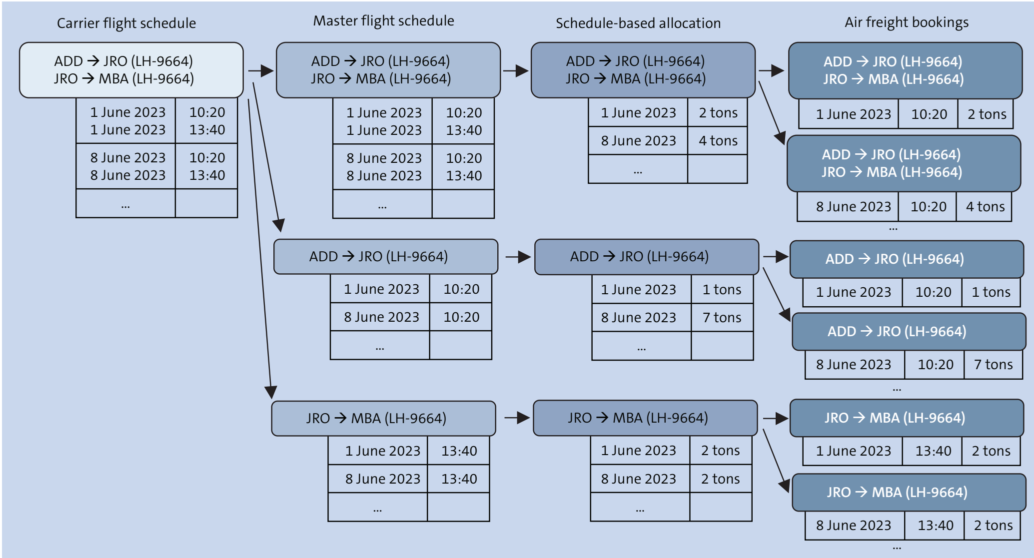


Figure 6.35 Example of a Multistop Flight

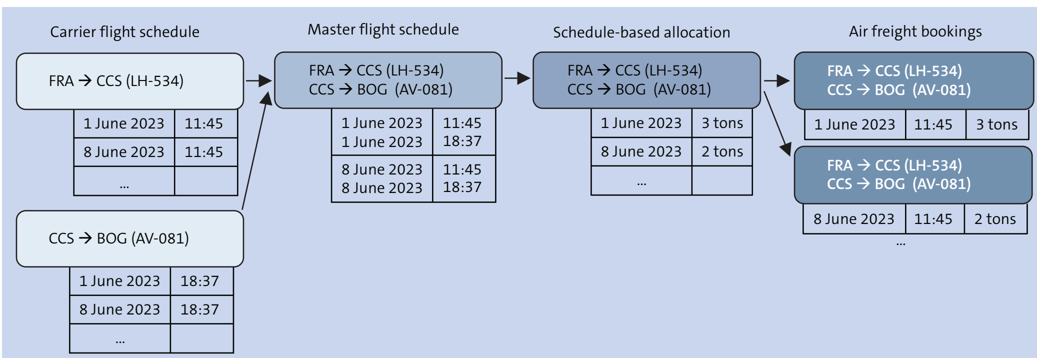


Figure 6.36 Example of Connection Flight

There are two direct carrier flight schedules from FRA to CCS and from CCS to BOG, offered by two different carriers. Assuming there are gateways in FRA and BOG, you can create a master flight schedule connecting the departures of the first carrier flight schedule with the departures of the second carrier flight schedule. In the master flight schedule, you can define the carrier who will receive freight bookings created for the schedule. The (connection) master flight schedule is referenced by one schedule-based allocation to assign capacities to each departure. The air freight bookings are created based on the master flight schedule and their schedule-based allocations.

For a specific trade lane and carrier, the freight agreement allocation defines the planned capacity per time bucket. Allocations allow different bucket types, such as daily, weekly, monthly, quarterly, yearly, and schedule-based, which we explain in

Section 6.4.4. Each allocation stores the available capacity per bucket and provides the already-consumed capacity per bucket, which can be determined automatically.

You can define the trade lanes in the freight agreements and, hence, the freight agreement allocations on the location-to-location level, but these are frequently defined on the zone-to-zone level to define rates and capacities on a more aggregated level. A zone can represent a set of regions or countries, and you can easily create zones for all regions and countries in the world, as described in Chapter 3, Section 3.2.2.

For example, you may have a freight agreement allocation from Frankfurt to the United States and schedule-based allocations from Frankfurt (FRA) to New York (JFK) and from Frankfurt to Chicago (ORD). Then, air freight bookings from Frankfurt to New York would match both allocations and consume their capacities (see Figure 6.37), with air freight bookings being identified by their MAWB number.

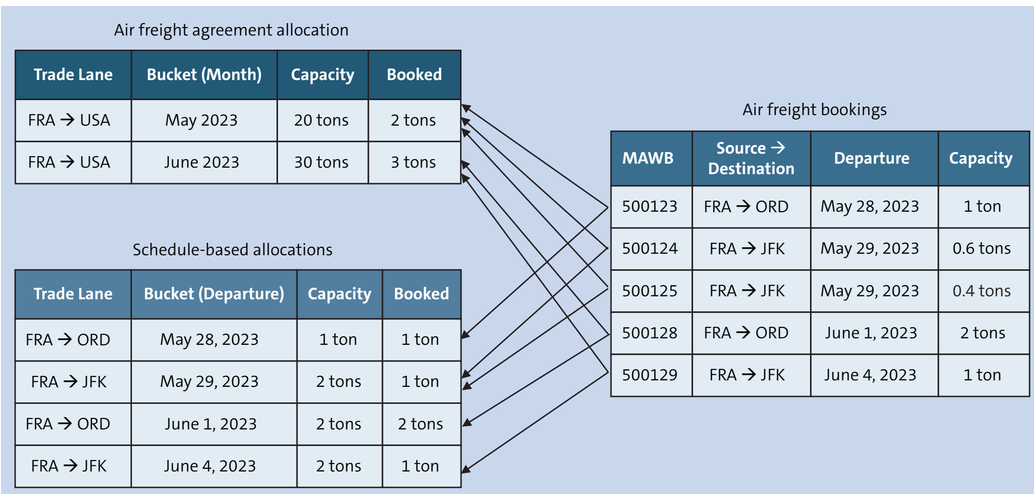


Figure 6.37 Air Freight Bookings Consuming Freight Agreement Allocation and Schedule-Based Allocation

To model the whole capacity management process, you have to define the following:

- Freight agreement allocation type in the freight agreement type
- Schedule-based allocation type in the master flight schedule type that enables references

It's possible to use only a subprocess with a subset of these objects or variants of the process. For example, you can omit the master flight schedule and the schedule-based allocation and directly create an air freight booking with reference to a carrier flight schedule or, in case of a connection flight, multiple carrier flight schedules. In this case, you explicitly maintain the booking's capacity.

6.4.2 Systematically Creating Schedule-Based Freight Documents

You can systematically create schedule-based freight documents by choosing **Logistics • Transportation Management • Administration • Background Processing • Creation of Schedule-Based Documents** in the SAP menu. In the **Planning Operation** tab, you can choose which freight documents are created: air freight bookings, ocean freight bookings, road freight orders, or rail freight orders. For each selected freight document category, an individual tab allows you to define selection criteria (see Figure 6.38), where you can see the schedule selection criteria to be used for creating air freight bookings.

Besides defining the criteria, you also set the time period for which freight documents are created based on the determined schedules' departures. If the report was run twice or with overlapping selection criteria, you may not want to create duplicate freight documents, so you should set the corresponding parameter accordingly. Some air freight–specific parameters are available, such as the default contract basis, which allows the creation of allotment, blocked space, charter, and ad hoc air freight bookings, as well as the trigger for MAWB creation.

The **Technical Settings** tab allows you to define the following system behavior:

- Cancel processing if a selection error occurs.
- Cancel processing if a freight document creation error occurs.
- Display the selected departures of the determined schedules.
- Save or show the freight documents in simulation mode without saving.
- Enable the package size to allow parallelization.

A log is written as shown in Figure 6.39. You can define whether message details are added and how long the log files are available in the system.

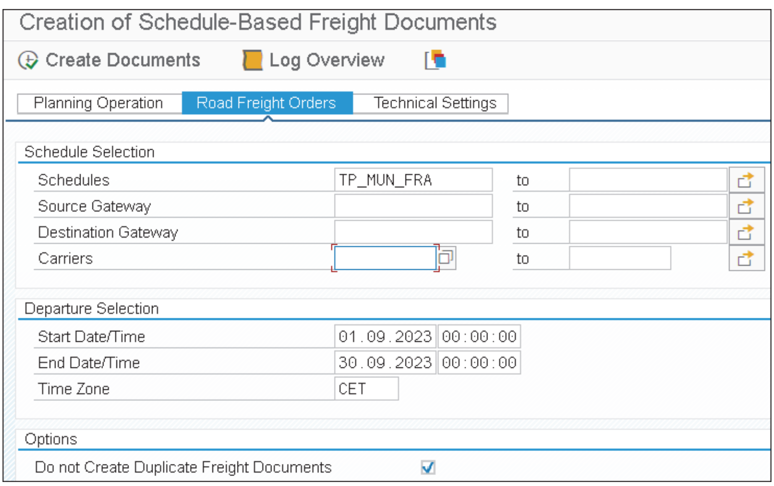


Figure 6.38 Selection Criteria for Creating Schedule-Based Freight Documents

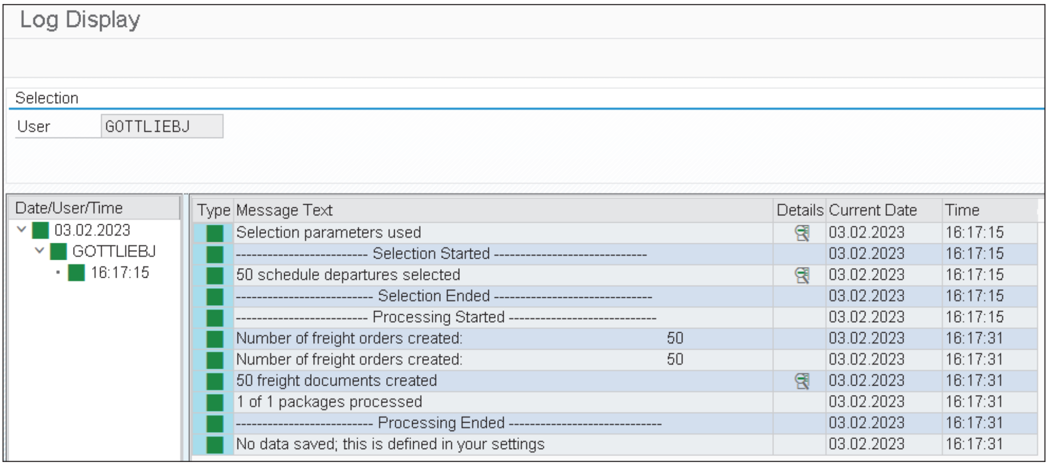


Figure 6.39 Log Information for Created Schedule-Based Freight Documents

6.4.3 Schedule Change Management

If you uploaded or manually created your carriers' schedules, defined schedule-based allocations, and created air freight bookings, then your operative flight plan is up to date. Frequently, the carrier alters the schedule by changing the departure date or time, omitting complete departures, or offering new departures. You can upload the changed schedule data as carrier flight schedules, and the system adjusts the previous versions accordingly. Alternatively, you can manually change the carrier flight schedule. This change has an impact on the subsequent business documents in the capacity management process.

In the event of a delay of the first flight by 10 minutes in a connection master flight schedule that has a connection time of 3 hours, you can accept this delay because 2 hours and 50 minutes is still sufficient to bring the freight from the first to the second airplane. However, if the delay of the first flight is 3 hours, you can't keep the connection and must decide whether to take a later departure of the second flight, choose a different carrier flight schedule for the connection, or, in the worst case, give up this connection master flight schedule and create an alternative master flight schedule with a different connection airport.

For connection flights, in particular, a delay of the first flight may invalidate the complete connection. For this reason, there is no automatic propagation of the changes into the subsequent business documents. Instead, the master flight schedule, schedule-based allocation, and air freight booking have a reference data status that indicates whether the underlying carrier flight schedule has changed. This status field is shown in the corresponding personal object worklist (POWL) queries for these objects so that you can easily identify the affected objects and manually react to the changes. Within these objects, the reference data status is shown on the header level and on the detail level:

- In a master flight schedule, the stages of the departure rules indicate whether the underlying carrier flight schedule's departure rule has changed.
- In a schedule-based allocation, the departure buckets indicate whether the underlying departure has changed.
- In an air freight booking, the stages of the carrier routing indicate whether the underlying departure has changed.

The UIs of these three objects allow you to copy the most recent information from the underlying carrier flight schedule or change the reference and take the data out of another carrier flight schedule. Thus, you can manually change the master flight schedule, schedule-based allocation, and air freight bookings so that they consider the changed carrier flight schedule. This is intended to be a manual step because the reaction to the change may require interaction with the involved carriers (e.g., via phone or email). However, by implementing the appropriate change controller strategies, you can automate this change process according to your needs.

Although explained in the context of air freight, the reference data status and capabilities for manual reactions to changes in carrier schedules are available for gateway schedules, schedule-based allocations, and freight documents in general—that is, for all modes of transport.

6.4.4 Allocations

An allocation represents the planned capacities for a carrier and a trade lane during a validity period. The capacities can be defined for multiple dimensions, such as volume, weight, and TEUs, as well as a sequence of time periods of the same granularity, which are frequently called (time) *buckets*. For each dimension and time period, the allocation captures the already-consumed portion of the maintained capacity. All freight documents matching the carrier, trade lane, and validity period consume the corresponding buckets of the allocation. As soon as a freight document is created, the matching allocations are determined asynchronously and updated according to the freight document's capacity. The consumed quantities are visible in the allocations and allow tracking of the capacities and their utilizations. Recall from Section 6.4.1 that one freight document can consume buckets of multiple allocations.

Figure 6.40 shows a schedule-based allocation for carrier **CSI-CA-LH**, a trade lane from a gateway in Frankfurt to a gateway in Chicago with the mode of transport air and validity from November 30, 2018, to December 30, 2019. The buckets represent departures of the underlying schedule 2000506 and the shown departures start on December 3, 2018. For each departure bucket, you can maintain the maximum gross weight and maximum gross volume. The corresponding consumption is shown as well. In this example, the allocation was newly created with no recorded consumptions yet.

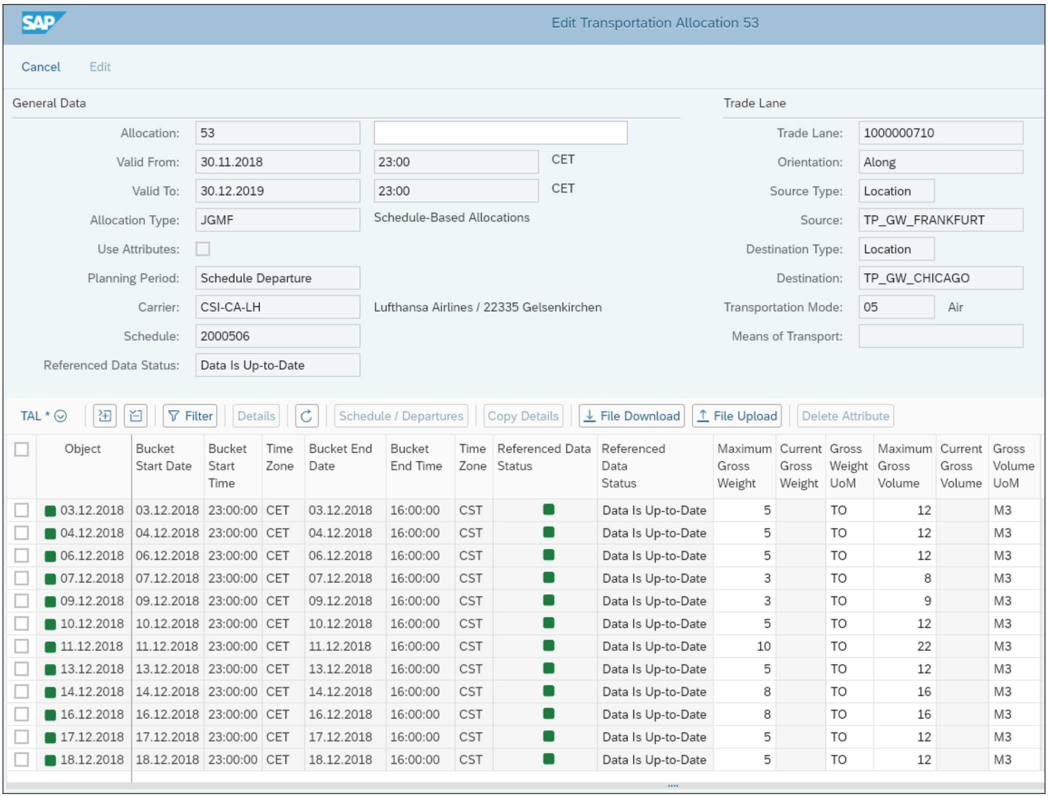


Figure 6.40 Schedule-Based Allocation for Air Freight

Figure 6.41 shows an allocation with monthly buckets covering transportation from Germany to the United States in 2019 by one ocean carrier. Here, the capacity is defined by the number of 20-foot containers per month, measured in TEUs. Consumed weight and volume can also be tracked, although no capacity was defined.

Schedule-based allocations can be created only from a schedule, as mentioned in Chapter 3, Section 3.2.4. You can create other allocations by using the Create Transportation Allocation app and specifying the allocation type. An allocation created out of a freight agreement is called a *freight agreement allocation*, and its only difference from other allocations is that it's contained in the freight agreement.

Alternatively, you can use the Transportation Allocations Worklist app for the POWL and choose the query for allocations to maintain allocations. It's possible to select multiple allocations and maintain them in the same UI, as shown in Figure 6.42. At the top, you can see general information about the allocations and choose which of them is shown in detail at the bottom, where the buckets are displayed.

The POWL allows uploading allocations from a file and downloading selected allocations into a file. Alternatively, you can upload allocations by choosing **Logistics • Transportation Management • Administration • Background Processing • Allocation Upload** in the SAP menu.

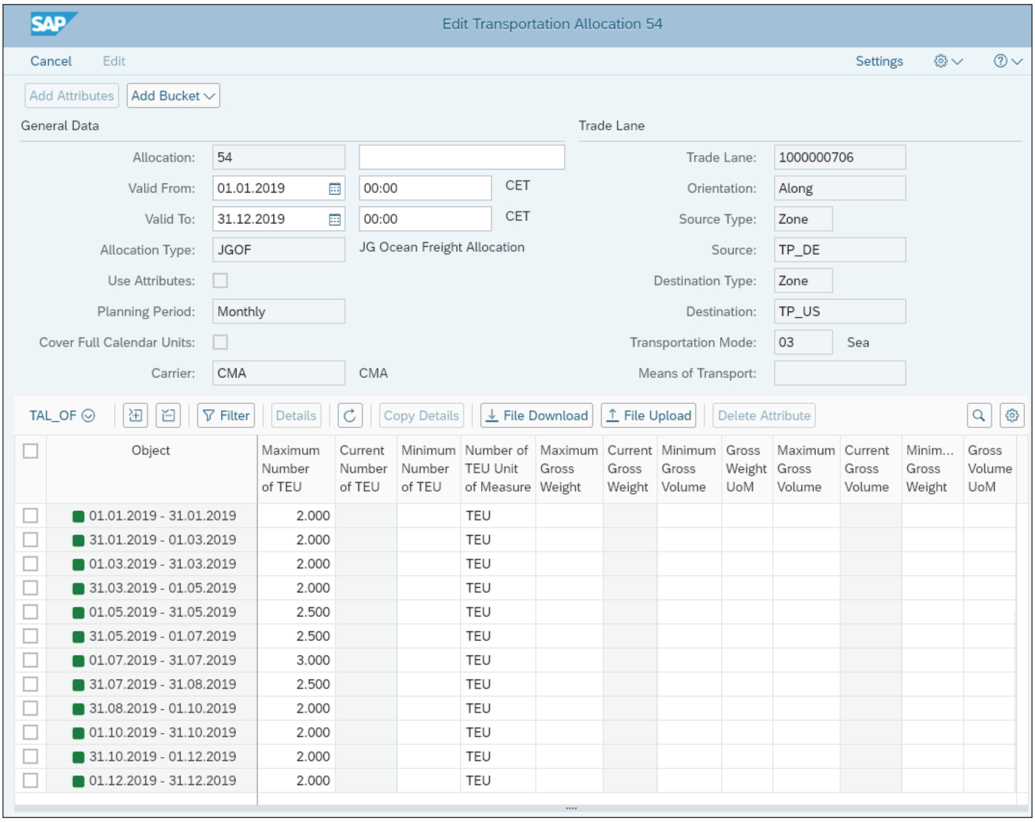


Figure 6.41 Monthly Allocation for Ocean Freight

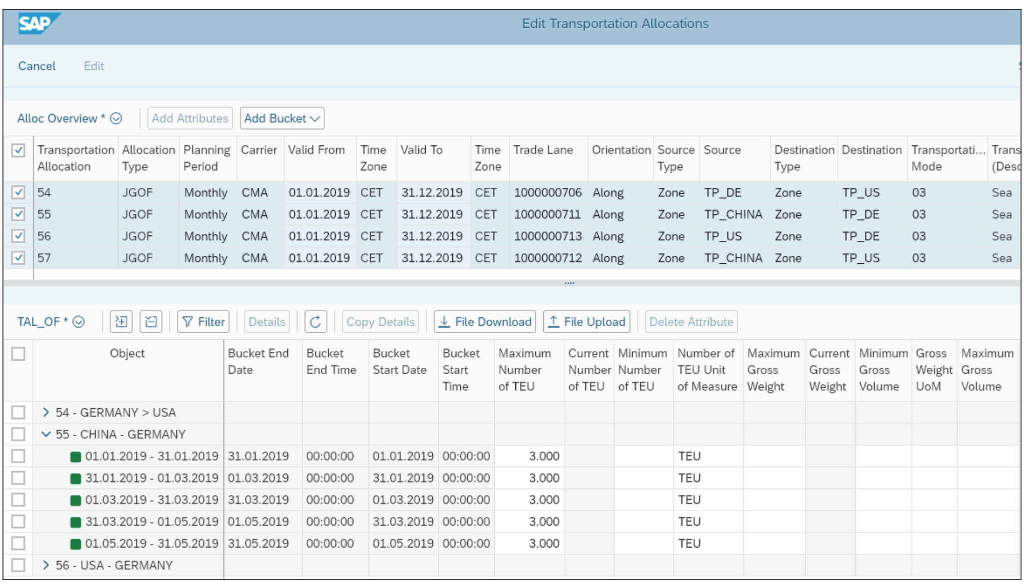


Figure 6.42 Maintaining Multiple Allocations in One UI

In the allocation maintenance UI, you can filter allocations and buckets, for example, according to a start and end time, reference data status being out of date, or their consumed quantity being above the maximum quantity. Whereas automatic carrier selection respects the allocations' capacities, it's possible to manually create freight documents that result in the capacity being exceeded. The user is informed about such a capacity violation via a warning message in the freight document and by the allocations' buckets showing higher consumption than capacity. Click the **Schedules/Departures** button to compare the current allocation's departure dates and times with those from the underlying schedule and decide which schedule data should be transferred into the allocation's buckets.

In Customizing, you can follow menu path **Transportation Management • Planning • General Settings • Define Transportation Allocation Types** and define allocation types by specifying the following parameters:

- **Default Type**
  If you created an allocation from scratch and didn't choose an allocation type, the default allocation type is chosen; it's set by this parameter.
- **Mode of Transport**
  You can define the mode of transport or omit this field.
- **Planning Period**
  You can choose among daily, weekly, monthly, quarterly, yearly, and schedule departure. Whereas the first considers all freight documents in the specified time period—also called (time) buckets—the last option refers to departures of an underlying schedule. This means that all freight documents created for that departure are covered by the bucket.
- **Schedule-Based Allocation**
  This specifies that the allocation depends on a schedule—that is, you can create the allocation only out of a schedule, for which the allocation type has been defined in the schedule type, as mentioned in Chapter 3, Section 3.2.4. The schedule determines the validity and trade lane of a schedule-based allocation.
- **Full Calendar Units**
  You can define whether the bucket fully covers a calendar unit or if it can start at any time but has a duration according to the planning period. If you use a daily planning period and don't use full calendar units, you can have a planning period from Monday at 8:00 until Tuesday at 8:00. If you use a monthly planning period and full calendar units, the bucket starts at 0:00 on the first day of the month and lasts until 0:00 on the first day of the next month.
- **Use Attributes**
  This allows you to create multiple buckets for the same period of time. The buckets consider different attribute combinations based on shipping type, contract basis, or handling code. Using handling codes for the upper deck and lower deck of an

airplane, you can define two buckets with individual capacities, one for the upper deck and one for the lower deck. The concept of attributes is described shortly in more detail.

- **Use Carrier Selection**
  This defines whether allocations of this type are considered by carrier selection.
- **Carrier Selection Unit of Measure**
  If carrier selection is activated, you can specify the allocation's unit of measure that is considered for carrier selection. You may define allocations with volume, weight, and TEU quantities and choose carrier selection considering the TEU capacities.
- **Update Quantity Automatically**
  This defines whether a newly created allocation or bucket gets an automatic update of its consumed quantities.
- **Bucket Overlapping**
  A freight document may cover multiple buckets of the allocation. Using this parameter, you can define whether all covered buckets get consumed by the freight document or only the first covered bucket gets consumed. This parameter should not be changed if allocations already exist in your productive system because the buckets will contain data according to both consumption modes, which makes the quantities hard to interpret.
- **Allocation BW Relevance**
  This specifies whether the allocation type is relevant for analytics based on SAP Business Warehouse (SAP BW).

It's possible to define multiple buckets for one time period based on different attribute combinations. The prerequisite is that you've selected the **Attributes** option in the allocation type Customizing. Now you can maintain an allocation and introduce attribute nodes by clicking the **Add Attributes** button, as shown in Figure 6.43, where two attribute nodes have already been created. The departure buckets are shown hierarchically below the attribute level. Each departure appears under each attribute node, which allows you to define the capacity for each attribute combination and departure.

Standard attributes are the contract basis (which can be allotment, blocked space, charter, or ad hoc), service level, and shipping type. In addition, you can click the **Details** button to add one or multiple handling codes, which characterize the goods that can be transported and the required equipment, such as three ULDs (as shown in Figure 6.43).

If you enter quantities in the attribute row, they are propagated into the departures' fields below. If you create freight documents for this allocation, one air freight booking is generated per attribute and departure combination, and the additional information, such as the handling codes and equipment, is copied into the bookings.

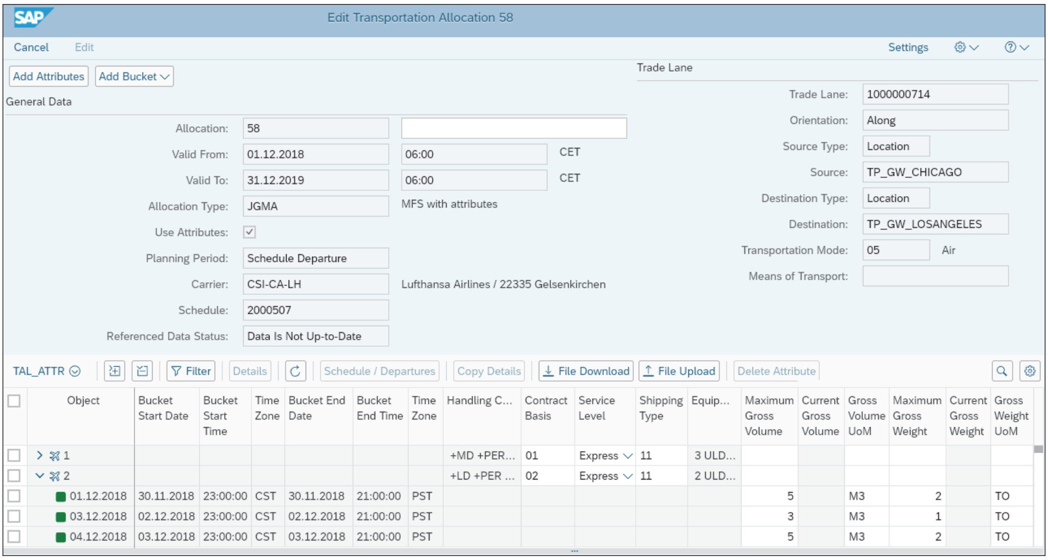


Figure 6.43 Schedule-Based Air Freight Allocation with Attributes

Handling Codes

Handling codes can classify goods and characterize how they are to be transported. You can define handling codes in Customizing by following menu path **Transportation Management • Basic Functions • General Settings • Define Handling Codes**. For each handling code, you can add a description and specify whether it's to be used in external communication or serves internal purposes only.

When adding handling codes in the attribute node of an allocation, you can choose among the following handling code constraint modes relevant for the freight documents created for the allocation:

- **Handling Code Must Be Identical**
  Only freight units with the same handling code can be assigned to the freight document. This constraint mode is shown in the allocation with the prefix **+**.
- **Exclude Objects with This Handling Code**
  Only freight units that don't have this handling code can be assigned to the freight document. This constraint mode is shown in the allocation with the prefix -.
- **Not Relevant for Planning**
  No constraints are imposed, and this handling code is used only for informational purposes. The handling code is shown directly in the allocation without prefix.

For example, defining the handling codes PER (perishables) and FRO (frozen goods) as external and defining C23 (special code 23) as internal, you can force the system to include perishables, exclude frozen goods, and mention special code 23 as a handling code for information purposes only. This combination is displayed as +PER – FRO C23.

If you want to use handling codes without allocations, you can select menu path **Transportation Management • Basic Functions • General Settings • Define Handling Code Constraint Profile** in Customizing, capture a combination of handling codes and corresponding constraint modes in a handling code constraint profile, and assign it to a means of transport. When you create freight orders with that means of transport, the handling codes and their constraint modes are copied from the profile into the freight order.

Handling codes can be entered in air forwarding orders, are propagated into the corresponding freight units, can be defined for freight documents as just described, and are considered by automatic and manual planning, where the handling codes can be displayed in the transportation cockpit. If marked as external, they are contained in the air freight booking messages sent to the carriers.

6.4.5 Business Shares

Although you may have your preferred carrier for a certain trade lane, you also collaborate with other carriers, perhaps to resolve bottleneck situations, peak demands, or other issues with your preferred carriers. Giving freight orders to other carriers only when you have severe problems may not be a good basis for a solid relationship.

To protect your relationship with the other carriers, you may decide to grant them a certain percentage of your transportation business each month. In this way, you can establish a stable relationship but still give most of your transportation business to your preferred carrier. In other scenarios, you may have an agreement with your two major carriers that each of them gets 50% of your transportation business in a certain region. This helps your relationship with the two carriers because they can rely on getting the agreed-upon amount of your business.

With TM, you can define such target shares per carrier as a business share for a trade lane and means of transport or mode of transport on a daily, weekly, monthly, quarterly, or yearly basis. The business shares are used by carrier selection, as described in Section 6.5.

Using the Create Business Share app, you can create business shares, as shown in Figure 6.44.

In the **Trade Lanes** area, you can define the trade lanes for which you want to define business shares. For each trade lane, you can define the means of transport or mode of transport. In this example, the trade lane represents all transports within the transportation zone US, and the business share is defined for means of transport **0001**. In the **Target Share** area, you can insert the relevant carriers and assign a percentage for each. The **Business Share Details** area specifies the validity period of the business share, business share period (which can be daily, weekly, monthly, quarterly, or yearly), and unit of measure that is used to determine the percentages among the freight documents that match the trade lane and the (time) buckets. As in the allocation type Customizing, you can also define whether the business shares refer to full calendar units.

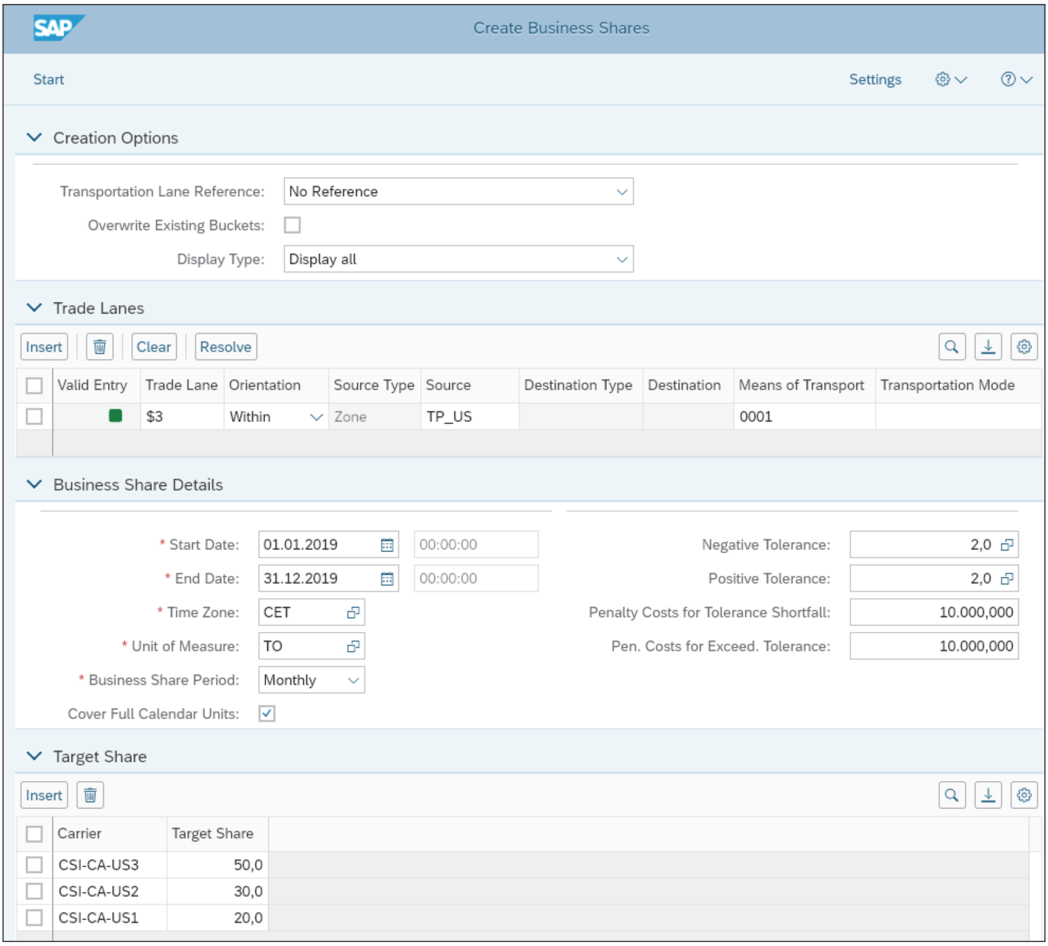


Figure 6.44 Creating Business Shares

Automatic carrier selection takes into consideration the negative and positive tolerances and corresponding penalty costs for violating the tolerances; these are explained in detail in Section 6.5.2.

The **Creation Options** area specifies how the business share is created:

- Without reference to a transportation lane
- Only if a corresponding transportation lane exists
- Only if a corresponding transportation lane exists with the data copied from the transportation lane

You can define whether existing buckets are overwritten. The display type determines whether only newly created business shares or all business shares are shown.

After you've maintained the data in all the areas, click the **Start** button to create the business shares. Then the created business shares are displayed and can be edited, as depicted in Figure 6.45. You can also edit business shares by using the Business Shares Worklist app, selecting multiple business shares and editing them in one UI, similar to the process for allocations described in Section 6.4.4.

Figure 6.45 Maintaining Business Shares

The current values of the business shares are updated automatically when new freight documents are created, the same as with the allocations' consumption values. In the previous example, the business shares have just been created, so all carriers have a share of 0%. The shares are calculated per bucket.

6.5 Carrier Selection

The primary objective of carrier selection is to assign a reliable and cost-efficient carrier to a freight order. This can be done in the background, interactively using manual steps, or by using an automated optimization procedure. The various options are described in the next section.

6.5.1 Process

The carrier selection process can be initiated using various methods interactively and in the background. Figure 6.46 shows the carrier selection process when initiated interactively. Carrier selection can be started directly from the freight order UI or from any worklist that displays freight orders. It can also be started for freight orders inside the transportation cockpit (**Planning • Transportation Cockpit**) or using an app dedicated to carrier selection (**Planning • Carrier Selection**). Finally, carrier selection can be executed as part of a planning strategy (e.g., by including method VSR_TSPS as in planning strategy VSR_1STEP, which is delivered as a standard planning strategy that combines VSR optimization and carrier selection; see Chapter 5, Section 5.8) or as part of a creation strategy CARR_SEL upon freight order creation.

The input data for carrier selection is one or more freight orders (selected interactively in a worklist) or a selection profile by which the freight orders that need to have a carrier assigned are determined. In addition, carrier selection settings are required to specify exactly how carrier selection should be carried out. The carrier selection settings (Section 6.5.4) are specified explicitly as part of the definition of a background job (/SCMTMS/TSPS_OPT_BGD) (see Figure 6.49); retrieved indirectly, perhaps because they have been assigned to the planning profile that was used to enter the transportation cockpit; or can be determined from freight order type Customizing either via a condition or by direct assignment.

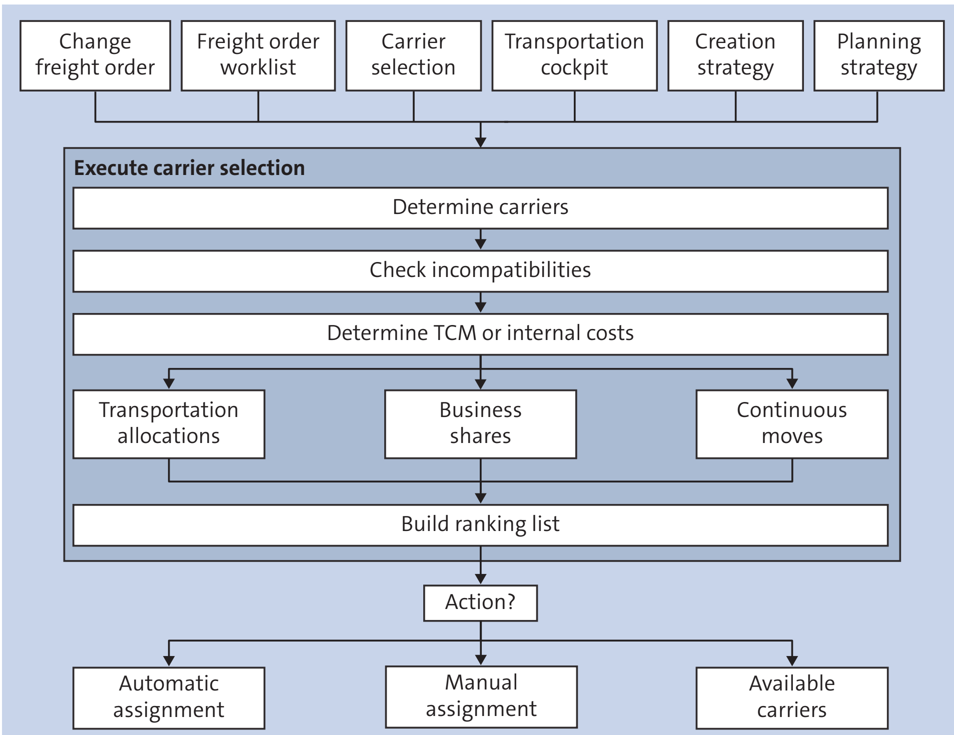


Figure 6.46 Carrier Selection Process

After carrier selection has been initiated, the system determines the available carriers for each selected freight order. A carrier is considered available if it has been defined as a valid carrier for the means of transport used in the freight order for a transportation lane from the source location to the destination location of the freight order. The list of available carriers is reduced by those carriers that are incompatible with the freight order. Incompatibilities arise in a number of ways, such as when a customer doesn't want to be served by a specific carrier or the freight units assigned to the freight order contain hazardous goods that the carrier isn't allowed to handle (e.g., because the carrier's drivers lack experience, haven't been trained for it, or don't possess a legally required permit).

Available Carriers

To determine which carriers are available, the system proceeds as follows:

1. For each stage of the freight order, the carriers defined for the means of transport used in the freight order in the most specific transportation lane that represents each stage are determined (see top half of Figure 6.47).
2. The carriers defined for the means of transport used in the freight order in the most specific transportation lanes from the source to the destination of the freight order are determined (see bottom half of Figure 6.47).
3. Depending on whether the **Overall Carrier Availability** checkbox has been set, either the carriers are considered available that have been identified for each stage in step 1 and in step 2 (checkbox is set), or only those identified in step 2 (checkbox isn't set) are considered available.

Figure 6.47 illustrates this procedure. If the **Overall Carrier Availability** checkbox is set, only carriers 1 and 2 are considered available, whereas carriers 1, 2, and 5 are considered available if the checkbox hasn't been checked.

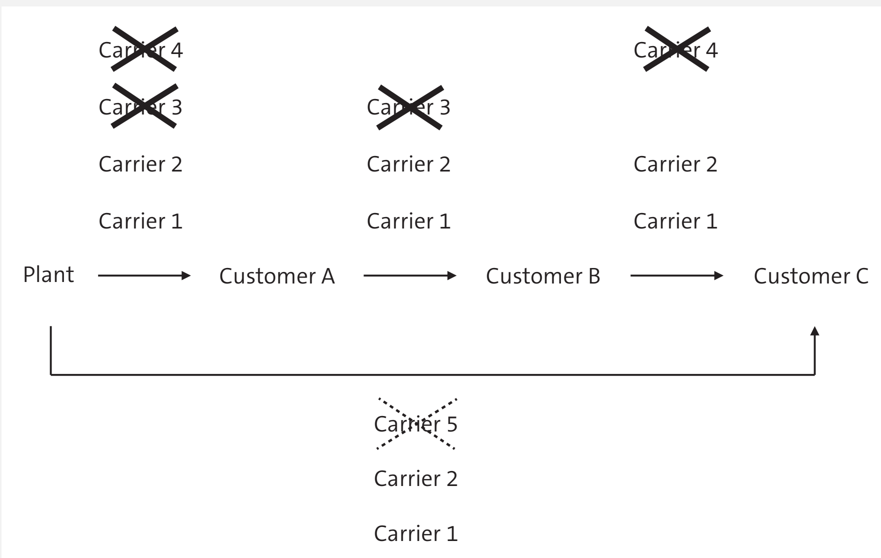


Figure 6.47 Available Carriers

After eliminating incompatible carriers, it's time to decide how to choose one from among the remaining carriers. Decision criteria can include priorities, internal costs, or transportation charge management costs based on the defined strategy.

The next step is an optimization procedure that takes into account the decision criteria calculated in the previous step, as well as all constraints that have been defined. (We outline objectives and constraints in Section 6.5.2 and Section 6.5.3, respectively.) The result of this process is a ranking list of all available carriers from the reduced lists based on the decision criteria. Figure 6.48 gives an example of a ranking list of the relevant information—such as the carrier name, SCAC, expected transportation cost, and priority—that a user requires to make a reasonable assignment. Note that the first-ranked carrier isn't necessarily the cheapest because its ranking may have been forced by constraints such as transportation allocations or business shares. All carriers beyond the first position are sorted in descending order of the decision criteria (e.g., cost or priority).

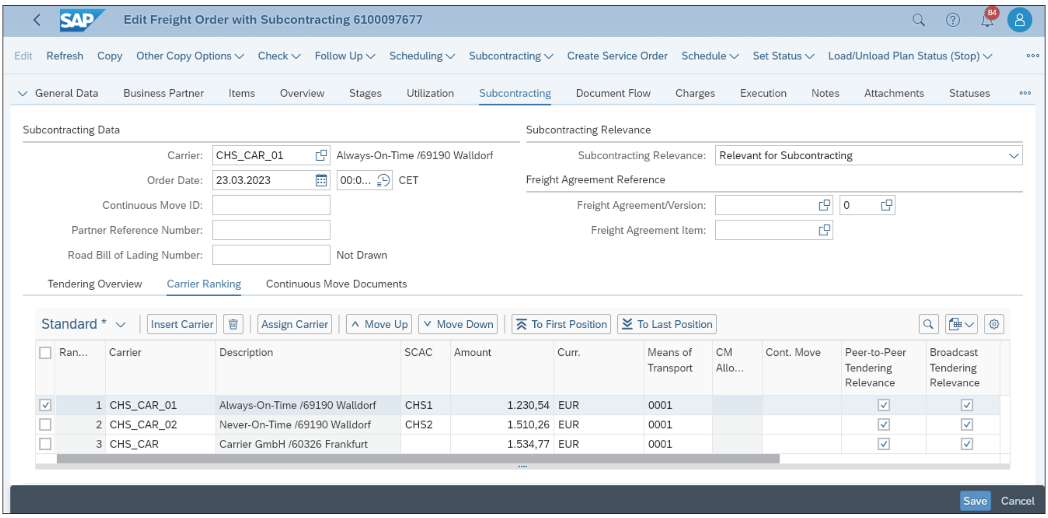


Figure 6.48 Ranking List

Finally, the carrier that is ranked first can be assigned to the freight order as part of the automatic carrier selection process, or the assignment can be delegated to a user in a manual process. If carrier selection hasn't been executed to *determine* a carrier but only to identify the *available* carriers, the ranking list can be used in a subsequent tendering process (Section 6.6). If carrier selection is done to initiate a broadcast tendering process, the optimization step can be skipped because the decision criterion (cost) is determined only then.

In addition to starting manual and automatic carrier selection and determining a list of available carriers, the transportation cockpit also interactively offers the functionality to delete existing carrier assignments, as well as existing carrier rankings for a freight order.

In the background, the carrier selection process can be initiated in the following ways:

- As part of the transportation planning process with background report /SCMTMS/PLN_OPT and using a planning strategy that includes carrier selection (e.g., VSR_1STEP)

- By scheduling report /SCMTMS/TSPS_OPT_BGD (see Figure 6.49)
- By assigning strategy `CARR_SEL` as a creation strategy in the freight order type Customizing

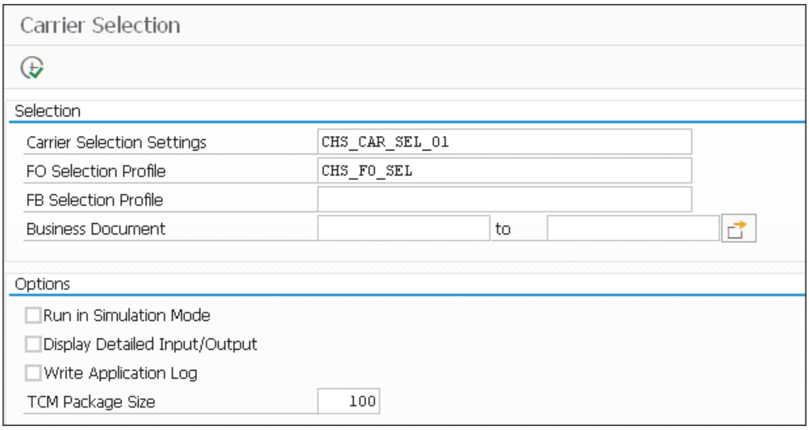


Figure 6.49 Background Report for Carrier Selection

The carrier selection process is predominantly used in land transportation. However, the carrier selection process can also be triggered for ocean freight bookings using the background report or from the freight booking UI. In contrast to carrier selection for freight orders, carrier selection for freight bookings will only consider transportation allocations—no business shares or continuous moves.

6.5.2 Objective of the Carrier Selection Optimizer

The objective of carrier selection is to assign the most suitable carrier to a freight order, which usually means assigning the cheapest one. However, there may be criteria other than cost involved, such as whether another carrier needs to be assigned to a defined minimum transportation quantity based on contractual obligations (minimum transportation allocation), which can force an assignment even if that carrier is more expensive for a specific freight order.

Carrier Selection Optimizer

The carrier selection optimizer converts the assignment problem into a *mixed-integer linear problem* (MILP). Based on the number of freight orders, the complexity of the constraints, and whether the runtime specified in the carrier selection settings is carefully chosen, the carrier selection optimizer usually returns the optimal solution. If the runtime isn't sufficient to determine the optimal solution, the best solution found within the specified runtime is returned.

Automatic carrier selection is based on an optimization algorithm that minimizes costs. The algorithm considers the following cost components:

- **Transportation charges for the freight orders of the assigned carrier**
  The transportation charges of the assigned carrier are often the only relevant cost component. For each freight order, the transportation charges are evaluated for all available carriers. The transportation charges can have two different origins. The transportation charges are calculated either via transportation charge management (which we cover in Chapter 9) and thus represent the expected real freight cost for a freight order or via internal costs. Internal costs can be defined in the transportation lane master data or, if they don't depend on the geography, in the carrier profile. You can also use a combination of both, if required.
- **Nonassignment charges for freight orders to which no carrier could be assigned**
  While the objective of carrier selection is to find an assignment of a carrier to each freight order, it's not possible, and the result is nonassignment. For example, finding a carrier may not always be feasible because it would violate the maximum transportation allocation of all possible carriers.

  Because this situation should be avoided, the system defines a penalty cost for not assigning any carrier to a freight order. This penalty can't be influenced by the user and is calculated to be prohibitively high to outweigh the other cost components and avoid nonassignment charges.
- **Penalty charges for violating minimum transportation allocations**
  If minimum transportation allocations refer to a monthly quantity, these may often not be fulfilled in the beginning of the month. Thus, minimum transportation allocations can't be considered a hard constraint because if there aren't enough freight orders waiting for assignment, it's impossible to fulfill all minimum transportation allocations. Therefore, this constraint is considered a soft constraint, and violation of minimum transportation allocations is penalized by costs. Similar to nonassignment charges, this penalty cost is calculated automatically by the system and set higher than the other cost components to avoid violation, if possible.
- **Penalty charges for noncompliance to business shares (outside negative and positive tolerance)**
  Business shares can be defined to yield a predefined distribution of freight orders among several carriers. This constraint can be used due to contractual obligations or simply to avoid assigning all freight orders to one carrier and therefore becoming too reliant on this carrier.

  To allow the assignment of carriers that have higher transportation charges, noncompliance with defined business shares is penalized, as outlined in Figure 6.50.

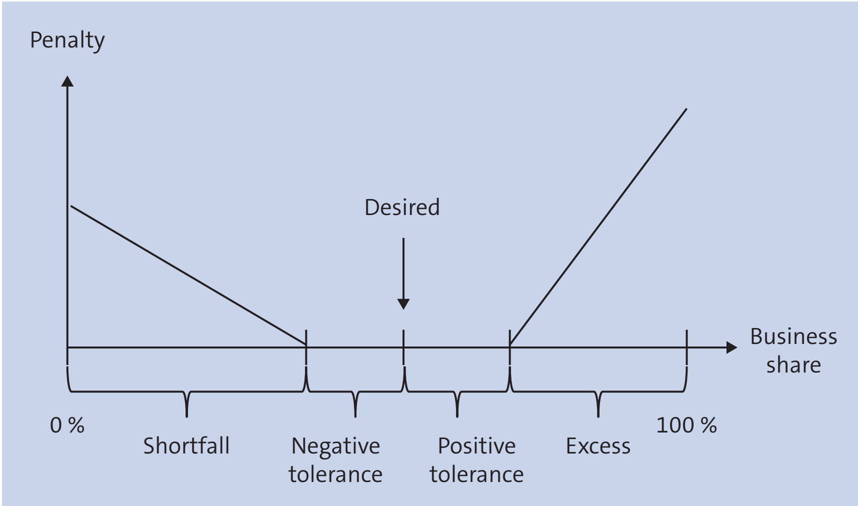


Figure 6.50 Business Shares

A negative and positive tolerance can be defined based on a desired business share for a carrier; actual business shares within these tolerances are cost free. A shortfall of the desired business share minus the negative tolerance or an excess assignment beyond the desired business share plus the positive tolerance is penalized with different penalty costs. Because the user is allowed to specify these penalty costs, the user can influence to what extent the consideration of business shares overrules the assignment of carriers based on transportation charges.

- **Discounts granted by the creation of continuous moves**
  In certain situations, carriers grant discounts to transportation charges. These discounts are also taken into account by the carrier selection optimizer.

Continuous Moves

Sometimes carriers grant discounts if they are assigned several freight orders for the same vehicle resource because the incentive reduces effort on their end to look for additional freight after having completed a single freight order. This situation is addressed in carrier selection by defining *continuous move* options. When carrier selection allows it, continuous moves are a way to save money on transportation costs.

Continuous moves may be offered for transports between regions that have economic disparities, such as mainland Europe and the United Kingdom. Because many more goods are transported from mainland Europe to the United Kingdom, many trucks have to return empty from the United Kingdom. A carrier may therefore be inclined to offer a discount on the transportation charges if it's also offered to transport freight on the return trip.

Figure 6.51 shows two continuous move types:

- **Simple continuous move**
  There is no relation between the destination of the second freight order D and the source of the first freight order A. Only the destination of the first freight order B and the source of the second freight order C have to be close.
- **Round trip**
  The destination of the second freight order and the source of the first freight order have to match A. In addition, the destination of the first freight order B and the source of the second freight order C have to be close.

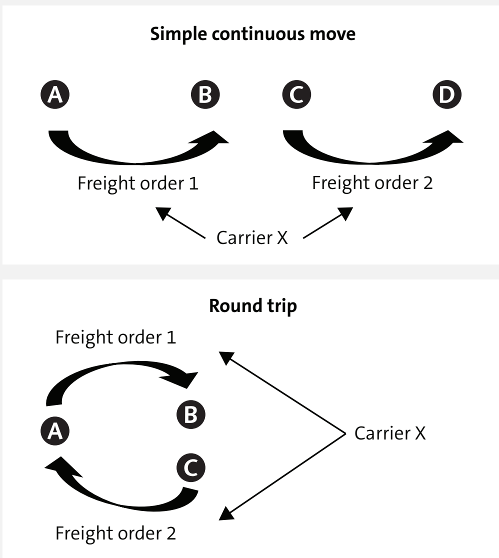


Figure 6.51 Continuous Move Types

A round trip is limited to two freight orders, whereas an unlimited number of freight orders can be combined by simple continuous moves. Closeness, or proximity, has the following two dimensions and is defined in the transportation lane:

- **Distance**
  A continuous move provides commercial benefit to the carrier only if the source of the second freight order isn't too far away from the destination of the first freight order. A maximum distance can be defined in the transportation lane master data.
- **Time**
  The departure time of the second freight order has to be reasonably close to the arrival time of the first freight order. It doesn't help the carrier if the carrier's vehicle has to wait for a week. Therefore, time constraints for these windows are also defined in transportation lane master data.

The continuous move types allowed for a carrier are also defined in the transportation lane and therefore can deviate by geography. In addition, the carrier needs to be marked as eligible for offering discounts on continuous moves in the carrier profile (**Continuous Move** checkbox).

If certain freight orders shouldn't be combined in a continuous move—even if these definitions would allow it—this can be specified via an incompatibility of type 82.

Before the carrier selection optimizer is started, an evaluation is carried out regarding whether two or more freight orders and carrier assignments qualify for continuous moves. These continuous move opportunities and their associated discounts are then provided as additional information to the optimizer, which takes these discounts together with the other cost components (freight charges, penalties) into account when calculating the optimal (cost minimal) solution.

If two or more freight orders build a continuous move, this is identified by a continuous move ID that is visible in the freight order (refer to the **Continuous Move Documents** tab in the **Subcontracting Data** section of Figure 6.48).

While cost is the most obvious objective, carrier selection can also be based on priorities or a combination of priorities and costs as an alternative. Using priorities may be an option if the focus of the implementation project is planning, and it's deemed to be too much effort to actually set up transportation charge management or internal transportation costs. If the contractual setup with carriers allows you to express preferences based on geographical information (transportation lane master data), priorities can be used as selection criteria for carrier selection.

One way of combining priorities and costs is to use the multiplication of both numbers as a decision criterion (*priorities × costs*). In this case, priorities can be interpreted as a key performance indicator (KPI) for carrier reliability. A value smaller than 1 indicates a bonus in the selection because of good customer service, whereas a value larger than 1 corresponds to a disadvantage, which increases the perceived costs of this carrier. Similarly, you can argue for using the sum of both decision criteria (*priorities + costs*).

6.5.3 Constraints

We recommend considering the following constraints during carrier selection:

- Transportation allocations
- Business shares
- Incompatibilities

In the carrier selection settings, each constraint can be switched on or off individually by geography (transportation lane level) or globally for one carrier selection optimizer run (Section 6.5.4). Transportation zone hierarchies and means of transport hierarchies are considered with these constraints.

Section 6.4.4, introduced transportation allocations in detail. A *transportation allocation* allows you to define minimum and/or maximum allocations (capacities) that *need to be* assigned to a carrier (minimum) or that *can be* assigned to a carrier (maximum).

The transportation allocation type customization defines whether a transportation allocation is valid for carrier selection (**Transportation Management • Planning • General Settings • Define Transportation Allocation Types**) and the unit of measure that is relevant for carrier selection. A transportation allocation can be created via menu path **Master Data • Create Transportation Allocation** and is defined by the following characteristics, which are shown in Figure 6.52:

- Trade lane
  - Orientation (see Chapter 3, Section 3.2.7, for details)
  - Source location or transportation zone
  - Destination location or transportation zone
- Transportation mode and/or means of transport
- Carrier
- Validity period
- Planning period
- Relevant unit of measure (defined via the allocation type)

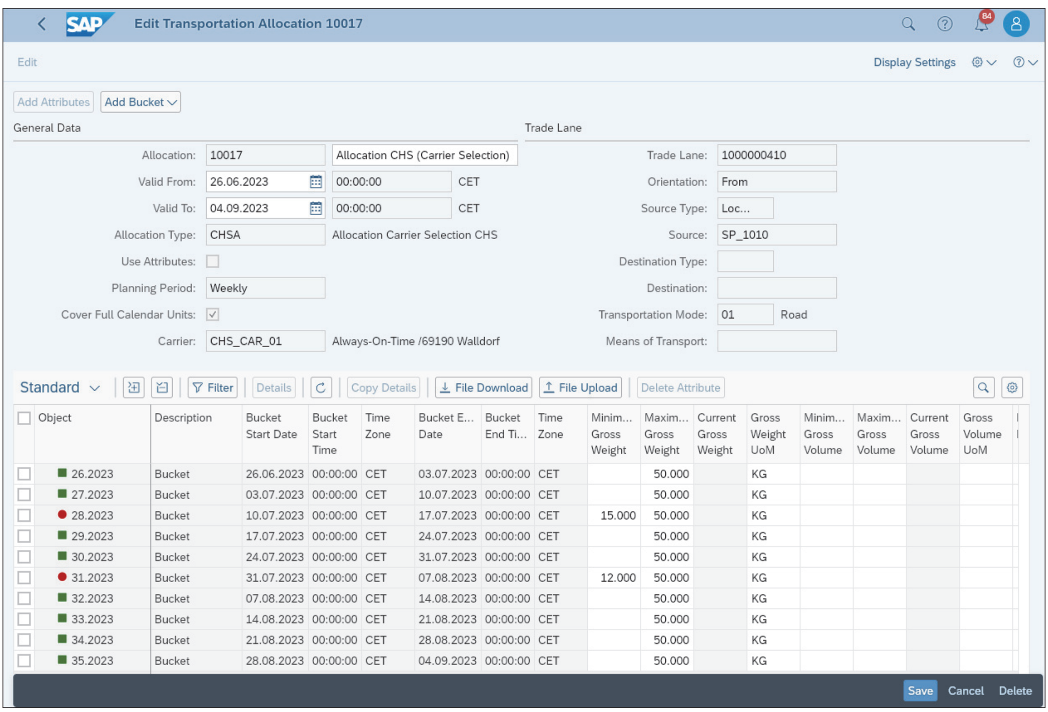


Figure 6.52 Creation of Transportation Allocations for Carrier Selection

Trade lanes and orientation define the geographical validity of the transportation allocation. Transportation mode, means of transport, and carrier identify exactly for whom and for what the transportation allocation is defined. The validity period defines the temporal validity of the transportation allocation. This time period is divided into buckets according to the setting of the planning period (e.g., daily, weekly, monthly, quarterly, or yearly).

Customizing the transportation allocation type also specifies the unit of measure for which the transportation allocation is defined. In the example used in Figure 6.52, gross weight has been defined as the relevant dimension. Therefore, in the transportation allocation, you can maintain a minimum and maximum weight for each bucket, as well as display what has already been allocated to the carrier for this transportation allocation (current gross weight).

Furthermore, in the transportation allocation type, you've specified how to account for transportation allocations. The **Bucket Overlapping** checkbox specifies whether only the first date (the requested start date) or the complete period of the freight order allocates capacity. If a freight order covers a period of three days (e.g., a truck driving from Spain to northern Germany), and the planning period for the transportation allocation is daily, this checkbox determines whether the transportation allocation takes this freight order into account on all three days or only once on the first day.

A freight order is considered relevant for a transportation allocation if all the following characteristics are met:

- The means of transport in the allocation is the same or superior to the means of transport used in the freight order.
- The requested start date of the freight order falls into the validity period of the transportation allocation.
- The geographical criteria (trade lane and orientation) are met for the source and destination location of the freight order, considering also the transportation zone hierarchy.
- The check for transportation allocations has been set in the transportation lane corresponding to the freight order or in the carrier selection settings.

One Freight Order Can Consume Several Transportation Allocations

Note that one freight order may consume several transportation allocations because means of transport hierarchies, transportation zones, and transportation zone hierarchies are taken into account when determining the relevant transportation allocations for a freight order. You can't automatically assign a carrier if even one transportation allocation is violated, but you can force the assignment manually.

For example, let's say that a carrier leaving plant P is allowed to take a maximum of 10 freight orders per week. A maximum of 3 freight orders per week is allowed for the same carrier from plant P to warehouse W. If 3 freight orders from P to W have been assigned to this carrier in a particular week, no additional freight order from P to W can be assigned to this carrier, even though there is an open allocation of 7 freight orders outbound from plant P. This assignment would violate the second transportation allocation (P to W).

If a freight order is created or changed, this updates all relevant transportation allocations, meaning that potential violations are checked. However, an update of the transportation allocation doesn't have an impact on existing carrier *assignments* to other freight orders.

Business shares have a lot of similarities with transportation allocations. They can be created by selecting **Master Data • Create Business Share** and are defined by the following characteristics, as shown in Figure 6.53:

- Trade lanes:
  - Orientation
  - Source location or transportation zone
  - Destination location or transportation zone
- Means of transport and/or transportation mode
- Validity period
- Business share period
- Positive and negative tolerances
- Penalty costs
- Target business shares per carrier
- Unit of measure

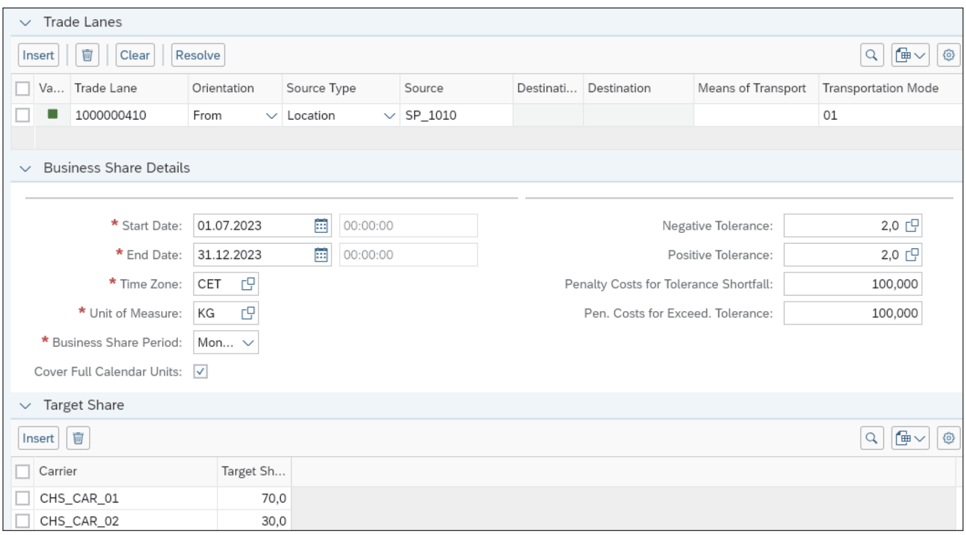


Figure 6.53 Business Shares

Similar to transportation allocations, defining and using business shares takes into account means-of-transport hierarchies, transportation zones, and transportation zone hierarchies. When you're calculating the actual business share, you consider not only the orders that are part of the selection for carrier selection but also those that already have a carrier assigned and that fall into the business share period (historical business share).

The major difference between transportation allocations and business shares is that business shares express preferences of carrier assignments in relative numbers (percentages), while transportation allocations represent capacity restrictions and are defined in absolute numbers with a unit of measure. In addition, business shares are represented as soft constraints that are considered based on penalty costs, whereas transportation allocations are hard constraints.

For carrier selection, two incompatibility types are relevant:

- **Freight order—carrier (type 81)**
  Incompatibilities between freight orders and carriers are used if a carrier won't be assigned to a freight order for any reason. Possible reasons are typically driven by the business, such as if a carrier is blacklisted by a customer and should therefore not be used in freight orders for this customer, or if a carrier won't process certain goods because it isn't certified for those goods.
- **Freight order—freight order (type 82)**
  Incompatibilities between freight orders are relevant for the determination of continuous move options only. For example, a truck's cleaning requirement prevents it from being used for backhaul activities.

Individual incompatibilities are defined as *incompatibility definitions* (**Profiles and Settings • Create Incompatibility**), which are grouped into *incompatibility settings* (**Profiles and Settings • Create Incompatibility Settings**) to finally be assigned in the *carrier selection settings* (**Profiles and Settings • Create Carrier Selection Settings**). This has been described in detail for planning-related incompatibilities in Chapter 5, Section 5.8.4.

Figure 6.54 illustrates in an example which information is considered for automatic carrier selection. Although the example doesn't consider alternative carriers or several means of transport, it shows that a lot of information needs to be processed to adhere to all constraints relevant for carrier selection. In real-world situations, several available carriers or means of transport organized in a hierarchy with transportation allocations or business shares defined on several levels may add complexity to the decision.

The example consists of four locations (A, B, C, and D), which are assigned to transportation zones Z1 (B and C), Z2 (C and D), and Z3 (A, B, and C via Z1).

Freight orders are for the following:

- Freight order 1 (FO1) from source A to destination B
- Freight order 2 (FO2) from source A to destination C
- Freight order 3 (FO3) from source D to destination C
- Freight order 4 (FO4) from source D to destination A

Three transportation allocations are in the scope of this scenario: one from A to Z1 (orientation: along), one from D to Z2 (orientation: along), and one for D (orientation: from). In addition, business shares have been defined from A to Z1 (orientation: along) and from D to Z3 (orientation: along).

In this example, FO3 has to respect two transportation allocations and one business share, whereas one transportation allocation and one business share are relevant for the other three freight orders each.

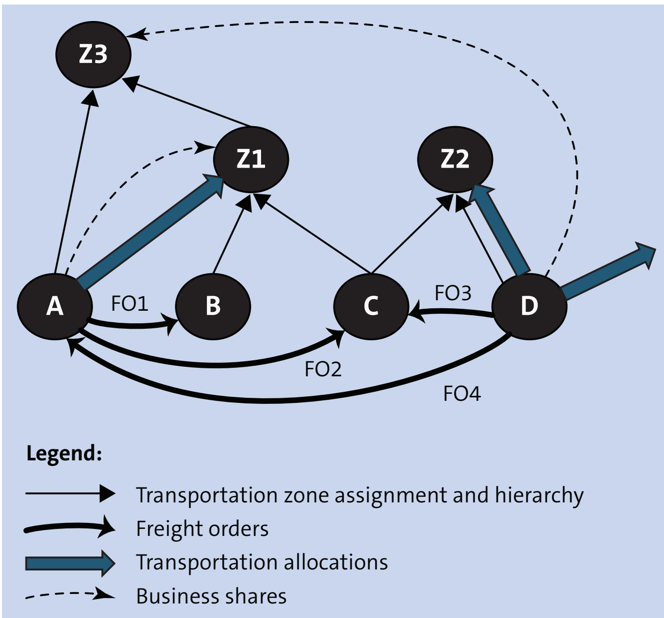


Figure 6.54 Example of Processed Information

6.5.4 Configuration

The configuration of carrier selection with all of its constraints is controlled by many objects. These objects have been explained in earlier chapters:

- Carrier profiles (see Chapter 3, Section 3.1.2)
- Transportation lanes (see Chapter 3, Section 3.2.3)
- Transportation zones and transportation zone hierarchies (see Chapter 3, Section 3.2.2)
- Transportation allocations (Section 6.4.4 and Section 6.5.3)
- Business shares (Section 6.4.5 and Section 6.5.3)
- Means of transport hierarchies (see Chapter 3, Section 3.3)

One central configuration step is the carrier selection settings (**Profiles and Settings • Create Carrier Selection Settings**), which are shown in Figure 6.55.

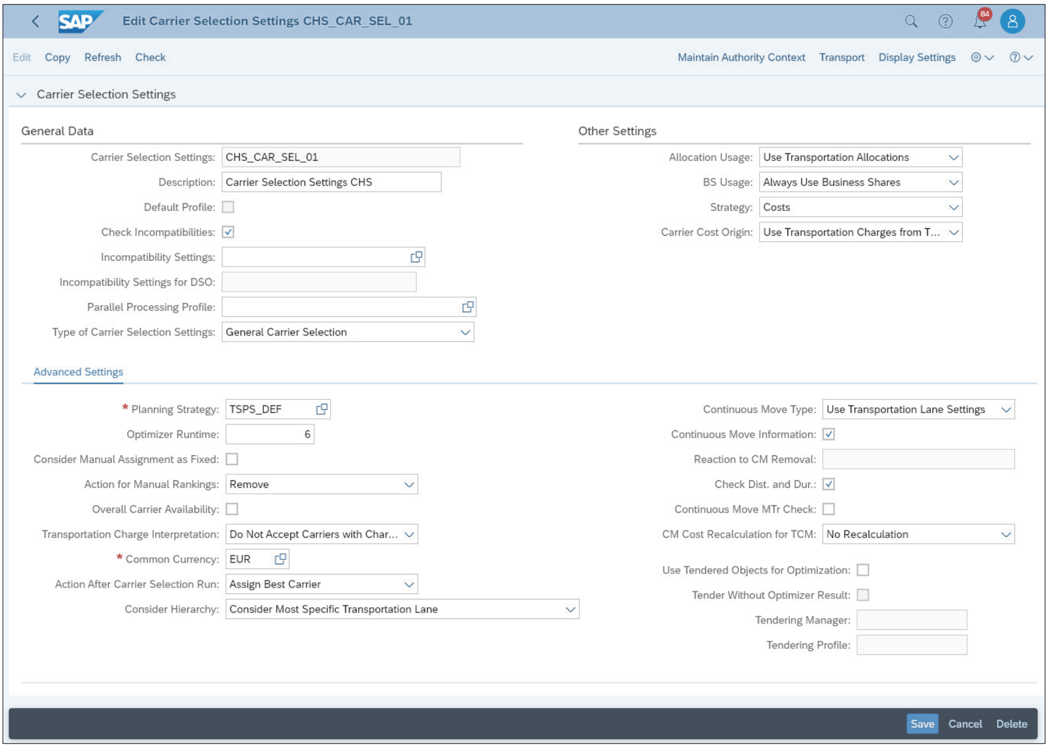


Figure 6.55 Carrier Selection Settings

These settings control the carrier selection process and determine which constraints are used and how. Therefore, configuring carrier selection settings for automatic carrier selection is mandatory.

The following fields are the most important to influence the carrier selection process:

- **Check Incompatibilities**
  Incompatibilities (Section 6.5.3) are checked only if this checkbox has been selected.
- **Incompatibility Settings**
  If the **Check Incompatibilities** checkbox is selected, incompatibility settings define which incompatibility definitions need to be adhered to.
- **Type of Carrier Selection Settings**
  This parameter defines the purpose of carrier selection. Available options are **General Carrier Selection**, **Carrier Selection for Tendering**, and **Carrier Selection for Direct Shipment**. The parcel process, which uses the carrier selection settings for direct shipments, is explained in detail in Section 6.1.3.
- **Allocation Usage**
  This parameter determines the consideration of transportation allocations. Available options are to use transportation allocations, not to use them, or to decide on the transportation lane level.

- **BS Usage**
  This business share usage parameter determines the consideration of business shares. Available options are to use business shares, not to use them, or to decide on the transportation lane level.
- **Strategy**
  The strategy determines how the objective of carrier selection is calculated in optimization. The objective can be based on cost, priority, cost plus priority, or cost multiplied by priority. In addition, the **Use Transportation Lane Settings** option in the **Continuous Move Type** field can delegate this decision by geography to the individual transportation lanes, so that in different geographical areas, different objectives can be pursued (e.g., priority in one transportation lane and costs in another transportation lane).
- **Carrier Cost Origin**
  Carrier cost origin defines how costs are calculated. Transportation charges from transportation charge management or internal costs can be used (Section 6.5.2). The **No Cost Determination** strategy may be used if carrier selection for tendering searches for the available carriers in a broadcast tendering process (Section 6.6). Like the settings for strategy with the **Use Transportation Lane Settings**, you can delegate this decision by geography to the individual transportation lanes.
- **Planning Strategy**
  The left column of Figure 6.56 shows the default planning strategy for carrier selection TSPS_DEF. The assigned methods illustrate the carrier selection process with all relevant steps from gathering relevant data (carriers, step 20; incompatibilities, step 30; continuous move opportunities, step 40; other constraints, steps 50 to 70) to optimization (step 80).

Method assignment to Strategy

Strategy	Method	Sequence	Description
TSPS_DEF	TSPS_PRE	10	CS: Preprocessing
TSPS_DEF	TSPS_CARR	20	CS: Get carriers
TSPS_DEF	TSPS_INC	30	CS: Check incompatibilities
TSPS_DEF	TSPS_CM	40	CS: Build continuous moves
TSPS_DEF	TSPS_FILT1	50	CS: Optimizer restrictions
TSPS_DEF	TSPS_TAL	60	CS: Load relevant TAL/BS
TSPS_DEF	TSPS_FILT2	70	CS: Process TAL Bucket Restrictions
TSPS_DEF	TSPS_EXEC	80	CS: Execute Process
TSPS_DEF	TSPS_POST	90	CS: Postprocessing

Figure 6.56 Planning Strategy TSPS_DEF

- **Optimizer Runtime**
  This parameter specifies the maximum runtime for the optimizer (in seconds). The optimizer returns the optimal solution prior to this runtime or the best solution found at this runtime.

- **Consider Manual Assignments as Fixed**
  Dealing with manual assignments in automatic carrier selection is an important topic because there is likely a reason for manual assignments, and they shouldn't simply be overridden. Therefore, manual assignments can be considered as fixed when this checkbox is selected.
- **Action for Manual Rankings**
  A similar question is how to deal with manual rankings. Available options for manual rankings are to keep them, remove them, or keep the carrier only when it's considered available (Section 6.5.1).
- **Transportation Charge Interpretation**
  If, for any reason, the transportation charges for a carrier for a freight order are evaluated as zero, this parameter determines how to deal with it. Available options are to either ignore the carrier availability for this freight order or accept the carrier for this freight order as either the cheapest available carrier or the most expensive one.
- **Action After Carrier Selection Run**
  Available actions after the carrier selection run are the automatic assignment of the highest ranking carrier to the freight order or doing nothing (i.e., leaving this decision to a manual process/user, based on the created carrier ranking). In addition, automatic or manual tendering based on the parameters for tendering (tendering profile, tendering manager) can be initiated. The tendering process is explained in detail in Section 6.6.
- **Consider Hierarchy**
  This parameter chooses the available carriers. Options include considering only those carriers defined on the most specific transportation lane or considering all transportation lanes to retrieve available carriers. The sequence in which hierarchies (based on source location, destination location, and means of transport) are evaluated to determine the most specific transportation lane are defined in Customizing activity **Transportation Management • Master Data • Transportation Network • General Settings for Transportation Network Determination**.
- **Continuous Move Type**
  With this parameter, you decide whether only simple continuous moves are allowed, only round trips are allowed, continuous moves aren't considered at all, or this decision is made on the transportation lane level (Section 6.5.2).

Having discussed the carrier selection process, its objectives, and constraints, as well as the available configuration options, the carrier selection process is primarily used for land transportation, if carrier rates are already available and a choice needs to be made. Next, Section 6.6 focuses on freight tendering and the configuration of the tendering process, which can also be used for carrier selection if no rates are known up front.

6.6 Freight Tendering

After you've created a freight order and potentially identified a suitable carrier, the final step prior to executing the freight order is tendering. The freight tendering process can be used to tender road freight orders to one or more carriers. Numerous process variants exist for this process, as shown in one variant in Figure 6.57.

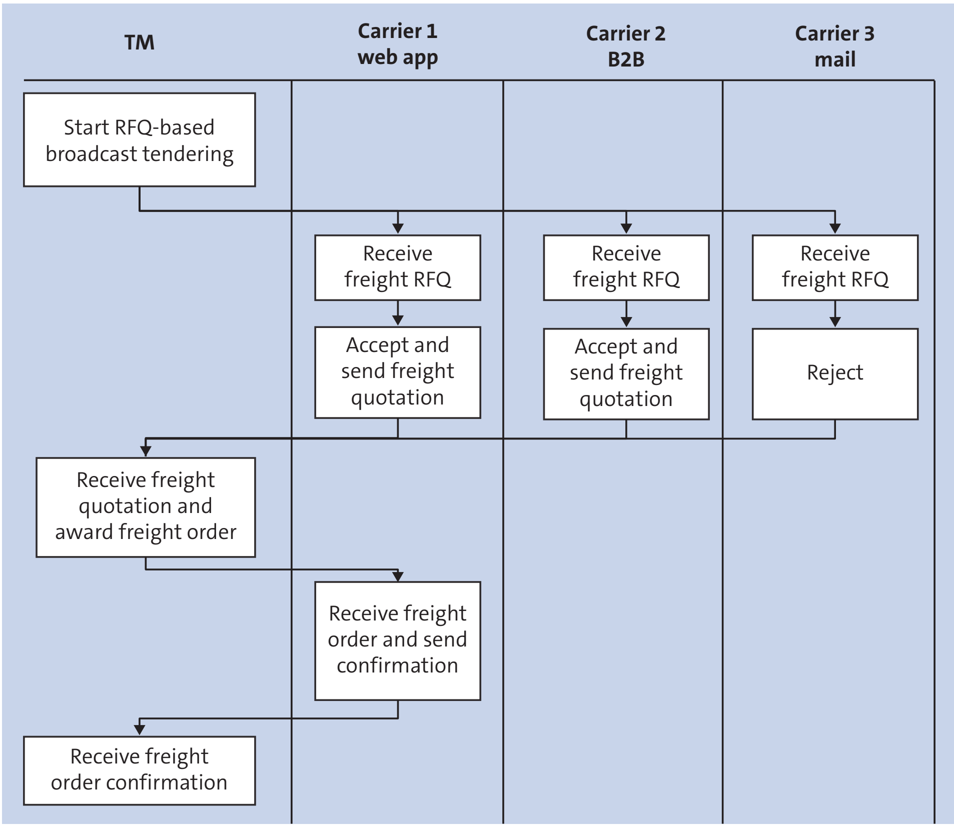


Figure 6.57 Tendering Process Example

In this example, you initiate the tendering process in TM by sending a freight request for quotation (RFQ) for a freight order to several carriers. These carriers receive and review the RFQ via different communication channels (email, web UI, business to business [B2B] communication). The carriers can accept or reject the tendered freight orders and quote prices in a freight quotation. TM evaluates the carriers' responses and awards the freight order to one carrier (carrier 1, in the example). This carrier receives the freight order and acknowledges receipt of the freight order with a confirmation message.

In this section, we'll walk through the configuration for freight tendering, the tendering process, and your communication options focusing on the SAP Business Network for Logistics.

6.6.1 Configuration

The tendering process can be configured in various ways using a tendering profile (**Profiles and Settings • Create Tendering Profile**), as displayed in Figure 6.58.

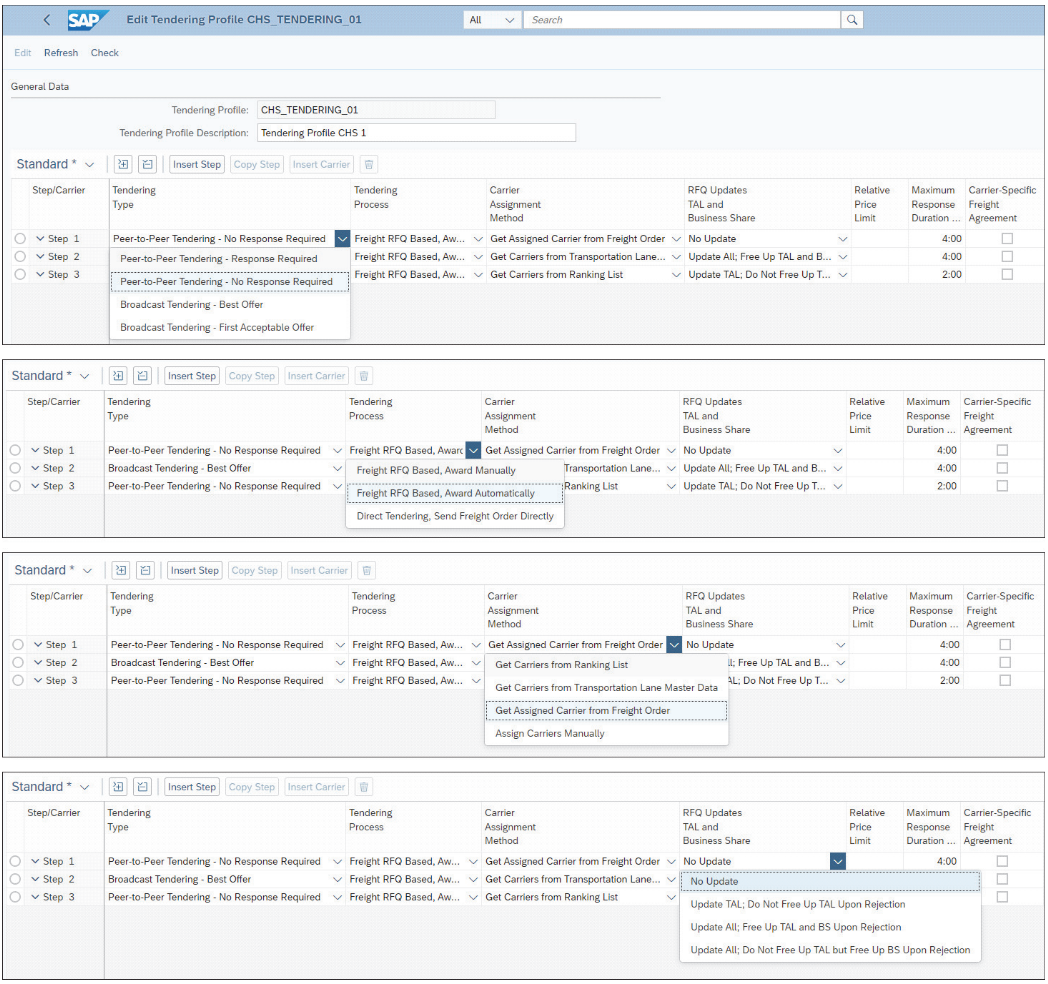


Figure 6.58 Tendering Profile

Tendering processes can consist of several steps, for example, because you want to limit the number of carriers to those you prefer in a separate step before you publish an RFQ to a larger group after none of the preferred carriers has responded in the previous step. In the tendering profile, you can combine different steps. The first step can be a peer-to-peer tendering process with the preferred carrier selected based on carrier selection (Section 6.5). A broadcast tendering to all available carriers defined in the transportation lane is a second step to quickly make an assignment if the preferred option (step one) failed. You can define the individual steps of a tendering process in the tendering profile. For each step, you define the following criteria:

- **Tendering Type**
  The tendering type specifies the auctioning mechanism that is used in the tendering process. Four available tendering types are offered:
  - **Peer-to-Peer Tendering** - **Response Required** initiates the tendering process with one or more carriers sequentially. This means that the system waits for a negative response from the first carrier before contacting the second (or third, etc.) carrier. **Response Required** indicates that the lack of a response is considered a rejection.
  - **Peer-to-Peer Tendering** - **No Response Required** also initiates the tendering process with one or more carriers sequentially, but, in this case, the system treats no response within the specified duration as acceptance of the tendered freight order. This tendering type can be used if carrier acceptance is the usual and expected behavior and thus reduces the number of messages exchanged between the involved parties.
  - **Broadcast Tendering** - **Best Offer** is an auctioning mechanism in which several carriers are contacted simultaneously. The evaluation of the different offers is based on the quoted price of the carrier.
  - **Broadcast Tendering** - **First Acceptable Offer** is also an auctioning mechanism in which several carriers are contacted simultaneously, but here the focus is on a fast response rather than the best price. With this tendering type, the first carrier to quote a price below the specified price limit is chosen.
- **Tendering Process**
  The tendering process can be specified as **Freight RFQ Based** or **Direct** tendering. The difference is that in the first method, a freight RFQ is sent to the carrier, whereas in the second method, the freight order is sent directly. The freight RFQ process always requires an award step (manual or automatic) after the freight quotation has been received from the carrier. The award step determines which carrier receives the freight order, and the freight order itself is only sent at this stage of the process as a separate message. In the direct tendering process, the freight order is automatically awarded to the carrier if the carrier hasn't rejected it explicitly within the maximum duration.
- **Carrier Assignment Method**
  An important decision in each step of the tendering process is the selection of the carriers that are included in each step. Four different options are available:
  - The carriers can be taken from the carrier ranking list, which has been created by the carrier selection process (Section 6.5) or manually.

- Carriers can be retrieved from the transportation lane.
- The carrier that is currently assigned to the freight order can be used.
- Carriers are manually assigned to a process step.

■ **RFQ Updates TAL and Business Share**
Section 6.5 introduced transportation allocations and business shares as a means of influencing the carrier selection decision based on, for example, contractual obligations. How are transportation allocations and business shares considered in a tendering process? If a minimum allocation of three freight orders per week has been agreed upon with a carrier, how is a rejection of a freight RFQ accounted for? Does this freight RFQ count against the minimum allocation? The answers to these questions can be influenced by this setting. The following options are available:
  - No update
  - Update of transportation allocations, but no update (free up) upon rejection
  - Update of transportation allocations and business shares, and update (free up) of both upon rejection
  - Update of transportation allocations and business shares and update (free up) of transportation allocation, but no update (free up) of business share upon rejection

■ **Relative Price Limit**
The relative price limit is important for the automatic award mechanism of freight orders to a carrier. It's used as a threshold to avoid awarding a freight order based on too high a price quotation. The relative price limit is therefore relevant for all four tendering types.

■ **Maximum Response Duration**
The maximum response duration specifies the time limit within which TM waits for carriers' responses. With tendering type **Broadcast Tendering** - **Best Offer**, it specifies the time after which the best available offer is selected.

■ **Carrier-Specific Freight Agreement**
If this checkbox is selected, the price limit is calculated per carrier with the carrier's specific freight agreement. If you rather want to calculate a generic limit, that applies to all carriers, you can define a generic carrier and freight agreement for this carrier and assign this carrier in the charges profile linked to the purchasing organization of the freight order. If this checkbox isn't selected, the price limited is calculated based on the valid freight agreement between the purchasing organization and the generic carrier.

■ **Price Details**
The price details define whether the calculated price limit is visible to the carrier as a lump sum (**Price Limit Only**) or whether the full hierarchy of charges calculated in transportation charge management is shown (**Charge Hierarchy**). Depending on the

visibility settings, the carrier can change either the total amount or the total value of the individual elements in the charge hierarchy.

- **Visibility Settings**
  The visibility settings are defined in Customizing (**Transportation Management • Freight Order Management • Tendering • Define General Settings for Tendering**) and determine the following:
  - Whether the price limit is disclosed to the carrier (read-only) or not (hidden)
  - Whether the submitted price can be edited, is read-only, or is hidden
  - Whether the stop dates can be edited, are read-only, or are hidden

  This allows you to specify whether the carrier is allowed to change stop dates of stages of the freight order to better accommodate the freight order into its vehicles' schedules. Any changes made by the carrier need to be reviewed to determine whether they fit into your plans before the freight order is awarded.

Which tendering profile is chosen can be decided manually or is specified in the tendering settings of the freight order type (see Figure 6.59). The process settings and communication settings can be defined per freight order type, based on a condition (with condition type /SCMTMS/TEND), or per default settings. The tendering profile is part of the process settings defined in Customizing (**Transportation Management • Freight Order Management • Tendering • Define General Settings for Tendering**).

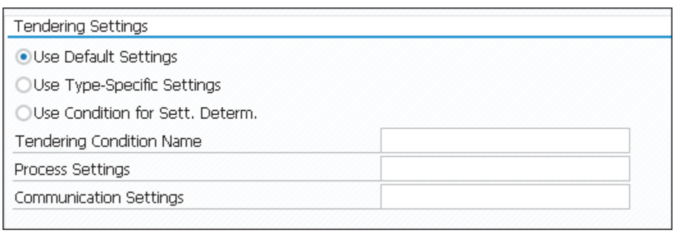


Figure 6.59 Tendering Settings

In addition, you can define the following in the tendering Customizing:

- In the process settings, you can define the tendering manager, visibility settings, tendering profile, and maximum response time for carriers.
- Rejection reason codes must be provided by the carrier in case of rejection and allow you a structured analysis of rejection reasons.
- In the communication settings, you select whether to send EDI messages, email, or SMS messages.
- Carrier-specific communication settings allow you to deviate the communication settings depending on the carrier you need to communicate with.
- You can enter content for email and SMS messages.
- You can select the default settings for the tendering process.

6.6.2 Tendering Process

The tendering process can be initiated interactively from the freight order UI or from the transportation cockpit. Additionally, you can initiate the tendering process in the background via report /SCMTMS/TOR_TENDERING_BATCH (see Figure 6.60) or by defining strategy TEND_START as a creation strategy of the freight order.

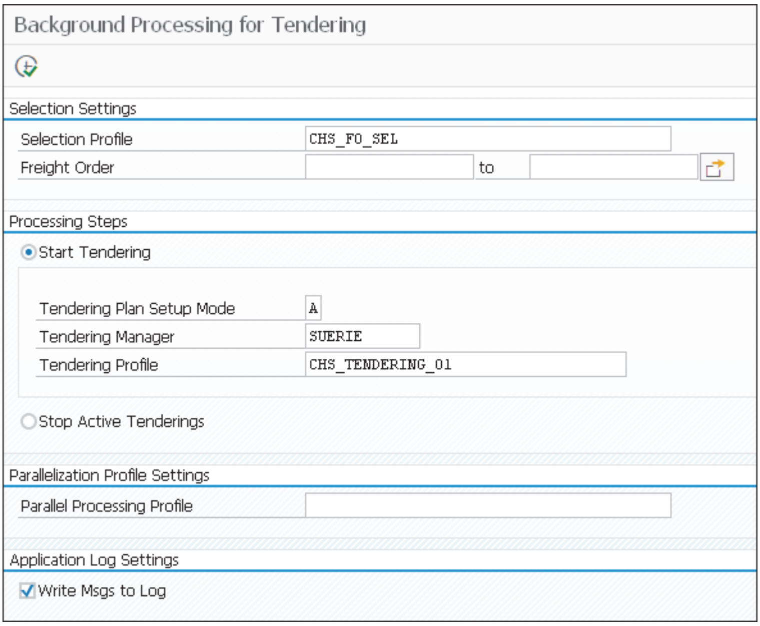


Figure 6.60 Tendering Background Report

With the start of the tendering process, the tendering profile is loaded into the freight order as a tendering plan. Which carriers are participating in which tendering step depends on the carrier assignment method of the relevant step in the tendering plan and whether the carriers are marked as relevant for peer-to-peer tendering or broadcast tendering in the carrier ranking list (refer to Figure 6.48) or in the transportation lane. You can also change the tendering plan locally in the freight order, for example, by adding carriers to/removing them from a particular process step or by adding/removing complete steps.

Freight RFQs and freight quotations can be monitored by the responsible user via worklists (**Order Management • Tendering (Worklist)**). Here, alerts are visible in separate queries (**Freight Quotations to be Reviewed**, **Unsuccessful Tenderings**, and **Tenderings Stopped Due to FO Changes**).

You can monitor the tendering process for a freight order with its individual steps in the **Subcontracting** tab of the freight order UI. Figure 6.61 shows an example. In the first step, the carrier **CHS_CAR_01** has responded to **RFQ 4500032900** with a rejection and provided the reason code **No time** as an excuse. The report to evaluate freight quotations hasn't run, so the award status is still **Evaluation Pending**. Once the evaluation has been executed, the second step of the tendering process, which is currently in the **Not Started** status, will start and send three RFQs in a broadcast tendering to carriers **CHS_CAR_01**, **CHS_CAR_02**, and **CHS_CAR**, which are lined up for this process step. Note, that if a carrier submits more than one freight quotation, the system considers only the last freight quotation of each carrier that is submitted within the maximum duration.

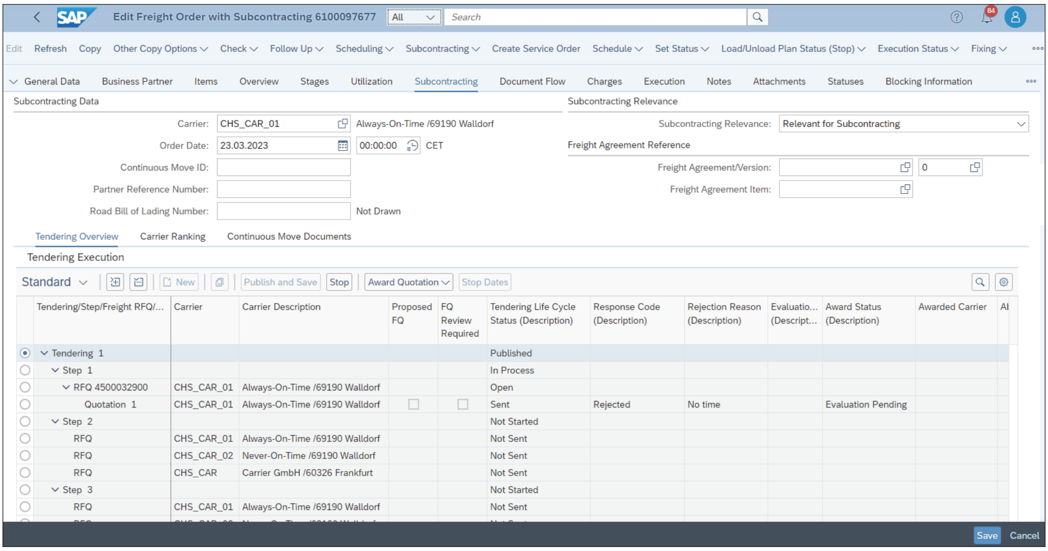


Figure 6.61 Tendering Overview

To be run automatically in the background, report /SCMTMS/TEND_CONT_PROCESS must be regularly scheduled. This report evaluates the responses received from the carriers.

6.6.3 Freight Tendering with SAP Business Network for Logistics

SAP Business Network for Logistics is a cloud solution for logistics collaboration. From a licensing perspective, it's offered in five variants: SAP Business Network Freight Collaboration; SAP Business Network Global Track and Trace; SAP Business Network Material Traceability; SAP Business Network, intelligent insights add-on; and SAP Business Network Trade Document Collaboration. SAP Business Network Freight Collaboration is the variant that integrates into the freight tendering process of TM. The infrastructure, onboarding, support, and operations are provided by SAP, while applications and content can be provided from SAP and partners. A general overview of SAP Business Network for Logistics is provided in Chapter 12, Section 12.6.

Other Communication Methods

There are three more communication methods available next to communication via SAP Business Network for Logistics:

- **Communication using B2B messages**
  With this communication method, web services messages are sent as freight RFQs, and responses are received as freight quotations.
- **Communication using email**
  To support email communication, the carrier business partner must have a relationship link to a contact person business partner with a valid email address. In addition, you must have defined settings for tendering by email in Customizing (**Transportation Management • Freight Order Management • Tendering • Define Settings for Tendering by E-Mail**). Here you define keyword markers (e.g., "&") and key words (e.g., "RFQ"), and associate those with a business meaning (e.g., "Freight Request for Quotation Number") to be able to interpret/parse an email text (e.g., "This is a freight quotation for &RFQ 34567") successfully. A carrier can accept or reject freight RFQs, enter rejection reason codes, and (depending on the visibility settings) quote a price. Technically, report /SCMTMS/TEND_PROCESS_INBOX converts the email into a freight quotation that then gets processed like any other freight quotation with report /SCMTMS/TEND_CONT_PROCESS.
- **Communication using a web app**
  You can also grant access to your TM system for carriers using a web UI via the Overview Tendering for Carriers app. Via this app, carriers can view their freight RFQs and submit freight quotations. A prerequisite for this communication method is that a collaboration user has been defined in the Maintain Collaboration User app and that this user is defined as the collaboration user for the carrier business partner.

  The collaboration user can use the Manage Freight RFQs app to see the number of freight RFQs that are due and when they are due. The user can view all freight RFQs based on their status (**Open**, **Closed**, **Responded To**) and sort and filter them. Open freight RFQs require a response. Freight RFQs that have been responded to are awaiting evaluation, and closed freight RFQs are either rejected, canceled, or their response time has been exceeded. For each freight RFQ, details such as transportation stops van be reviewed. Freight RFQs can be accepted without changes or—depending on the tendering settings—can be accepted with changes to price and/or start or stop dates.

  In the Display Freight Quotations app, the collaboration user can view all existing freight quotations. The app title displays the number of awarded and rejected freight quotations. The freight quotations can be displayed by status (**Pending**, **Awarded**, **Rejected**), filtered, and sorted. In the detailed view, details for each transportation stop, including which items to load and unload at this stop, can be displayed.

  The Confirm Freight Orders app enables the collaboration user to manage and respond to freight orders. The app title displays the number of freight orders that require confirmation. Freight orders can be displayed by status (**For Confirmation**, **Confirmed**, **Closed**) as well as filtered and sorted. Closed freight orders are those that have been either completed or canceled. In the detailed view, details for each transportation stop, including which items to load and unload at this stop, can be displayed.

The solution scope of SAP Business Network Freight Collaboration is much wider than only the tendering process. It supports the end-to-end process of collaboration with carriers, from subcontracting to settlement. In addition to the tendering process, it provides functionality in the areas of freight execution (reporting of events, sending geo-information, uploading proof of delivery or proof of pickup documents), dock appointment scheduling (self-booking of appointments for loading and unloading), and settlement (creating invoices, sending invoices, dispute unplanned freight costs on self-billed freight orders).

With respect to tendering, there are two relevant processes integrating TM and SAP Business Network for Logistics that will be discussed here: The first one is the administrative onboarding process, which is illustrated in Figure 6.62. The second process is relating to subcontracting and includes freight RFQ and freight quotation processing and the freight order confirmation.

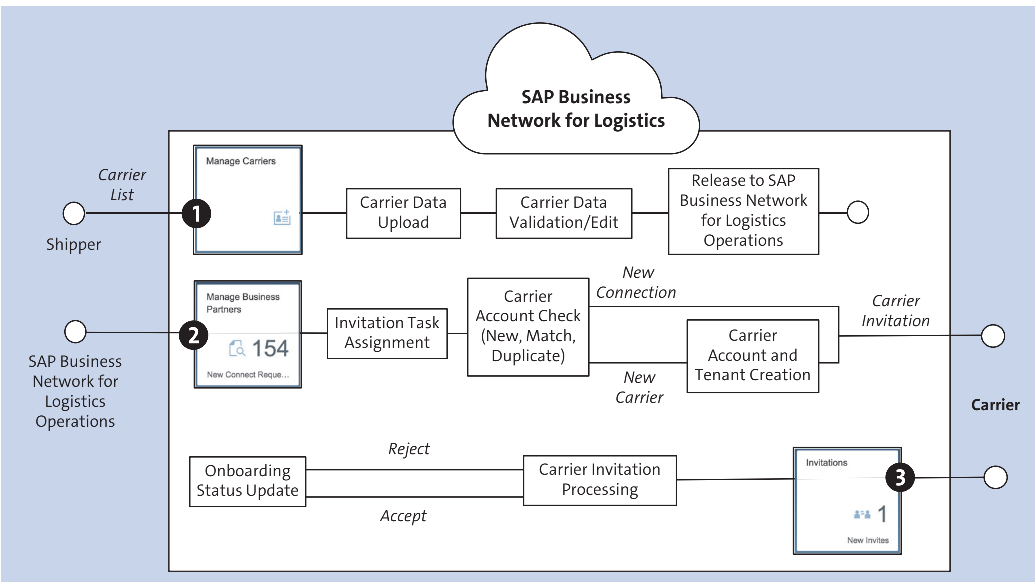


Figure 6.62 Onboarding Process with SAP Business Network for Logistics

Figure 6.62 shows the three steps of the onboarding procedure. A prerequisite to initiate the process is that the shipper has purchased an account on SAP Business Technology Platform (SAP BTP) and created users for this account with relevant roles. In addition, the purchasing organization used in a subcontracting/tendering process needs to be assigned a unique network ID created from SAP Business Network for Logistics. This unique network ID is assigned on the **Identification** tab of the business partner linked to the purchasing organization (**Master Data • Define Business Partner**).

The first step in the onboarding process is the creation of a list of carriers that the shipper wants to collaborate with on SAP Business Network. This list can be created using report /SCMTMS/LBN_CARRLIST. In the Manage Carriers app, this list is uploaded to SAP Business Network where it can be edited, validated and, finally, submitted.

Once submitted to SAP Business Network for Logistics, the SAP Business Network for Logistics backend operations team manages the carrier invitations. This is the second step of the process. Depending on whether the carrier already has an account and/or connection, the invitation is linked to an existing account and connection, or a new one needs to be created. The carrier can respond to invitations in the Invitation app by accepting or rejecting. When a carrier accepts an invitation to connect with the shipper/LSP, the unique network ID of the carrier must be updated. The unique carrier network IDs can be updated in TM by downloading them from the Manage Carriers app in SAP Business Network for Logistics and uploading to TM via report /SCMTMS/LBN_BPID_UPD.

The processing of freight RFQs and freight quotations by the carrier in SAP Business Network for Logistics is the key element of the tendering process in the freight collaboration scenario. First, a freight RFQ is sent from TM to SAP Business Network for Logistics, where it can be accessed by the carrier in the Freight Request for Quotation app. The freight RFQs are displayed in a list view or detailed view. The carrier can filter, sort, and search for freight RFQs in the list view. Figure 6.63 shows the detailed view with general information, cargo-related information, addresses, and planned dates and times, for all stops including contact details. Notes and attachments can also be reviewed here. The remaining time to respond to the freight RFQ is shown, and the carrier can accept, accept with changes (price and dates), or reject the freight RFQ from the detailed view or one or more freight RFQs at the same time in the list view. Reason codes for rejection can be defined and are sent from SAP Business Network for Logistics to the TM system.

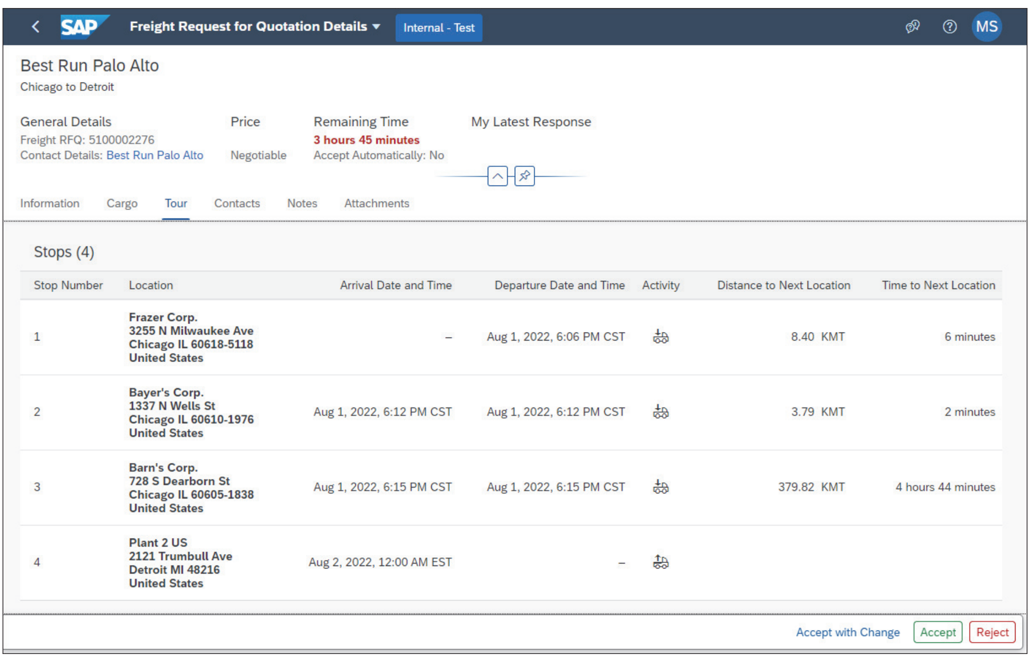


Figure 6.63 Freight RFQ (SAP Business Network for Logistics)

Next, with the carrier's response in the Freight Request for Quotation app a freight quotation is created and sent from SAP Business Network for Logistics to the TM system. In the Freight Quotations app, the carrier can view the past quotations in a list view and a detailed view. Figure 6.64 shows the list view of the Freight Quotations app. The carrier can filter, sort, and search for freight quotations in the list view and review the ordering party's response or whether it's still missing. In the detailed view, the carrier can see similar information such as in the detailed view for the freight RFQ plus information on the carrier's submitted quotations such as the proposed price.

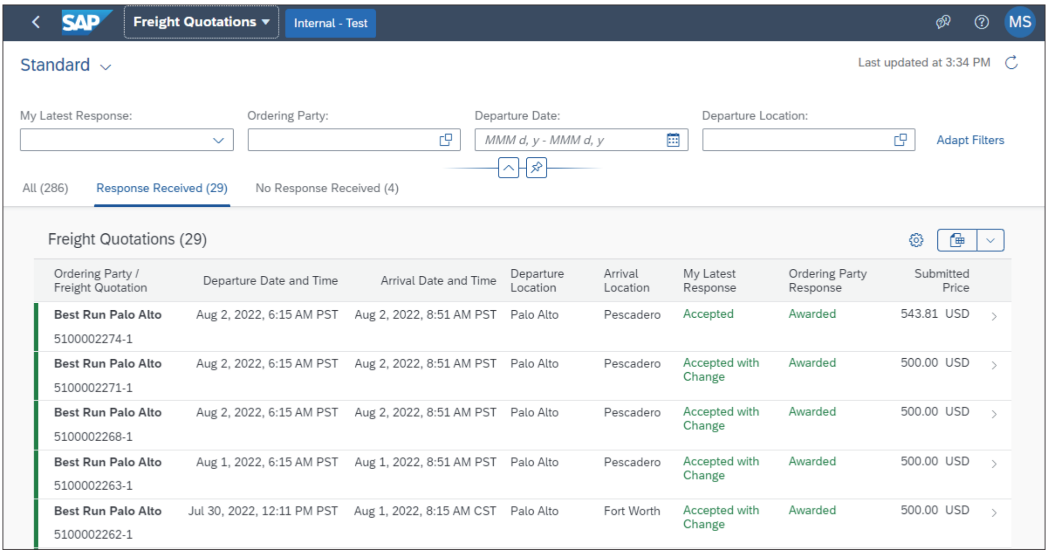


Figure 6.64 Freight Quotations (SAP Business Network for Logistics)

Once a freight quotation has been awarded, the corresponding freight order will become visible in SAP Business Network for Logistics, and carriers can confirm freight orders to the ordering party (shipper or LSP), as shown in Figure 6.65. In this process step, freight orders are sent for confirmation from TM to SAP Business Network for Logistics. In the Freight Orders for Confirmation app, the carrier can confirm or reject freight orders. Similar to the two other apps, the Freight Orders for Confirmation app offers a list view, in which one or more freight orders can be confirmed or rejected at the same time, as well as a detailed view. In the detailed view, the carrier can review logistical and financial information for the freight order, as well as add execution information such as driver name, license plate, or text, which becomes available on the freight order UI as a note.

The Freight Orders for Confirmation app can be used not only in the tendering process but also if the carrier has been determined by the carrier selection process, which was discussed in Section 6.5.

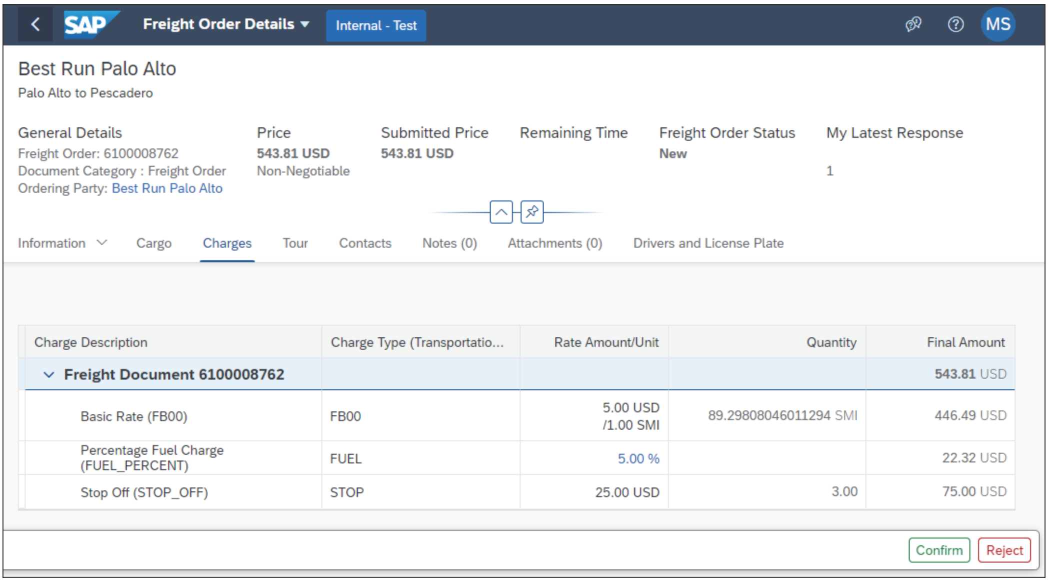


Figure 6.65 Freight Orders for Confirmation (SAP Business Network for Logistics)

Upon completion of the subcontracting/tendering process, the carrier can also manage the subsequent steps in the lifecycle of a freight order with SAP Business Network for Logistics.

Connecting to External Marketplaces

Frequently, marketplaces are used to bring together companies that want to ship goods with carriers that offer these services. With small enhancements, the standard freight tendering process can be used to take advantage of freight marketplaces. In this process, the marketplace is specified as the carrier to which the freight RFQ is sent. The marketplace assigns the real carrier, and its response includes the real carrier and price information. Thus, based on the marketplace's response, only the real carrier and its price need to be assigned to the freight order.

6.7 Summary

This chapter has dealt with freight orders that are created primarily as a result of planning, especially in land transportation. Their configuration and UI has been presented. Building on freight orders their counterparts in air and sea transportation have been introduced as air and ocean freight bookings. Similarities and differences between freight orders and freight bookings have been pointed out. While all of these documents represent some form of transportation capacities, the consignment order as a purely logical concept has been explained to conclude the group of documents in freight order management.

Furthermore, this chapter has introduced the capacity management process and its building blocks for planning capacities from long-term, mid-term, and short-term perspectives. We've discussed schedules as the basis for systematically creating freight documents and change management capabilities. Allocations are used to allocate capacities for a carrier on a trade lane to certain (time) buckets. Business shares allow defining the desired distribution of your transportation business on a trade lane across multiple carriers, again per bucket.

Freight orders can get subcontracted to a carrier selected via the carrier selection process, the tendering process, or a combination of both. The carrier selection process is typically based on cost and can consider several constraints, such as business shares or transportation allocations. The tendering process can deal with a group of carriers sequentially or simultaneously and combine several tendering steps into one process.

Now that the planning process is complete, the next chapter covers the view on freight orders from the execution perspective, including the printing of freight documents.

Chapter 7
Transportation Execution and Monitoring

Managing and controlling transportation processes is the focus of transportation execution, which includes the use of transportation management (TM) in SAP S/4HANA, SAP Event Management, and SAP Business Network Global Track and Trace with required support for end-to-end cargo movements.

Transportation execution and monitoring allows you to manage all required process steps around organization and documentation of activities focused on preparation, physical movement, handling, and monitoring of cargo along the supply chain. The SAP system supports employees working in documentation and freight-handling departments of logistics service providers (LSPs) and shippers' logistics departments to fulfill their responsibilities in a compliant manner and create an audit trail for the actual cargo movement.

Freight movement processes are executed and monitored using one or more of the following components:

- **Freight order management**
  The freight order management component of TM allows you to manage all steps in terms of preparation, organization, handling, loading, movement, and unloading of cargo. This includes creation of documents related to the cargo movement as well as initiating checks for compliance, such as documentation of actual quantities and details of the cargo. You can record discrepancies that occur between order capture and planning on the one hand and physical checking and handling on the other. Moving cargo also results in updates of order and cargo status, such as documenting a loading status either manually out of the TM system or automatically in conjunction with, for example, SAP Event Management. The organizational aspect of the cargo movement is supported by export/import handling, which provides you with the handover capability between multiple organizational units along the path of a cargo move.
- **SAP Event Management**
  SAP Event Management is an extremely flexible, efficient, and generic software tool for management and visualization of track and trace processes, status management processes, and key performance indicators (KPIs) based on these process types. You

can use SAP Event Management in logistics and beyond to automatically record activity information related to cargo movements, order processes, resource lifecycles, and financial management aspects related to shipments (e.g., cargo prepayment). SAP Event Management is provided as a private track and trace tool; that is, it needs to be operated by a customer and isn't a public cloud service or general networking tool.

Based on high customer demand, SAP went a logical step forward in 2021 and made SAP Event Management available as add-on on for SAP S/4HANA (SAP Event Management on SAP S/4HANA). Function-wise, the SAP S/4HANA-based version is equal to the SAP NetWeaver version from SAP TM 9.2. However, the main benefit is that no additional SAP installation is required anymore when running transportation management and event management together.

- **SAP Business Network Global Track and Trace**
  Fueled by the innovation of the SAP logistics technology, SAP Global Track and Trace was first released in 2018 as a new tool for collaborative process tracking. From technology and use cases, this tool was designed for parties engaging in a joint logistics process in the public cloud. SAP Business Network Global Track and Trace started as an independent cloud tool and has now become part of SAP Business Network for Logistics. However, as SAP Business Network Global Track and Trace is very close to SAP Event Management, we'll give a detailed overview in this chapter. For other SAP Business Network for Logistics topics, refer to Chapter 12, Section 12.6.

  Global track and trace functionality can be licensed in two different versions:

  - As part of SAP Business Network Freight Collaboration, SAP Business Network Global Track and Trace provides tracking support for a fixed set of events such as loading, departure, arrival, or unloading in relation to transportation processes driven from TM.
  - When licensing SAP Business Network Global Track and Trace as part of SAP Business Network for Logistics, you may use its functionality more flexibly, as you can define required events, event-driven activities, and backend integration in a more versatile way, which gives you a scope and behavior comparable to SAP Event Management.

In this chapter, we'll explain the features and background of transportation execution and tracking through each of these three solutions: freight order management in TM (Section 7.1), SAP Event Management (Section 7.2), and SAP Business Network Global Track and Trace (Section 7.3).

7.1 Transportation Execution

Transportation execution comprises all activities involved with handling and documenting shipments in transit. It's more than just tracking a vehicle on the road: it includes recording any changes to the planned transport and handovers to other business partners or entities.

In previous chapters, we mainly talked about how to use the TM functionality to record, plan, and subcontract transportation requirements. Actual pallets, containers, and wagons hadn't yet been loaded, let alone put into motion. The freight order management component within the TM functionality not only supports transportation management during the planning phase but is also used after the vehicle has left the loading location.

Before the vehicle actually leaves for the transit, the loading process gathers new information that might be relevant for the shipper or carrier. So far, we've been dealing with planned quantities, but now the carrier has to deal with actual quantities, which could differ from the freight quantities ordered. These discrepancies between ordered and actual quantities can be recorded and, depending on the agreement between the ordering party and the carrier, taken into consideration for charge calculation.

In international, multimodal transports, more than one LSP unit is often involved in the overall transportation. Sometimes importing in the destination country can be very specialized, and a local LSP unit or organization can support the import leg much better than a foreign LSP unit. Therefore, we can observe a handover between the exporting LSP unit (which is also the single point of contact for the customer) and the local importing LSP unit.

In addition, transportation isn't only about moving goods from point A to point B. Sometimes it seems like it's more about moving paper or information from point A to point B. Waybills, customs declarations, bills of lading, and other documents need to be generated, printed, and transported with the goods or transmitted in advance. Often legal requirements also need to be respected.

More than moving goods from one place to another, transportation execution involves significant administrative effort, legal requirements, transparency, and organizational interactions. The freight order management component supports all these areas, so we now delve deeper into each of them to show you how you can leverage these requirements with the TM functionality.

7.1.1 Document Creation

Regardless of which transportation mode is involved, creating, printing, and carrying documents is very important in the transportation process. Depending on the perspective from which we look at the transportation process, several documents are involved. In this section, we concentrate on the creation of bills of lading and waybills.

The difference between these two documents is their legal and practical purposes. The *bill of lading* (B/L) serves as proof that a contract or order has been issued between a shipper and a carrier stating that certain goods need to be transported. A *waybill* is the more logistical document, listing the goods that need to be transported.

However, in a process involving a freight forwarder as an agent between an actual carrier and shipper, the B/L and waybill can mean the same thing. The LSP now issues its own B/L, called the *house bill of lading* (HBL), which is at the same time also called a house waybill. Because waybills are usually seen in the context of the transportation mode, the terminology for waybills is usually used together with the mode of transport (e.g., sea waybill for ocean transports or air waybill for air transports).

If we look at it from a shipper's perspective, for some modes of transport (e.g., ocean), we're obliged to hand over a B/L to the consignee that lists all goods to be transported. The B/L is a legal and negotiable document enabling the receiver—who is usually the consignee—to claim the goods at the port of discharge. On the other hand, the consignee may also sell the goods during ocean transit and hand over the B/L to the buyer.

The LSP or carrier who manages the order for the shipper issues the B/L. For consolidated transportation for different shippers, the LSP issues itself a B/L or receives one from the carrier for the consolidation and issues multiple HBLs, which the LSP provides to the involved shippers.

Making It Simple

Recall that the terminology of waybills is often used in combination with its mode of transport. To make this chapter easier, we use air transportation as an ongoing example from now on; therefore, we refer to *house air waybills* (HAWBs) and *master air waybills* (MAWBs).

HAWBs can be created from the forwarding order as well as from the freight units, freight orders, or freight bookings. By customizing the forwarding order, you can define how the number of the HBL or HAWB should be put together. We talked about this already in Chapter 4, Section 4.2.1. Nevertheless, you can also define in Customizing how the HBL should be composed by defining a process controller strategy that takes over the job of creating HBLs.

Several possibilities are offered with the standard strategies. In general, the HBL is built out of the *items* of a document, not the header data:

- **By shipper and ship-to party**
  All items containing the same shipper and ship-to party combination are consolidated into one HBL. There are also additional, more specific strategies available that group the items on a HBL by container or transportation group of the material in addition to the shipper and ship-to party information.
- **By destination location**
  In some cases, the goods are transported to the same location, but different consignees will later receive the goods. This is the case if an importing business unit will take over the goods at the port of discharge.

- **By forwarding order**
  If the HBL or HAWB is created by an LSP, all items belonging to the same forwarding order can be put together in one document.
- **By freight documents**
  Again, this scenario is built for LSPs. All items planned on the same document on the main carriage are consolidated into one HBL.

Which strategy you use and from which document you would like to create the HBL depends on your business case and industry.

The waybill, on the other hand, is the logistical document passed between two parties cooperating in a transportation business. The waybill document comprises the information about the cargo, transportation route, and terms.

The consumer of a transportation service and the provider of that transportation service share a common number range from which the consumer can draw a number to give to the provider. This number is then a unique referral for both parties of the transportation business. In the TM functionality, the number ranges are stored in *waybill stock IDs* that define agreed-upon number ranges.

Waybills in TM can be separated into house waybills and master waybills. The house waybills represent the transportation documents between the sales side of the company using TM and a sold-to party. The master waybills represent the purchasing document between the company using TM and a carrier. You can compare this differentiation with freight settlement documents and forwarding settlement documents—they are similar-looking documents but are built for different parts of the transportation process.

Waybills Aren't Separate Entities

Other than with freight settlement documents and forwarding settlement documents, waybills aren't represented with their own separate entities in the TM system. Waybills serve as print documents only on the forwarding orders and freight orders, freight bookings, and freight units. These documents provide the functionality of drawing the right number. However, there is no separate business object designed for the waybills.

To create waybill stock IDs, you need to carry out some Customizing activities. Remember that the number ranges in TM are stored as waybill stock IDs. To create these waybill stock IDs, you need to define *waybill stock types*, which you can do in Customizing via IMG menu path **Transportation Management • Master Data • Waybill Stock • Define Waybill Number Stock Types**.

As shown in Figure 7.1, you can customize several details about the waybill number stock before you define the waybill number stock itself. Waybill number stocks are always dependent on the transportation mode, so the assignment of a transportation mode is mandatory in this Customizing activity. With the stock category, you specify whether the number stock is used as a waybill number or as a tracking number.

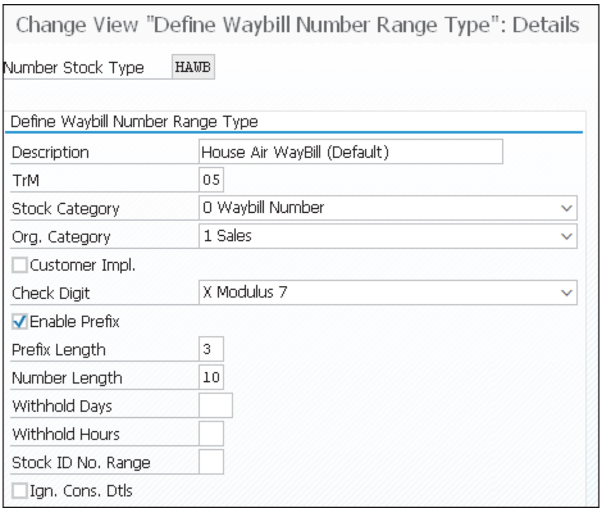


Figure 7.1 Number Stock Customizing

Waybill Numbers and Tracking Numbers

Technically, there is no difference between a waybill number and a *tracking number*. Both numbers are used to identify a transport uniquely in communication between the transportation service consumer and the provider.

However, the different terms are used in different transportation scenarios. Air, sea, road, and rail transportation use the waybill number; we refer to tracking numbers in parcel scenarios.

Later in this section, you'll see that tracking numbers are maintained the same way waybill numbers are.

The organization category defines whether the waybill number stock we're creating is supposed to be used for master waybills or house waybills. Recall that house waybills are used between the sales side and a sold-to party, while master waybills are used between the purchasing side and a carrier. Therefore, the house waybill usually represents the entire transportation ordered, and the master waybill represents only a certain transportation leg.

The lower part of the Customizing activity illustrated in Figure 7.1 addresses how the number should be composed. First, you can define that a carrier-specific prefix should be added by selecting the **Enable Prefix** checkbox.

Carrier Prefix

The prefix for the carriers is also defined in Customizing. In the Customizing activity found via IMG menu path **Transportation Management • Master Data • Business Partner • Define IATA Airline Codes**, you can assign a waybill prefix to the carriers.

In addition, waybill numbers may have a check digit. TM offers two possibilities for automatically adding a check digit to the waybill number. The waybill number is calculated with either Modulus 7 or Modulus 10. If none of the provided calculation rules fit the specific waybill number stock requirements, you can implement custom implementation using a business add-in (BAdI).

Calculation with Modulus

Calculation with modulus is often used in IT. When you use the calculation operation MOD, the base number is first divided by the divisor. But it's the remainder after the division that's important, not the result of the division.

For example: 11 MOD 3 = 2.

As you would expect, the waybill number stock type also defines the general length of the waybill number. The waybill number is always extended with leading zeros to match the waybill number length defined in the waybill stock type.

In certain processes, master waybill numbers can be returned, such as the cancellation of a freight booking for which a waybill number was already assigned. Although the returned number can't be directly reused by other documents, it needs to be withheld for a certain time because the cancellation might be replicated into other systems, as well. Therefore, a withholding time in days and hours can be maintained in the waybill stock type.

After defining a waybill stock type, we can create the actual waybill number ranges. In the SAP Fiori launchpad, you can find the corresponding Waybill Number Stocks app in the **Master Data** tab. Here you can see a personal object worklist (POWL) that differentiates among house waybills, master waybills, and tracking numbers.

When creating a new waybill stock with the **New** button on the top of the POWL list, you'll see that you need to select a waybill stock type first. After you've chosen a waybill stock type, the definitions from Customizing are automatically propagated into the waybill stock.

Terminology

In this chapter, we use the terms *waybill stock*, *waybill stock IDs, and waybill number ranges*. All these terms describe the same entity in TM: the waybill stock.

With the waybill stock, you now define the actual number range for the waybill document in the **From Number** and **To Number** fields. For air waybills, the waybill stock needs to be assigned a specific airline's prefix, as you can see in the top-right corner of Figure 7.2.

However, as you can see in the lower part of Figure 7.2, the waybill stock can be defined among several organizational units (sales organizations for a house waybill and purchasing organizations for a master waybill) and several external parties (sold-to parties in house waybills and carriers in master waybills).

Waybill numbers can automatically be drawn on all TM documents that are related to waybills. In air freight bookings, you can do this with a follow-up activity called **Draw MAWB Number** (in ocean freight bookings, the action is called **Build House Bill of Lading**); in forwarding orders, you have a separate button in the global toolbar called HBL, where you find the **Draw HBL Number** action.

Numbers are drawn for waybills based on the waybill stocks that we defined earlier. For house waybills, the system looks for waybill stocks that have the sales organization and sold-to party of the corresponding forwarding order assigned. If several waybill stocks are found, a popup appears, where you can choose between the different relevant waybill stocks. During searches for waybills stocks, the validity dates of the waybill stock are also considered; only waybills stocks that are currently valid are taken into consideration.

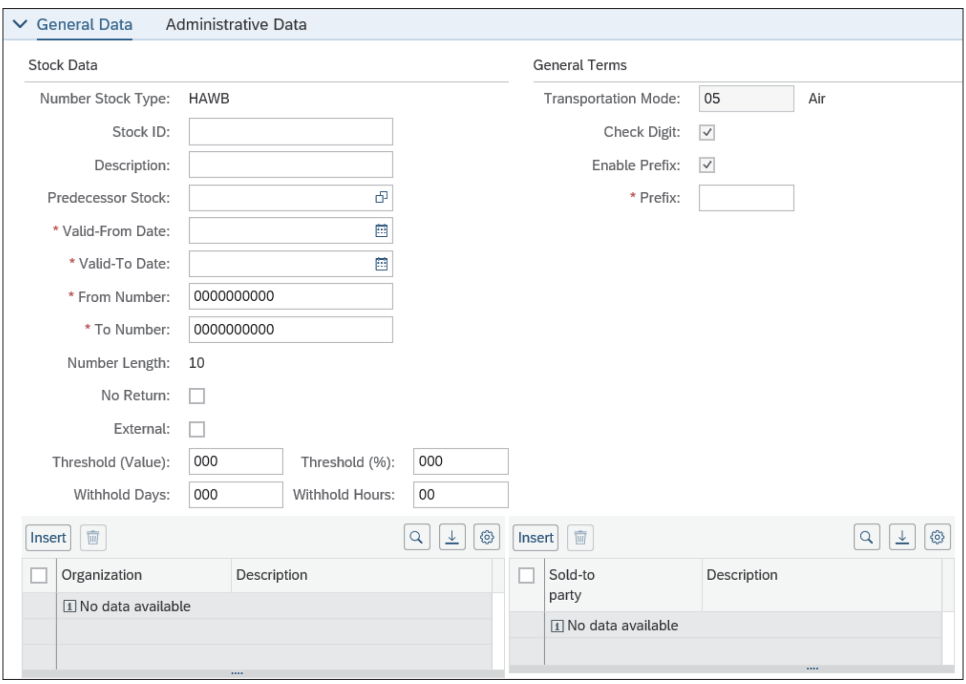


Figure 7.2 Defining Waybill Stock

Predecessor Stocks

If several valid waybill stocks represent the required organizational unit/ordering party combination, you need to choose the waybill stock manually from a popup.

However, you can use the predecessor stock functionality to define a priority among waybill stocks that are valid at the same time. You can see in Figure 7.2 that you can insert an ID of another waybill stock as the predecessor stock. If a predecessor stock is maintained, numbers from this predecessor stock are drawn first.

Only when the predecessor stock is exhausted will the next waybill stock be considered.

If there is no valid house waybill stock that represents the combination of sales organization and sold-to party, the system next looks at waybill stocks that have only a sold-to party assigned. If no waybill stocks are found in this case, either, waybill stocks that have only sales organizations assigned are then considered.

This logic doesn't exist for master waybills because these should always represent a certain combination of carriers and purchasing organizations.

If the waybill stock is running out of numbers, you can define a threshold value (either an absolute value or a relative value) for your waybill stock. When the use of the waybill stock exceeds the threshold value, the user sees a warning message when drawing another number from the almost-exhausted waybill stock.

When a waybill stock that represents a number range agreed upon between an organizational unit and an external party is eventually exhausted, the organizational unit has to approach the external party to agree on a new number stock. However, if the organizational unit foresees that only one more number is needed, this number can be drawn from another waybill stock that wasn't designed for the relationship between this organizational unit and the external party. This process is called *delegation* of a waybill number. When you access your waybill stock in the lower part of the SAP Fiori screen, you can see which waybill numbers have already been used and on which documents they were used.

You could access the freight document directly from this list. If a number was returned, but the withholding time hasn't yet expired, the number is still displayed together with the freight document it was previously used on, but the status of the number is **Returned**.

If you want to delegate a number to another organizational unit as just explained, you can also do this in the waybill stock. If you click the **Delegate** button, the next available number from the waybill stock is drawn and added to the list of numbers in the **Details** area of the waybill stock. The status is set to **Delegated**, and you can now enter the organizational unit to which you would like to delegate the number.

Restrictions on Delegation

Note that delegating waybill numbers is possible only for master waybills, not for house waybills. Furthermore, the number will only be delegated to another purchasing organization; the carrier has to remain the same.

After the delegation is entered in the waybill stock, the next automatic drawing of a waybill number takes the delegated number into consideration.

As you know from Chapter 3, organizational units can be created hierarchically, representing the responsibilities of some organizational units to other units. The organizational hierarchy is considered in the number drawing of waybill numbers as well. In waybill stocks, you can enter not only purchasing organizations as organizational units but also other functional roles such as forwarding houses and companies.

If different waybill stocks are defined for purchasing organizations and forwarding houses, the automatic number drawing only considers the more specific organizational unit; in this example, this is the purchasing organization. Only if the waybill stock of the most specific organizational unit is exhausted is the next higher level considered as a fallback solution. With this functionality, you can make sure you have some fallback numbers maintained if a waybill stock unexpectedly runs out of numbers.

Now that we've discussed the process of drawing waybill numbers, let's look at the waybill itself. In Customizing of the freight order or freight booking type, you define which documents can be printed out of the corresponding document. Via IMG menu path **Transportation Management • Freight Order Management • Freight Booking • Define Freight Booking Types** (or the definition of freight order types), you can assign two output profiles to the document type, as shown in Figure 7.3.

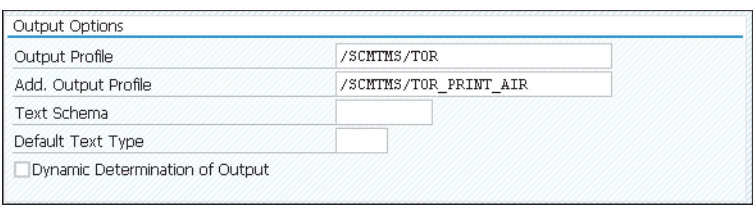


Figure 7.3 Assignment of Output Profiles to a Document Type

The output profile defines which documents may be printed for the document. Therefore, you can find output profiles for each supported transportation mode in Customizing. If you want to define your own output profiles, you can do this in the Post Processing Framework (PPF) that was discussed in Chapter 2, Section 2.3.3.

TM provides a standard format for MAWBs. You can change the layout of this document in Transaction SFP with Adobe Document Server, as we described in Chapter 2, Section 2.3.4.

When you want to print a waybill from a freight document, such as a freight order or freight booking, define the printing options in the configuration of the corresponding action of the PPF. In the freight booking or freight order itself, you can navigate to the **Output Management** tab, where you'll be able to preview the waybill documents when selecting a corresponding action.

House waybills on forwarding orders can be printed and viewed on the **Output Management** tab. If the output profile was assigned to the forwarding order type, the document automatically appears on this tab.

7.1.2 Discrepancies

So far, we've discussed only transportation process steps that deal with requested and planned quantities. However, in some cases, the actual quantity can't be estimated precisely beforehand, for example, when transporting bulk freight. When the transportation execution starts, the actual quantity needs to be recorded as well. This process in the TM functionality is called *discrepancy handling*.

Discrepancies are a hassle for transportation execution because they might affect the choice of vehicle resource being used for the transportation or lead to a different charge calculation. Therefore, discrepancies need to be discussed with the shipper before transportation can continue.

The transportation process starts as usual, requested quantities are entered into a forwarding order, and freight units are created out of this document. After the freight units are planned, the execution of the transportation may begin. The carrier now physically receives the cargo and checks the actual quantities against the requested quantities. This checking and reporting are performed by the carrier and communicated to us as the freight forwarder. We'll then enter the actual quantities in the freight order's items, as shown in Figure 7.4.

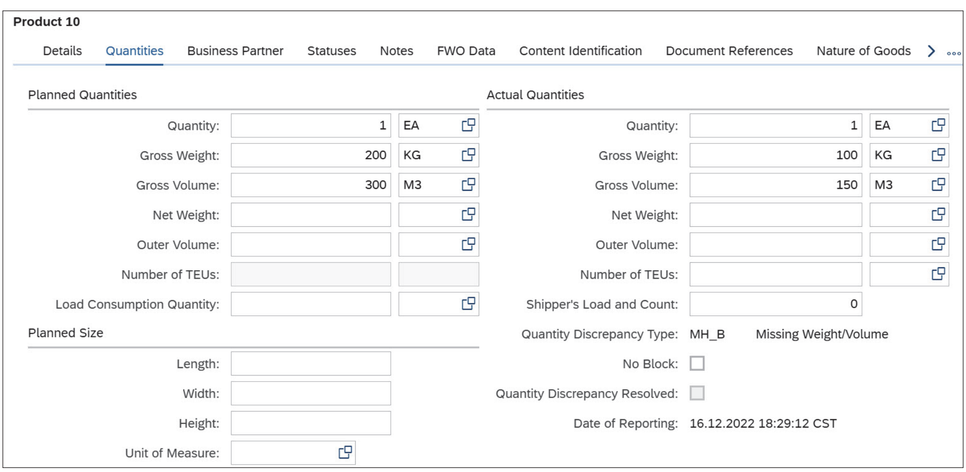


Figure 7.4 Actual Quantities on the Item Level

If the carrier doesn't receive the cargo as planned, you need to report the discrepancy. In general, you can differentiate between two types of discrepancies:

- **Quantity discrepancies**
  The actual quantities are different from the requested quantities because of a change in the quantity, gross weight, or volume.
- **Other discrepancies**
  These are the discrepancies that are *not* caused by a change in quantities. If the cargo is damaged or documents are missing for the cargo, these events can be recorded as other discrepancies.

When the carrier discovers a quantity discrepancy, the carrier can report it using TM. The system automatically checks the actual quantities against the requested quantities. If a discrepancy exists, it's automatically reported.

You can define different types of discrepancies in Customizing by following IMG menu path **Transportation Management • Freight Order Management • Define Discrepancy Profile**.

For the discrepancy type, you can define a tolerance range, meaning that if the actual quantities are within the defined tolerance range, no discrepancy is recorded. The tolerance range is defined as a percentage.

Discrepancy types are clustered in a *discrepancy profile* in the same Customizing activity. The discrepancy profile is assigned to a freight order or freight booking type so that different freight documents can react to discrepancies differently.

After a discrepancy is recorded, the actual quantities of the subsequent transportation stages and the actual quantity of the freight units are updated. The carrier now has to discuss the discrepancy with the customer before the execution of the transport may continue. Therefore, after a discrepancy is reported, all transportation stages carrying a freight unit with unresolved discrepancies get a planning and execution block. In discrepancy type Customizing, however, you can specify that the reported discrepancy of a special discrepancy type doesn't lead to a planning and execution block. If you remove the freight unit with unresolved discrepancies from the freight document, the planning and execution block is also removed.

In the freight order on the **Items** tab, you can select the item for which you've entered discrepant quantities. In the **Details** area below the table of items, the reporting of discrepancies is first drafted on the **Discrepancies** tab, and a corresponding event (assigned to the discrepancy type in Customizing) is triggered.

If the carrier discusses the discrepancy directly with the shipper, you can report the resolution of the discrepancy directly on the **Items** tab. From the toolbar above the list of discrepancies, select **Resolve • Resolve Discrepancy**, as shown in Figure 7.5.

After the discrepancy is set to **Resolved**, the planning and execution block is removed.

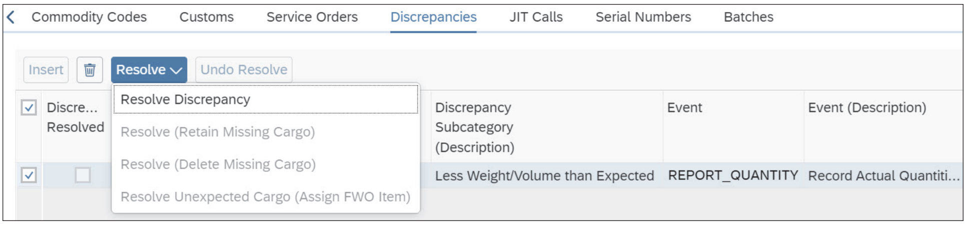


Figure 7.5 Resolving Discrepancies in the Freight Order

In other cases, the carrier notifies only the freight forwarder of the discrepancy, and that freight forwarder has to discuss the discrepancy with the shipper. Therefore, the discrepancy is also propagated to the forwarding order. If you select the item of the forwarding order, you'll see the **Discrepancies** tab in the **Details** area of the forwarding order items.

As you can see in Figure 7.6, the freight forwarder can now also set the discrepancy to **Resolved** by selecting **Resolve • Resolve Discrepancy**, which leads to the removal of the planning and execution block of the stages in the assigned freight documents.

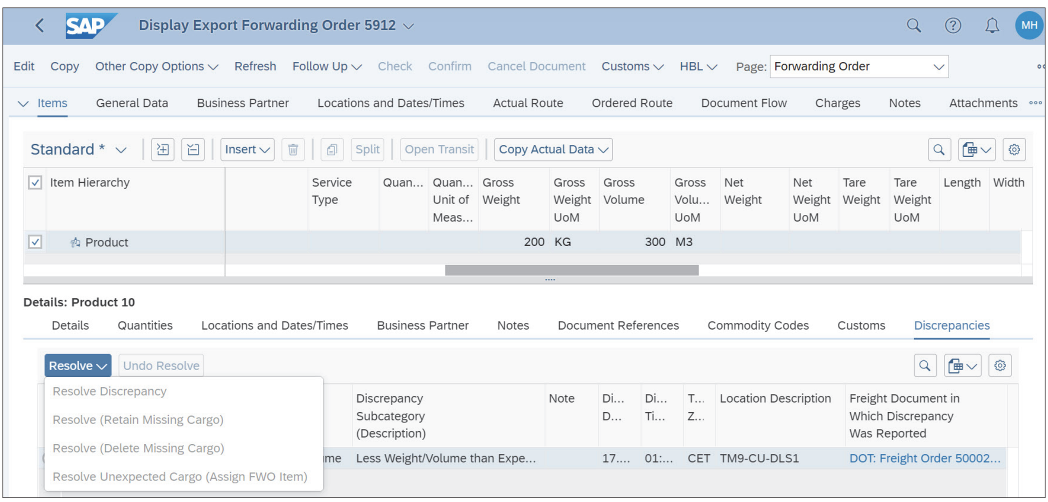


Figure 7.6 Resolving Discrepancies in the Forwarding Order

If the cargo was already damaged when handed over to the carrier, the carrier can report discrepancies, as well. In Figure 7.5 shown earlier, you can also insert discrepancies on the **Discrepancies** tab without entering actual quantities in the cargo information of the freight order or freight booking. The processing of other discrepancies is exactly the same as the processing of quantity discrepancies.

If you've reported a wrong discrepancy, or the discrepancy was resolved by changing the quantity, you can click the **Delete** button to reset the discrepancies so that the actual quantities no longer differ from the requested quantities.

7.1.3 Export/Import Processing

In international, multimodal transports, several organizational units or even business partners are often involved in the planning and execution of the transport. It's not uncommon for an export organization to organize the pre-carriage and main leg of the transportation while an import organization deals with the on-carriage of the same transport. Due to customs regulations and special circumstances in the importing country, this makes sense because organizations with local knowledge can participate in the transportation planning, making the transport more efficient and, in most cases, cheaper.

Let's take a deeper look at how the interaction between export and import organizations is established in TM. As an example of the process, we concentrate on an ocean transport ordered at the export organization. The export organization deals with the pre-carriage and main carriage, while the import organization is responsible for the organization and execution of the import transportation leg. Figure 7.7 illustrates this division of labor.

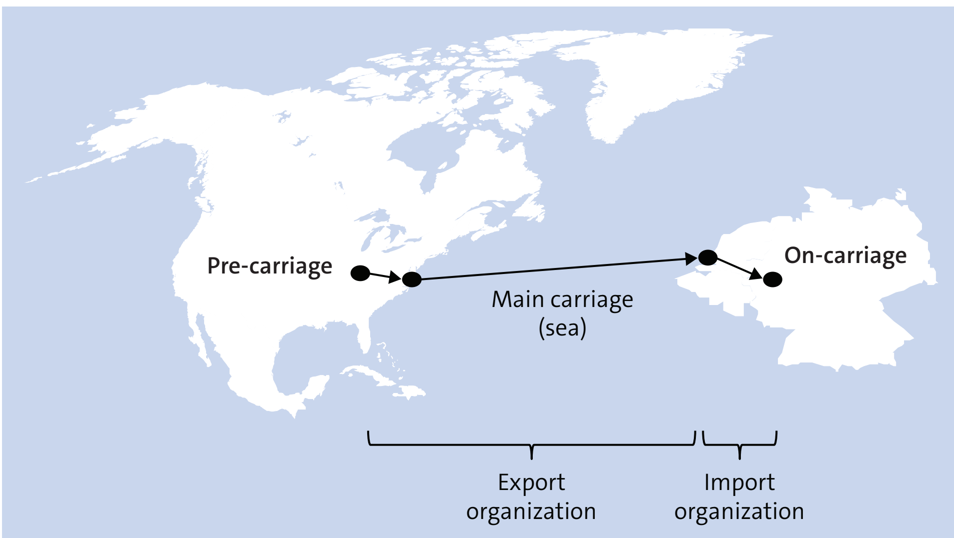


Figure 7.7 Responsibilities in an Export/Import Process

In general, we can differentiate among different scenarios in the export/import process:

- **Full container load (FCL)**
  Because a full container is shipped completely from the shipper to the carrier, there is exactly one transportation request (TRQ) on the export side and one TRQ on the import side. The number of freight documents is also exactly one on each side.
- **Less than container load (LCL)**
  The number of TRQs on either side still matches. However, because several TRQs are now consolidated into one container, more than one TRQ is created on each side, but there is still only one freight document on each side.

- **Buyer's consolidation**
  In this scenario, the export side needs to deal with several pickup transports from many shippers and consolidate them at the port. The import side, however, receives only one container that can be delivered as a whole to the ship-to party. Therefore, the export side creates several TRQs and one freight document (for the main leg); for the import side, however, it's sufficient to create only one TRQ.
- **Shipper's consolidation**
  As in the buyer's consolidation scenario, consolidation effects should be exploited. In this scenario, the shipper creates only one TRQ (because the pre-carriage and on-carriage are transported in one container) and one freight document, but the import side now needs to create one TRQ and one freight document per ship-to party (also because one waybill needs to be created per consignee).

As you've seen while browsing through the different scenarios, two documents in the TM functionality are crucial to using the export and import process: the TRQ (in our case, a forwarding order) and the freight document (in our case, freight booking).

If you know the forwarding order quite well, you'll be wondering how the information about the export and import organizations is stored on the forwarding order. In the forwarding order, you can define whether the forwarding order should be for export or import purposes with the **Traffic Direction** field. If it's an export forwarding order, the sales organization of this TRQ is the export organization of the entire transport. If you're viewing an import forwarding order, the sales organization of this forwarding order acts as the import organization for the transport.

Forwarding Houses

Recall from Chapter 3 that an organizational unit can be a sales unit, purchasing unit, or forwarding house. In the export/import process, the organizational units used as sales organizations of the forwarding order and purchasing organization of the freight documents should be created as forwarding houses so that the same organizational units can be used for purchasing and selling.

On an export forwarding order, the import organization is assigned on the **Business Partner** tab shown in Figure 7.8.

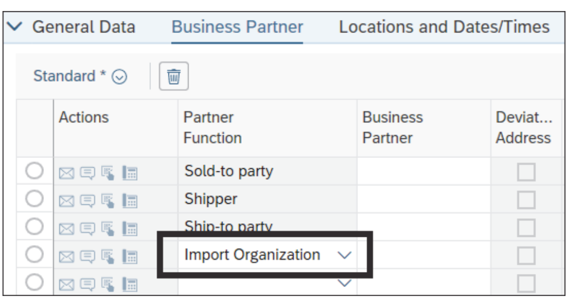


Figure 7.8 Import Organization on an Export Forwarding Order

With the partner function **Import Organization**, you can assign the business partner created for the organizational unit to the export forwarding order as the import organization. This also applies to import forwarding orders, where you can assign an export organization in the same way.

Business Partners for Organizational Units

To assign the import organization to the export forwarding order as shown in the preceding figure, the import and export organizational units have to be created as business partners as well. They also need to be assigned to the organizational units.

There are several ways to create organizational units and business partners and to link these two entities. The easiest way is to ensure that a business partner is automatically created upon creation of the organizational unit. Maintain the following entry in database table T77S0:

```
GRPID = HRALX
SEMID = HRAC
GSVAL = X
```

If you've already created organizational units and business partners separately, you can also assign the business partner to the organizational unit in Transaction PPOME. Manually assign the business partner in the **Org. Data** tab.

Report /SCMB/ORG_CREATE_BP_ASSIGNMENT automatically links organizational units to business partners if both entities have already been created. To establish the link between organizational unit and business partner, the business partner's **Search Term 1** needs to be the name of the organizational unit, and **Search Term 2** needs to be the description of the organizational unit.

Let's look at how the export and import organizations interact and which documents need to be created in TM. In general, we can differentiate between an internal communication of two organizational units and an external communication. In the internal communication, both organizational units use an TM system and even access the same client; this means that no web service–based information flow needs to be established. In the external communication, the two parties use different transportation management systems (TMSs), but at least one of them uses TM (otherwise, we wouldn't describe this case in this book!).

Let's first look at the ideal case of both organizational units working in the same TM system: The general transportation process starts as usual with the creation of a forwarding order. In our case, we create an export forwarding order. The traffic direction (which defines whether we're dealing with an export or import forwarding order) can be entered manually in the document or predefined in the forwarding order document type via Customizing in IMG menu path **Transportation Management • Forwarding Order Management • Forwarding Order • Define Forwarding Order Type**. It makes sense to define one dedicated forwarding order type for export forwarding orders and another for import forwarding orders.

As we've already discussed, the export organization acts as the forwarding order's sales organization, while the import organization is an additional partner function on the **Business Partner** tab. For the shipper's consolidation scenario, you might not want to define one import organization for the entire forwarding order but, instead, define several import organizations for each item of the forwarding order in the **Details** area of the forwarding order items (discussed in Chapter 4, Section 4.2.1).

After the forwarding order is defined, the export organization can start planning the pre-carriage and main carriage. The method of planning the two stages is completely up to the planner. We've taken a look at the different planning methods in Chapter 5.

Because the export and import processes usually take place in ocean or air scenarios, TM supports these processes only when you're using freight bookings for the main carriage, which can be either an ocean booking or an air booking. For you to realize the interaction between the export and import organizations, the main leg has to be planned on a freight booking.

The traffic direction of the freight booking must now also be **Export** because it was created by the export organization. In addition, we again enter the import organization on the **Business Partner** tab of the freight booking. Alternatively, this is done automatically due to the setting in the freight booking's document type Customizing that business partners should be taken over from the predecessor document, which, in our case, is the forwarding order. The export organization now has to deal with all the necessary process steps regarding the customs declaration for exporting the goods. The freight booking in this case is therefore used as the supporting document for the export declarations but also in general for the capacity reservation at the carrier.

After the freight booking is **Set to Shipped on Board** (in air freight booking, the status is **Uplift Confirmed**), as shown on Figure 7.9, the TM system automatically starts generating the import documents.

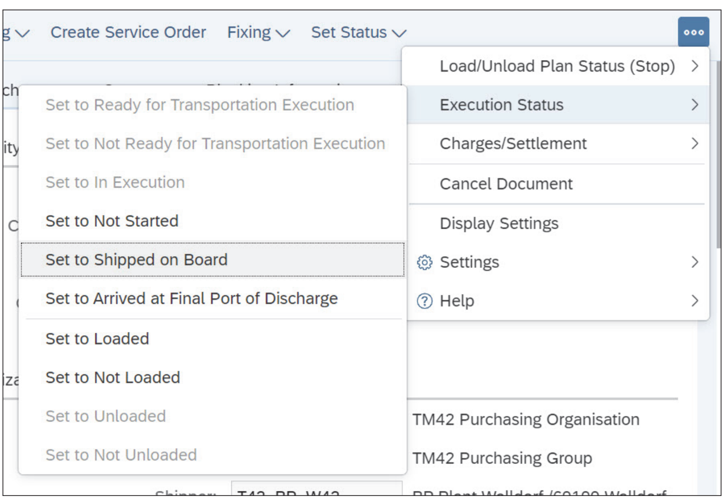


Figure 7.9 Setting the Ocean Freight Booking to Shipped on Board Status

From a process perspective, this means the import organization is notified by the upcoming TRQ only after the cargo is loaded onto the vessel or aircraft.

After the **Execution Status** of the freight booking is **Set to Shipped on Board**, the automatic generation of import documents is triggered by the PPF.

To enable the internal communication—that is, create the import documents within TM—the corresponding output profile has to be activated and assigned to the document type of the export freight booking in Customizing, as shown in Figure 7.10.

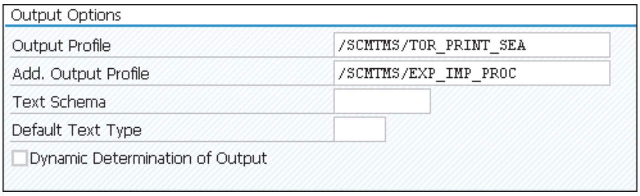


Figure 7.10 Assigning the Output Profile for Export/Import Processing to the Freight Booking Type

The import documents are created by a PPF action. For this to occur, import document types for the import freight booking, import forwarding order, and import freight units need to be defined up front. The correct document types can be determined during the automatic creation of import documents in two ways:

- **Assignment of import document type based on export document type**
  In Customizing of the forwarding order type and of the freight booking type, you can directly assign a corresponding document type for the import document. During the creation of the import document from the export document, the corresponding document type is taken into consideration.
- **Condition-based document type determination**
  TM offers two condition types for the condition-based determination of the import forwarding order type and the import freight booking type:
  - Condition type /SCMTMS/FWO_TYPE can be used to determine the forwarding order type for the import document.
  - Condition type /SCMTMS/FRB_TYPE_IMP can be used to determine the import freight booking type.

Both condition types are singleton conditions, meaning they can't be assigned anywhere in Customizing, and you need to define one global condition for all use cases.

The TM functionality first creates an import freight booking out of the export freight booking. The import organization can use this import document to carry out the import declarations for customs, and it's also the basis on which to plan the on-carriage.

After the import freight booking is created, the import forwarding order and freight units are also created from the booking. The freight units are now created by the freight unit building rule assigned to the import forwarding order type, so the automatic import document creation actually has nothing to do with the creation of import freight units. This is done independently by the forwarding order functionality.

Relation of Forwarding Orders and Freight Bookings

Remember the beginning of this chapter when we discussed buyer's and shipper's consolidation? For a shipper's consolidation, one import booking is created, but because the items will eventually be delivered to different ship-to parties, several import forwarding orders are created—one for each ship-to party.

With the import documents created, the import organization can now start with the import declarations and plan the on-carriage based on the freight units created out of the import forwarding order.

On the import freight booking, the purchasing organization is now automatically the import organization, and the export organization is entered as the additional partner function in the **Business Partner** tab. The same applies to the import forwarding order that was automatically created. The import organization now acts as the sales organization of the forwarding order, and the export organization is shown on the **Business Partner** tab in the corresponding partner function.

The import forwarding order and import freight booking were created in the **Draft** status. In a document with this status, data can't be changed, except for the purchasing organization in the freight booking or the sales organization in the forwarding order. The import organization now has to check the forwarding order and the freight booking for completeness; then it can set the status manually to **In Process** when starting the on-carriage planning.

Import Documents and Service Items

In TM, the standard process is to copy only cargo items from the export documents to the import document. Service items aren't transferred. However, you can influence the system's copy logic by implementing a BAdI via IMG menu path **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management • Basic Functions • Export/Import Processing • BAdI: Service Item Processing for Import Forwarding Orders**. With this BAdI, you can make changes to the copy logic so that service items are copied to the import document.

The external communication scenario isn't especially different from the internal communication scenario because the physical and legal process doesn't differ from the internal communication. Only the use of TMSs is different here.

With the external communication, we need to differentiate between two cases:

- **Only the export organization uses TM**
  In this case, we can start the process just like in the internal communication scenario because we're going to create an export forwarding order and export freight booking.

After that, the information concerning the import is sent out to the import organization's TMS.

- **Only the import organization uses TM**
  If the import organization uses TM, the TRQ communicated by the customer is recorded in an external TMS. Only after the cargo is loaded into the vehicle executing the main transportation leg is a message sent to TM to create import documents.

We'll now look at both cases, starting with the export organization using TM.

As already mentioned, the export organization—just like in the internal communication scenario—starts creating an export forwarding order and plans the freight units created out of this forwarding order on an export freight booking. Now when **Execution Status** is **Set to Shipped on Board**, as shown earlier in Figure 7.9, the system needs to react differently.

For external communication, a web service is called that sends out all the necessary information to the import organization's connected external TMS. Service interface `TransportationOrderBookingWaybillNotification_Out` is sent to SAP Process Integration, where the routing of the message is processed.

System Landscape Setup

To use external communication between the export and import organizations, the external TMS needs to be connected to the system landscape on which the SAP S/4HANA system is located that is running the TM functionality. We recommend that you connect the external TMS with the SAP S/4HANA system using SAP Process Integration or any other middleware.

When the import organization uses the TM system, another service interface can be used. Service interface `TransportationOrderBookingWaybillNotification_In` integrates the information from an external TMS into SAP S/4HANA and triggers the creation of an import freight booking, as well as the creation of an import forwarding order, based on the information provided by the service interface.

Let's compare internal and external communication. First, the TM functionality within SAP S/4HANA—as well as the standalone deployment of TM—supports both scenarios. However, internal communication offers some advantages because export document updates are received seamlessly on the importing side. In addition, internal communication provides more transparency because the import organization, using the same system, can be notified by upcoming imports earlier. They can proactively look for export documents with shipments to the region the import organization is responsible for. Furthermore, internal charging between export and import organizations can be performed, which we'll look at in Chapter 11.

In rare cases, manual creation of freight bookings is necessary. Import freight bookings can therefore be created manually in the system. As always with the manual creation of freight bookings, you need to ensure that the necessary information from the export freight booking is correctly copied into the import freight booking. For manually created import freight bookings, you can't use all the functionalities that you usually use on an export freight booking, such as the following:

- **Subcontracting the freight booking**
  Because the export organization handles the planning and execution, the import organization doesn't have to do anything about subcontracting the freight booking.
- **Assignment of schedules**
  As with subcontracting of the freight booking, planning (and therefore also schedule assignment) is done by the export organization.
- **Automatic drawing of master waybill number**
  The waybill number has been negotiated by the export organization and the carrier. Therefore, the import organization isn't aware of the number ranges available for the freight booking. However, if the waybill number is already known from the export document, the user can manually enter the waybill number in the import freight booking.

After the import freight booking is manually created, the user can also manually create the import forwarding order as a follow-up action, as shown in Figure 7.11.

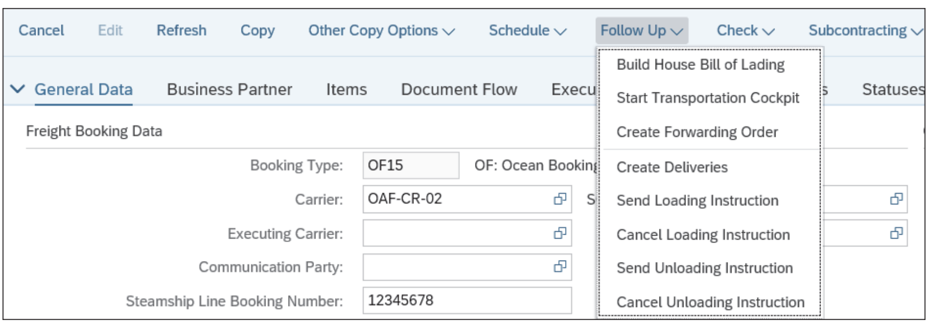


Figure 7.11 Creating a Forwarding Order from the Import Freight Booking

7.1.4 Statuses of Execution Documents

On execution documents, such as the freight order or freight booking, a **Statuses** tab shows the statuses of the document (see Figure 7.12). This tab shows not only statuses of the execution of the freight booking but also process steps that are handled before the actual execution. They include **Subcontracting**, as well as statuses that are of a more technical nature, such as the **Fixing Status**. However, this section is only concerned with statuses of the execution of the transport.

Among the execution statuses, we can differentiate among three types: the **Handling Execution Status**, the **Cargo Execution Status**, and the **Unload/Load Plan Status**.

To understand the difference between these three statuses, let's look at an example. We have a freight booking that is supposed to consolidate different freight units into one container to transport these freight units together on the main leg. The **Cargo Execution Status** tracks the progress of loading these freight units (meaning package items) into the container. The **Handling Execution Status**, on the other hand, tracks the progress of the container being loaded onto the vessel. The **Unload/Load Plan Status** identifies whether the execution data collected in the document is fit to be transmitted to the next stop, advising what freight will arrive and how it's loaded.

General

Life Cycle Status: In Process — Changed By:
Archiving Status: Not Archived
Fixing Status:
Fixing Status of Requirement As... :

Subcontracting

Subcontracting Status: Carrier Assigned — Changed By:
Confirmation Status: No Confirmation Yet — Changed By:
Invoicing Status: Not Invoiced
Dispute Case Status: No Dispute

Planning

Unload Plan Status (Stop): TGE_CFS_DEHAM ( ) Not Plann...

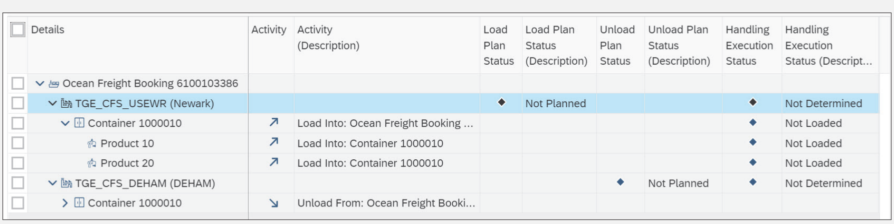
Execution

Execution Status: In Execution
Logistical Execution Status: TGE_CFS_DEHAM (DEHAM) Not Unloaded
Manifest Status: Manifest Not Created
Booking Confirmation Status: Not Sent to Carrier
MBL Received: Master Bill of Lading Not Received
Shipped-on-Board Status: Shipped on Board — Changed By:

Figure 7.12 Freight Booking Statuses

Load Plan Status and Unload Plan Status

As you'll see in Figure 7.13, both **Load Plan Status** and **Unload Plan Status** are shown. Both statuses relate to the fact that a plan on what needs to be loaded or unloaded is finalized and can be communicated to the location where loading or unloading will take place. To simplify the flow of this chapter, we'll only mention the **Load Plan Status** in the course of this section. Keep in mind, however, that the functionality described for the **Load Plan Status** also holds true for the **Unload Plan Status.**



Details	Activity	Activity (Description)	Load Plan Status	Load Plan Status (Description)	Unload Plan Status	Unload Plan Status (Description)	Handling Execution Status	Handling Execution Status (Descript...
Ocean Freight Booking 6100103386								
TGE_CFS_USEWR (Newark)			◆	Not Planned			◆	Not Determined
Container 1000010	↗	Load Into: Ocean Freight Booking ...					◆	Not Loaded
Product 10	↗	Load Into: Container 1000010					◆	Not Loaded
Product 20	↗	Load Into: Container 1000010					◆	Not Loaded
TGE_CFS_DEHAM (DEHAM)					◆	Not Planned	◆	Not Determined
Container 1000010	↘	Unload From: Ocean Freight Booki...						

Figure 7.13 Execution Statuses for the Items of the Freight Booking

Because freight bookings can have multiple stops (e.g., in the case of connecting schedules), the **Handling Execution Status** needs to be tracked on every stop and for every item of the freight booking. If the **Handling Execution Status** is updated for an item, the same status is propagated to the subordinate items. The **Cargo Execution Status**, on the other hand, is defined only on the container item level because it's assumed that the container will only be loaded and unloaded once during the transportation part covered by the freight booking.

Both the **Handling Execution Status** and the **Load Plan Status** can be seen on the **Items** tab in the freight booking or freight order. (In air freight bookings, this tab is called **Operations**.)

Keep It Simple

In this chapter, we refer only to a very simple example to show the course of the execution statuses. In addition, we refer to the freight document as a freight booking, meaning an ocean freight booking.

Bear in mind that the execution statuses for the freight documents also apply to more complex scenarios and are used (and work in the same way) on freight orders or freight bookings for other modes of transport.

For the **Handling Execution Status** on the item level, TM provides the following statuses:

- **Not Determined**
  This is the initial status after the freight document is created. After the freight document is ready for execution (covered later in this chapter), the initial status changes to the first status in the process.
- **Not Loaded**
  After the freight document is ready for execution, the **Handling Execution Status** for the items changes to this status because the system now awaits the loading of the container onto the vehicle or vessel.
- **Loaded**
  The packed container is confirmed to be loaded to the transporting vehicle.
- **Not Unloaded**
  At its destination, the container is still sitting on the transport vehicle waiting for unloading.
- **Unloaded**
  The container was unloaded from the vehicle.

Because the last three statuses are probably self-explanatory, we need to add here that the **Handling Execution Status** on the item level always adapts to the current location. This means that in a multistop freight booking, the item status changes from **Not Loaded** to **Loaded**, and at the destination location of the first transportation stage, it changes to **Not Unloaded** and **Unloaded**. However, if the first transportation stage is finished, the status of the item changes to **Not Loaded** again.

The **Handling Execution Status** on the stop level represents the statuses on the item level and offers the additional events **Departed** and **Arrived** (i.e., **Checked-In** and **Checked-Out** for road transport). Usually, these two events are reported by SAP Event Management, as we explain in Section 7.2. In addition, the **Handling Execution Status** on the stop level also represents all the statuses in the **Cargo Execution Status**. If the current stop is the first stop of the freight booking, meaning this is where the cargo is loaded into a container, then the **Handling Execution Status** on the stop level also shows the current progress of the loading of the cargo into the container. If the current stop is an intermediate stop, these statuses aren't shown.

Now let's look at what statuses in **Cargo Execution Status** the system offers. As already mentioned, the **Cargo Execution Status** is only *defined* on the item level but is also *shown* on the stop level using the **Handling Execution Status** if the current stop is a stop where cargo is loaded or unloaded.

TM offers the following statuses in **Cargo Execution Status**:

- **Not Determined**
  As with the **Handling Execution Status**, the **Cargo Execution Status** is first set to this initial status before the execution process is started.
- **Cargo Ready for Loading**
  Before the cargo can actually be loaded, it needs to arrive at the loading location. In an ocean scenario, we can imagine that the cargo is brought to the port with trucks, and the container waits for the cargo at the port. Therefore, the container and subordinate items are ready for loading only when the cargo items have arrived, meaning that the prerequisite freight order has arrived at its destination location.
- **Cargo Not Loaded**
  None of the cargo items have been loaded yet. Because the previous status **Cargo Ready for Loading** is optional, this status can also show that cargo loading hasn't started yet.
- **Cargo Partially Loaded**
  In the example shown earlier in Figure 7.13, each subordinate item needs to be loaded into the container separately. If some package items have already been loaded into the container and others haven't yet, the container's **Cargo Execution Status** would be **Cargo Partially Loaded.**
- **Cargo Loaded**
  After all the cargo items have been loaded, the **Cargo Execution Status** of the freight booking or freight order is changed to this status.
- **Cargo Ready for Unloading**
  As already mentioned, when the freight booking has arrived at its final destination, the cargo needs to be unloaded from the container again. Note that this applies only

to the last location of the container item; the **Cargo Execution Status** isn't changed on intermediate stops. All statuses regarding the unloading process correspond to the loading statuses, so we'll only list the unloading statuses without going into detail.

- **Cargo Not Unloaded**
  Similar to the **Cargo Not Loaded** status, this status indicates that the system expects unloading to happen next. This can mean that the truck is still traveling to the loading location, or it's already there but waiting for an available door. The difference from **Cargo Ready for Unloading** is that the status **Cargo Not Loaded** can also mean the truck hasn't yet arrived.
- **Cargo Partially Unloaded**
  This status indicates that unloading has started, and some of the cargo items that are supposed to be unloaded at this location have already been unloaded. However, more cargo items are still due to be unloaded.
- **Cargo Unloaded**
  When the **Cargo Execution Status** shows this status, it means that all cargo was unloaded at this location. If this was the final location of the freight order, this would also mean that the overall **Execution Status** of the freight order is changed to **Executed**. If there are more unloading stops after the current one, the overall **Execution Status** remains in the **In Execution** status.

The **Load Plan Status** is used to define when information on the cargo can be passed to the next locations where loading and/or unloading takes place. This is connected to the transit warehousing scenario, which we'll describe in further detail in Chapter 12, Section 12.2. After the **Load Plan Status** is set to **Finalized**, the application will send a message to the extended warehouse management (EWM) functionality to create the corresponding documents to prepare unloading and loading. The **Load Plan Status** can be set to the following statuses:

- **Not Planned**
  There isn't yet a load plan defined for this stop.
- **Planned**
  The load plan is created, but it may be preliminary. No message is sent to the EWM functionality in this status.
- **Finalized**
  The plan is finalized. After this status is set, a message with the information about the cargo to be unloaded/loaded at the next stop is sent to the EWM functionality.
- **Invalidated**
  The plan is invalidated. A message is sent to the EWM functionality to cancel any documents that were already created on the EWM side. The plan therefore needs to be put back to **Finalized** to create new documents in the EWM functionality.

The **Items** tab on the freight booking is used not only to monitor the current statuses of the cargo items but also to manually set these statuses. Recall that the **Handling Execution Status** and **Cargo Execution Status** can be linked to SAP Event Management events. Because we cover this in Section 7.2, for now, we'll just focus on setting these statuses manually. This is applicable in many use cases because the loading and cargo loading is often done not by the shipper or LSPs (which created the freight booking in the TM functionality), but by the carrier, who doesn't have access to the SAP S/4HANA system and therefore can't set the **Execution Status**. Because of this, the carrier calls the LSP to report the current status of the cargo and container.

If the freight booking is ready for execution, you can start setting the execution statuses in the freight booking.

Readiness for Execution

A freight booking's readiness for execution depends on various factors and information in the freight booking. For example, if a freight booking type is defined in Customizing as relevant for subcontracting, then the freight booking needs to have a carrier assigned to it before the freight booking is ready for execution.

You can check the readiness for execution by selecting **Check • Ready for Transportation Execution** in the global toolbar of the freight booking.

If you want to set the **Cargo Execution Status** or **Load Plan Status** manually in the freight booking, click the **Execution Status • Set to Loaded** button above the item hierarchy displayed in the **Items** tab, which should be set to the **Status Management** hierarchy.

As you can see in Figure 7.14, the choice of statuses combines the different statuses of the **Cargo Execution Status** and the **Handling Execution Status**. Note also that not all the statuses are selectable. Which statuses are selectable depends on the current status of the items. For example, if the freight booking has already left the port of loading, you can no longer select any statuses that are concerned with loading cargo into the container.

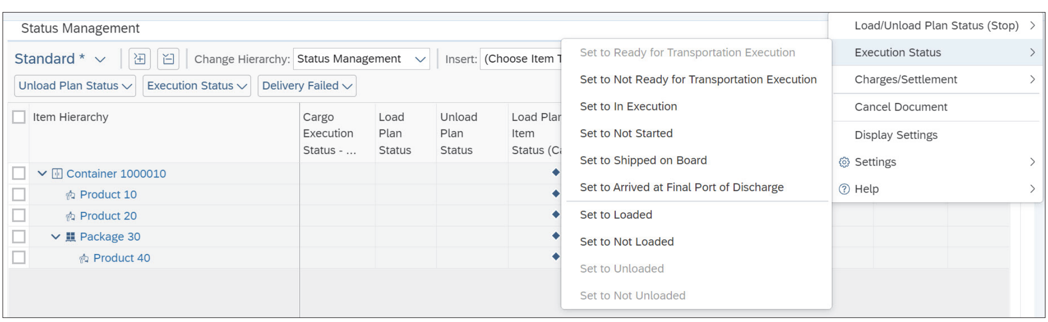


Figure 7.14 Setting Execution Statuses Manually

In addition, you can set the **Handling Execution Status**, **Cargo Execution Status**, and **Load Plan Status** by clicking the corresponding buttons shown in Figure 7.14.

The Statuses Need to Be in Order

The statuses have a defined sequential order in which they can appear. Therefore, the cargo must be loaded into the container before the container can be loaded onto the vessel. The same applies at the port of discharge: the container needs to be unloaded from the vessel before the cargo can be unloaded from the container. This reflects the common use case at ports and airports, where the containers are usually unloaded outside the vessel or aircraft.

You can see in Figure 7.15 that the execution statuses of the items change depending on the overall execution progress of the freight booking, including the first product loaded into the container ❶, the second product loaded into the container/container loaded into the vessel ❷, the finalized load plan ❸, and the departed vessel/finalized unload plan ❹.

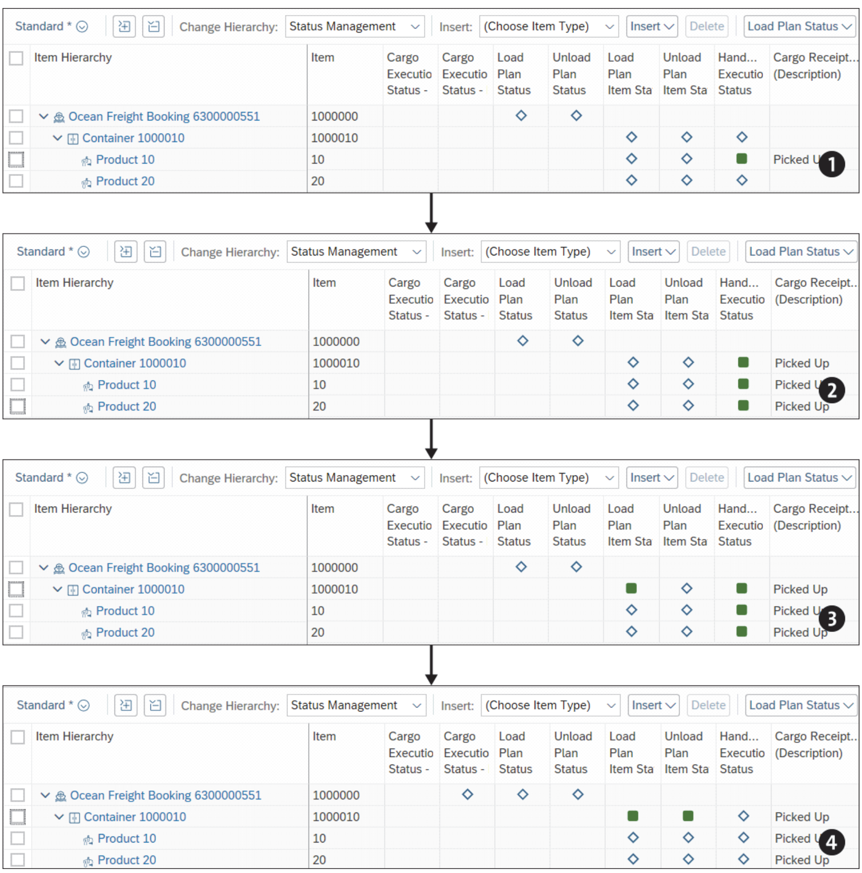


Figure 7.15 Progress of Execution Statuses

The vessel leaves the port after the cargo is loaded into the container and the container is loaded onto the vessel. After the vessel has left the port, the **Handling Execution Status** is reset to a status awaiting the next execution at the next port.

Recall from Figure 7.12 the overall status, called the **Execution Status**, which we haven't yet discussed. The following are some of the most important execution statuses:

- **Not Started**
  This is the initial status of a newly created freight booking.
- **Ready for Transportation Execution**
  All preparations for the shipment have been successfully finalized, and the shipment is ready to go.
- **In Execution**
  The resource used in the freight booking has left the source location but hasn't yet reached the destination where the container and cargo can be unloaded. Think of this as en route.
- **Executed**
  The resource has reached its final destination, and the cargo has been unloaded from the container. In Customizing of the freight order type, as described in Chapter 6, Section 6.1, you can specify which event from SAP Event Management is supposed to set the overall **Execution Status** to this status. There is also the possibility to change the last stop or event via BAdI `/SCMTMS/TOR_LAST_EXP_EVENT`.
- **Not Relevant**
  If you've defined in the Customizing of the freight booking type that the freight booking isn't relevant for execution tracking, the execution status will always be **Not Relevant**.

The overall **Execution Status** is influenced by the handling execution level on the stop level. If the **Handling Execution Status** on the first stop changes to **Loaded** or **Partially Loaded**, the overall **Execution Status** changes to **Loading in Process**.

The same applies to the actual transportation of the goods. If the **Handling Execution Status** has been set to **Departed** (which, as we said, is usually done by an event in SAP Event Management), the overall **Execution Status** changes to **In Execution.**

Now that we've discussed some execution statuses, it's time to delve deeper into the area of execution tracking. Recall from this section that many of the statuses described are tied to SAP Event Management, which will automatically set these statuses.

7.2 SAP Event Management

SAP Event Management is a versatile and adaptable tool that manages processes for object and status tracking and tracing, as well as performing collection, and analysis of

KPI data. SAP Event Management can be integrated into an SAP and legacy system landscape that communicates with partner systems in a worldwide network.

AMR Research (*https://amr-research.com/*) breaks SAP Event Management's functions into five core areas:

- **Monitoring**
  Monitoring of processes and objects is based on their statuses and events that are expected to happen within the process or with the object. Usually, monitoring has certain real-time requirements; there sometimes need to be immediate reactions to occurring or missing events. An example of monitoring is the tracking and tracing of a shipment.
- **Notification**
  Decision makers need to be notified if a process deviates from a planned progression. First, the deviation needs to be detected (which is an outcome of the monitoring function). Then a notification via an appropriate channel is raised, giving information about and access to the critical situation (e.g., sending an email that alerts the recipient of a delay in the delivery of a shipment).
- **Simulation**
  In the case of process deviations or delays, it can be sensible to simulate different options for recovery or alternative progression. Simulation is a tool for decision-making that allows evaluation of the impact of actions in terms of complying with definitions at the customer or internal service level.
- **Control**
  Any situation within a process that is monitored through events or status values can lead to reactions that allow you to control the process itself or dependent activities within a business system. The decision on the type of control required for a situation is based on a rule set. An example of control is posting a goods receipt in a distribution system if a customer reports the complete arrival of the goods at the customer's premises.
- **Measure and analyze**
  The planned and actual process data, status, and event information can be used in a variety of ways to identify weak points in processes or determine KPIs of the capabilities of an organization. This data can be collected by SAP Event Management and evaluated in a business warehouse. An example is the average delay time of deliveries made by a certain carrier.

SAP Product Roadmap for SAP Event Management

As an extremely versatile tool, SAP Event Management has a very widespread and flexible use and footprint in many customer implementations. However, it's not a public cloud tool and reaches a maturity of 20 successful years. Based on the SAP strategy, which moves toward providing track and trace functionality as a software service in the public cloud, SAP Event Management still has many use cases and a large fan base.

Despite initially being indicated to be at the end of its maintenance lifetime, SAP decided due to requests from large customers to provide the component as a new add-on to SAP S/4HANA (SAP Event Management on SAP S/4HANA) to enable its further utilization. Therefore, SAP Event Management will still be available and used by customers.

SAP Event Management is now available in two versions:

- SAP Event Management 9.2 is a software version that is provided on and can be installed as a standalone component on an SAP NetWeaver 7.50–based system (or higher release). It can be deployed standalone or together with, for example, SAP ERP or SAP TM, as long as the SAP NetWeaver release prerequisite is met.
- SAP Event Management on SAP S/4HANA 1.0 is a new SAP Event Management component that is functionally equivalent to SAP Event Management 9.2. However, it isn't a successor of this version, so there is no upgrade path available and it requires a new installation. As a prerequisite, installation needs to be done on SAP S/4HANA release 1809 or higher. The deployment of SAP Event Management on SAP S/4HANA can either be done standalone or as an add-on to an SAP S/4HANA or SAP TM system. The component can work with TM either on the same system or side-by-side. In addition, on-premise or private cloud deployment is supported.

SAP Event Management 9.2 has no installation as part of SAP S/4HANA. Therefore, an implementation on the same instance together with TM in SAP S/4HANA isn't possible. If SAP Event Management 9.2 needs to run together with TM in SAP S/4HANA, the SAP Event Management should reside on its own instance. Figure 7.16 shows the deployment options for SAP Event Management together with TM in SAP S/4HANA.

License-wise, TM allows users to utilize SAP Event Management in the context of the scenarios predefined for TM. Going beyond the defined scope would require a separate licensing.

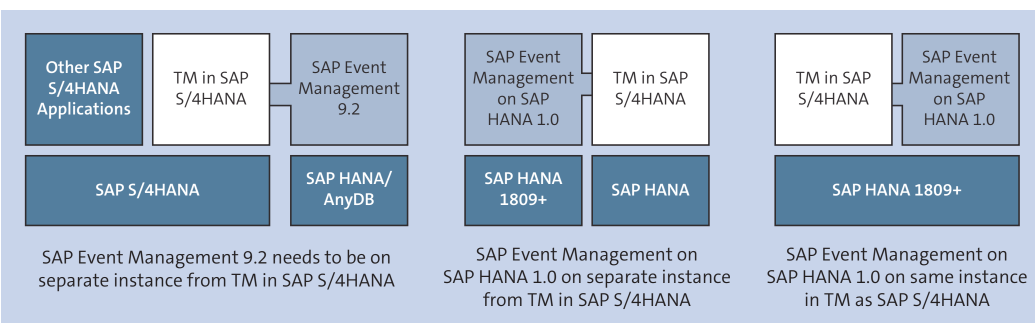


Figure 7.16 Installation Options for SAP Event Management Running Integrated with TM in SAP S/4HANA

An upgrade of SAP Event Management from 9.2 to the version on SAP S/4HANA would require a crossover of SAP Event Management onto a separate instance and isn't provided. Therefore, you always need to do a fresh installation. However, as SAP Event Management 9.2 works with SAP NetWeaver and SAP S/4HANA–based versions of TM, there is a good chance to have SAP Event Management reside in its current place and connect it to the new SAP TM instance remotely. In a properly decoupled implementation, this would not cause much overhead except running a second instance.

Real-world business processes usually entail a variety of process requirements that need to be reflected in an implementation of an event management process. Because SAP Event Management isn't bound to any predefined designated business objects (e.g., a sales order), you have flexibility in deciding which object type, process steps, and reactions you want to model and implement in a tailor-made event management process. Yet, because SAP Event Management is the standard tracking and tracing system within SAP logistics applications, many of the processes it covers are connected to a corresponding preconfigured scenario (in SAP TM, enabling plug-and-play integration to process visibility).

Event Management Purpose

The purpose of event management is an implementation of a real-world process in an event management system (EMS), where major milestones and characteristics of the process are reflected in the system. The event management process can have different flavors depending on the main emphasis:

- Control processes keep control over a business process.
- Track and trace processes show the current status of a process.
- Visibility processes provide an end-to-end overview of a process.

Let's dive into SAP Event Management, including event handling, the event management process, configuration, processing, and integration.

7.2.1 Event Handlers and Event Messages

The key business object of SAP Event Management is the event handler. All event management processes are based on at least one event handler, which allows you to define main characteristics, statuses, and steps that need to be tracked and controlled. Event handlers can represent a material object, process, or virtual operation. The following are examples of material objects that need to be tracked:

- A pallet that is used as the package for a shipment that needs to be tracked (you're interested in the shipment, but the pallet carrying it is the object that is identifiable from outside)
- A container asset that needs to be tracked during its complete ownership lifecycle
- A production device whose correct operation needs to be monitored and logged
- A shipment such as an express parcel that needs to be tracked from pickup to delivery

Examples of more process-specific visibility scenarios include the following:

- A customer order handled in various steps of order processing
- A payment process that should result in the balance of an invoice
- A purchase order that needs to be tracked from ordering time to delivery and quality inspection of goods

Event Handlers for an Example with Multiple Views (Car)

Let's consider an example of a process with multiple views, which can be set up in SAP Event Management.

In the automotive industry, a car can be tracked from at least two different viewpoints:

- As a to-be-produced material object that will be sold in the future
- As an order from a customer who wants a made-to-order car

In such a process, either form may occur first (i.e., an order for a specific car that isn't produced yet or the production of a specific car that hasn't yet been ordered by a customer). Because the sequence isn't known up front, all the related objects (customer order or car production order) need to be modeled in SAP Event Management and be instantiated independently of each other. For this purpose, you can create two linked event handlers:

- One event handler will represent the order for the car.
- A second event handler will represent the production order for the car.

Both can be created independently from the other and be linked as required.

Each event handler has a lifecycle that corresponds to the lifecycle of the object or process it represents. An event handler is instantiated by an incident in a business process, which could be related to a certain status (e.g., order accepted) or to the creation of a business object (master data object for a container created). During its lifetime, the event handler processes a variety of events and reacts to them according to a defined rule set. It can be put to sleep and woken up again before being deactivated and finally archived. Table 7.1 lists some examples of typical event handler lifecycles and event counts.

Characteristics	Event Handler Type (Business Usage)		
	Tendering Process	Shipment Tracking	Container Resource Tracking
Lifecycle	2 hours	4 weeks	5 years
Number of processed events	3–5	approx. 20	>10,000

Table 7.1 Examples of Event Handler Lifecycles

To underline the flexibility and comprehensive applicability of SAP Event Management, let's consider a few examples of how it's used throughout various SAP industry segments:

- Order management, including production monitoring, delivery, and invoice settlement (mill industry)
- Tendering and visibility for logistics execution (high-tech industry)
- Distribution processes in a complex environment (industrial machines and components)
- International ocean freight, including customs management (retail industry)
- Purchase order management process for LSPs managing the supply chain of their customers (fashion industry)
- Returns management (automotive industry)
- Tracking of handling units in logistics outbound processes (LSPs)
- Spare parts and equipment management (aerospace and defense industry)
- Tracking of parcels, including hierarchical loading (postal services)
- Railcar management (chemical and mill industry)
- Integration with vehicle management systems (automotive industry)
- Integration with the Trader's and Scheduler's Workbench (oil and gas industry)

High-Performance Tool

SAP Event Management is designed to process scenarios with large amounts of data. Many large postal companies use SAP Event Management for parcel tracking, where several billion events need to be processed every year. Big data isn't new to SAP Event Management.

SAP Event Management runs on an SAP HANA database, which enables in-memory use of event handler and event message data. Data access has been adapted to SAP HANA, resulting in the capability of processing more than 1,000 events per second.

Event messages are notifications related to real-world processes or objects represented in an event management context. These messages are communicated in a standardized form to SAP Event Management; they carry information to identify the related process or object, the incident, time and location, and further contextual details. Event messages can be created and communicated in various ways:

- Interactive creation by humans (e.g., with a mobile device, scanner, internet application, or business system)
- Automatic creation by machines (e.g., a technical system, production system, or RFID scanner)
- Forwarded by external business systems (e.g., Electronic Data Interchange [EDI] or XML messages with business content)

We can define events by some essential characteristics:

- **Identification (tracking ID)**
  What is the identification of the process or object this message refers to, for example, number of a pallet that arrived or number of an order that has been dispatched. Usage of multiple IDs per process or object is possible; for example, a shipment can be referred to by the shipment number or by the waybill number.
- **Event type**
  The event type is a definition of the incident that is reported by the event message (e.g., acceptance of an order, departure of a shipment at a location, or proof of delivery of a shipment).
- **Repeatability**
  The repeatability defines whether the event type occurs only once in the context of the current process, or the same event type can reoccur at the same or another location (e.g., an *arrival event* may happen multiple times during a truck tour as several customers are visited).
- **Expected event date/time**
  Expected dates/times define a point in time or a time frame when an event should happen; an earliest and latest point in time may be assigned to the expected event.
- **Expected message date/time**
  Even if an event is expected to happen within a certain time frame, it may be reported via an event message at a different time. The expected message date/time or time frame is a characteristic that can be defined as a benchmark for reporting compliance.
- **Actual event date/time**
  If an event is reported, the actual date and time of event occurrence are defined. At this point, they can be measured against the expected date and time.

An event management process usually has initialization and termination events. The various other events happening during the process can be assigned to four event categories. Event categories are determined as part of the monitoring function of SAP Event Management and lead to different behavior in terms of notification, simulation, control, and analysis. Figure 7.17 shows an overview of the event categories in the context of an event handler lifecycle, which moves from left to right. We can divide the example events in Figure 7.17 into four event categories:

- **Regular events**
  A *regular event* is defined by a milestone in a business process that is reflected in the definition of the expected event and its expected time frame. The actual event occurs within the expected time frame and is reported within the expected message time frame.

  Say, for example, a container should arrive at a terminal between 9:00 a.m. and 10:00 a.m. The confirmation is expected until 1:00 p.m. The container arrives at 9:43 a.m., and the confirmation (event message) is sent at 10:35 a.m.

In some cases, a regular event can occur without a defined expected time frame (e.g., it can happen anytime, but it needs to happen at least once).

- **Early or late events**

  Like a regular event, the *early or late event* is a milestone that is expected to happen within a defined time frame. The actual event occurs either earlier or later than the expected time frame, or it's reported earlier or later than the expected messaging time frame.

  Say, for example, a container should arrive at a terminal between 9:00 a.m. and 10:00 a.m.; the confirmation is expected until 1:00 p.m. Instead, the container arrives at 10:33 a.m., and the confirmation (event message) is sent at 3:27 p.m.

  A specific real-time reaction to the early or late event isn't planned. Instead, the fact that the process isn't executed according to the expected milestones is registered and used for analytical and process improvement steps (perhaps to evaluate the quality of service of a business partner).

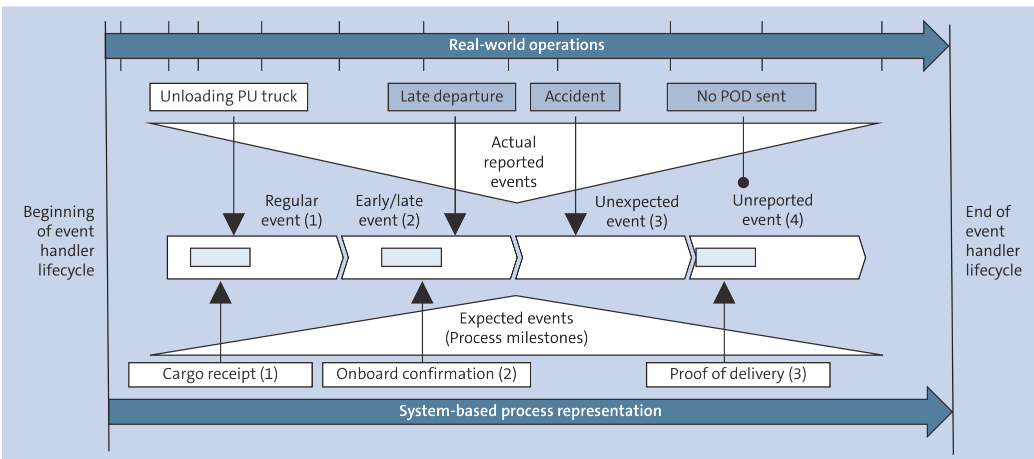


Figure 7.17 Event Types and Event Handler Lifecycle

- **Unexpected events**

  Unexpected events don't have a corresponding milestone in the business process, and there is no expectation that the event is reported. We need to differentiate between two situations:

  – The event simply happens and is registered (e.g., location is reported by a GPS device in a truck).

  – The event indicates a more or less serious problem, and some corrective measures must be taken (e.g., accident report of a delivery truck).

  In some cases, the situation needs to be evaluated based on further event characteristics (e.g., if a railcar is reported to be in a switchyard in Chicago when it should be routed from Denver to Los Angeles).

- **Unreported events**
  Unreported events are also based on an expected and time-defined milestone, but either the actual event doesn't happen, or an event message isn't received within the required time frame. The missing information on the event is rated as noncompliance and immediately leads to exception handling. This allows at least a notification to be raised to someone (or a system) who can assess the situation and take further actions. For a well-defined escalation process, an automatic control process can be initiated as the reaction.

7.2.2 Event Management Process

An event management process is usually triggered by one of the following sources:

- A transactional object in a business system is created or set to a status, which triggers the process to start (e.g., an order that reaches the status **Accepted**).
- A master data object is created in a business system (e.g., a company's own container resource).
- A process in a business system reaches a state (e.g., a delivery process reaches the state of goods issued).
- A message from external sources indicates that an event management–relevant process has been kicked off, and event messages are expected in the future (e.g., a shipment is sent of a sender and future tracking information will arrive).
- A process implemented in SAP Event Management starts with manual creation of an event handler for pure event management-based handling. This kind of process is special because SAP Event Management may be creatively used to run a business process on the implemented event handlers without a backend business system (e.g., starting a standalone returns management process on SAP Event Management).

Business Objects and Application Objects

In a business system, manifold business objects represent substantial entities of the business processes (e.g., sales order, freight unit, or invoice), which are configured by Customizing to represent the real entities (e.g., a domestic truck shipment or the ocean leg of an international shipment). In the context of event management, *application objects* define an even more granular and semantic classification of objects, which depends on the individual characteristics of a business object. This is necessary because an event management process may differ considerably depending on what a business object represents. In the context of event management, the business systems are generally also referred to as *application systems*.

According to the previously mentioned example, a freight order business object can, for example, represent a domestic less than truckload (LTL) truck tour or a bulk railcar shipment. You can determine the nature of the business object only by looking up characteristics or indicators (e.g., freight order type, mode of transport, main resource, stage type, or type of cargo).

Depending on these characteristics, SAP Event Management needs to initiate a different event management process and use an individual type of event handler. Therefore, based on the business object characteristics, the *application object type* and the related data are determined to control the event management process.

Figure 7.18 illustrates the elements of SAP Event Management that are involved in an event management process. Usually, the process starts in a business system such as TM, where the originating object or process is created. While running the event management process, the following stages or steps are executed:

1. A business process is started in the backend business system (e.g., TM). At a certain step, the process reaches a status when an event management process needs to be triggered (e.g., freight order is ready for execution). When the business object is saved, the business object data is handed over to the PPF or a BAdI layer (SAP TM) for post-save action handling. In both cases, the business object data is handed over to the SAP Event Management application interface, which is a configurable integration component that manages the communication with SAP Event Management.

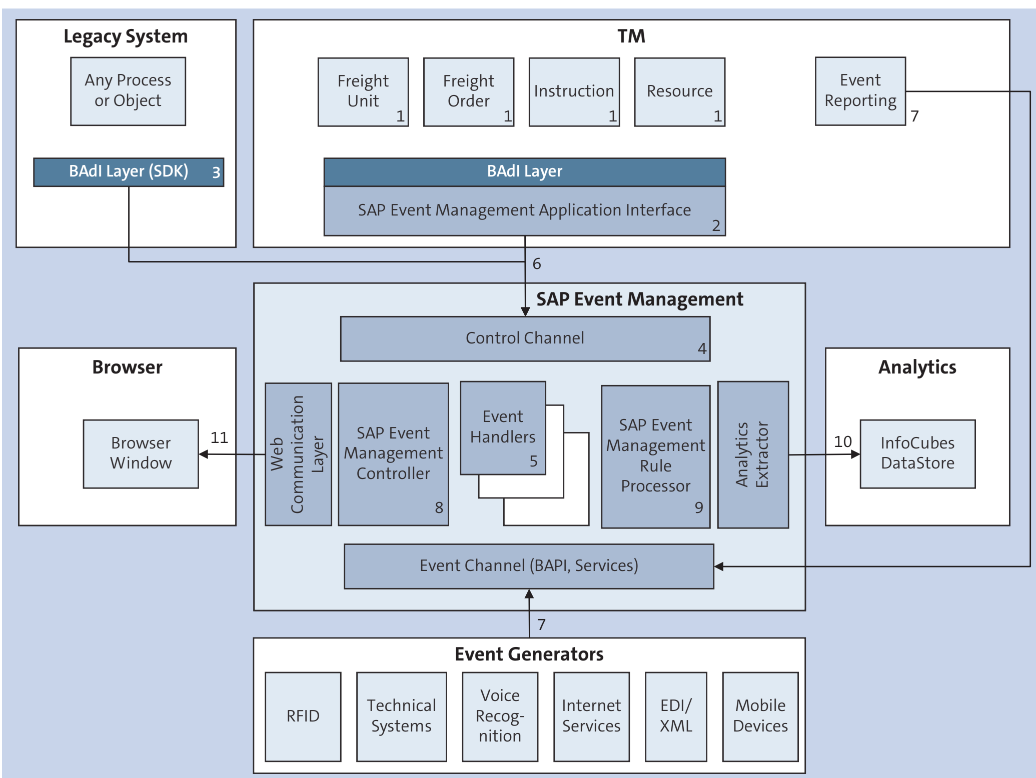


Figure 7.18 Elements of SAP Event Management

2. The application interface determines the tracking relevance of the business object by checking configured rules of the application object type and analyzing the related business object data (e.g., freight order of type **XYZ1** and status is switched from **Not Planned** to **Planned**). If an application object type is relevant for tracking, and the object status requires communication with SAP Event Management, the relevant context data is extracted from the business object, and several data packages containing object data in a standardized form are created (e.g., expected events, tracking IDs, and general parameters). In addition, the SAP Event Management instance to be used is determined (it's possible to use multiple SAP Event Management instances for different purposes). Finally, the data packages are sent asynchronously to the SAP Event Management instance. The same procedure applies in the case of updates or deletions of business objects, where change or delete requests are sent to SAP Event Management.
3. Legacy systems don't have an application interface (unless they are built on an SAP NetWeaver ABAP stack). Therefore, a legacy system needs to determine the tracking relevance on its own, build the application data packages, and send them over to SAP Event Management using a Business Application Programming Interface (BAPI) or web service call. This integration isn't uncommon; one of the largest customer installations of SAP Event Management used this integration technique with a legacy mainframe.
4. The control channel in SAP Event Management receives the request from the application interface of the business systems or from the legacy systems. The received data is forwarded to the event controller, which determines if an event handler exists or, if not, which type of event handler needs to be created.
5. If an event handler is created, SAP Event Management checks to see if messages have already been received (sometimes external parties send event messages before the event handler is created). If so, the buffered messages are processed in sequential order. If an event handler already exists, it's first changed according to the new data (e.g., it may contain changed or new expected events). Then the already-received messages can be reprocessed to check whether the altered event handler is still compliant with the previously received event messages.
6. SAP Event Management finally sends back a status protocol of applied change steps to the application systems, where this information is logged in the application log (Transaction SLG1, object **SAPTRX**, subobject **APPSYS**).
7. Event messages can be received from various sources as single messages or a batch of messages. The messages are sorted by tracking ID and sequenced by event date/time before being forwarded to event processing by an event controller and rule processor.
8. The event controller retrieves the event handlers for the event messages to be processed and hands over the individual batches of messages to each event handler.

9. Each event handler processes its batch of event messages sequentially using the rule processor. The rule processor analyzes the received event message and applies the rule set defined for the event handler type to the event and event handler context. Based on current and previous data of the event handler, a decision on reactions to reported events can be made.
10. Extraction of event management data for analytics is one sort of reaction. The extracted data on process performance is sent to the analytics system.
11. The web communication layer allows data to be retrieved from one or multiple event handlers and to be presented in a role-based web interface. Due to its configurability, the web communication layer can be used to present visibility data to customers and provide access for partners or internal employees.

7.2.3 Setup and Configuration

SAP Event Management configuration requires settings on the SAP application side (e.g., in SAP S/4HANA, SAP ERP, or SAP TM), as well as the SAP Event Management side, which need to match in some regards. In this section, we describe how to set up SAP Event Management system instances, data extraction, and communication in the application interface, and how the directly related Customizing is done in SAP Event Management. Visibility process configuration components are also explained.

Configuration in SAP Application Systems

SAP Event Management–related configuration capabilities of an SAP application systems are provided by the application interface and are part of application basis in SAP NetWeaver or SAP_BW software component of SAP S/4HANA. Therefore, you can use it in all systems of SAP Business Suite or SAP S/4HANA.

The technical integration between the business processes and the application interface is delivered out of the box for various business objects. Table 7.2 provides an overview of the logistics-related SAP Event Management integration objects in TM.

Object	Object	Event Management Usage (Examples)
Freight unit	TMS_TOR	Cargo item/container tracking
Freight order/freight booking	TMS_TOR	Shipment tracking, master bill tracking
Resource	TMS_RES	Equipment tracking
Standard operating procedures (SOP) instruction	TMS_INS	Tracking of SOP
TRQ	TMS_TRQ	Forwarding order

Table 7.2 Logistics-Related TM Objects with SAP Event Management Integration

The application interface provides a standardized way of configuring the integration between business processes and the corresponding event handling. Depending on the semantic context of a business object, configuration can control which process in SAP Event Management is fed with data and expected milestones. The configuration is controlled mainly by definition of business object type and application object type.

The business process type is directly related to the business objects as they are defined in the business object repository of the application system (e.g., a transportation order object). It relates to a technical integration of the business object with the application interface and a list of data tables with object content that can be used for extracting data and events to be sent to SAP Event Management.

You can customize the business process type by following IMG menu path **Integration with Other SAP Components • Event Management Interface • Define Application Interface • Define Business Process Types**. For each business process type, settings for technical data posting (dialog task, V1 update task) and queuing are defined. In addition, a list of data structures is provided that allows you to characterize the Data Dictionary (DDIC) structure used and gives an indication of how to evaluate business object changes. The indicator allows you to define, for example, which value in a structure field indicates a newly created object that needs to be communicated to SAP Event Management.

Figure 7.19 shows the business process types of a TM system and some details of the application table definition of the business process type **TMS_TOR** of the transportation order object.

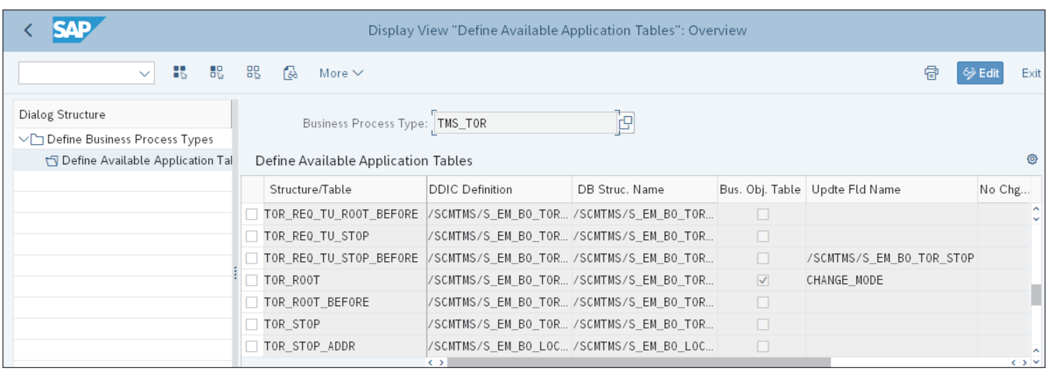


Figure 7.19 Business Process Types of TM and Application Tables of the TOR Object

Definition of Application Object and Event Types

You can define the settings for application object types via IMG menu path **Integration with Other SAP Components • Event Management Interface • Define Application Interface • Define Used Bus. Proc. Types, Appl. Obj. Types, and Evt Types**. Each application object type is directly related to a business process type.

Using Multiple Event Management Systems for Your Visibility Processes

If you integrate your application systems, you have the option to connect multiple SAP Event Management clients or systems for different tracking purposes. In application object configuration, you can choose which EMS should handle the processes for an application object type (e.g., shipment tracking on EMS A and resource tracking on EMS B for load distribution).

In the **General Data** settings of the application object type, you must define the EMS where the visibility process is started. In addition, you can set the behavior of the application object creation (e.g., whether the application object is relevant to trigger an SAP Event Management communication; you can use this to deactivate an application object type).

The **Control Tables** settings define which of the business object data tables represent the main object. An application object may, for example, be created for a whole shipment (header level) or for each shipment item (item level). In the first case, the main table would be the object's header table; in the second case, the main table would be the item table, and the header table should be assigned as a master table. For some objects, deleted records are kept in separate tables. In this case, the table for deleted objects could deviate from the main object table.

On the **Object Identification** tab, you can configure how the application object ID is compiled. The application object ID identifies the object or part of it, which is directly related to the event handler. You can extract it from one or two fields of the business object data tables or use a function module for extraction. If you want to track item 0020 of freight order 001234, for example, the application object ID may be set to 0012340020.

The **Event Mgmt. Relevance** settings determine when an application object is communicated to the EMS. The determination can be done by either a condition or an ABAP function module. Alternatively, the application object can be set to be always relevant, which triggers a communication to SAP Event Management as soon as a business object is created or changed.

Using ABAP Function Modules in SAP Event Management

In application system and EM configuration, there are many settings where ABAP function modules are used to either extract data or perform processing (e.g., rules engine). Many function modules are delivered with the standard software. You also have the option to create your own function modules from templates that are available or as copies of existing modules. If you assign such a function module in Customizing, you first need to create an entry for it in Customizing because the function module name isn't directly entered, but a logical name is assigned to it. You can find the assignment via IMG menu path **Integration with Other SAP Components • Event Management Interface • Define Application Interface • Define SAP EM Extraction Functions**.

In the **Parameter Setup** tab, you can define which data of the business object is handed over to SAP Event Management to create or update an event handler. There are multiple categories of data to be extracted, as follows (Figure 7.20 shows the Customizing screen):

- **Tracking ID Setup**
  Tracking identifications (IDs) and code sets are used to identify the event handler when event messages are received. Tracking IDs are usually numbers such as shipment numbers, B/L numbers, pallet numbers, or order numbers. The code set associated with the number classifies the ID and helps you find the correct event handler (there might be a shipment with number 12345 identified by SHP 12345, and an order with number ORD 12345, where SHP and ORD represent the tracking code set, and 12345 represents the tracking ID). Tracking IDs can be extracted via a table field reference or an ABAP function module. You would have to use the ABAP function if you want to assign multiple tracking IDs to one event handler, which may all be used for event reporting (e.g., shipment SHP 12345 and B/L number BLN 9876543).
- **Cntl Data Extract./Info Data Extract.**
  Control and information data extraction provides containers to hand over any kind of data in the format name-index-value to SAP Event Management. This data is related to the object or process and gives additional information. The control data container holds information that can directly influence the SAP Event Management logic and which can be accessed by rules processing (e.g., an indicator that a shipment contains dangerous goods, that the cargo type is bulk, or that the used truck is of medium size). The information data container holds additional object characteristics (e.g., the name of the truck driver), which usually aren't used to control the process. The index is used to relate several entries belonging to the same group (PRODUCT[1] = "Television", QUANTITY[1] = "200", TYPE[1] = "Yamamoto DXTV-230", PRODUCT[2] = "Dishwasher", etc.).
- **Query ID Extract.**
  Query IDs provide the option to assign additional code set/ID pairs to an event handler that can be used for data retrieval from SAP Event Management but not for message processing.
- **Exp Event Extract.**
  Expected event extraction allows the retrieval of milestones from the application object that are later used to create the expected events in the event handler. Because the extraction is done in an ABAP function module, you have the option to enhance the expected event list by calculating or enriching the milestones given in the business object context. If, for example, a shipment object contains only a departure date, you can additionally create a gate check-out date 30 minutes later, which allows you to track your internal operation schedule compliance.

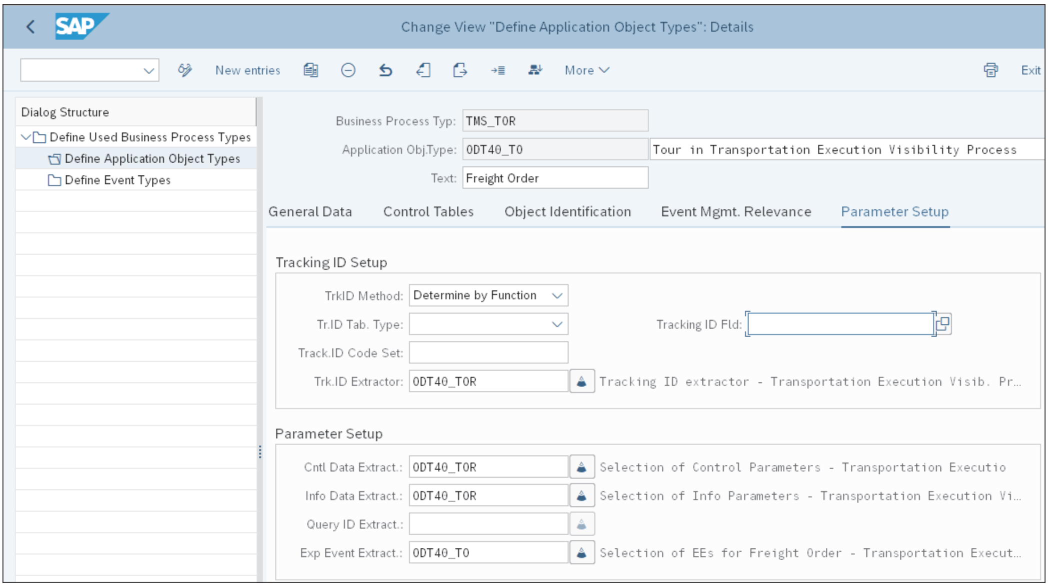


Figure 7.20 Parameter Setup of an Application Object Type

For each business object type, you can configure one or multiple event types in the application system. Event types allow you to set up event messages to be sent from the application to a connected EMS in the context of the backend process. An example is the confirmation of goods issue in an SAP S/4HANA delivery, which needs to be registered in the shipping process tracking in SAP Event Management or via a load status on a freight order in TM.

Data extraction from the application is done in an assigned ABAP function module that allows you to build the event message context in a very flexible way. Figure 7.21 shows the event types defined for the TM transportation order objects (freight order and freight booking).

The standard application log, which you can start via Transaction SLG1, provides detailed information on the success or failure reasons for the activities happening within the application interface. You can access details about the event management relevance of application objects, data extraction and application data, or event transmission to the EMS. The response of SAP Event Management to the application system requests is transmitted back to the application system and stored in the log (e.g., no suitable event handler type could be determined in SAP Event Management). You can see the complete process by accessing the log via Transaction SLG1 for object **SAPTRX** and subobject **APPSYS**.

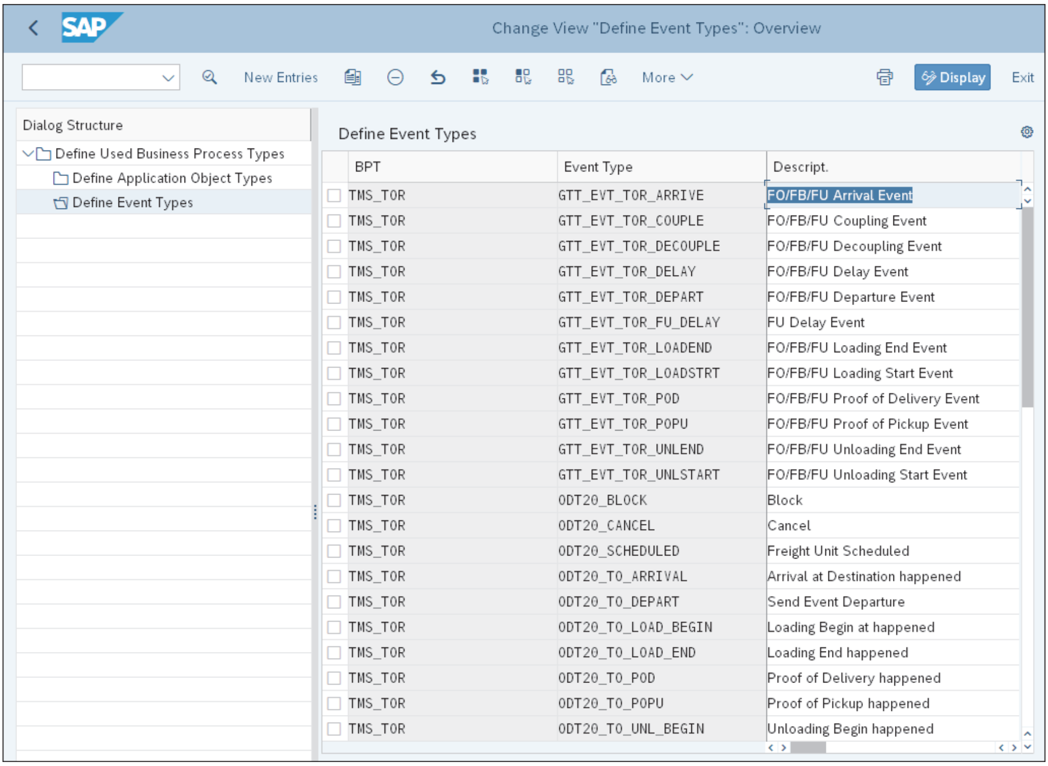


Figure 7.21 Definition of Event Types for the Transportation Order Object of TM

Configuration of SAP Event Management

The configuration of SAP Event Management allows you to define the behavior and characteristics of the visibility processes. Other than the Customizing of the application system, the settings of the EMS are only available if the SAP Event Management on SAP HANA 1.0 add-on is installed or the system is set up with SAP Event Management 9.2; that is, you don't find it on a normal SAP S/4HANA instance. The Customizing entries are identical on both versions. The main activities in SAP Event Management configuration are to define the following:

- Event handler types, expected event messages, and status settings
- Event handler type determination and data mapping from the application system data
- Event messages and event codes to be processed
- Rules about how to react to received or missing event messages
- Setup of personalized web transactions for accessing event management data

To allow process synchronization between application systems and SAP Event Management, you need to make a few essential settings to connect application system processes with SAP Event Management configuration. You can find these settings in the SAP Event Management IMG by selecting **Event Management • General Settings in SAP Event Management**:

- Define remote function call (RFC) connections to enable technical communication.
- Define logical systems to identify application systems and EMSs.
- Define application systems to give a name to the systems for which you set up processes in SAP Event Management.
- Define business process types because you need them to synchronize the application system extraction process to the event handler creation process.

Definition of different event handler types allows you to control the creation, composition, and behavior of individual visibility processes on the event management side. Event handler types are always related to a business process type, which you need to define in the event handler type settings, however, many event handler types can refer to the same business process type. Figure 7.22 shows the setup of an event handler type that you can find in SAP Event Management Customizing by selecting **Event Management • Event Handlers and Event Handler Data • Event Handlers • Define Event Handler Types**.

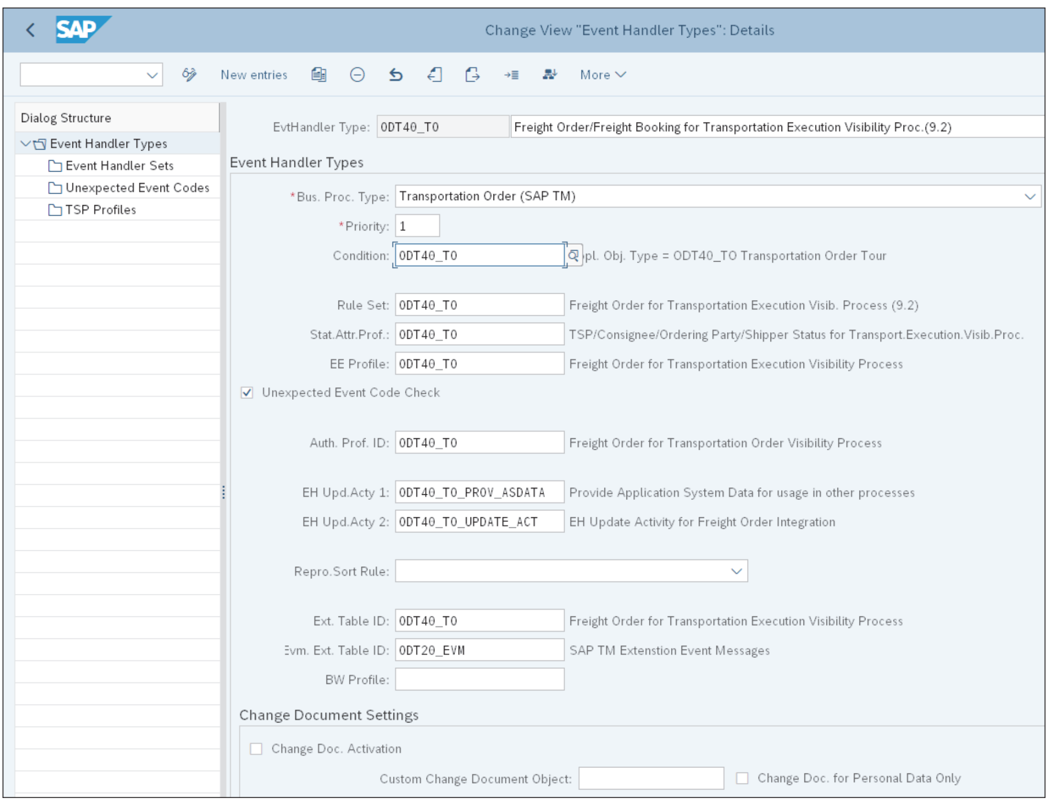


Figure 7.22 Configuration of an Event Handler Type

The main fields of the event handler type are as follows:

- **Bus. Proc. Type**
  You must assign the event handler type to a *business process type*.
- **Priority** and **Condition**
  You can set a *priority* to allow a ranking within the event handler type determination. You define a *condition* that specifies the applicability of the event handler type (e.g., only to be used for a specific application object type).
- **Rule Set**
  The rule set defines how the created event handler reacts to incoming or overdue event messages.
- **Stat.Attr.Prof**
  Using the status attribute profile, you can detail the creation of status fields and set an initial value to it during event handler creation.
- **EE Profile**
  The expected event profile summarizes the expected events that are created with the event handler based on application system milestones or other expected events.
- **Auth. Prof. ID**
  Using the authorization profile, you can define who has access to which part of the event handler data if data is accessed or displayed on the web.
- **EH Upd.Acty 1** and **EH Upd.Acty 2**
  The event handler update activities allow you to specify ABAP function modules to update data of the application system before creating the event handler or update the event handler after running through the standard event handler creation process. They can be used like traditional BAdIs.
- **Ext. Table ID**
  The extension table IDs for event handlers and event messages allow you to add fields on the header level of event handlers and messages.
- **BW Profile**
  The **BW Profile** defines which data is extracted from the event handler to be sent to a connected data warehouse system (SAP Business Warehouse [SAP BW] or SAP HANA).
- **Change Doc. Activation**
  Changing document activation and logs allows you to capture additional data for auditing purposes and may range from no log to a very detailed one (verbose mode), which may also influence performance.

Event Handler Header Extension Tables and Use of Logs

As the header fields of each event handler (type) are the same, and there are mainly only technical or admin fields, you can use an extension table to extend the event handler header for various purposes and make it more case specific. Most important is the ability to create fields specifically to a particular event handler type that are part of a database index and allow a fast search (e.g., a field for location of last sighting) without modifying the header table for all event handler types. Each event handler type can have its own extension table and therefore may have specific indexing and access characteristics.

Event handler logs—especially in the verbose mode—should be used very carefully or mainly for testing when running SAP Event Management in high-performance scenarios or with high data volumes. They may create multiples of the data load of the pure tracking process and slow down the process.

Figure 7.23 gives example data of an event handler. The event handler header keeps the references between the application system and SAP Event Management and provides identification and control characteristics for the process. Milestones, tracking IDs, and other attributes are stored in related tables. The header extension table contains important context data for the process. Control and information parameters store more detailed information that can be used in rules or presented upon request.

An event handler that needs to work with milestones must be assigned an expected event profile. You can define expected event profiles in IMG by selecting **Event Management • Event Handlers and Event Handler Data • Expected Events • Define Profiles for Expected Events**.

Event handler header

GUID	*Appl. object type*	*Appl object ID*	*Business process type*	*Event handler type*
34eG62fs6DF	SHIPMENT	9926007	TMS_SHPMT	TMS_CONT

Tracking IDs

Codeset	*ID*
CONTNR	EASU7777779
SHPMNR	9926007
HAWBNR	EASC -2777098-2
MAWBNR	EASC -8755545

Query IDs

Codeset	*ID*
ORD_NR	35500726
PO_NR	978925007-08

Extension table (System parameters) Z_CONT_EH_TAB

Origin	*Destination*	*Container type*	*Last sighting*	*Container line*
HAMBURG	SINGAPORE	22GP	ROTTERDAM	EASC

Control parameter

Name	*Idx*	*Value*
COMMODITY	1	Toys
COMMODITY	2	Furniture
HTS	1	34526700
HTS	2	34584100
WEIGHT	1	3360 KG
WEIGHT	2	7840 KG

Info parameter

Name	*Idx*	*Value*
VESSEL	1	Northstar
SHIPPING LINE	1	EASC
CUSTOMS AGENT	1	MÜLLER&CO
CONSIGNEE	1	Jun Chen Ltd., Singapore, Main St.1

Expected events

Event	*Actual time*	*Location*	*Partner*	*Reporting time*
LOADING	03.02.13, 14h00	HAMBURG	HHLA	04.02.13, 12h00
DEPARTURE	03.02.13, 22h00	HAMBURG	EASC	05.02.13, 12h00
SIGHTING	05.02.13, 04h00	ROTTERDAM	EASC	06.02.13, 0h00
ARRIVAL	23.02.13, 17h00	SINGAPUR	EASC	25.02.13, 12h00
UNLOADING	23.02.13, 23h00	SINGAPUR	SGP_PORT	25.02.13, 12h00

Measurements

Measurement	*Expected*	*Actual*	*Status*
OVERALL WEIGHT	11200 KG	11350 KG	OK

Figure 7.23 Example Data of an Event Handler (Not a Complete Data Set)

When an event handler is created, SAP Event Management uses the information in the expected events profile to generate a list of expected events to serve as milestones for processing actual received event messages and as a basis for detecting overdue events. The right side of Figure 7.24 shows an example of an expected event list for a truck shipment with a trailer and customs clearance.

The expected events of a profile can be bundled into groups to allow alternative processing of events. One example is a group of events where either an approval or rejection event is expected. Either of these two events fulfills the requirement to receive an answer for a request and therefore satisfies the necessity to receive an answer within a defined time frame.

The detailed setting for expected event generation (see the left side of Figure 7.24) allows you to define how an expected event is created. You can relate the event to an expected event communicated from the application system. Dates and times can be directly moved or manipulated as required. You can also create an expected event by referencing a previously generated expected event (e.g., loading end is always 30 minutes after loading begin). If the event scheduling follows a more complex rule or needs to reference other data, you can use an ABAP function module to determine the correct date and time.

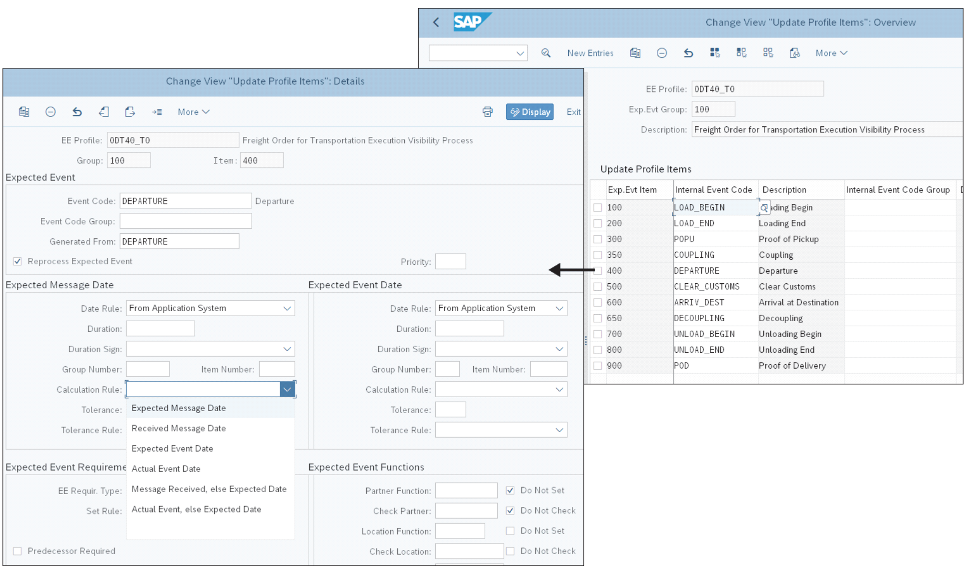


Figure 7.24 Event List in an Expected Event Profile and Detail Settings for Expected Event Generation

Each expected event can have event and message dates with a defined earliest/latest time frame. If an event code occurs multiple times in a process, the individual event instances can be enriched by event locations or sending partners (e.g., if a departure event occurs multiple times on a distribution tour).

Keeping Track of Original Plans

Within the expected event structure, an event handler keeps track of the expected and actual event date and time. In addition, an original expected event date and time is kept. Even if a plan changes multiple times, the first (original) plan is retained in the expected event structure. In-between changes are usually overwritten in the structure, but may be looked up in the log data in verbose mode, which is the most talkative level of logging event handler activities and event processing.

Because business processes often require quite specific status settings, SAP Event Management provides a tool to define the status of each event handler type individually. You can configure the Customizing for status attribute profiles by selecting **Event Management • Event Handlers and Event Handler Data • Statuses • Define Status Attribute Profiles**. The profiles, which are assigned to one or multiple event handler types, consolidate a list of status attributes, each offering a status definition, possible status values, and an initial value that is set when the event handler is instantiated. Transition of the status values from one setting to another is accomplished by rules processing with specific status modification activities. Figure 7.25 shows an example of a status attribute profile (TM transportation order event handler) with status attributes for block, delivery, and transportation status.

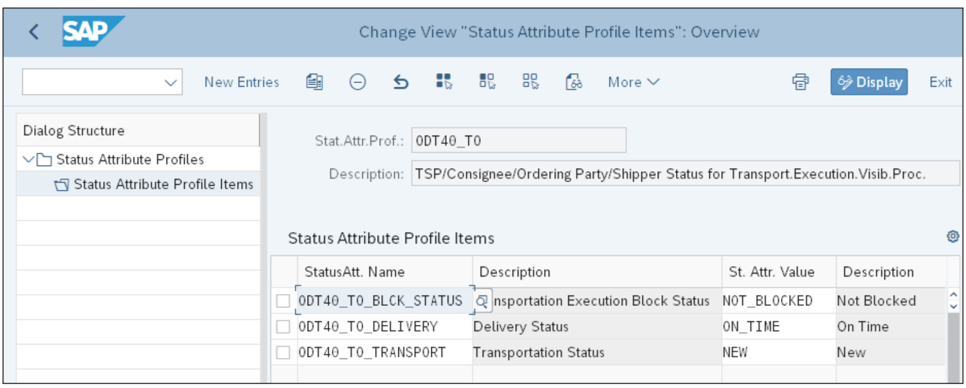


Figure 7.25 Status Attributes of an Event Handler for Transport Order Tracking

When an event handler is created by request from an application system, the extracted and transmitted data is used to determine the appropriate type of the event handler. The first step is to compare the business process type assigned to the application object against the business process type assigned to event handler types. The two should match. Optionally, the alternative business process type assigned to the application object is compared. Event handler types matching the business process type are now ranked by their priority. Subsequently, the conditions of the event handler types are checked until the first applicable one is found. This event handler type is then used to instantiate the event handler.

Because not all application systems are structured the same way, you can harmonize individually created parameters in a common process using the parameter mapping functionality. Even in the SAP world, orders of different kinds exist (e.g., SAP purchase orders [materials management] or sales and distribution orders). To avoid a cross-system harmonization of transmitted parameters, SAP Event Management offers a parameter mapping tool to assign parameter entities to a joint EMS-specific naming definition. For example, a `PO_NUM` parameter from material management and an `ORDERNUM` parameter from an SAP S/4HANA sales order can be mapped to an `ORDERNUMBER` parameter in the event handler. The assignment of a corresponding mapping profile in the IMG under **Event Management • Event Handlers and Event Handler Data • Parameters • Define Parameter Mapping** is mandatory; otherwise, the event handler can't be created, and you'll find a mapping error in the application log. In a simple case, the mapping profile just defines that all parameters are routed through event handler creation the same way they are received from the application system (i.e., the mapping profile defines that nothing is mapped).

7.2.4 Event Messages and Event Processing

An event message is a structured set of data that conveys information to SAP Event Management about what, when, where, by who, and why did something happen in a real-world incident. SAP Event Management uses this information to identify potential event handlers as receivers by comparing the tracking ID of the message with the tracking IDs of the event handlers. All active event handlers with matching tracking IDs and code sets get a feed of the event message.

Technical Processing of Event Messages

Event message processing is mass enabled for support of high volumes of event messages to be passed to SAP Event Management with a single transmission. All received raw event messages are first saved in the database before being forwarded to message processing, which can be done either synchronously or asynchronously, depending on how quickly the receiver needs to be listening again.

Message processing then picks the messages up from the queue, packages received messages by tracking ID, sorts the packages by actual event time stamp, and pushes each package into the event handler update process. In the end, the processing status and logs are saved with the messages. The event handler update process assigns the internal event code, checks the feasibility of message processing, and finally executes the rule processing for each message.

Synchronous processing of event messages should be used when you expect an immediate response on the success or outcome of an event message (e.g., if a truck departure is posted on a mobile device, and the status update is immediately shown on the mobile UI after refresh).

An event code characterizes the purpose of an event message. Event codes are divided into an external and internal view. Because there are many standards that define how to report a specific incident (e.g., by standards such as Electronic Data Interchange for Administration, Commerce, and Transport [EDIFACT], American National Standards Institute [ANSI] X.12, and RosettaNet), the external view needs to be flexible. Therefore, you can define external event codes and a mapping rule to harmonize and transform them into an internal view defined by internal event codes.

You configure the event codes in Customizing under **Event Management • Event Handlers and Event Handler Data • Codes**. There are multiple settings to define external and internal views and the possibility to group them. Figure 7.26 shows the definition and grouping of internal event codes.

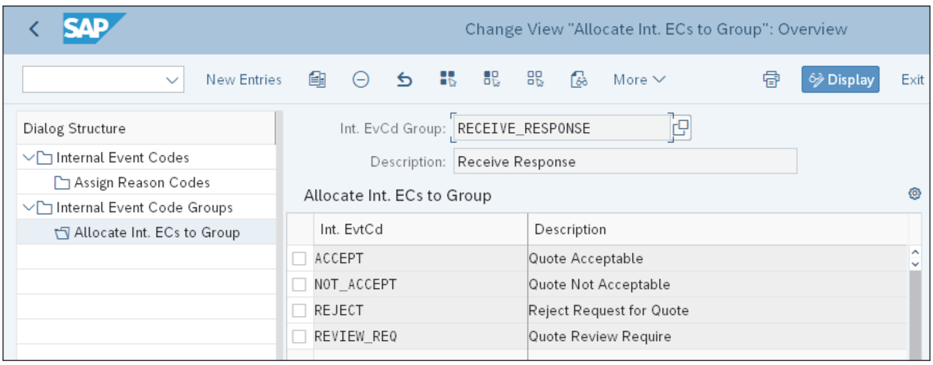


Figure 7.26 Internal Event Code Definition and Grouping

Event message processing is organized through the definition and use of rule sets. A rule set is a sequence of activities conditionally applied upon receipt of an event message or, alternatively, if an expected event is overdue with respect to either an expected event or message data.

A rule set is directly associated with an event handler. It can be a comprehensive list of rules, where each rule contains a condition under which it's executed, and a definition of which activity should happen if the condition is true or false. The activity may be an ABAP function module or method, or an SAP Event Management procedure containing multiple other activities (see Figure 7.27).

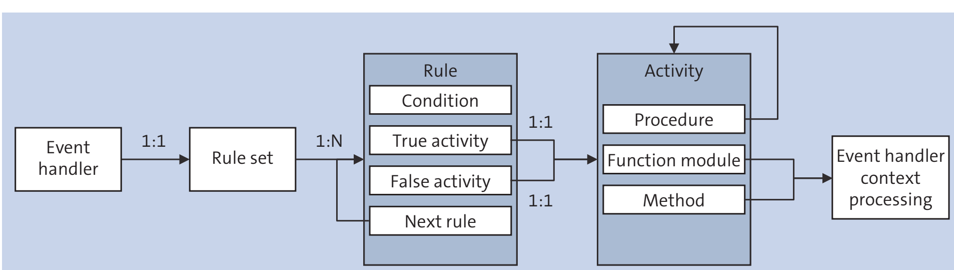


Figure 7.27 Associations among Event Handler, Rule Sets, Rules, and Activities

You can also define a next rule that should be executed based on the result of a called activity, which could be true, false, or an error.

Using Rules to Build an Event Handler Hierarchy

If you need hierarchical relations of event handlers (e.g., a tracked box in a tracked container), inheritance of tracking IDs allows you to easily indicate this reference. As soon as the box is packed into the container, the container event handler passes its tracking ID to the box event handler so that each message for the container event handler is now also processed by the box event handler (same tracking ID). This can be easily managed by rules and activities in the SAP Event Management activity repository (see the IMG under **Event Management • General Settings in SAP Event Management • Functions, Conditions, and Activities in SAP Event Management**). After the box is decontainerized, the box event handler deactivates its relation to the container event handler, and it can then be tracked on its own.

You define rule sets in Customizing under **Event Management • Reaction to Event Messages • Define Rule Sets**. Here, you can manage rule sets and define their single activities and logic. You also have access to activity definitions, multitasking activities (procedures), and rule conditions. To use this function, you can click the **Display Rule Set** button on the **Rule Sets** level of the Customizing transaction.

To provide a better overview of complex rule sets, you can also display rule set details, which takes you to a screen where the complete rule set with all its rules, conditions, and activities are displayed. Figure 7.28 shows the rule set maintenance and the rule set details display. In the details display, you can identify the procedural structure of the rule set, for example, in the **LOADING_BEGIN** section.

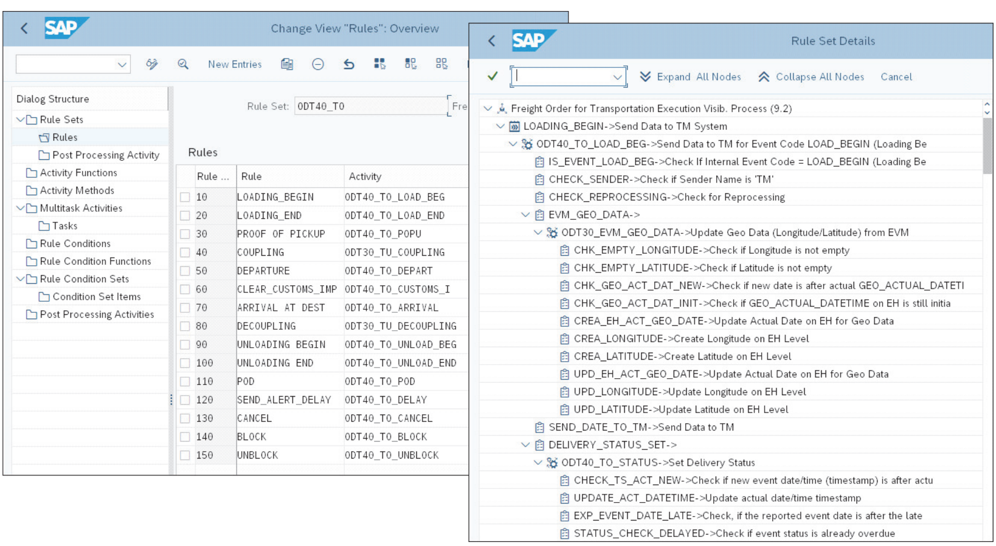


Figure 7.28 Rule Set Maintenance and Details Display

To ease and support the development and distribution of SAP Event Management settings, you can use solutions and scenario definitions to package all settings done for a scenario implementation on the SAP Event Management or application system side. In the IMG, the setup can be found under **Event Management • Solutions and Scenarios**. Here, you can assign event handler types, rule sets, extension tables, parameters and conditions, functions, activities, web interface transactions, users, and document flows to a scenario. Each scenario can then be exported from SAP Event Management as a business configuration (BC) set, which allows you to import it into another EMS.

7.2.5 End User Interaction, Lists, and Background Processing

SAP Event Management offers different methods of end user interaction:

- Role-based web end-user interaction to retrieve data from SAP Event Management and display it and interaction based on sending event messages
- List processing for power users to execute maintenance, retrieval, and inspection tasks
- Transactions for simple event message input

The role-based web interface allows you to define web transactions for event handler data retrieval and posting of event messages. It can be used to provide tracking information to end users and customers or partners and offers them the possibility to take part in the event reporting. An example is a transaction for parcel tracking, where you as receiver can follow the status of your parcel, and, after receipt, you can send a proof of delivery event if the package is in the correct condition.

Because the web transactions are role based, you can assign different authorizations to each role and define the kind of event handlers and event messages, as well as the details a particular user can see. In addition, the event reporting feature can be authorized or restricted. You can find the setup of the web interface in the IMG under **Event Management • Event Messages, Status Queries, and Web Interface • Web Interface**, where you can define the web interface transactions, configure the visibility of data and authorization, and assign users or roles to the web interface transactions. Figure 7.29 shows an example of a web interface transaction where drilldown capabilities have been configured to do complex intermodal container tracking for an LSP.

With the lists in SAP Event Management, you can either retrieve information as a professional user or control the processing of data. Control processing can be done interactively, when a user starts the corresponding transaction, or as a background process started by a batch job to regularly do data processing. The following list processes are provided in SAP Event Management:

- **Event handler list (interactive)**
  Using the event handler list, you can find and retrieve event handlers from SAP Event Management. You can drill down into the event handler overview and the detail display, which offers an in-depth overview of all event handler data. From the

event handler details, you can also update event handler data, which is a functionality that should be used only for maintenance purposes because it may corrupt data consistency.

- **Unprocessed message list (background or interactive)**
  The unprocessed message list allows you to process received messages that could not be processed (e.g., due to a locking situation). If an event handler receives two independent messages within a millisecond time frame, the second message may find the event handler locked while processing the first message. In this case, the unprocessed message processor can be scheduled and run regularly to resolve this situation.
- **Expected event overdue processing (preferably background)**
  The expected event overdue processing should be done regularly, best triggered by a batch job in less than an hour time frame (usually 5–10 minutes, depending on the on-time criticality). The processing checks whether any expected event was overdue and raises an exception processing of the corresponding event handlers that can be handled in the rule set.
- **Event message reprocessing (interactive)**
  In situations where event handler rules need to be tested, reprocessing can support the process so that not every test requires new event messages.

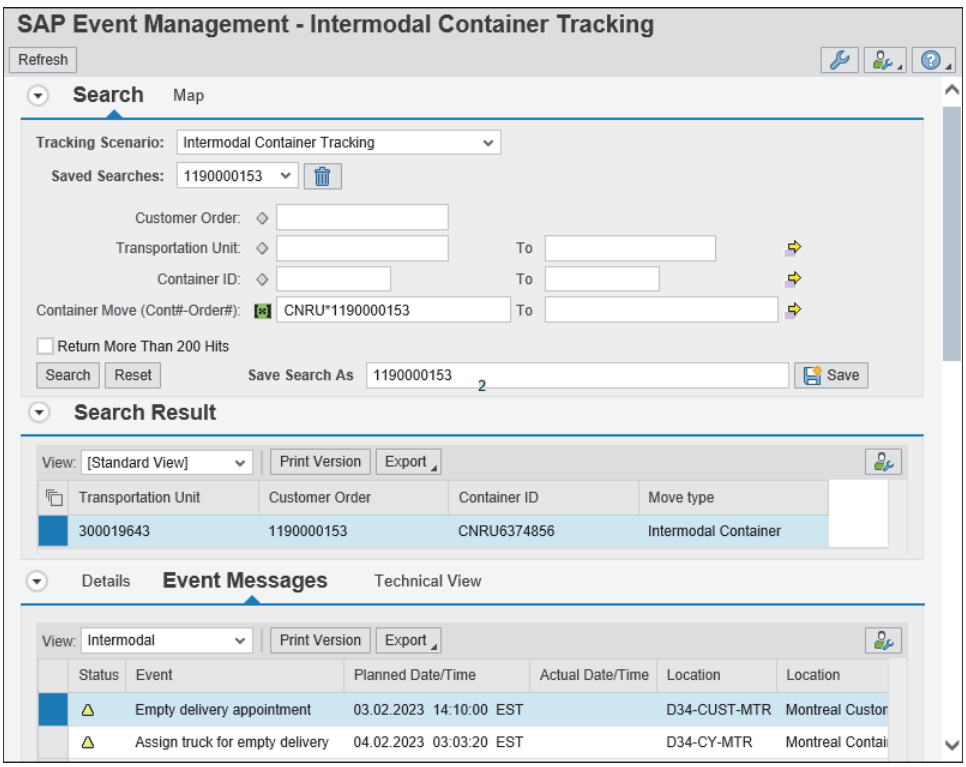


Figure 7.29 Web Interface of SAP Event Management

- **Status list for event message processing**
  This status list shows the processing status of the event messages that have been received for the selected event handlers.

7.2.6 Integrating SAP Event Management with Other Components

In Section 7.2.2, we described the integration of application systems (which includes TM) with SAP Event Management for creating event handlers or posting event messages. On top of this very fundamental integration, SAP Event Management offers a variety of predefined content and additional integration points with TM and other components and legacy systems, which we'll discuss in this section.

Predefined Transportation Management Content

For TM application objects, there is a corresponding preconfigured process, which you can use out of the box just by enabling it in Customizing, as follows:

1. Activate the SAP Event Management integration in the corresponding settings of the TM object type (e.g., in the freight order type).
2. Enable and set up the application interface for the corresponding process (Section 7.2.3).
3. Enable and set up the SAP Event Management process (Section 7.2.3).

The visibility processes shown in Table 7.3 are ready to use.

Visibility Process	Application Object	Event Handler Type
SOP instruction tracking	ODT30_INS	ODT30_INS
Freight unit tracking	ODT30_FU	ODT30_FU
Freight order/freight booking tracking	ODT30_TO	ODT30_TO
Resource tracking	RES30_RESOURCE	RES30_RESOURCE

Table 7.3 Visibility Processes and Their Implementations

Integration between Transportation Management and SAP Event Management

There are two additional integration points between TM and SAP Event Management:

- The first is the posting and update of TM-relevant data from SAP Event Management to TM as a result of rule processing. In many scenarios, receipt of an event needs to update corresponding data in TM. If, for example, an event handler has an expected event for arrival at a destination that is derived from a TM transportation order arrival date, then the rule processing can call an activity, which updates the TM transportation order actual date upon receipt of the arrival event message (see Figure 7.30).

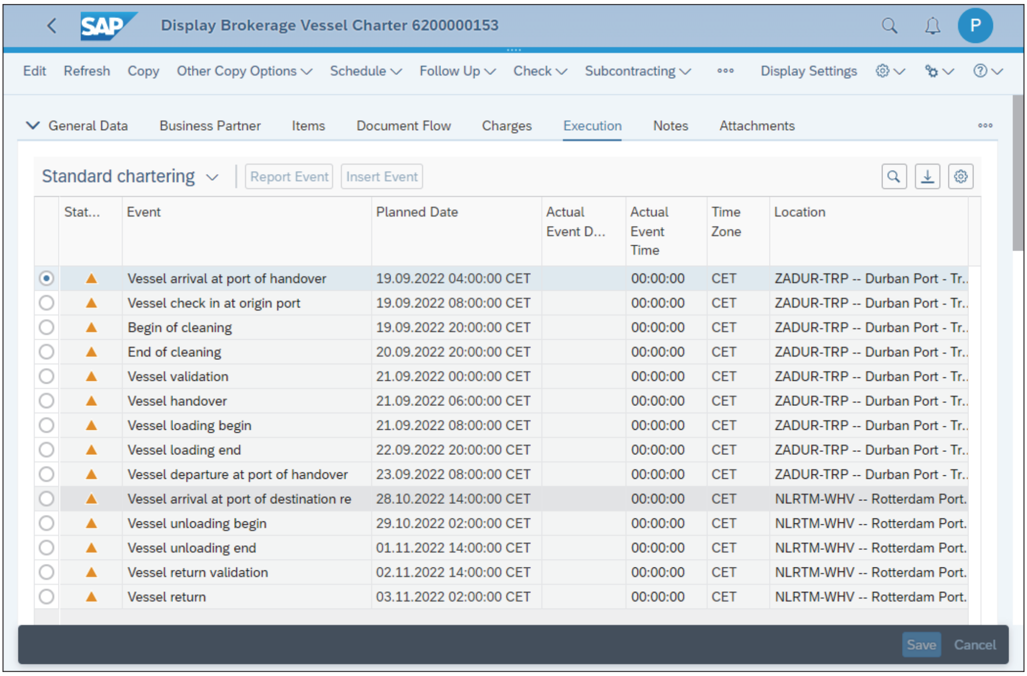


Figure 7.30 Event Message Data Displayed in TM Freight Booking Context

- TM and other systems can retrieve event handler data for displaying inside the application context. With this integration, a user can see the event handler status without calling a web transaction. The data is displayed as part of the current transaction (e.g., in the TM **Execution** tabs). TM also offers the sending of event messages to SAP Event Management upon manual setting of the actual dates, for example, in the freight booking maintenance. Figure 7.30 shows an example of displayed event message data in an TM freight booking context.

Integrating SAP Event Management with Other Systems

SAP Event Management offers three important interfaces for communication, which can be used as BAPIs, enterprise web services, or IDocs. The interfaces can also be used to integrate with non-SAP systems such as legacy systems running in a customer's landscape.

Due to its flexibility and universality, SAP Event Management can also be connected and integrated with many other SAP components. The following integration cases have, for example, been done within SAP environments as prototypes, as part of standard products, or as custom development projects:

- Integration of SAP Event Management with SAP Global Trade Services (SAP GTS) for tracking customs approval status
- Integration of SAP Event Management with SAP EWM to track the detailed movements of items in a warehouse or yard

7.3 SAP Business Network Global Track and Trace

SAP Business Network Global Track and Trace is a public cloud–based service that allows joint access and scenario usage. The event processing, visualization, and process handling capabilities are provided for all related and registered parties.

Renaming

SAP Logistics Business Network has been renamed to SAP Business Network for Logistics. See Chapter 12, Section 12.6, for more information.

Implemented scenarios don't represent the view of one company as usually provided in SAP Event Management (i.e., the process owner), but a common view on a scenario where all relevant companies can visualize and contribute. Typical use cases for SAP Business Network Global Track and Trace are as follows, for example:

- You want to track order fulfillment and associated goods in transit with milestone and geolocation tracking with predictive estimated time of arrival (ETA) and enable customers to track the progress of their order.
- You want to track order fulfillment and associated goods in transit from suppliers with milestone and geolocation tracking with predictive ETA.
- You like to track inbound advanced shipping notifications (ASNs) via milestones and associated tracking to update inbound shipments.
- You want to track truck, ocean, air, and small volume parcel shipments via milestones and with geolocation tracking with predictive ETA (shipment and delivery only or in combination with sales or purchase order processing).
- You like to extend or customize tracking scenarios with additional process integration and additional milestones.

We'll see what's available for SAP Business Network Global Track and Trace, as well as integration scenarios, in the following sections.

7.3.1 Architecture and Features

SAP Business Network Global Track and Trace has gone through some architectural changes since the previous edition of this book. Instead of being an independently built tool, it has become an integral part of SAP Business Network for Logistics from a business and technical perspective. Figure 7.31 depicts this change of technology setup for the components, where SAP Global Track and Trace is now an option in (i.e., a part of) SAP Business Network for Logistics 2.0. You can use SAP Business Network Global Track and Trace as a standalone component for a variety of purposes, comparable to SAP Event Management. On the other hand, SAP Business Network Global Track and Trace also provides a part of its functionality to support SAP Business Network Freight Collaboration with standardized tracking support. You can use SAP Business Network Global Track and Trace here to track your shipments with a fixed set of events, derived from TM. For more information on SAP Business Network for Logistics and SAP Business Network Freight Collaboration, refer to Chapter 12, Section 12.6.

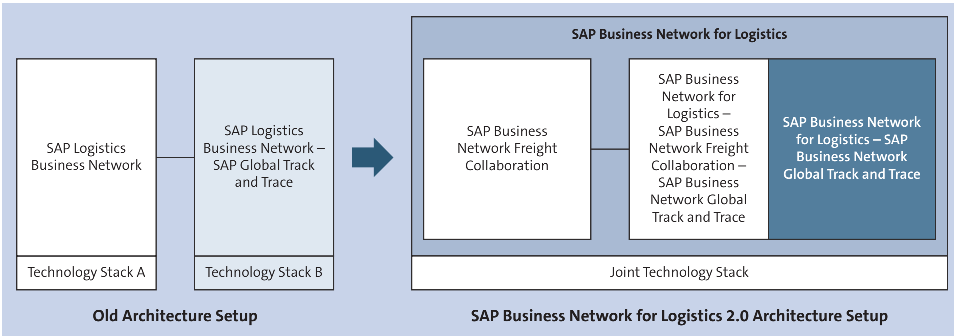


Figure 7.31 Change of Component Relations in SAP Business Network for Logistics

As SAP Business Network for Logistics is a public cloud tool, it also has a release schedule, which is quite independent of that of TM. SAP Business Network for Logistics and SAP Business Network Global Track and Trace as an intrinsic part, will get monthly updates. SAP Business Network for Logistics version 2304 should be available by the time you're reading this book.

On a high level, the components of SAP Business Network Global Track and Trace are comparable with those of SAP Event Management. From an application side, a variety of logistics systems can be connected as originating systems for objects or processes to be tracked. This could be SAP S/4HANA, TM on SAP S/4HANA or SAP TM, or SAP ERP. You also have the option to connect to legacy systems. From the SAP Business Network Global Track and Trace side, IDocs, RESTful, and OData services are provided. On the tracking system connection side, SAP Business Network Global Track and Trace provides a list of published APIs. These are already adopted by a list of tracking providers such as project44 or Shippeo, which can connect to SAP Business Network Global Track and Trace processes directly. Figure 7.32 gives you an overview of the high-level architecture and integration of SAP Business Network Global Track and Trace in its environment.

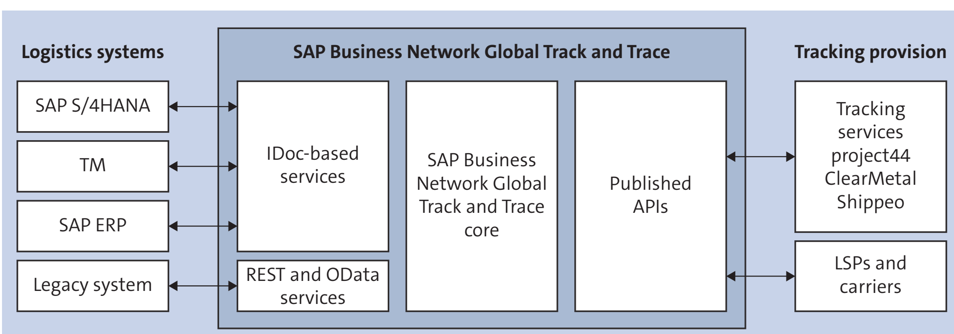


Figure 7.32 Integration of SAP Business Network Global Track and Trace into Logistics Systems and Tracking Provider Systems

SAP Business Network Global Track and Trace offers quite a range of new features and technologies when it comes to collaborative tracking and data evaluations. This allows for a certain strength compared to SAP Event Management, which is based on the innovative architecture and foundation. Table 7.4 shows you a comparison of the features of SAP Business Network Global Track and Trace and SAP Event Management.

Feature	SAP Business Network Global Track and Trace	SAP Event Management on SAP S/4HANA
Onboarding support	X	
Master data consolidation	X	
Integration to SAP S/4HANA	X	X
Integration to SAP TM	X	X
Role-based access	X	X
Role-specific view and filtering		X
Standard tracking	X	X
Tracking of parts/items	X	
Internet of Things (IoT) sensor tracking integration	X	Needs interface
Alerting, rules engine, process control	X	X
Attachments to events	X	X
High configurability/Customizing in model setup	X	X
Event handler sets		X
Serialization support, Electronic Product Code Information Services (EPCIS)	X	X
Analytics	X	X
On-premise installation		X
Cloud service	X	X (only private)
Cloud scalability on demand (performance)	X	X (only private)
Multitier visibility	X	

Table 7.4 Comparison of SAP Business Network Global Track and Trace and SAP Event Management Features

Feature	SAP Business Network Global Track and Trace	SAP Event Management on SAP S/4HANA
Archiving		X
Strong business network support with predefined connections to track and trace suppliers	X	
Machine learning and blockchain integration	X	
Shipper processes	X	X
LSP processes	Can be configured	X

Table 7.4 Comparison of SAP Business Network Global Track and Trace and SAP Event Management Features (Cont.)

As tracking processes in SAP Business Network Global Track and Trace can be jointly used due to the cloud access capability, implementation of complex product provenance proofs can be implemented more easily. A trust chain from raw material to point of consumption with a complete electronic record and forward as well as backward traceability of the material can be expected to be implemented in the future. The availability of new IoT and sensor integration technologies coming with SAP Business Technology Platform (SAP BTP) opens a large field of integration possibilities to enrich the data and event reporting in logistic chains. The SAP platforms also allow embedding of the relevant tracking information into workspaces and platforms.

Industry-Related Utilization of SAP Business Network Global Track and Trace

SAP Business Network Global Track and Trace is quite an established tool, which is reflected in its capabilities and ongoing development progress as well as in its industry-related utilization. Due to the necessary efforts, usage in all industries still isn't in focus. Therefore, typical use cases that match capabilities and integration paths are provided for the shipper industries. An integration with TM, as is required for LSPs, for example, is available, but not yet prepared to match LSP industry requirements.

Because SAP Business Network Global Track and Trace is a public cloud–based solution, the deployment cycles for new functionalities and features are much shorter compared with an on-premise version. Therefore, existing, updated, and new features that users need to be made aware of are directly accessible through the UI of the SAP Business Network Global Track and Trace launchpad start page. In Figure 7.33, you can see the help function for new release updates of SAP Business Network Global Track and Trace.

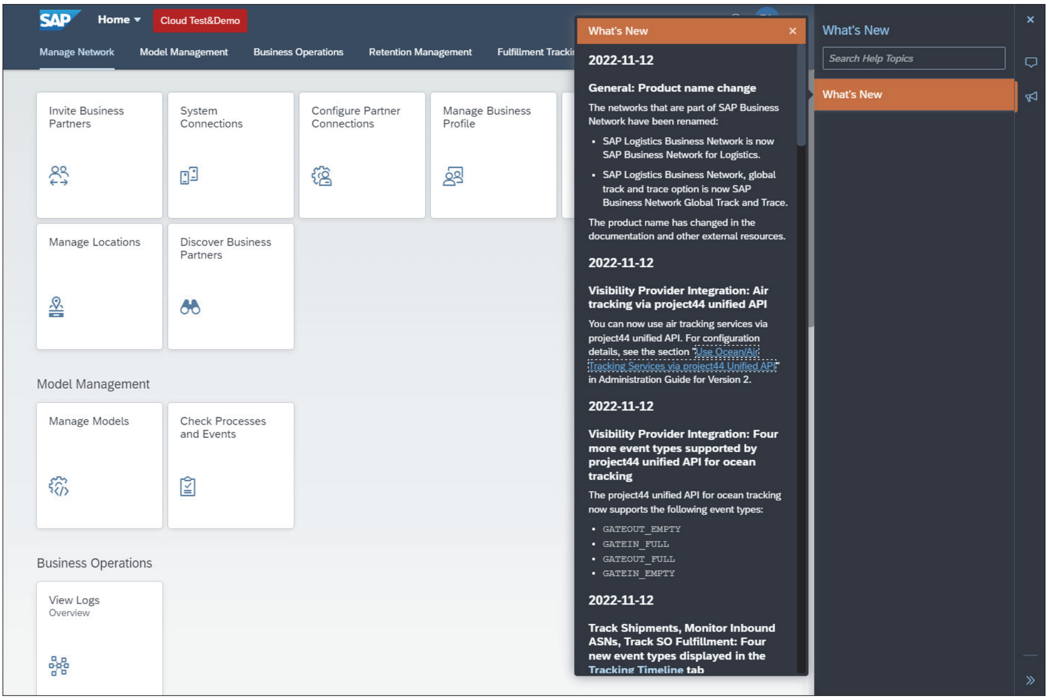


Figure 7.33 SAP Business Network Global Track and Trace Launchpad Start Page with Menu Content and Feature Updates

SAP Business Network Global Track and Trace works for air, ocean, and truck modes of transport and provides the following functionalities:

- Standard apps and template apps for out-of-the box consumption and extension
- Geolocation tracking with predictive ETA
- Scripted actions as exception management for stakeholder notification in case of predefined event occurrences (delays, exceptions, etc.)
- Document flow–based overview of transportation execution to show the correlation between orders, deliveries, and shipments
- Integration of third-party tracking providers
- Qualtrics integration for structured and free-text feedback on deliveries
- Capture of transportation-related CO2 emissions

7.3.2 Integration Scenarios

Within SAP Business Network Global Track and Trace, real-time and event visibility is established at a granular level that is determined by the company employing it and therewith providing transparency on the most crucial steps of transportation execution. Based on predefined scenarios, follow-up actions can be scripted, such as the automatic sending of emails in case of disruptions, to further strengthen the operative control of the moving parts of a business. Furthermore, the network participants may share expected data on when a disruption will be resolved to further strengthen the planning capability of companies and their customers.

As an example for operative use, with this tool, a sales employee can directly access the tracking data of a specific sales order, receive notifications if something is amiss, and directly act upon the disruption without searching for the right shipment numbers or contacting further personnel. This ultimately supports the increase of customer service levels while simultaneously decreasing cost. Similarly, delays in incoming shipments can be made visible directly to the procurement specialist and immediately integrated to the respective deliveries to allow for timely alternate sourcing or adaption of production plans.

As of the time of writing, SAP Business Network Global Track and Trace has some major scenarios and standard apps embedded, which are directly integrated with the logistics functionality of SAP S/4HANA as pure public cloud solutions:

- **Track sales order fulfillment (including outbound delivery) and track purchase order fulfillment (including inbound delivery)**
  Tracking of inbound or outbound deliveries created in an SAP S/4HANA ERP system (sales and distribution/materials management) with real-time feedback of event data. There doesn't need to be a TM system in place. The following features are included:
  - Ensures on-time, in-full delivery to customers by surveying all relevant milestones to increase customer satisfaction
  - Provides granular, real-time purchase order status information from your business partner ecosystem to avoid costly firefighting
  - Includes a list overview with indication of fulfillment rate and status:
    - Detailed page per order for in-depth analysis
    - End-to-end document flow visual tracking (exceptions displayed in red) and an aggregated execution status across business documents (e.g., outbound delivery and sales order)
  - Works with TM freight documents and LE-TRA shipments
  - Displays estimates by data providers and provides and on-time, in-full (OTIF) status calculation
- **Tracking of shipments**
  Tracking of inbound and outbound shipments coming from a source system (TM or LE-TRA) with real-time feedback of event data. Attachments can be done for specific events such as proof of delivery. The following features are included:
  - List overview with indication on status
  - Detailed page per shipment for in-depth analysis
  - Support for buyer and supplier managed transportation

  - Freight documents can be fed either from SAP S/4HANA or an external source system
  - Real-time and map-based transportation visibility with updated ETA
  - Manual maintenance of events
  - Ability to sync back events to TM
  - Display of impacted documents of delayed shipments
  - Display of estimated status provided by service providers
- **Monitoring of inbound ASNs**
  Track goods that are in transit and keep track of assets/returnables as they move along the entire supply chain to reduce operational costs. The following features are included:
  - List overview with indication on fulfillment rate and status
  - Detailed page per ASN for in-depth analysis
  - Ability to feed inbound deliveries or ASNs from SAP S/4HANA or external source system
  - Create Inbound ASN app to allow manual creation via SAP Business Network for Logistics
  - Display of related shipments and delivery items
  - Updates ETA of related inbound deliveries
  - Status and tracking timeline with current and estimated statuses and times

Figure 7.34 shows the availability of the predefined and integrated apps and scenarios on the launchpad of SAP Business Network Global Track and Trace. In Figure 7.35, you can see the tracking of a shipment in SAP Business Network Global Track and Trace with a list as an entry step, an overview, and a map view.

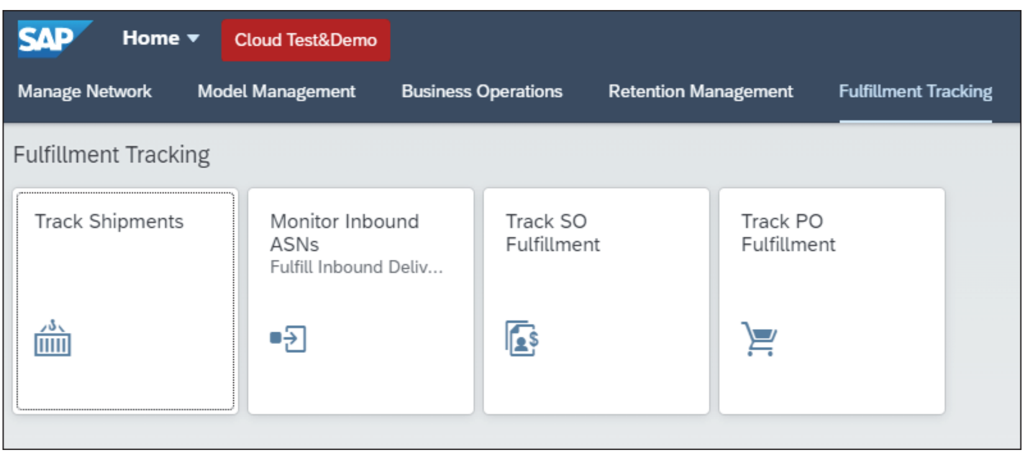


Figure 7.34 Launchpad with Predefined Tracking Apps and Scenarios

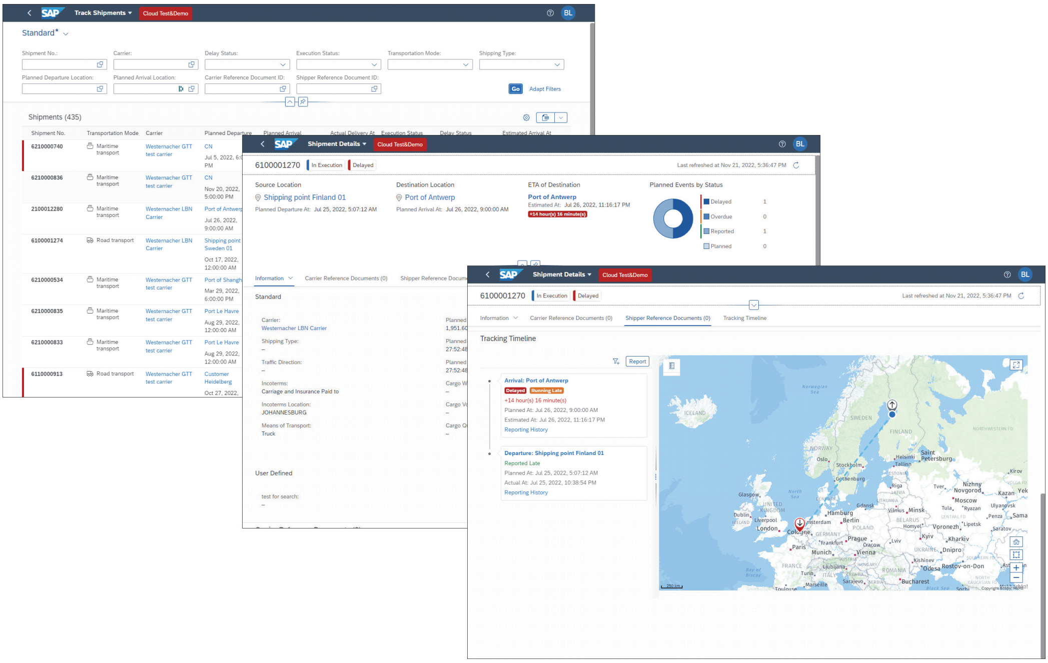


Figure 7.35 Tracking of Shipment in SAP Business Network Global Track and Trace: List, Overview, and Map

As an example for a tracking app (Track PO Fulfillment), Figure 7.36 shows the tracking of fulfillment as a full document flow (based on the corresponding purchase order positions), including deliveries and shipments, which is made visible by the status indicated by color and values.

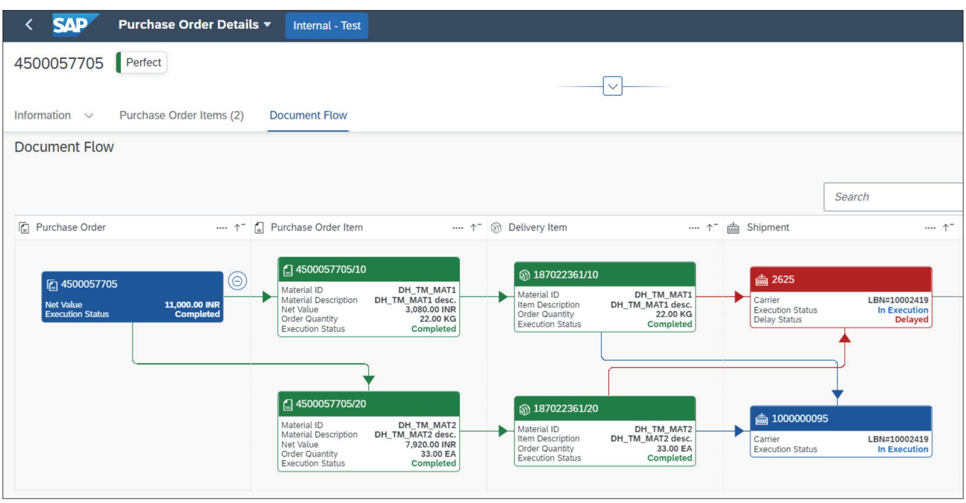


Figure 7.36 SAP Business Network Global Track and Trace Document Flow and Status of a Tracked Purchase Order Fulfillment

Concerning flexibility of models, there is still a higher configurability and Customizing capability in SAP Event Management, as it's on-premise as an individual instance and not provided in the public cloud. In SAP Business Network Global Track and Trace, models are also pretty flexible, but they must be created using a metadata modeling app with a language called CDS definition language (CDL), which runs as a part of the SAP Business Network Global Track and Trace plug-in for SAP Web IDE full-stack. There, you can define, design, and deploy SAP Business Network Global Track and Trace projects, which allow you to activate it in the cloud. For maintenance purposes, the Manage Models app is available. In Figure 7.37, you can see the metamodels and their status, which are deployed into SAP Business Network Global Track and Trace.

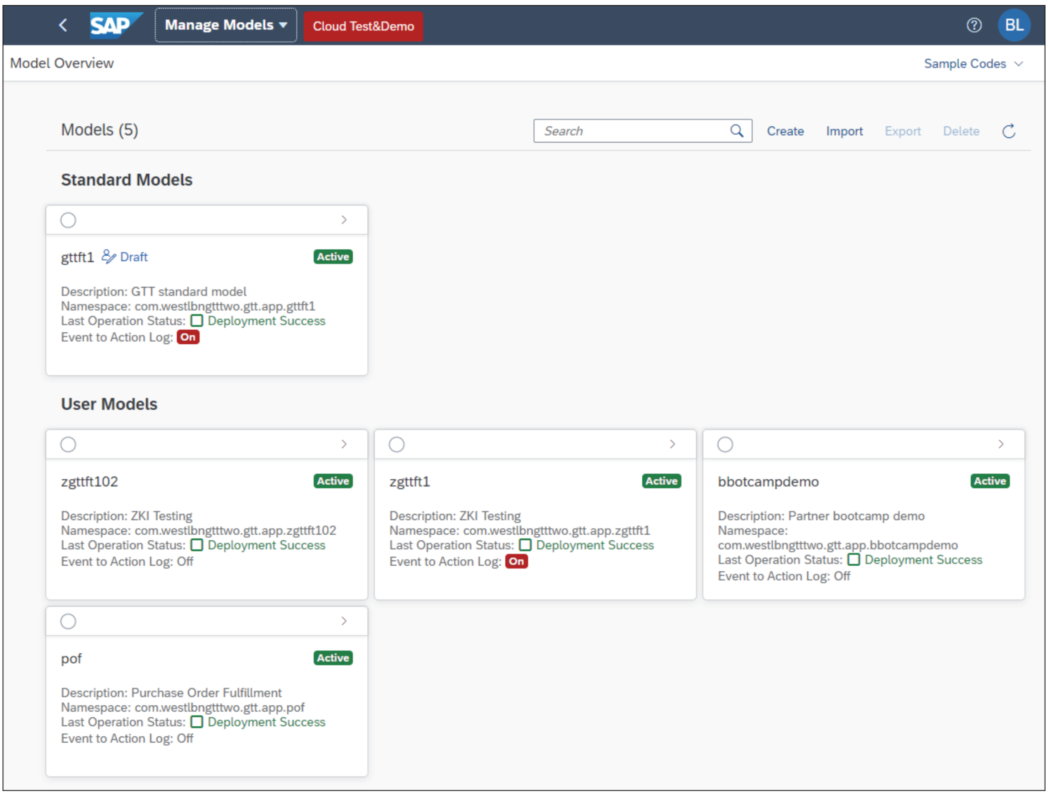


Figure 7.37 SAP Business Network Global Track and Trace Models Overview

If you drill down into the models, you can, for example, see or access the model definition or data used within the models, as shown in Figure 7.38.

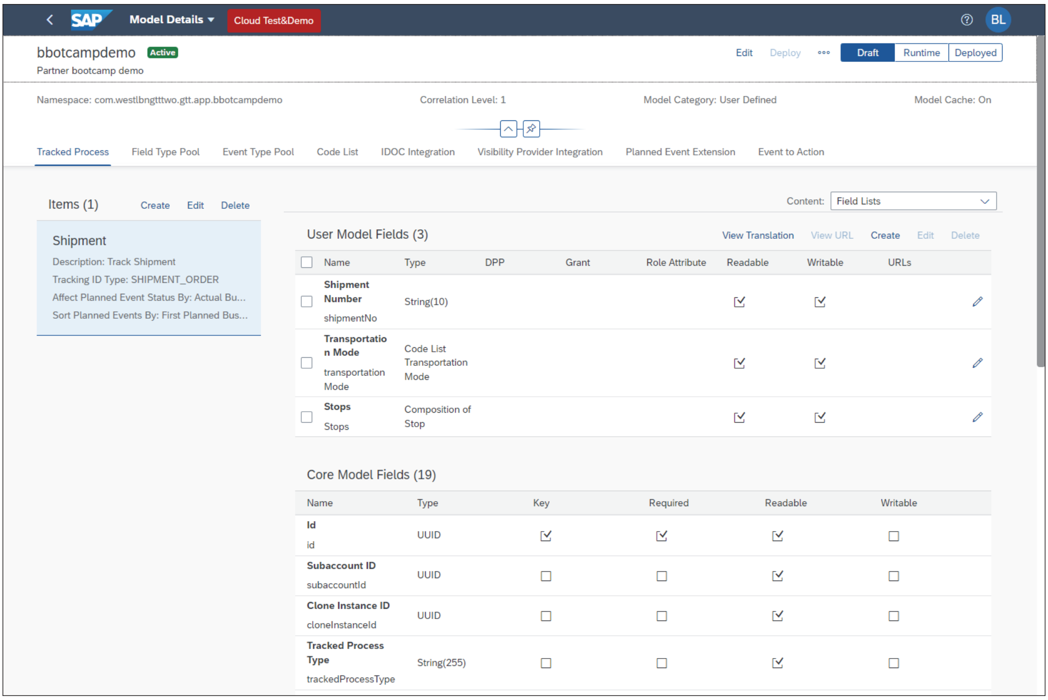


Figure 7.38 Data Usage in SAP Business Network Global Track and Trace Models

Users can build their own models or applications on SAP Business Network Global Track and Trace. The system provides template apps for this purpose, which allow you to easily reuse certain features given by the standard apps of SAP Business Network Global Track and Trace. The templates include the following:

- Model template (can be imported into your Manage Models app)
- ABAP coding – ERP extractor and BAdI implementations
- SAPUI5 frontend coding
- OData read service to be consumed
- Instructions (including basic system setup)

SAP Business Network Global Track and Trace will see further developments and features in the future and is already prepared to support the processes coming with the new digital age of logistics.

7.4 Summary

This chapter gave an overview of how to execute and monitor transportation processes. Regarding transportation execution, we explained how you can work with the result of planning and execute freight orders and freight bookings, introducing the concept of print documents and discrepancies. We also introduced the concept of interaction between an export and import organization and how this can be handled with different sets of documents on either side.

In the SAP Event Management and SAP Business Network Global Track and Trace sections, you learned which visibility options you have with the traditional SAP Event Management or what the new SAP Business Network Global Track and Trace will bring.

In the next chapter, we offer insight into transportation compliance handling in terms of legal and trade compliance and dangerous goods regulations. In addition, we'll look to processes of TM that are supported by connecting to third-party providers in terms of compliance and security.

Chapter 8
Transportation Compliance

In addition to your transportation-related activities, the SAP portfolio supports your legal, environmental, and trade compliance needs. This chapter focuses on two SAP components that can be integrated with transportation management (TM): SAP Global Trade Services (SAP GTS) and product safety and stewardship (PS&S) in SAP S/4HANA. It also introduces the option to interface with compliance services of external providers.

Highly globalized markets and integrated supply chains offer many opportunities to companies acting in international economies. Cross-border and nonstandard business can easily involve risks for supply chains and the environment, as well as being relevant according to numerous national and international regulations. Dealing with such hurdles in an effective manner without neglecting a company's core obligations can be a challenge for many businesses. SAP applications for transportation compliance support you in overcoming these obstacles.

Transportation compliance describes the expectation of abiding by local and international laws and regulations in transportation and logistics. The following list categorizes the different areas of transportation compliance, which may have to be met when you're using TM to manage your transportation business processes (some areas are already handled by SAP S/4HANA):

- **Trade compliance and screening**
  Management of blocked and sanctioned business partners is an important step in compliant trade. This includes blocked documents as well as embargo checks or licenses for any kind of traded materials.
- **Customs management**
  Every country checks incoming and outgoing cargo regarding customs obligations and ensures conformance with national and international trade laws. This requires the creation of export/import declarations to authorities. In addition, trade-related finance services can fall under this category to ensure payment of goods via a letter of credit. Import/export systems that require a data exchange between companies and customs authorities include the following:
  - US Automated Export System and Automated Broker Interface
  - Brazil Nota Fiscal Electronica

- European New Computerized Transit System (NCTS)
- German ATLAS System

- **Special customs procedures**
  The usage, categorization, and further processing of goods can entail various exceptions to regular import/export customs requirements, which are called special customs procedures. Goods that remain in bond, that is, which are brought into a country but remain in a special, enclosed warehouse before being exported again, aren't subject to customs duty. Inward/outward processing prevents custom obligations if goods are being exported, processed abroad, and reimported. Only the value added is subject to customs duty. The same applies for raw materials that are imported and exported again after processing or assembly.
- **Trade preference management**
  Countries have preferences about importing goods from certain countries and prohibitions against others. Trade preference management is the process of managing the eligibility of products for reduced import duty rates by managing supplier declarations and setting a preference origin for products.
- **Intrastat**
  Intrastat is the country-specific provision of data for an intra-European trade. The data is provided in a standardized format to the corresponding customs authorities.
- **Classification**
  For legal control purposes, materials are classified in an appropriate coding system to allow easier determination of rules that are applicable for trade compliance processes. Classification is also used for customs and preference processing.
- **Security filing**
  Security filing is a legal requirement demanded by more and more countries to collect and check information on any kind of shipment and cargo entering the borders or sovereign territory of a country. The process of up-front filing of shipment and cargo information mainly concerns air and ocean transports. It's demanded by security-aware countries such as the United States, China, Canada, Japan, or EU countries and implemented in individual IT-based services, for example:
  - Advanced Manifest System (AMS) in the United States
  - Importer Security Filing (ISF) in the United States
  - Advance Commercial Information (ACI) in Canada

  Security filing requires the carrier or forwarder to send detailed information on the shipped cargo, its packaging (containerization), and the related business partners. The information usually has to be sent at least 24 hours before the corresponding transport leaves the exporting country to receive clearance or otherwise can still be off-loaded and stopped. The cargo may not be shipped with uncleared security status.
- **Dangerous and hazardous goods**
  Dealing with dangerous goods (DG) and hazardous goods exposes companies to additional risks and therefore more responsibilities. Multiple legal regulations must

be followed depending on a categorization of products according to both national and international law. This includes specific requirements for documentation and operational limitations, such as mixed loading prohibitions, and averting the use of unsuitable container types, trucks, or transport of certain goods as cargo on passenger aircraft. Complete import bans or quantity restrictions can be applied to certain dangerous and hazardous goods classes.

The core applications in the SAP portfolio that support your business in dealing with challenges regarding TM transportation compliance are SAP GTS and its related SAP applications, as well as PS&S functionality in SAP S/4HANA. The applications are integrated with TM processes and contain individual functional components to support compliance requirements:

- SAP GTS is part of SAP's governance, risk, and compliance (GRC) portfolio. It's integrated via interfaces with SAP S/4HANA, SAP S/4HANA Cloud, SAP ERP, SAP Extended Warehouse Management (SAP EWM), and SAP TM. We look at SAP GTS in Section 8.1.
- SAP S/4HANA for international trade is a lean implementation of some compliance functions available in SAP GTS and is an integral part of SAP S/4HANA. To better understand the difference between SAP GTS and international trade, see Section 8.1.2.
- PS&S, which works in SAP S/4HANA (as well as SAP ERP) and uses mainly SAP GUI, is well integrated into the TM processes. It's the software component that's used when it comes to DG activities in transportation. PS&S allows DG checks as well as registration, evaluation, and authorization of chemicals (REACH) and dangerous and hazardous goods management. We look at PS&S in Section 8.3.

  SAP S/4HANA for product compliance, which is only available in SAP S/4HANA and uses SAP Fiori, is a new software product and has evolved to have comparable features as PS&S. However, according to the release news for TM as of SAP S/4HANA release 2022, it's not yet supported (see SAP Note 3232331, number 5). Therefore, it's not recommended to use SAP S/4HANA for product compliance in the same client as PS&S, as its functionality isn't compatible with the use of the traditional PS&S. This may change in future releases.

Furthermore, TM offers integration scenarios with compliance and booking service providers via web services. These services are open to be utilized with any provider via SAP Process Integration if the integration and data mapping is provided on the service provider side. We explain these services in Section 8.2.

8.1 SAP Global Trade Services

SAP GTS is the most extensive application in the SAP portfolio for trade compliance management. It's highly integrated into the SAP landscape, especially into SAP S/4HANA and TM, where it's now part of SAP S/4HANA for international trade. In this area, SAP GTS has the following five functional components to support your business:

- **Export management**
  SAP GTS helps you streamline complex export processes to ensure faster delivery to your customers. SAP GTS automates your interactions with authorities due to its numerous interfaces with customs applications.
- **Import management**
  Like the export process, you can expedite customs clearance for import shipments and reduce costly buffer stocks, aiming for just-in-time (JIT) inventory management. SAP GTS allows you to easily classify products, calculate duties, streamline electronic communication with customs authorities, ensure import compliance, and manage letters of credit.
- **Trade preference management**
  You can determine the eligibility of your products for preferential customs treatment and issue certificates of origin to your customers.
- **Special customs procedures**
  This functional component supports you in managing your in-bond customs warehouses. You can drive process efficiency for duty reliefs regarding inward and outward processing and decrease costs by referring duty obligations.
- **Special regional procedures**
  Businesses operating in the European Union can use SAP GTS to manage and calculate the restitution for the export of common agricultural products (CAPs) out of the EU with capabilities to assign securities, manage export licenses, maintain recipes, and calculate and apply for refunds.

In the following sections, we'll explore the functions of SAP GTS (including international trade), explain the integration with TM, and walk through key features and services.

8.1.1 Functional Overview

Let's take a closer look at specific SAP GTS functionality related to logistics and transportation to explain how you can use it in a standard implementation. We'll also take a look at the newest version—SAP GTS, edition for SAP HANA.

> **SAP S/4HANA versus SAP ERP**
>
> SAP GTS functionality is integrated with both SAP S/4HANA and SAP ERP. Keeping in line with our pattern, our discussion will use SAP S/4HANA as the base system with an SAP S/4HANA–based TM solution either embedded or side-by-side.

Import and Export Management

The first key functionality in import and export management is the import/export classification. Companies are required to ensure that they have licenses for certain goods and declare their license codes when filing customs declarations with authorities. SAP

GTS allows you to assign import/export control classification number codes to your existing materials from your SAP S/4HANA system (products in SAP GTS). This functionality is mainly used for shippers because most logistical service providers (LSPs) don't maintain product masters for goods they ship for their customers.

The second core functional component, import and export compliance, is supported by three capabilities: sanctioned party list screenings, embargo checks, and license management. You can use complex checks to screen your business partners for denied parties. This functionality is used with integrated sales orders and purchase orders, financial accounting (to prohibit financial interactions), TM order management, and transport execution. Embargo checks follow the same concept. For both embargo checks and sanctioned party lists, you can use SAP GTS to manage all blocked documents centrally.

Third, SAP GTS has a strong functional component that supports you in generating and processing customs declarations, as well as interacting and communicating with customs authorities. If you work as a shipper, you'll benefit from the goods classification of your materials and product master data. If you work as a freight forwarder, you'll collect most customs-relevant information directly from the shipper/consignee; however, due to the missing product master, the functionality may be limited. SAP GTS offers numerous interfaces to local authorities with standardized e-filing formats.

Special Customs Procedures

Besides numerous obligations and regulations in international trade, authorities still support your international business with certain customs exceptions. SAP GTS supports three key processes to benefit from such duty exemptions.

First, SAP GTS supports you in your customs warehouse activities to store duty-unpaid goods (bonded warehouse). This is permitted in two situations. If you keep cargo in transit before it's shipped to another (possibly yet unknown) country, no duties apply. Alternatively, you can keep a stock of duty-unpaid goods if they are being processed for free circulation with a prescribed end use for industrial assembly. For both cases, SAP GTS is tightly integrated into SAP S/4HANA and extended warehouse management (EWM) (embedded in SAP S/4HANA or standalone SAP EWM) for warehouse processes. When you're receiving inbound deliveries based on POs, SAP GTS can automatically detect whether they are to be treated as in-bond goods. SAP GTS helps you in its integration with EWM to manage stocks of in-transit and duty-unpaid products.

Second, you can manage your processes of free circulation with prescribed end use and processing under customs control. The goods you've imported have a higher duty obligation than the finished product they might be used for in an assembly or industrial process. SAP GTS supports identification of goods that qualify for such treatment, monitoring stocks, warehouse movements, and interactions with authorities to calculate duty deductions. It's integrated with both SAP S/4HANA and EWM.

Third, you can declare goods for outward and inward processing. This process aims at you as a manufacturer, exporting products into another country for processing and reimporting them for assembly/disposition (outward processing). You must pay customs duties only for the newly added product components/value. The import process works the other way around. You must declare products for inbound processing if you intend to reexport them after processing. Again, SAP GTS is the core application that supports this process, which is integrated into billing documents and orders.

SAP GTS, Edition for SAP HANA

With the new SAP GTS, edition for SAP HANA (as of release 2020), SAP GTS also moved away from its traditional main menu screen to the new SAP Fiori launchpad functionality, which is much more in line when it comes to user interactions spanning multiple system instances. In Figure 8.1 you can see the launchpad and an example app—the Manage Blocked Documents app—from the new SAP GTS, edition for SAP HANA.

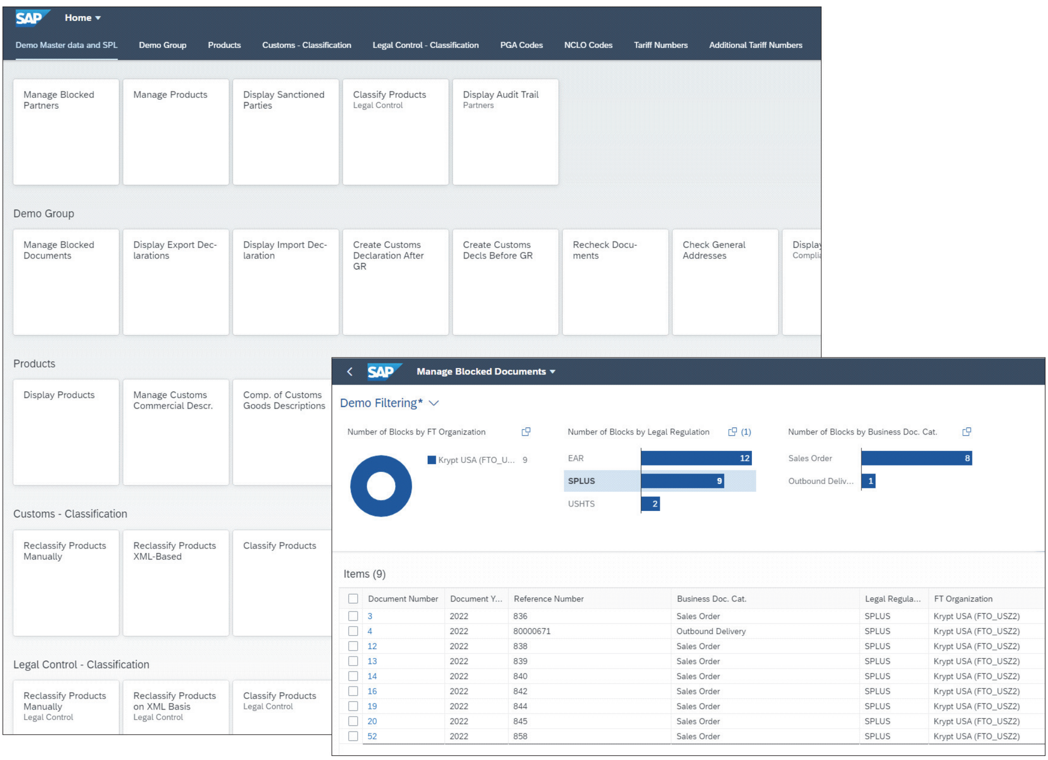


Figure 8.1 SAP Fiori Launchpad and Apps for SAP GTS, Edition for SAP HANA

8.1.2 International Trade

As mentioned in the first section of this chapter, you may use trade compliance functionality either based on the full-featured SAP GTS or as part of SAP S/4HANA for international trade. Table 8.1 shows you the differences between both components. International trade is part of the SAP S/4HANA core and can be used free of additional license payment.

Functional Areas of Trade Services	Coverage (SAP GTS)	Comment	Coverage (SAP S/4HANA for International Trade)	Comment
Export/import classification	Full	Commodities and various code systems	Partial	Commodities and some code systems
Export/import compliance	Full	Full and partial embargos, nested licenses and agreements	Partial	Full embargos, simple licenses, no bill of material handling
Outbound customs services	Full	Direct customs filing and brokers	None	
Inbound services customs	Full	Direct customs filing and brokers	None	
Business partner screening	Full	Various content systems and integration to sales, procurement, and transport	None	
Customs warehouse	Full	EU customs warehouse	None	
Special customs procedures	Full	Inward and outward processing and foreign trade zones	None	
Trade preference management	Full	Inbound aggregation and preference determination	None	
Special regional procedures	Full	Intrastat and security filings	Partial	Only Intrastat

Table 8.1 Comparison of Functional Areas of SAP GTS and SAP S/4HANA for International Trade

8.1.3 Integration of SAP GTS and TM

The previous section explained the process of how logistics-relevant functional components of SAP GTS are integrated into systems, such as SAP S/4HANA, TM, and EWM.

Table 8.2 summarizes the SAP applications that are linked to different functional components of SAP GTS.

Functional Areas of Trade Services	SAP S/4HANA	EWM	TM
Export/import classification	X		
Export/import compliance	X		
Export declaration	X		X (freight order, forwarding order manual and automatic)
Import declarations	X		X (forwarding order)
Transit procedures			X (freight order open and close, freight unit)
Business partner screening	X		X
Customs warehouse	X	X	
Special customs procedures	X	X	
Trade preference management	X		
Special regional procedures	X	X	

Table 8.2 Functional Areas in SAP GTS and Integration to/Use of SAP Components

Technically, most of the components working with SAP GTS are connected via remote function calls (RFCs). TM is an exception here, as web services are used to connect the business objects of TM with the objects and services in SAP GTS. Another exception is the connection to SAP Analytics Cloud. You can see an overview of the available connections in Figure 8.2.

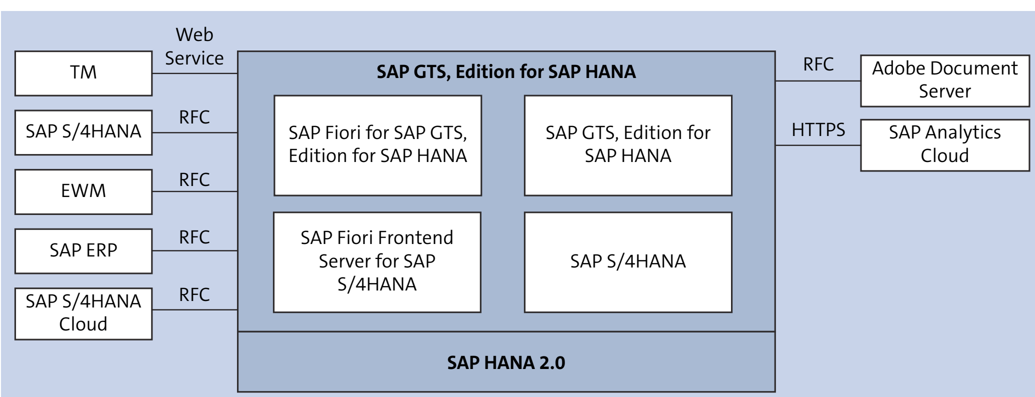


Figure 8.2 Technical Connection between SAP GTS, Edition for SAP HANA and Other SAP Components

Let's shift our focus to the functionality that is used in the integration between TM and SAP GTS only. From a transportation perspective, the transactional process is enabled for two major technical objects in TM: the transportation request (TRQ) representing the customer order side, and the transportation order (TOR) for the subcontracting side.

Integration of Master Data

With TM in SAP S/4HANA, master data no longer needs special integration. You only need to synchronize the master data from your backend SAP S/4HANA or SAP ERP system to SAP GTS if SAP TM is running standalone. After a successful integration of master data, you need to enrich records with additional SAP GTS–specific information, such as product classifications (to identify goods based on customs authority definitions) or product groupings (which allow logical grouping of goods with equal customs requirements). Additional master data needs to be maintained directly in SAP GTS because it's used solely in SAP GTS, for example, country groupings (assignment of country of departure and country of destination to country groups), customs list (import/export classification numbers), licenses for import/export, and sanctioned party lists.

Integration of Transactional Data

The transactional integration between SAP GTS and TM is based on web services using SAP Process Integration. Alternatively, it's possible to define point-to-point (P2P) connections without going via SAP Process Integration but still facilitating the Enterprise Services Repository (ESR) in SAP Process Integration. Freight orders and forwarding orders are the main transactional documents that are interfaced with SAP GTS for specific functionality. Figure 8.3 shows which objects can be used for which functionalities in the integration with SAP GTS.

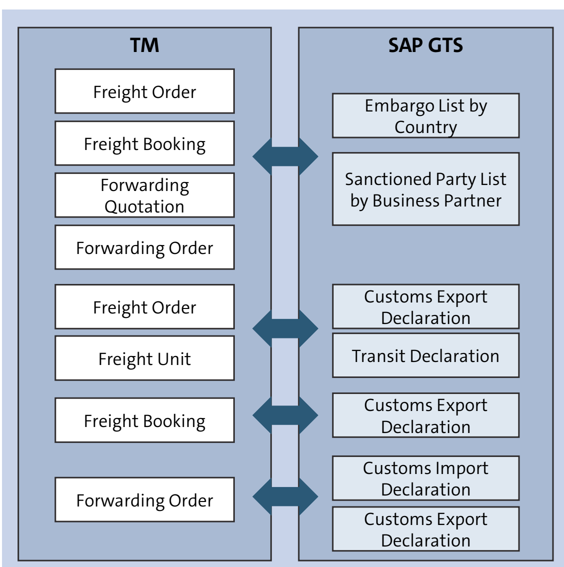


Figure 8.3 Integration of TM and SAP GTS

The forwarding order, for example, can be validated against a sanctioned party list because this is where you maintain your shipper, consignee, and other business partners. In the upcoming sections, we'll introduce the details of the functionalities in the transactional context. It's important to highlight that the integration between TM and SAP GTS for customs services is currently available only in the standard for export customs services, export compliance, and import services and compliance for particular business objects.

8.1.4 Export Compliance for Sanctioned Party Screening and Embargo Checks

Various historical events, especially the terrorist attacks of September 11, 2001, led to stricter legal regulations to monitor and blacklist companies if they violate local law. Different countries and legal authorities have issued blacklists that name all businesses and individuals with whom it's prohibited to have a business relationship, including import and export of goods. Companies are legally obliged to check their business partners against government blacklists of sanctioned parties. The challenges in this process are that companies can have thousands or even millions of records of business partners with various spellings and addresses. Blacklists frequently change and require updates, which makes manual maintenance very difficult, if not impossible.

It's similarly relevant for both shippers and freight forwarders to validate business partners and check destination or transit countries against sanctioned parties and embargo lists that appear in your orders and freight documents. Figure 8.4 gives an overview of the entire process for both shippers and LSPs.

In the white boxes on the right side, you can see the LSP-specific objects, such as the forwarding order. The white boxes on the left illustrate the shipper scenario. Some objects are relevant for both LSPs and shippers, such as the freight units, freight orders, or freight bookings. As a shipper, you can start the process for compliance checks by creating orders and deliveries in SAP S/4HANA. Alternatively, as a freight forwarder or carrier, you would start the process by creating a forwarding order directly in TM.

Figure 8.5 shows that an LSP performs the compliance checks directly when capturing a forwarding order or providing a quotation to a customer. This allows you to prevent the creation and execution of an order very early in the process. After a forwarding order is created, it's automatically blocked for execution with the category **Compliance**.

After the document is saved, the business partners and country information are handed to sanctioned party list screening for validation. SAP GTS returns the compliance status as either **Not Compliant** or **Compliant**. If a business partner or country is detected as blacklisted or under an embargo, you can cancel the forwarding order or manually release the business partner or document as compliant in SAP GTS to release the execution block in the forwarding order.

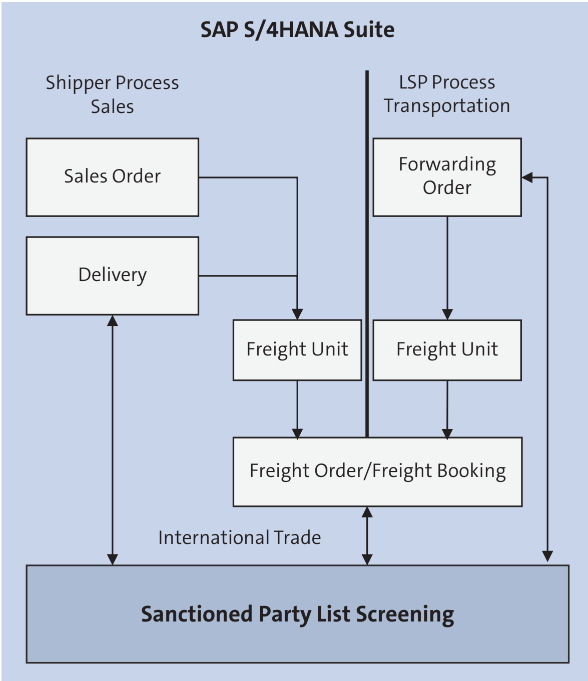


Figure 8.4 Sanctioned Party Checks with TM and SAP GTS (International Trade)

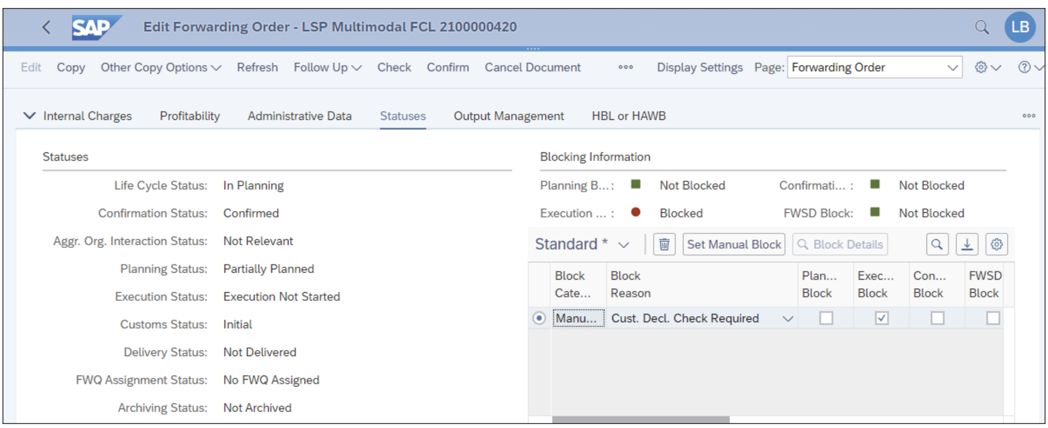


Figure 8.5 Blocking for Sanctioned Party Screening in Forwarding Order

If you work as a shipper, you don't use the forwarding order. Instead, you can perform the compliance checks either from the sales and distribution documents in ERP or after transportation planning from either the freight order or the freight booking. As an LSP, you can use the same functionality to validate freight orders and freight bookings. After you've successfully created a freight order or freight booking, the compliance status is set to **Not Checked**, and the execution block is activated. Only after you save the document is the interface to SAP GTS triggered. SAP GTS again validates the business partners and countries against blacklists and embargos. The document is released or blocked, depending on the screening result. You can now handle the exceptions of blocked freight orders or freight bookings in SAP GTS. You can monitor all blocked documents and business partners and manually release them with the appropriate reason code (e.g., a mistaken identity).

In TM, very few Customizing settings are required to enable embargo checks and sanctioned party screenings. You must select the **Enable Compliance Check** checkbox for the following document type: forwarding order type, freight quotation type, freight order type, and freight booking type.

To enable the sanctioned party screening and embargo checks in SAP GTS, you have to configure activities in international trade Customizing:

- Maintain the Customizing table to enable the sanctioned party checks for different business partner functions.
- Define the check rules for the sanctioned party screening (e.g., using address information and keywords).
- Assign the defined check rules to a legal regulation, such as the German Foreign Trade Regulations. You can specify which types of sanctioned party lists should be considered, as well as audit trails and notification workflows.
- Enable embargo checks and implement active legal regulations (e.g., the UN embargo regulation). For each legal regulation, you can select settings to assign business partner groups that are relevant for checks.

8.1.5 Export Customs Services

To process your international shipments successfully, as both a freight forwarder and a shipper, TM offers integration with international trade for export customs services. You can check whether your outgoing shipments are customs relevant, depending on the origin and destination country of the shipment. You can't process a shipment without appropriate legal documentation, so the application blocks orders and shipments until appropriate documentation has been issued. SAP GTS supports the generation of the customs declaration and the electronic communication with authorities via Electronic Data Interchange (EDI). SAP GTS supports the creation and printing of export documentation based on customs (e.g., legally required documentation), compliance (legally required certificates), and customer-specific requirements (individual documents).

Figure 8.6 shows the process overview for both a freight forwarder (top row) and a shipper (bottom row). As the central application, SAP GTS is used the same way for shippers and freight forwarders. The major difference is that a freight forwarder triggers the generation of a customs declaration directly from the order, whereas a shipper starts the generation of a customs declaration from a freight order or freight booking.

The first activity in export customs processing is to check whether the forwarding order or freight order/freight booking requires customs documentation at all. For shipments within the European Union, for example, no export customs declaration except Intrastat reporting (standard with SAP GTS) is required. When you save your document, the customs relevance check is automatically performed directly in TM. If the result is customs relevant, you see that the freight order/freight booking is automatically blocked from execution for the reason **Customs Declaration Check Required**.

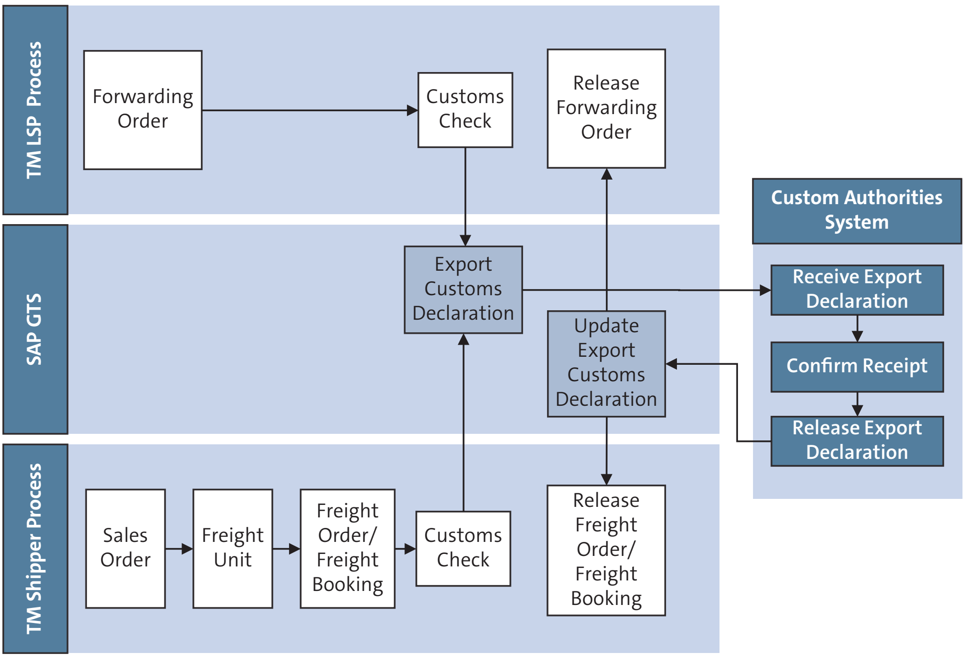


Figure 8.6 Process Overview for Export Customs Services

We'll take a closer look at how to manage and configure export customs in the following sections.

Export Customs Declaration Management

After a freight order/freight booking or a forwarding order has been identified as customs relevant, you need *customs groups* because each freight order/freight booking or forwarding order can contain multiple consignees or goods sellers, and you might need to generate a separate customs declaration for each one. The freight unit items are grouped together in a customs group. Each customs group created in TM generates one export customs declaration in SAP GTS. You'll see that the generation of customs groups happens automatically and is flexibly configurable. At least one customs group is required to generate an export declaration in SAP GTS. Each TM object—the forwarding order, freight order, and freight booking—has a **Customs** tab on the items to manage customs details and show the latest statuses.

You can create the export customs declaration by choosing **Customs • Create Export Declaration**. SAP GTS offers you the ability to monitor all incoming and generated declarations. You can perform the setup for customs checks in the IMG under **Transportation Management • Basic Functions • Global Trade**. Here, you can define and assign customs-relevant checks, activities, and profiles.

After the communication has been sent, and a successful answer is received from the authorities, a reference number (e.g., the movement reference number [MRN]) is returned to both the export declaration in SAP GTS and the related forwarding order or freight order/freight booking in TM. The customs status in TM changes to **Approved**. Only now is the TM document released from the execution block. For a rejection or hold, the corresponding documents in TM stay blocked with an appropriate status.

Configuration for Export Customs Management and Services

To enable the process of export customs integration between TM and SAP GTS, you need to perform settings in both components. You can define multiple ways to split the items of a freight order or freight booking. There are two standard methods provided to group the items: per consignee and per LSP. This is defined in a method that you can access by following menu path **Transportation Management • Basic Functions • Process Controller • Define Method**, for example, method `GT_B_EX_FU` providing a grouping for **Build Customs Groups: Export by LSP**.

The last step is to assign the method to a strategy. As a result, the strategy combines the service and method for splitting and grouping items. We use the strategy later and assign it to a customs profile.

The customs relevance check defines whether a freight order or freight booking in TM requires customs clearance. This differentiates all national shipments from international transports. The customs relevance check can be defined via menu path **Transportation Management • Basic Functions • Global Trade • Define Customs Relevance Check**. You must maintain the status values that you want to be displayed depending on the processing status of a customs procedure (e.g., **Requested**, **Approved**, etc.). Follow menu path **Transportation Management • Basic Functions • Global Trade • Define Cumulation of Customs Statuses**.

A customs activity combines some of the settings we described, such as the customs relevance check and the process controller grouping strategy. These settings determine what status an object (e.g., freight order) needs to have for TM to trigger the check of customs requirements. Last, the customs activity contains the list of all status values related to the customs process that will be displayed in your documents.

8.1.6 Import Customs Services

To ensure end-to-end transportation across countries, more than an export declaration is required from a customs service perspective. You also need an appropriate import declaration to declare goods and determine customs duty. Alternatively, you can issue a transit procedure if goods aren't declared at the border and will be transported duty-unpaid or under bond. The importing country can have very specific requirements for the content and procedure for import declarations and transit procedures.

We must emphasize that this functionality in standard TM doesn't have an integration with SAP GTS. The process is executed standalone and manually in TM. A business add-in (BAdI) is provided to implement a custom integration, which we cover shortly. The functionality of the import customs declaration is aimed solely at LSPs and freight forwarders acting as the customs broker for a shipper. Consequently, the functionality is enabled only for the freight unit object in combination with the import forwarding order. The transit procedure also involves your freight documents.

When generating an import forwarding order in TM for a customer, you first need to select the **Import Declaration by LSP** checkbox in the **General Data** tab. If a customer always requires import customs clearance, you can maintain this checkbox on the business partner as well, which defaults it to the forwarding order. Per forwarding order item (e.g., products and containers), you can find the **Customs** tab. In this tab, it's necessary to specify what customs activity needs to be performed for the forwarding order item. You can choose between a transit procedure and, in our case, the import declaration. You also need to specify in which location the cargo is imported to a country. Select **Customs • Create Import Declaration** in the top panel of the forwarding order to generate the customs groups, for example, based on the customs location. The forwarding order is blocked for execution because processing and approval of the import declaration is required. You need to set the status to **Customs Declaration Approved** as you receive the actual approval from the customs authorities. As mentioned earlier, the entire generation of the customs declaration—as well as its submission to and handling by customs authorities—isn't supported as of the time of writing. After the status for all freight unit custom groups is set to **Customs Declaration Approved**, the forwarding order is released from the execution block.

As an alternative to the import customs declaration, you can generate a transit procedure. Navigate to the **Customs** tab in the forwarding order items, and set the inbound customs activity as **Transit Procedure**. You can enter relevant data, such as commodity codes. In the **Stages** tab, you can mark each transportation leg (each stage) that requires a transit procedure for each freight unit in the forwarding order. After you've planned your forwarding order and assigned the freight units to freight orders and freight bookings, TM automatically marks the same stages in the freight documents as **Transit Procedure Relevant**. The freight documents that are affected can be blocked for execution. You can open and close transit procedures to indicate whether the goods are currently in transit (e.g., between the border to a trade union and the transit end location). To open a transit procedure, navigate to the freight document, and select **Customs • Open Transit**. You can manually interact with the authorities, and, as soon as the transit is approved, change the status to **Open Transit Approved**. You can also store the customs document number and MRN manually; these are provided by the authorities. The freight document is released from an execution block.

A similar process can be followed to close the transit procedure: choose **Customs • Request Unload**. TM generates a new customs activity and customs group, which can be processed manually to reflect the offline interaction with authorities. Each customs group's status can be changed to **Transit Unload Approved**. In addition to the capability of opening a transit procedure from a freight document, you can trigger it directly from a freight unit. The closure still happens from the freight document.

To enable import customs management in TM, you must perform configuration in Customizing. First, you need a forwarding order type with a traffic direction of import. Set **Customs Handling** to **Automatic**. Only forwarding orders that have been set to automatic customs handling are considered for import customs. All other required settings are very similar to the export declaration.

Another requirement is to set up the process controller by using an import declaration strategy (`IMP_FU`) and a method (`GT_B_IM_FU`). The transit procedure must be set up the same way (e.g., strategy `TRA_OPEN`, `TRA_CLOSE`, and `TRA_OPENFU`). To do this, follow menu path **Transportation Management • Basic Functions • Process Controller**. You must also implement the customs relevance check, a customs activity, and a profile—just like the export process. A key difference from the export process is that you need to assign the customs profile to a freight unit type. To enable both the transit procedure and import customs declaration, you need to generate two separate customs activities and assign them to a customs profile.

To enable automated communication with customs authorities via a customs management application, such as SAP GTS, you can implement a BAdI provided in standard TM. You can find the BAdI in TM Customizing via menu path **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management • Basic Functions • Global Trade • Declarations**.

8.2 External Compliance Service Providers

TM already has a comprehensive coverage of export and import functionality in conjunction with SAP GTS. However, as customers—especially LSPs—often need a broader scope in terms of supported countries or functional depth, SAP has introduced enterprise services to connect to external compliance service providers and booking services.

These interfaces have been developed with the Descartes Systems Group, which offers a wide range of shipment- and connectivity-related services for the logistics industry as part of their Global Logistics Network (GLN).

The SAP side of the interfaces is designed generically as a web service. There isn't a direct integration with a security filing service such as Automated Manifest System (AMS) available, but the SAP interface is mapped by the provider into the relevant format and the actual data exchange, and detailed process handling is done through the provider. This means that the scope of possible compliance scenarios is defined mainly by the service provider enabling the various country- and regulation-specific procedures, which, in many cases, also need to be certified by the government agencies behind them.

The compliance interfaces are initiated in TM via the Post Processing Framework (PPF). A decision on when to trigger communication via the interfaces is controlled through settings in Customizing via menu path **Transportation Management • Basic Functions • Global Trade**, where you find settings to define customs activities, profiles, customs relevance checks (including security filing related settings), and so on. Figure 8.7 shows Customizing settings for the definition of customs activities, where you can, for example, set up the status handling and relevance checks for US security filing for import processes.

After the relevance checks for customs activities have been successfully completed, and the activity is triggered either manually or automatically, the communication is initiated via PPF. The security filing information is transmitted using the same physical message format as the customs filing/declaration. The type of filing required is defined in the message content. The system also uses the same message types for triggering and handling the filing processes from the TRQ/forwarding order and TOR objects.

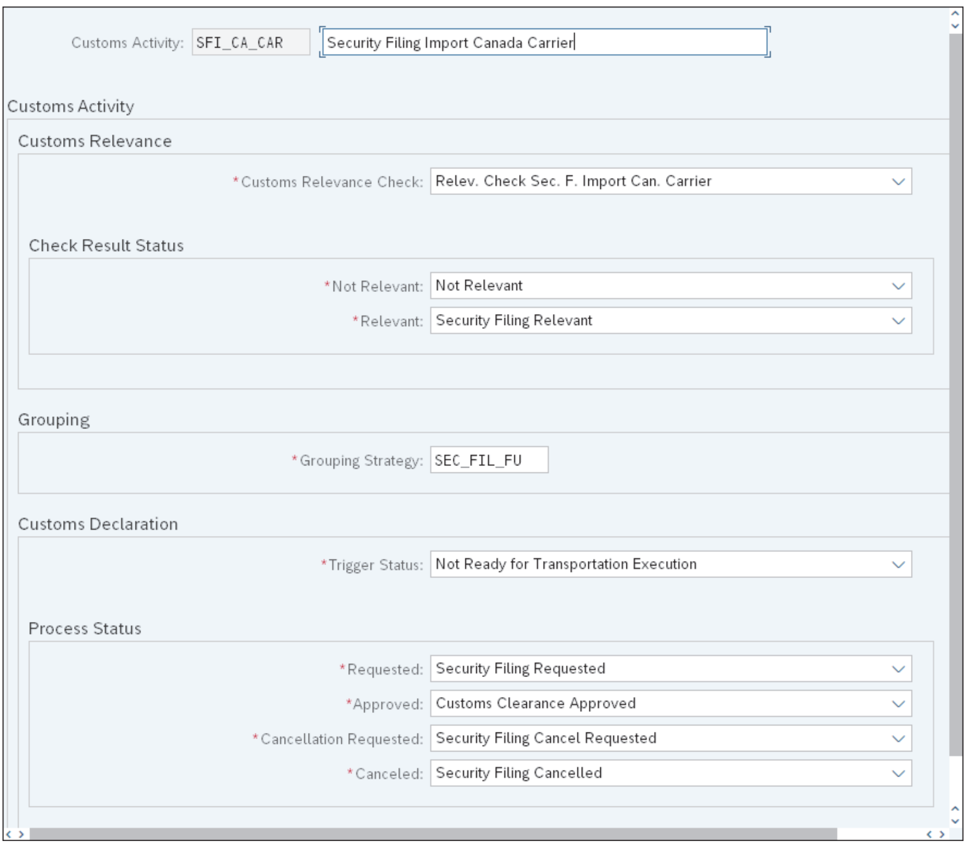


Figure 8.7 Customizing Settings for Security Filing (Example)

During the filing process, the TM order isn't updated but stays blocked for execution. An intermediate filing status can be reviewed in the integrated compliance partner system, such as the Descartes GLN. After the government agencies respond with a release or rejection, the corresponding information is converted back by the compliance service provider into the TM web service message and then transmitted back to update the TM order. For a release, the execution block is reset, and the processing can continue. For a rejection, the execution block stays. You may view the detailed reasons for the rejection in the compliance partners portal. You can see the available integration scenarios in Figure 8.8.

Export and import declaration handling, as well as trigger of a transit procedure, can be achieved in a similar way as the security filing. Relevance determination starts the configured relevance rules for customs filing.

The air freight booking process with partner systems, such as Descartes Global Freight Exchange (GF-X), uses the standard mechanisms supplied with TM in the scope of the freight booking. Sending a booking request message is triggered by invocation of the **Send Booking** action in the air freight booking object. The same functionality can, of course, also be used for ocean freight bookings; however, the necessary adaptation and mapping of messages hasn't been provided so far with respect to partner booking systems.

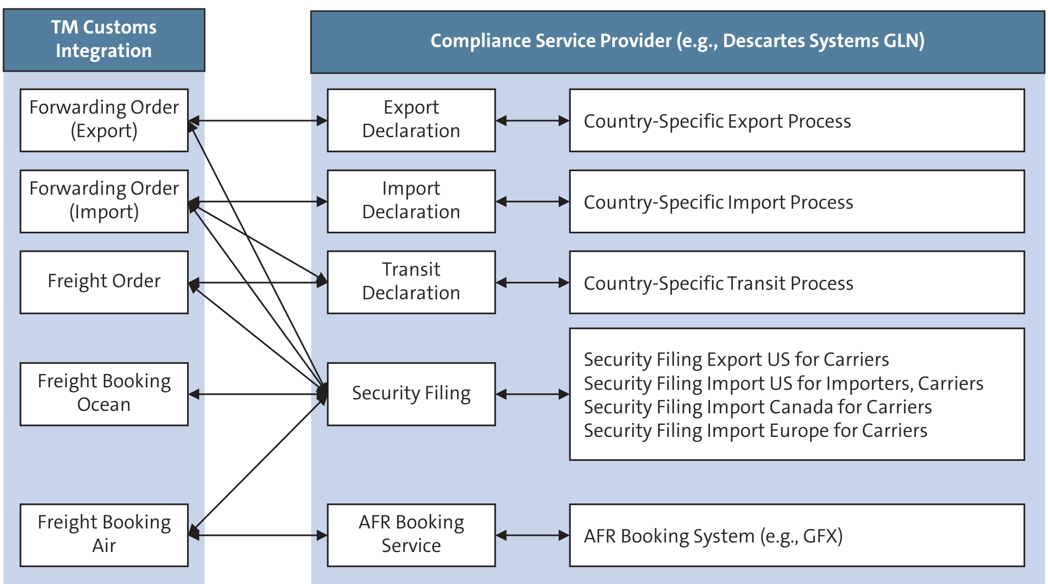


Figure 8.8 Integration Scenarios between TM and External Compliance Service Providers

The action to send the booking sets the corresponding communication status in the freight booking, which is subsequently updated by receiving a booking confirmation or booking rejection from the carrier or partner booking system.

8.3 Dangerous Goods

Cargo moved in shipments often needs to be transported in line with DG compliance regulations. DG compliance—also known as DG handling, hazardous materials, hazmat, or dangerous and hazardous (DnH)—refers to dealing with material solids, liquids, and gases that can harm people, other organisms, or the environment. Shipments moving these DG can therefore have a direct influence on the environment, the health of people who are in contact with them, and the safety of all surrounding material objects. The risk of moving DG is based on multiple factors and characteristics:

- The characteristics of the material itself and the impact on the environment, including whether it's flammable, explosive, corrosive, radioactive, oxidizing, toxic or asphyxiating, pathogenic or allergenic, or biohazardous in nature
- The risk of inappropriate transportation or handling, which includes improper or damaged means of transport; unsuitable transportation routes; and unqualified, unreliable, or overworked personnel
- Risk factors due to external influences, such as terrorism

In SAP S/4HANA, you can perform checks to ensure safe and compliant transportation of DG. These checks reflect the international and national regulations regarding DG transport and depend on transportation mode, transit countries, and other factors. SAP S/4HANA PS&S provides a framework for delivering certain checks. It's used in combination with TM and consists of several components:

- Basic data and tools
- Product safety
- Occupational health
- Industrial hygiene and safety
- Waste management
- DG

From this set of components, basic data, tools, and DG verifications and activities are integrated with TM.

8.3.1 Dangerous Goods Regulations

Dangerous goods regulations (DGR) differ by mode of transport, issuing country or region, verifying transportation organization, and activity category or material status. For example, warehouse handling rules for flammable materials in the United States may differ from regulations that determine flammable materials transportation rules in Switzerland, especially in tunnels.

Several globally valid DG agreements and regulations are relevant for transportation. The following are some important ones:

- **International Maritime Dangerous Goods (IMDG) Code**
  The IMDG has been defined by the International Maritime Organization (IMO) to standardize terminology, packaging, labeling, and markings of DG and advice on stowage, segregation, handling, and emergency reactions for DG transport on vessels.
- **IATA Dangerous Goods Regulations**
  The International Air Transport Association (IATA) is the governing body of airlines and published the 64th edition of the *Dangerous Goods Regulations* in 2023. *Dangerous Goods Regulations* is a guide to safely shipping cargo or passenger luggage by air.
- **ICAO Safe Transport of Dangerous Goods by Air**
  The International Civil Aviation Organization (ICAO), which is an association of countries, has defined joint rules for safe air cargo transportation in annex 18 of their international standards and recommended practice (SARP).
- **Hazardous Materials Regulations (HMR) of the Code of Federal Regulations (CFR)**
  The HMR is regulated by the US Department of Transportation (DOT) in Title 49 CFR Parts 171-180. The HMR applies to transportation of hazardous materials in interstate, intrastate, and foreign commerce by aircraft, railcar, vessel, and motor vehicle.

Some European regulations are also commonly used:

- **Regulations concerning the International Carriage of Dangerous Goods by Rail (RID)**
  The RID, issued by the Intergovernmental Organization for International Carriage by Rail (OTIF), regulates DG processes on rail cargo for European, Middle Eastern, and some North African countries.
- **European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)**
  ADR regulations are targeted at transnational transport of DG in Europe and were launched by the UN Economic Commission for Europe (UNECE).
- **European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN)**
  Like ADR, ADN regulates the transport of DG on inland waterways in Europe.

8.3.2 Dangerous Goods Classification

DG classification is to some extent harmonized through the UN "Recommendations on the Transport of Dangerous Goods" with the goal of making it easy to understand what kind of cargo is transported and what hazards are entailed without having in-depth knowledge of chemistry or physics. DG are divided into the following classes:

- Class 1: Explosive substances and articles:
  - 1.1: Substances and articles that have a mass explosion hazard
  - 1.2: Substances and articles that have a projection hazard but not a mass explosion hazard

- 1.3: Substances and articles that have a fire hazard and a minor blast hazard, minor projection hazard, or both, but not a mass explosion hazard
- 1.4: Substances and articles that present no significant hazard
- 1.5: Very sensitive substances that have a mass explosion hazard
- 1.6: Extremely insensitive articles that don't have a mass explosion hazard

- Class 2: Gases, including gases and vapors compressed, liquefied, and dissolved under pressure:
  - 2.1: Flammable gases (e.g., butane and propane acetylene)
  - 2.2: Nonflammable and nontoxic, likely to cause asphyxiation (e.g., nitrogen and CO2), or oxidizers (e.g., oxygen and fluorine)
  - 2.3: Toxic (e.g., chlorine and phosgene)
- Class 3: Flammable liquids
- Class 4: Flammable solids:
  - 4.1: Flammable solids, self-reactive substances, and solid desensitized explosives
  - 4.2: Substances liable to spontaneously combust
  - 4.3: Substances that, in contact with water, emit flammable gases
- Class 5: Oxidizing substances and organic peroxides
  - 5.1: Oxidizing substances
  - 5.2: Organic peroxides
- Class 6: Toxic and infectious substances
  - 6.1: Toxic substances
  - 6.2: Infectious substances and biohazardous materials
- Class 7: Radioactive material (e.g., uranium and plutonium)
- Class 8: Corrosive substances (e.g., acids and alkalis)
- Class 9: Miscellaneous dangerous substances and articles (e.g., asbestos, airbag inflators, self-inflating life rafts, and dry ice)

Detailed material classification is given by the four-digit UN number (currently, the number range is from 0001 to 3600). We recommend referencing, for example, UN resources for a detailed list of UN numbers or general resources (*https://en.wikipedia.org/wiki/Category:Lists_of_UN_numbers*).

8.3.3 Requirements for Dangerous Goods Checks in Transportation

DGR cover various aspects of DG handling, movements, accident avoidance, and legal documentation. In transportation, a subset of these requirements is applicable, and they differ slightly from a shipper's and an LSP's perspective.

Shippers involved in transportation usually have very detailed master data on the products and materials they manufacture or trade. The corresponding master data records are home to the related DG characteristic that controls the processing and documentation behavior in transportation. For shippers, the DG master data is maintained in the SAP S/4HANA material master definition. The applicability of a DG check for a shipper depends on whether the shipper is executing and planning transportation versus subcontracting it to an LSP.

In the first case, the shipper is obligated to thoroughly execute all checks required and provide its personnel with appropriate training and transportation documentation, such as a shipper's declaration for DG or DG sheets. If the shipper subcontracts complete DG transportation, the shipper needs to simply provide accurate DG data for the forwarding orders to the LSP.

An LSP that actively handles DG transportation usually doesn't have detailed master data records for the materials shipped (unless it's a contract logistic business, where the LSP manages the supply chain for the shipper). In this case, the forwarding order needs to bring the correct and detailed classification for the forwarding order items that allow running the checks for transportation of DG. Checking for DG in transportation encompasses the following auditing steps (see also Figure 8.9):

1. Check the forwarding order to determine whether transportation of the ordered items can be done at all. It may not be feasible for the following reasons:
   - There are no appropriate vehicles or trained personnel.
   - Certain materials (e.g., ammunition) aren't accepted.
   - Origin, destination, or transit countries don't allow the materials to be shipped.
2. Check a single forwarding order or freight unit to determine whether quantities, packaging, and shipment properties comply with the regulations:
   - Certain quantities can't be exceeded.
   - Certain material combinations can't be shipped together at all or together in one transportation or packaging unit (on a pallet, in less than *x* yard distance, in the same container, on the same truck, etc.).
   - The evaluation of all cargo items must not exceed a certain limit in an evaluation scale (e.g., "1,000-point rule").
   - Certain materials aren't allowed to be shipped on certain routes (e.g., flammable liquids in tunnels).
3. Check a consolidation of cargo or transportation plan details during or after transportation planning. All rules for the single forwarding order are applicable here too:
   - Respect quantity limits, prohibited combinations, overall evaluation of hazard potential, allowed vehicles, and allowed shipping routes for the consolidated cargo.
   - In multistop shipments, loading limits for each stop need to be checked individually. For example, for a container line business, there are certain limits on the number of containers that can be loaded or unloaded in a port.

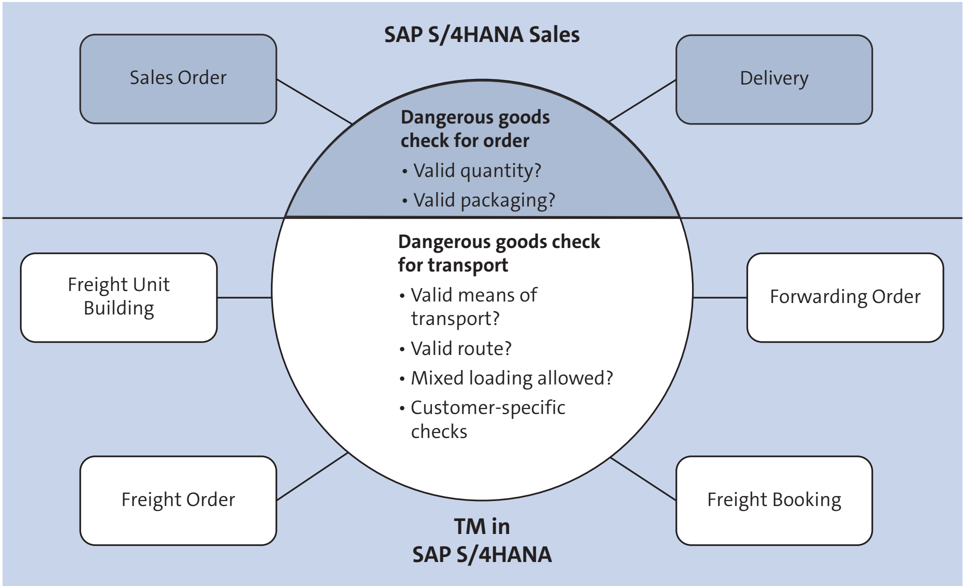


Figure 8.9 DG Checks for TM in SAP S/4HANA

TM can perform many of these checks, but for some others (e.g., the load restrictions per port), the use of custom extensions is required.

8.3.4 Dangerous Goods Checks Configuration for TM

Companies handling DG in transportation need to prepare their SAP S/4HANA system for use of the DG compliance functionality in the following areas:

- Product master–related DG compliance settings
- Sales and distribution–related DG compliance settings
- Transportation-related DG compliance settings

We'll discuss each in the following sections.

Product Master Settings

Manufacturers and shippers need to maintain their product master data for raw, semi-finished, and finished goods to be procured, used in production, or sold in materials management or sales and distribution. For each maintained product, you can define additional DG data (as described in Chapter 3, Section 3.1.4). SAP S/4HANA offers a variety of processes for DG compliance for shippers and manufacturers in terms of handling their distribution requirements:

- **Packaging proposals in deliveries**
  In the handling unit (HU) functions of delivery management, the system can propose allowed DG packaging codes based on packaging data in the DG master. In

addition, proposing allowed packaging materials is done based on packaging codes and packaging approval specification.

- **Packaging and mixed packing checks within a delivery**
  If incompatible or noncompliant DG are packed together but have UN numbers that aren't allowed to be packed together, the system sends an error message and blocks further processing.
- **Mixed loading checks and transit country checks for SAP S/4HANA basic shipping**
  Shippers using the transportation functionality may use the DG checks embedded in the SAP S/4HANA basic shipping scope. The HU-based mixed packing checks work the same way here as in the delivery. In addition, the checks are implemented across all deliveries assigned to the shipment. If the route and stages of the shipment have been defined, DG checks can also be done for the transit countries passed.

Dangerous Goods Integration for Decentralized TM

In scenarios and systems where SAP S/4HANA is the main operational system for production and delivery processes, data integration for DG is already embedded in the system. If you're using a decentralized TM system, master data integration between the instances is done via DRF. In this case, the following data transmission procedures are used provide DG checks:

- Transfer of DG master data from the main SAP S/4HANA system to the SAP S/4HANA TM system:
  - DG master data and text phrases are distributed via Application Link Enabling (ALE) integration. This is still the same process as in SAP ERP versions.
  - The material master of SAP S/4HANA is distributed via the DRF.
- Transactional data transmission is embedded in the integration processes between SAP S/4HANA sales orders and order-based transportation requirements (OTRs) and between SAP S/4HANA logistics execution deliveries and delivery-based transportation requirements (DTRs). The required DG data and master data records are provided via web services to SAP S/4HANA TM business objects, where they are available as references to the DG master.

After material and DG master data have been transmitted to the decentralized TM system, the DG checks are technically done in the same way as in an embedded system.

Configuration

Many settings can be found under the PS&S services topic of transportation basic functions in the Customizing IMG of the SAP S/4HANA system. Before you can use the DG checks of SAP S/4HANA PS&S, you must enable the checks in Customizing. If you follow IMG menu path **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PS&S • PS&S Services • Basic Services • Specify Environment Parameters**, you need to set the environment parameter `DG_SERVICES_ACTIVE` to value `X`.

Product Compliance

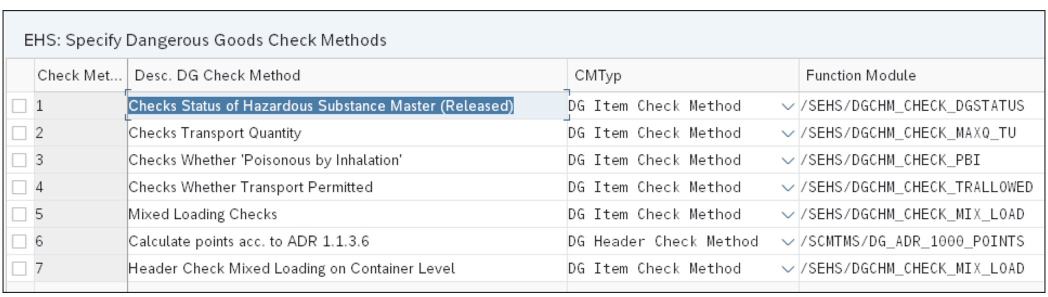
Under menu path **Transportation Management • Basic Functions • Dangerous Goods**, you'll notice that you can also choose **Activate Product Compliance** to activate SAP S/4HANA for product compliance, which also provides DG functionality. However, as we discussed at the beginning of this chapter, SAP S/4HANA for product compliance doesn't work with the full scope as of the time of writing. In addition, only one of the two components can be used in one client, as they aren't compatible. Therefore, we recommend using PS&S until the full required scope is released by SAP.

The SAP S/4HANA PS&S functionality has a variety of settings where you can configure the behavior of DG management and phrase management:

- Phrase management settings allow you to define phrase libraries and language definitions for the phrases.
- DG management provides the setup for the different DG codes, categories, regulations, and classes that build the legal framework.
- DG checks provide the configuration for the check rules and the reaction of the system on success or failure of a check.
- DG documents allow you to set up the output conditions, formatting rules, and languages for DG paperwork.

You can find these Customizing settings in TM via IMG menu path **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PS&S**. Here, you can define, for example, the error behavior of the TM-related DG checks or quantity definition for the 1,000-point rule according to ADR 1.1.3.6.

Because many DG checks within SAP S/4HANA PS&S are based on check rules, which must be embedded in a rule framework, you need to maintain individual rules. Alternatively, you have the option to load DG content via a loader so that not everything needs to be set up from scratch. Figure 8.10 shows the maintenance of check methods and the level of granularity for operations (e.g., header level and item level).


EHS: Specify Dangerous Goods Check Methods

Check Met...	Desc. DG Check Method	CMTyp	Function Module
1	Checks Status of Hazardous Substance Master (Released)	DG Item Check Method	/SEHS/DGCHM_CHECK_DGSTATUS
2	Checks Transport Quantity	DG Item Check Method	/SEHS/DGCHM_CHECK_MAXQ_TU
3	Checks Whether 'Poisonous by Inhalation'	DG Item Check Method	/SEHS/DGCHM_CHECK_PBI
4	Checks Whether Transport Permitted	DG Item Check Method	/SEHS/DGCHM_CHECK_TRALLOWED
5	Mixed Loading Checks	DG Item Check Method	/SEHS/DGCHM_CHECK_MIX_LOAD
6	Calculate points acc. to ADR 1.1.3.6	DG Header Check Method	/SCMTMS/DG_ADR_1000_POINTS
7	Header Check Mixed Loading on Container Level	DG Item Check Method	/SEHS/DGCHM_CHECK_MIX_LOAD

Figure 8.10 DG Check Methods Maintenance in TM

You can maintain the check methods in Customizing via menu path **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PS&S • PS&S Services • Dangerous Goods Management • Dangerous Goods Checks and Dangerous Goods Documents • Dangerous Goods Checks • Specify Dangerous Goods Check Methods**.

As a means of managing and segregating DG, you can find segregation keys and rules in Customizing via **Transportation Management • Basic Functions • Dangerous Goods • Dangerous Goods Processing Based on PS&S • PS&S Services • Dangerous Goods Management • Dangerous Goods Checks and Dangerous Goods Documents • Dangerous Goods Checks • Specify Settings for Mixed Loading Groups**. Segregation keys are used to define criteria to keep materials apart from each other in stowage, loading, and consolidation. Segregation key definition is done as part of DG master data maintenance. Segregation keys are maintained on the **Mixed Loading Rules** setting. In PS&S Customizing, you can set up the segregation rules for mixed loading and define the system response if you plan to load two cargo items with segregation keys together. The result of rules also depends on the individual DG regulation and can be either a warning or an error.

8.3.5 Dangerous Goods Content Loader

The DG content loader allows you to import dangerous good regulatory content into the DG master data tables. The content had been available on the former SAP Service Marketplace for download but has recently been outsourced to external providers (e.g., Verisk or 3E). You usually need some form of license to get the content files, which you may use to easily implement the rules required to provide your system with capabilities of DG checks according to standard regulations. You may also input these rules manually, but this would require DG expertise and some quite intensive data maintenance.

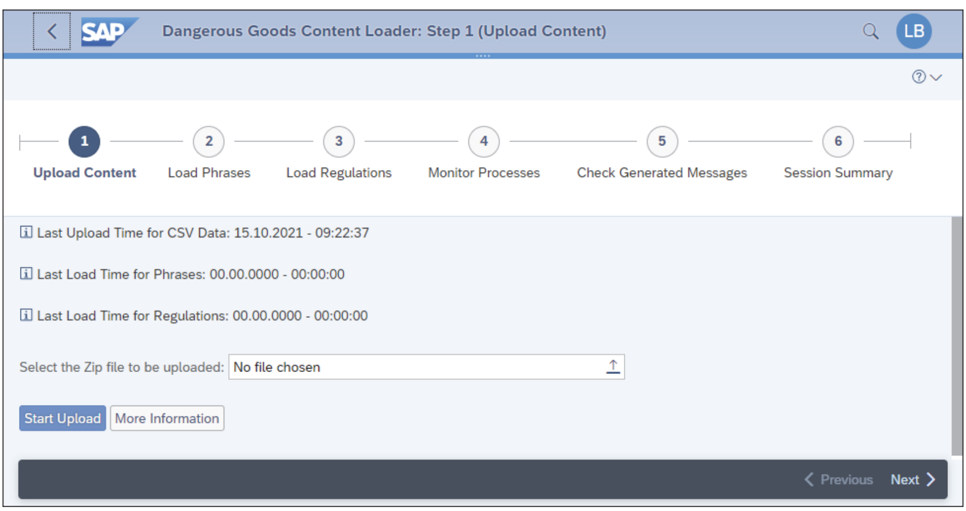


Figure 8.11 DG Content Loader

The provided content files contain DGR, regulation texts such as substance names and phrases, and Customizing data to implement the regulations and its check rules. Figure 8.11 shows the content loader UI, which you can call in the TM application under **Application Administration • Dangerous Goods Content Loader**.

The content loader can be very useful for LSPs to get the system quickly set up with the data and regulations that concern the shippers. The imported content can be used to perform consistency checks on the forwarding order data provided by shippers. In addition, it provides template data for document-based DG records.

8.3.6 TM Application-Level Setup for Dangerous Goods Support

You can create individual user interfaces (UIs) for document-based DG data that reflect the specific data and phrase requirements of the DGR.

The UIs specified in a UI profile can hold tabular and field data with individual field labels (see Figure 8.12). Fields can be assigned to UI groups. You can define check functions for a UI profile and use them by invoking them on the forwarding order.

You can find the tool for defining DG UI profiles in the TM application menu via **Application Administration • Edit UI Profile for Dangerous Goods**. The assignment of the UI profile to the forwarding order is done on the forwarding order item level. You can set the DG UI profile in the Customizing of the item types for forwarding order management.

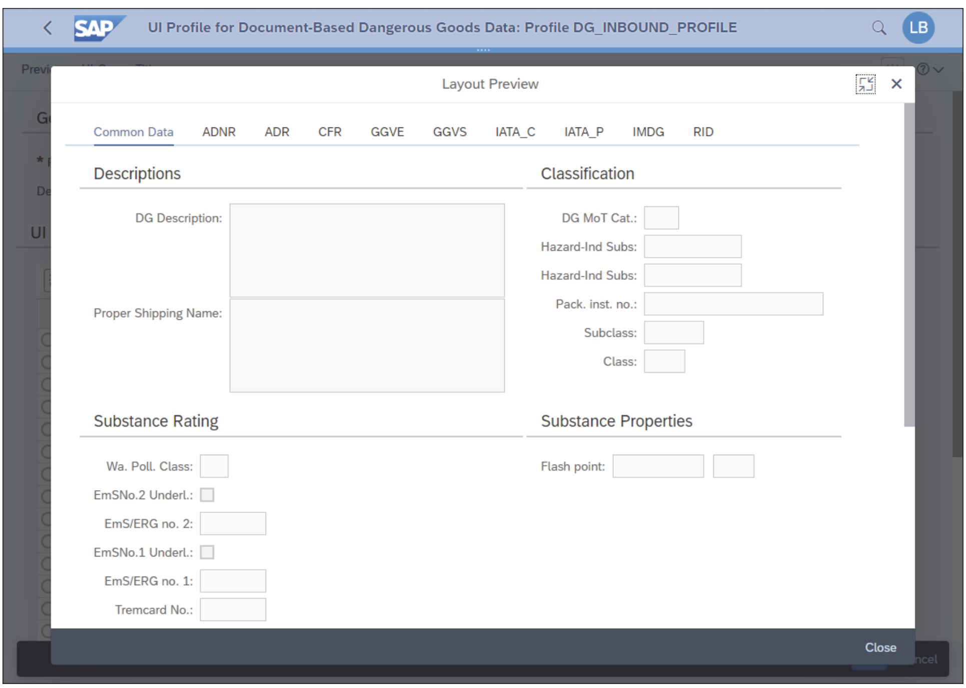


Figure 8.12 Configuration for a DG UI Profile

8.3.7 Dangerous Goods Data and Checks in TM

As described in Section 8.3.3, DG data definition and DG checks are done mainly on the forwarding order and TOR level (freight order and freight booking). Additionally, DG are considered in freight unit building and transportation planning.

Figure 8.13 shows a forwarding order item with a UI profile that has only an **ADR** tab. To execute the check, you can click the **Check Record** button on the forwarding order's **Dangerous Goods** tab.

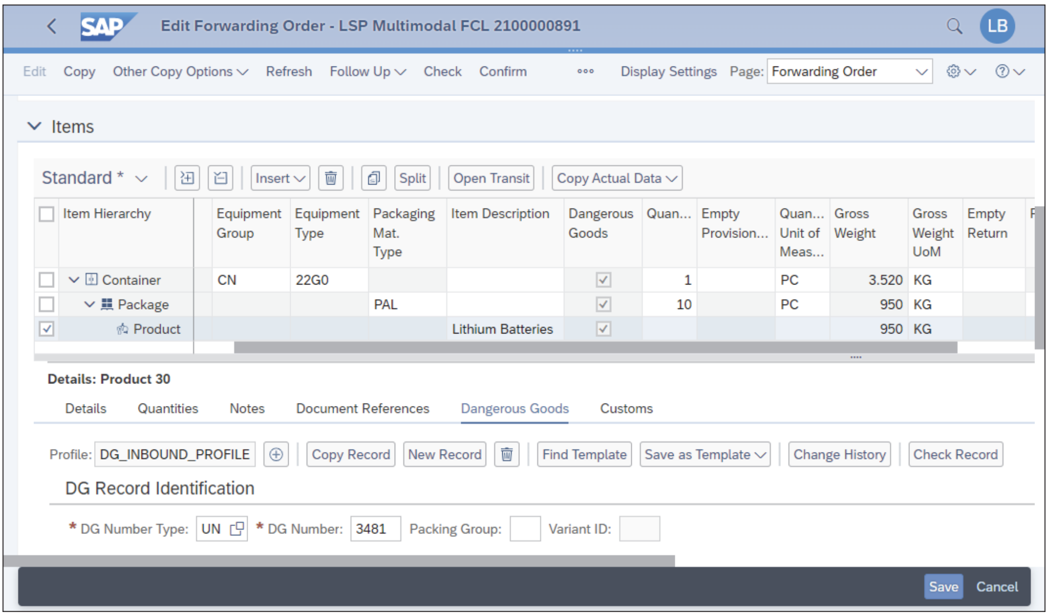


Figure 8.13 DG Item Details Screen in a Forwarding Order

In the forwarding order, most of the DG information is made available on the item level. The header contains only status and summary information, such as the DG indicator, ADR points, or an ADR exemption indicator. Recall from the previous section that you can assign individual, regulation-dependent UI profiles to the item types of the forwarding order. If multiple regulations are assigned, you'll see as many subtabs under the forwarding order item as you have regulations defined.

If you invoke the check functionality in the forwarding order, the configured DG checks are also executed, and the result of the checks is displayed in the message log of the forwarding order. When you start planning in the transportation cockpit (see Chapter 5), the mixed loading checks are applied to the consolidated items of the freight units that you plan to move together in one vehicle. Material compatibilities are inspected in any mode of transport. Additionally, the system summarizes the ADR points of all cargo items that should go on a truck in road transportation.

8.4 Summary

This chapter showed how customs and trade compliance, security compliance and air freight booking, and DG compliance can be run with TM and SAP GTS, a compliance partner, or PS&S. In the next chapter, we'll give you an overview of transportation agreements (contracts) and the mechanisms of charge calculation.

Chapter 9
Transportation Charge Management

Understanding the flexible contract management and charge calculation capabilities in transportation management (TM) will benefit your supply chain processes. In this chapter, you'll learn how to maintain freight contracts with carriers and logistics service providers (LSPs), store complex rate agreements, and calculate charges in your shipping documents.

Managing transportation charges is a core process requirement for shippers and LSPs. From a shipper's perspective, it's necessary to maintain contracts with carriers or freight forwarders and to ensure full visibility of transportation costs. As a freight forwarder, you equally need transparency of your carrier contracts and costs. In addition, it's a key requirement for your commercial processes to maintain and manage customer contracts and have visibility of your profitability.

The transportation charge management component of TM is a very powerful and flexible engine; it allows you to maintain transportation contracts and fully integrate them into your operational processes. This means that contracts are centrally maintained and will be cardinally used for the automated charge determination in your freight documents: forwarding orders and quotations, freight orders, freight bookings, consignment orders, service orders, freight units (for parcel rate calculation), and settlement documents. Consequently, charge calculation processes across all modes of transport for shippers, freight forwarders, and carriers are supported.

In this chapter, we introduce to you the basics and some details of transportation charge management. We start by setting up the master data objects in Section 9.1. We explain each master data element and its core Customizing settings. With this foundation, we dive into Section 9.2 and focus on how these master data objects are derived to calculate charges in freight documents. In Section 9.3, we clarify the actual charge calculation logic using various scenarios as an illustration. Mode specifics for road and rail are covered, and the concept of event-based charge calculation is explained. Finally, in Section 9.4, strategic vendor contract management is addressed. This includes freight procurement planning and analytics as well as the process to establish a freight agreement request for quotation (RFQ). The forwarding side as well as air- and sea-specific costs will be covered in Chapter 11.

Let's start by introducing the architecture in Figure 9.1. In the center of the figure, you can see the core master data objects: agreements, calculation sheets, rate tables, and scales. These allow you to store contracts with all their details, such as validity periods, currencies, payment terms, prices, and calculation rules.

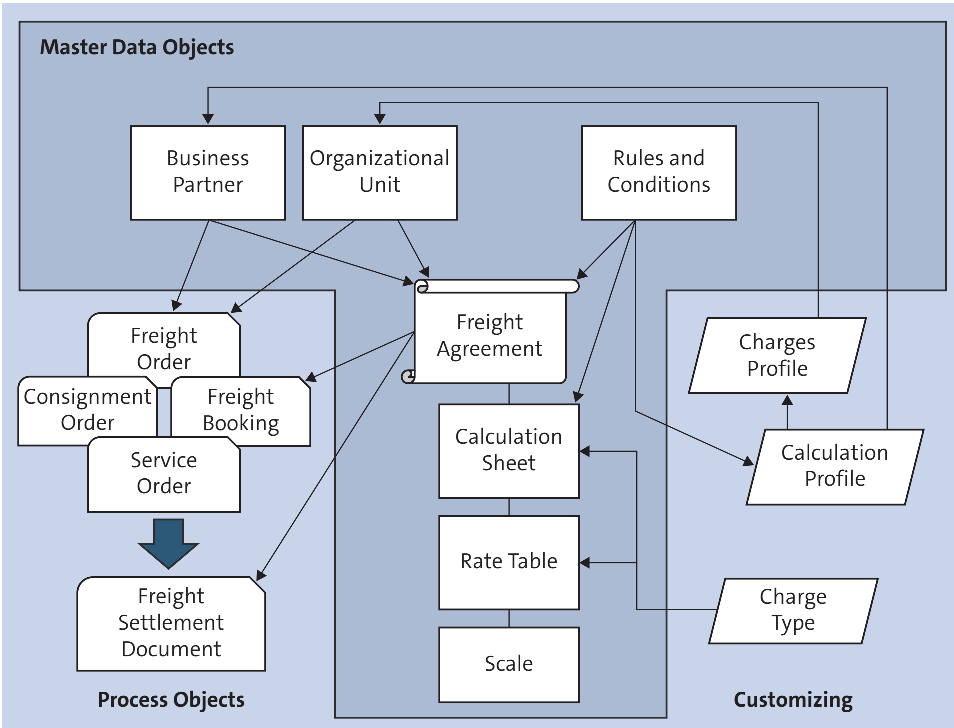


Figure 9.1 Overview of Transportation Charge Management

The relevant freight agreement is determined from freight orders, freight bookings, consignment orders, service orders, and freight units (for direct parcel shipments) to calculate the transportation cost. When any of these business documents needs to be settled, the calculation is redone in the freight settlement document. The determination of the relevant freight agreement, which will be explained in more detail in Section 9.2, is usually based on the business partner and organizational unit (purchasing organization), which must match in the order/booking and the agreement.

Rules and conditions can control the determination of agreements, calculation sheets, and rate tables. These are referenced in the agreement header, agreement items, calculation sheet, and calculation profile. The charges profile, which is assigned to the organizational unit, provides the link to other profiles, such as the calculation profile or settlement profile in Customizing.

The introduction of master data objects is the starting point of the journey into the depths of transportation charge management.

9.1 Charge Calculation Master Data and Customizing

The following elements constitute master data and are the basis for the configuration of transportation charge management:

- **Freight agreements**
  Freight agreements serve as contracts with companies providing transportation services, such as carriers and LSPs, as well as service providers for transportation-related services, such as warehousing or port operations. They contain charges and rate information, as well as capacity commitments.
- **Calculation sheets**
  Calculation sheets have an n:m cardinality to agreements. Each agreement has at least one calculation sheet that lists all charge types (e.g., basic freight charges and surcharges) relevant for its calculation. It also controls the behavior of the actual charge calculation for each charge element.
- **Charge type**
  Each line in a calculation sheet uses a specific charge type. Any number of charge types can be used in a calculation sheet.
- **Rate tables**
  Rate tables are the central place where all the actual values of your rates and charges are maintained. Rate tables have an n:m cardinality to charge types and calculation sheets. Each calculation sheet can contain multiple rate tables, but the same rate table can also be used in multiple calculation sheets.
- **Scales**
  Several scales can define the dimensions of a rate table.

The left side of Figure 9.2 depicts the hierarchical relationships among agreements, agreement items, calculation sheets, charge types, rate tables, and scales. On the right, we apply these concepts to a business example to show how you can use this flexible structure in an ocean freight scenario. Here, the freight agreement is a contract with an ocean carrier and can have the scope of multiple trade lanes as items of the agreement, for example, based on geography.

Each trade lane has its own calculation sheet with different global and country-specific charges (basic ocean freight, bunker adjustment factor, terminal handling charge, etc.). For each charge, an applicability rule or condition can be maintained. In addition, a rate table that contains all the actual rates is assigned to each charge. Rate tables are constructed based on multiple scales, such as origin, destination, equipment, and commodity.

You maintain all freight agreements in a central repository. Select **Charge Management • Charge Management Worklist • Master Data Cockpit for Freight Agreements** to get an overview, query all charge-relevant master data objects, and search through different agreements, rate tables, calculation sheets, and much more.

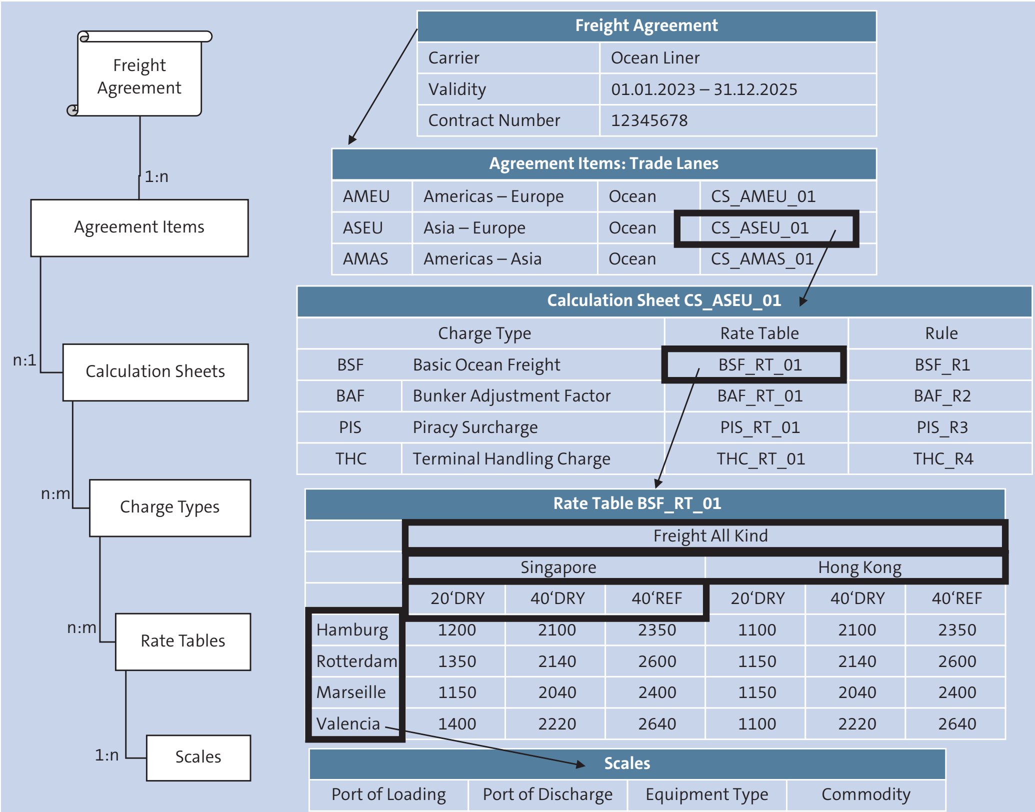


Figure 9.2 Transportation Contract Management Component with a Business Example

The *master data cockpit* is extremely useful when you want to update charge types and rates of multiple agreements. Numerous search attributes help you find an agreement (e.g., based on the organizational unit or an involved business partner). From the cockpit, you can also trigger currency conversions and Microsoft Excel downloads. One benefit of this functionality is that you can search for agreements based on the most granular components, such as a single rate table entry or source destination, and the results are all agreements that contain this specific rate table line.

Let's turn our attention to the individual elements in more detail.

9.1.1 Freight Agreements

The freight agreement is of great relevance for both shippers and LSPs because both parties use freight agreements to store contracts with trucking companies, airlines, ocean carriers, railways, and freight forwarders. Freight agreements are created using **Contract Management • Create Freight Agreement**.

Each freight agreement requires the choice of a freight agreement type, which is shown in Figure 9.3. The freight agreement type is defined in Customizing via **Transportation**

Management • Master Data • Agreements and Service Products • Define Freight Agreement Types. It allows you to control number range assignment (**No. Range**), whether multiple parties can use it (**Multiple Parties**), the user interface (UI; **WD Appl. Config.**), and whether a duplicate check is performed during save or check (**Duplication Check**). Enabling the **Approval Workflow** for the release of a freight agreement allows the delegation of authority to a second user, such that one user is responsible for the creation and maintenance of the freight agreement, whereas the second user is responsible for its release. The approver is the user that holds the position of head in the responsible organizational unit.

To protect released freight agreements from editing, you can restrict the authorization to super users using authorization object T_AGR_FRS or allow it for all users in Customizing via **Transportation Management • Basic Functions • General Settings • Define General Settings for TM**.

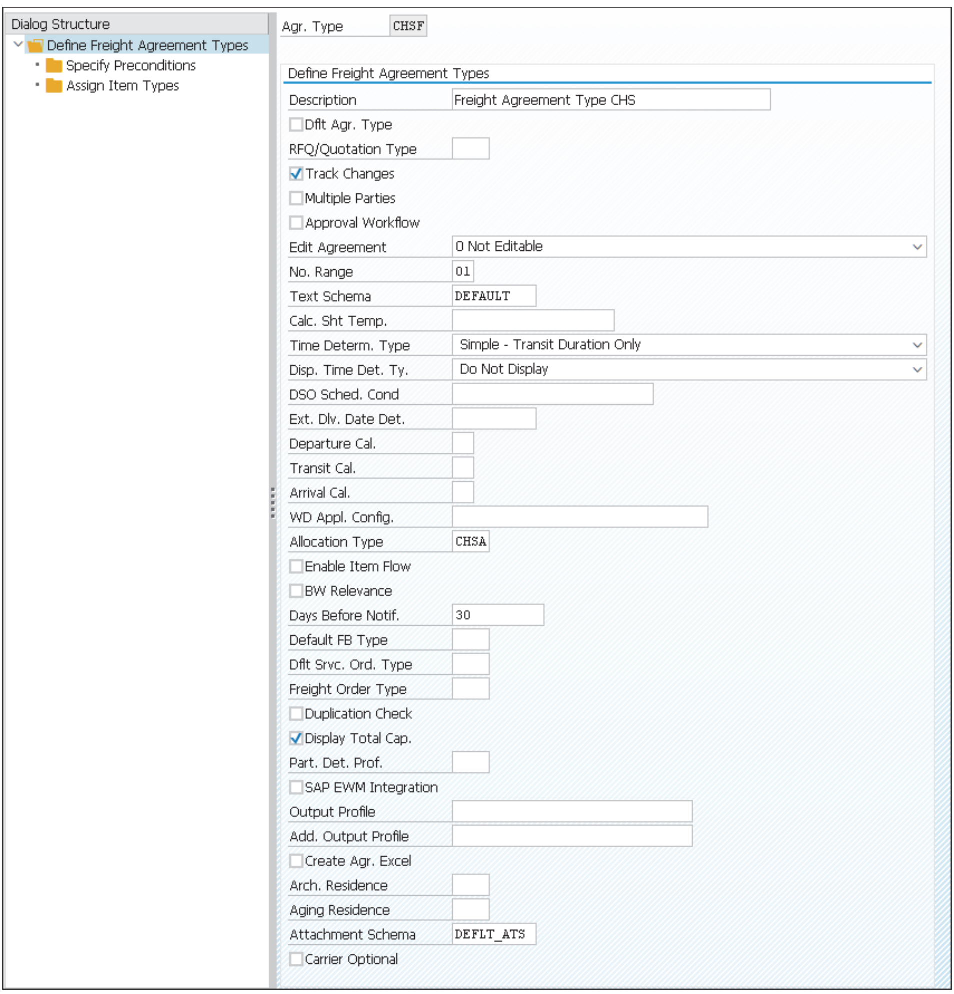


Figure 9.3 Freight Agreement Type Customizing

Freight agreements can be created manually from scratch, can be based on freight agreement templates, either as master data (**Contract Management • Create Freight Agreement Template**) or as Customizing (**Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Templates • Define Freight Agreement Templates**), or can result from a strategic freight procurement process as described in Section 9.4.

Figure 9.4 shows the header section of a freight agreement. On the **General Data** tab, the **Basic Data** area lists the internal and external reference as well as the agreement status. Only released agreements can be used for freight charge calculation. The **Involved Parties** are the purchasing organization on one side and the carrier on the other side. If the agreement type allows, multiple parties can be maintained here. The **Details** area contains the validity dates of the contract and the document currency. It can also contain a dimensional weight profile and an exclusion rule in case you want to exclude an agreement for specific charge calculations (see Section 9.2.2 for more details on rules and conditions).

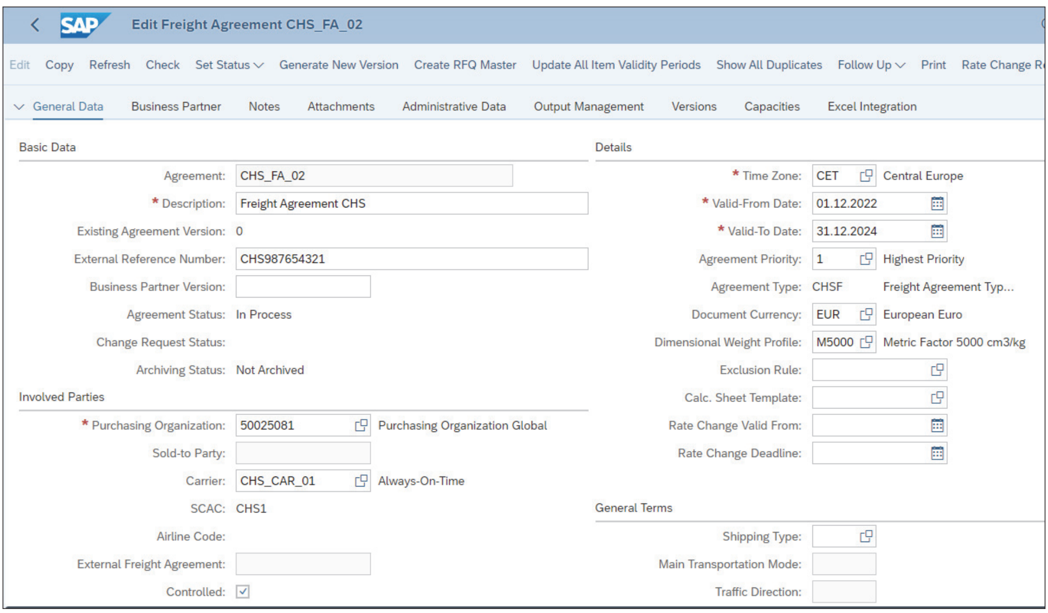


Figure 9.4 Freight Agreement Header

On the **Business Partner** tab, the relevant business partners can be maintained based on their function. The confirmed capacities are stored on the **Capacities** tab. You can add notes and store attachments on the **Notes** and **Attachments** tabs, respectively. The entire capabilities of the output management to print a document or trigger a workflow, email, or alert are available on the **Output Management** tab. Downloading into a Microsoft Excel format and uploading from Microsoft Excel are also supported from the **Excel Integration** tab. Freight agreements support versioning, and other versions of the freight agreement can be accessed via the **Versions** tab. Versioning allows you to reuse an agreement, when its validity period expires or other details of the agreement change for a specific time period. The validity periods of different versions can overlap and you can revert to an earlier version by deactivating the released version and releasing the earlier version. However, only one released version can exist for any point in time.

From the freight agreement header, you can change the agreement status; check for duplicates, that is, search for freight agreements that cover the same scope; generate new versions of the agreement; or generate an RFQ master to start a strategic freight procurement process. Furthermore, you have the option to trigger a rate change request and initiate the update of the items' validity periods. A freight agreement can have one or more items, as shown in Figure 9.5. Each item has one calculation sheet (or determination rule) assigned and has its own validity. Preconditions are used to define which item is selected for charge calculation in a freight order, freight booking, consignment order, or service order, if you want to distinguish in the same agreement between different calculation logic, for example, for ocean and inland transport.

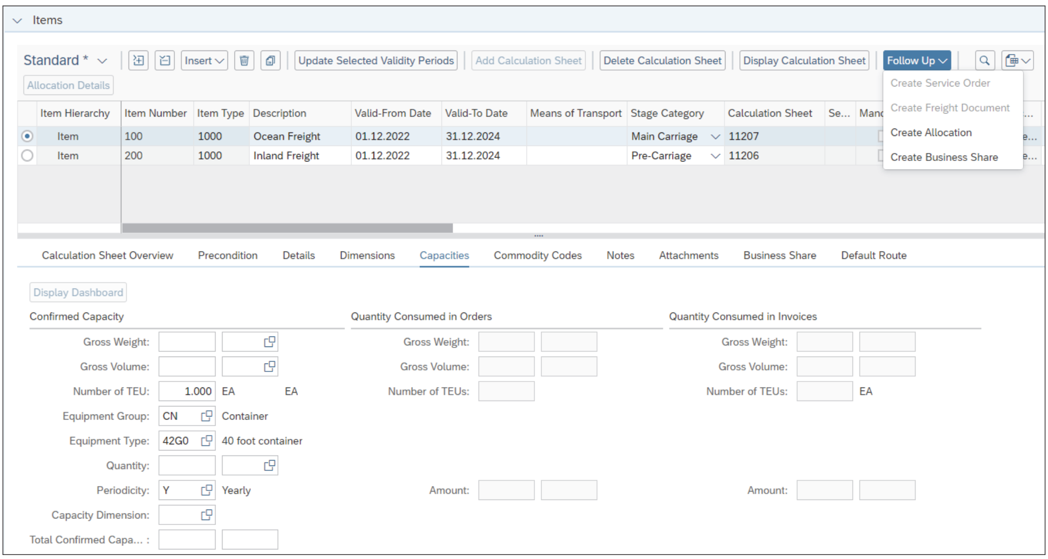


Figure 9.5 Freight Agreement Items

While the main elements of each item are its calculation sheet and preconditions, additional information can be maintained at this level. One of these is the maintenance of **Capacities**, as you can see in Figure 9.5. When you negotiate a contract with an LSP, it's a common business practice to not only agree on rates but also capacities to be shipped under a contract. This allows you as a consumer of space to better forecast and manage capacities. Higher capacities can be associated with discounts on the rates for you as a shipper or LSP. Besides the **Confirmed Capacity** in the contract, you can actively monitor the consumption of capacities. Consumption in both freight orders and invoices is tracked in the agreement. Various reports are available based on an embedded dashboard to display the year-to-date or periodical consumption of confirmed capacities. Different dimensions, such as containers (20-foot equivalent units [TEUs]), gross weight, or gross volume, are available.

From the **Capacities** tab shown in Figure 9.5, you can trigger the creation of allocations as a follow-up action. This will generate an agreement allocation based on the maintained capacities of the agreement item. To enable this capability, you need to assign an allocation type to your freight agreement type in Customizing. The navigation from the agreement item to the allocation document is then possible via the **Allocation Details** button. Besides generating allocations from a freight agreement, it's also possible to generate business shares. This capability allows you to distribute your total demand in capacity among different suppliers. Business shares are considered during carrier selection for freight orders. (Refer to Chapter 6, Section 6.4, for more details on allocations and business shares, and Section 6.5 for the explanation of the carrier selection process.)

The functionalities to add notes and attachments are available on the item level as they are on the header level.

Each item can have an item type, which is defined in Customizing (**Transportation Management • Master Data • Agreements and Service Products • Define Freight Agreement Item Types**). Item types can default the freight order or freight booking types, if these are created directly from the freight agreement item. Furthermore, preconditions can be linked to the item types. A freight agreement type can be linked with none or any number of item types and none or any number of preconditions.

9.1.2 Calculation Sheet

As mentioned in the previous section, the calculation sheet is the main element of each freight agreement item. The calculation sheet will store the charge types and assigned rate tables for each charge line. This setup is mandatory to do charge calculation for freight orders, freight bookings, consignment orders, service orders, and freight settlement documents.

The calculation sheet contains all charges you need to pay to your carrier or LSP as part of an agreement. Calculation sheets control the behavior of the charge calculation logic, which we describe in Section 9.3. It's tremendously important because in the calculation sheet, you map rate tables to each charge. Calculation sheets contain the logic for how to apply charges and the sequence in which they need to be calculated. In addition, any advanced or mode of transport–specific charge logic is defined and set up in the calculation sheet.

Let's dive into calculation sheet structure, setup, and Customizing.

Calculation Sheet Structure

To generate a calculation sheet, you generally have two alternatives:

- **Embedded calculation sheet**
  You can create the calculation sheet directly from an agreement. Notice the buttons at the top of the screen to add, display, or delete calculation sheets in the freight agreement item shown earlier in Figure 9.5. Clicking the **Add Calculation Sheet** button will automatically generate a calculation sheet in the background and assign it to the agreement item. By clicking the **Display Calculation Sheet** button, you navigate directly to the calculation sheet for maintenance or display based on whether you had opened the freight agreement for maintenance or display.
- **Standalone calculation sheet**
  You can also create a calculation sheet separately and assign it to agreement items later. For this purpose, you can use the Create Calculation Sheet app, which you can find in **Charge Management • Create Calculation Sheet**.

The calculation sheet contains very little header information, as you can see in Figure 9.6. Most important here is the **Charge Usage** field, which you can use to limit potential assignments to agreements because, unlike an agreement, calculation sheets can be generically used in forwarding, freight, or internal agreements.

The main element of the calculation sheet is the item table. Each item represents a charge line. Each line is calculated individually starting at the lowest hierarchy level and sequentially based on the line number ascending on each hierarchy level. In the example in Figure 9.6, the calculation will start with the line numbers 20 to 70, which represent the lowest hierarchy level, and then the sum (line number 10) will be calculated. The example shows a business scenario for ocean freight charges with a base freight, bunker adjustment factor, currency adjustment factor, terminal handling charges, and a piracy risk surcharge. Each line has assigned a charge type, which is defined in Customizing and will be explained in Section 9.1.3. This flexible structure can also be used for any other mode of transport or business context, and you can define your own charge types.

Each charge line needs to be assigned either a fixed rate amount or, most commonly, a rate table. Charges can be absolute values maintained in a currency or relative values defined as percentages either in rate tables or directly in the calculation sheet. If they are defined as relative values, they need to reference another charge line or a range of charge lines (reference from and reference to), which is used as a basis for their calculation. Each line item in the calculation sheet has a **Details** section with multiple tabs, such as **Basic Data**, **Rate**, and **Classification**, which you can use to maintain important settings to control the charge calculation logic. These item details are covered in detail in the next section.

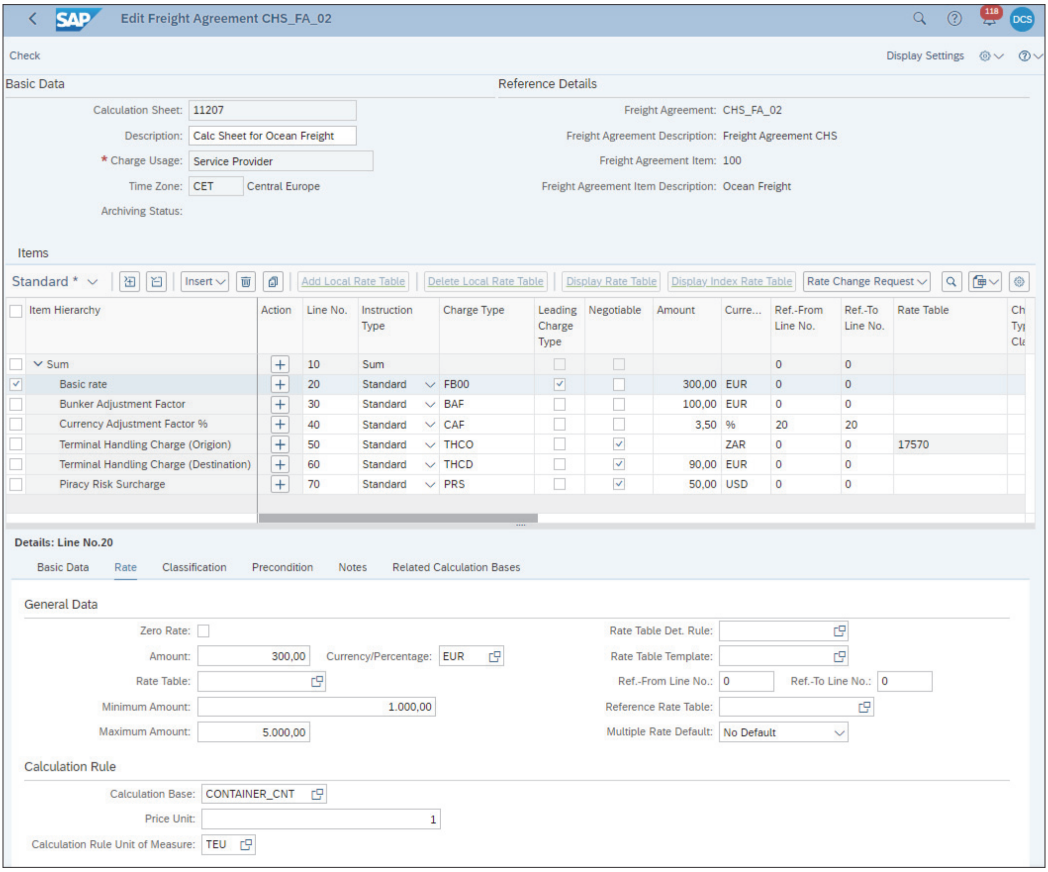


Figure 9.6 Calculation Sheet

Calculation sheets don't need to be created from scratch every time. Calculation sheet templates can be defined as master data using the Create Calculation Sheet Template app from **Charge Management • Create Calculation Sheet Template** or as Customizing via **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Templates • Define Calculation Sheet Templates**. The calculation sheet template contains the most important elements of a regular calculation sheet. When you generate a new calculation sheet, you can pick a template as a source, which will automatically populate all specified charge types and other settings defined in the template. Furthermore, a calculation sheet template can be assigned to an agreement type in Customizing. As a result, that calculation sheet template is defaulted when you generate a calculation sheet from the agreement.

Calculation Sheet Setup and Customizing

The details of each calculation sheet line item can contain many settings that are evaluated by the system during charge calculation. While we describe many of the available settings here, more details about the impact of some of these settings will become obvious only when the charge calculation logic itself is explained in Section 9.3. Keep in mind that most of these settings are optional and are only required if you want to model specific use cases, such as handling codes for air freight or provisioning and return of empty containers in ocean freight.

On the **Basic Data** tab in Figure 9.7, you specify the charge type of each item. You can mark a charge type as the leading charge type. If the system identifies more than one charge calculation sheet as valid during charge calculation, it checks the leading charge of each calculation sheet to determine which one to use. If you don't require this logic, you can disable this feature in the charges profile by not selecting the **Evaluate All Agreements** checkbox (look ahead to Figure 9.17).

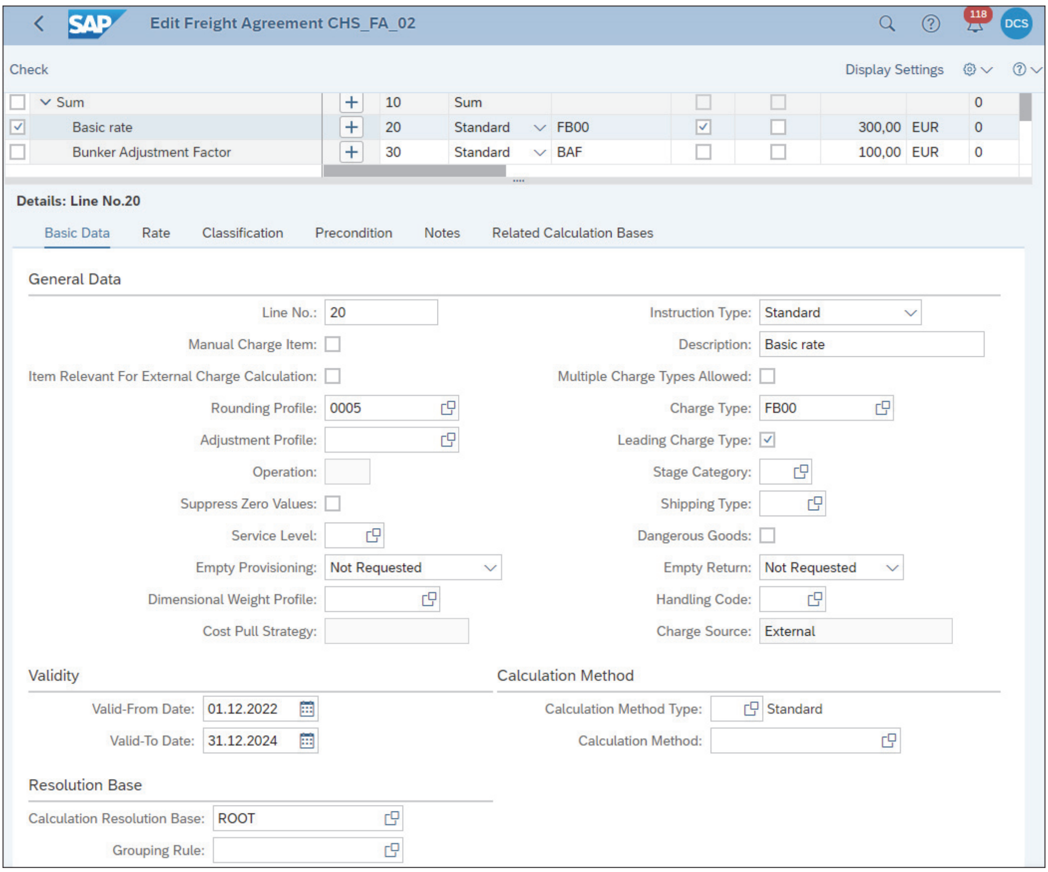


Figure 9.7 Calculation Sheet Line Item: Basic Data

You can assign a rounding profile—which you must define in Customizing via **Transportation Management • Basic Functions • Charge Calculation • Rounding • Define Rounding Rules**—to round calculated charges up or down. A commonly used feature is the manual charge calculation where a user can specify an amount for the charge item in the transactional document (freight order, freight booking, consignment order, or service order). The **Manual Charge Item** checkbox must be enabled in the calculation sheet in this case.

As a shipper or freight forwarder, you'll find that the chargeable weight is very important in your charge calculation logic. You can specify dimensional weight profiles in Customizing (**Transportation Management • Basic Functions • Charge Calculation • Data Source Binding • Define Dimensional Weight Profile**) to calculate the correct chargeable amounts (e.g., 1,000 kilograms to 1 cubic meter for the metric system or 1 pound to 166 cubic inches in the imperial system). Besides maintaining the dimensional weight profile per charge in the calculation sheet line-item details, you can also maintain it on the agreement line item, on the agreement header, or in the calculation profile. The calculation logic will check in the same sequence to determine the relevant dimensional weight profile on the lowest defined level.

A very powerful option is the definition of a **Calculation Method**. Whenever you expect the system to simply read a rate from a rate table, no specific calculation method is required. However, if a more complex computation is needed, such as clipping or for break-weights in air freight, a set of standard calculation methods is available. You can also develop your own calculation methods as an enhancement and assign them in Customizing (**Transportation Management • Basic Functions • Charge Calculation • Enhancements to Charge Calculation Engine • Define Calculation Methods**) to use them in the calculation sheet.

Furthermore, the **Calculation Resolution Base** and **Grouping Rule** are of great importance for charge calculation. The calculation resolution base defines on which level you apply a charge in your transactional document (e.g., per container, per package, or once per document [root]). On the other hand, the grouping rule allows the system to calculate one combined charge for multiple items. Let's assume you want to calculate charges for a freight order that transports five packages from your warehouse to customer A and three packages from your warehouse to customer B. While the calculation resolution base "package" would retrieve eight (different) rates (one for each package), the grouping rule "by destination" would allow you to retrieve two rates only (one for the five packages to customer A and another one for the three packages to customer B). If weight breaks are defined in a rate table, it obviously will make a big difference if you check for the applicable rate eight times (once for each package) or only twice (once for the combined weight for each customer). Your choice of calculation resolution base and grouping rule will lead to a different calculation result.

How to determine the relevant rate for each charge line in the calculation sheet is defined on the **Rate** tab shown earlier in Figure 9.6. The simplest way of defining a rate is to enter a fixed amount and currency here. The most common scenario is to store a rate table because it offers much more flexibility. You can either associate exactly one rate table to the charge line or reference a rate table determination rule (e.g., per origin country). As the name indicates, this option allows you to define a rule that is evaluated during charge calculation to determine the relevant rate table for the transactional document. A use case may be the definition of country-specific surcharges with different organizations being responsible for their maintenance. More details on the implementation of rules related to charge calculation and conditions can be found in Section 9.3.1.

The **Calculation Rule** determines how to calculate a charge based on a fixed amount or inside the rate table. For example, if you maintain a charge per distance (kilometers), you must multiply this rate by the actual distance a vehicle has traveled, which is retrieved from your transactional document. The actual rule needs to specify a calculation base, which specifies the data access to the transactional document (in our example, this is **CONTAINER_CNT** for the number of containers). The calculation logic in our example shown earlier in Figure 9.6 is as follows:

1. The rate amount is 300 EUR.
2. This rate will be multiplied by the number of TEUs.
3. A minimum of 1,000 EUR or a maximum of 5,000 EUR will be applied.

If you maintain a rate table for the charge line item, the calculation rule will be defined in the rate table itself. See Section 9.1.4 and Section 9.1.5 for more details on the calculation base and scales, respectively.

Next, in the **Classification** tab, you indicate whether a charge is a statistical charge, a tax, or a mandatory charge. Statistical charges are used in the charge calculation like any other charge, but they aren't included in the total and aren't settled in the invoicing process. Using the tax indicator, you can classify a charge as a tax. If you specify a charge line as being mandatory by activating the appropriate checkbox, and this charge fails to calculate a value in a transactional document, an error message is displayed to the user, and the transactional document is blocked for subsequent processing steps (settlement).

The **Preconditions** tab provides an important functionality for the charge calculation logic. This setting allows you to maintain flexible rules and conditions as well as to define trade lanes to control whether this charge line is evaluated or not. A precondition can be maintained in three ways:

- Use trade lanes to maintain geographical limitations.
- Specify that a charge line is applicable only to specific business partners.
- Assign a precondition rule to the calculation sheet item.

Business Examples for Conditional Charges

In the air, rail, and, especially, ocean freight business, you can find numerous rules and conditions for various charges. Some regional examples are as follows:

- All ocean freight transports with the destination Spain must pay a mandatory banking charge that is a percentage value of the amount to be paid in Spain.
- In India, a mandatory service and education tax must be paid for every inbound and outbound shipment.

- For all shipments going to the United States, a mandatory surcharge must be paid for legal filings.
- Surcharges apply if a ship crosses the Panama Canal or Suez Canal.

Similar examples in air freight apply, such as specific terminal handling charges, screening charges to x-ray cargo, and other security surcharges that are based on origins and destinations.

Because each charge line has a charge type assigned to it, let's turn our attention to the configuration of charge types.

9.1.3 Charge Type

The initial configuration already includes a basic set of charge types, which can be extended based on project needs. Charge types are defined in Customizing (**Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Define Charge Types**). Figure 9.8 shows the definition of charge type **CAF** as an example. A charge type can be linked to a charge category and charge subcategory, which may be defined based on global standards such as United Nations/Electronic Data Interchange for Administration, Commerce, and Transport (UN/EDIFACT) code list 5237. Charge categories and charge subcategories can be defined in Customizing themselves (**Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Define Charge Categories** and **Define Charge Subcategories**). Charge type descriptions can be maintained in multiple languages.

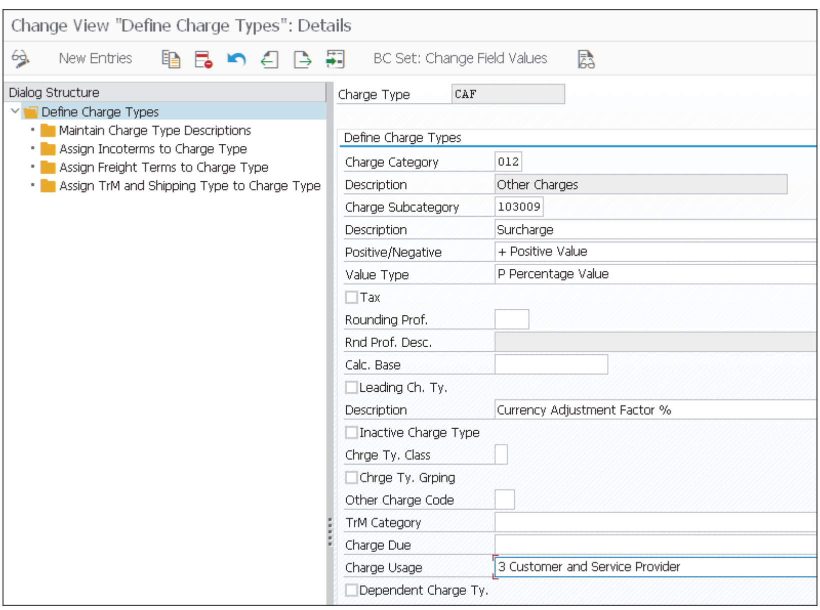


Figure 9.8 Charge Type Customizing

You can define whether a charge type can result only in a positive or negative value (e.g., for discounts) (**Positive/Negative**) or whether it can be an absolute or percentage value (**Value Type**). For either setting, you can specify that both options are valid and enter the details in the calculation sheet line-item details. The rounding profile (**Rounding Prof.**) is optional and either defaulted to the calculation sheet charge line or directly defined there. To limit the usage of a charge type to specific use cases, you can specify a transportation mode category (**TrM Category**) (e.g., to limit the usage to air transports) or **Charge Usage** (e.g., to limit the usage to freight opposed to forwarding charges).

Charge types can be used in a calculation sheet and can be assigned to rate tables, which are covered next.

9.1.4 Rate Table

Rate tables contain all prices that are required for the charge calculation. A rate table can never be used standalone. It must be assigned to a calculation sheet, which itself needs to be assigned to an agreement. You can maintain rate tables manually, by using the upload and download function for single rate tables, or by using mass update functions.

In this section, we'll discuss the creation, structure, and maintenance of rate tables.

Creation and Structure

You have two options for creating a rate table:

- **Calculation sheet**
  To create from a calculation sheet, you select one charge line in the calculation sheet and choose **Add Rate Table** to generate a new rate table in the background. If you've maintained a rate table template in the calculation sheet item details, this will prepopulate the new rate table. Rate table templates can be defined as master data in **Charge Management • Create Rate Table Template** or as Customizing via menu path **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Templates • Define Rate Table Templates**.
- **Standalone**
  To generate and maintain a standalone rate table, navigate to **Charge Management • Create Rate Table Definition**. You can specify a rate table type or a rate table template to prefill certain elements of the rate table and define attributes of the rate table.

The rate table type is defined in Customizing via **Transportation Management • Master Data • Rate Tables • Define Rate Table Type**. In Figure 9.9, you can see which attributes of the rate table are defined in the rate table type. You can enable a rate table for workflow approval. In this case, a user with the relevant authorization is required to approve changes made to validity periods in a rate table. Furthermore, you can specify whether the rate table or its values should be editable or not. If rate validity split (**Rate Val. Split**) is enabled in a rate table, you can change rates without needing to update all the rates of the parent validity period in the rate table.

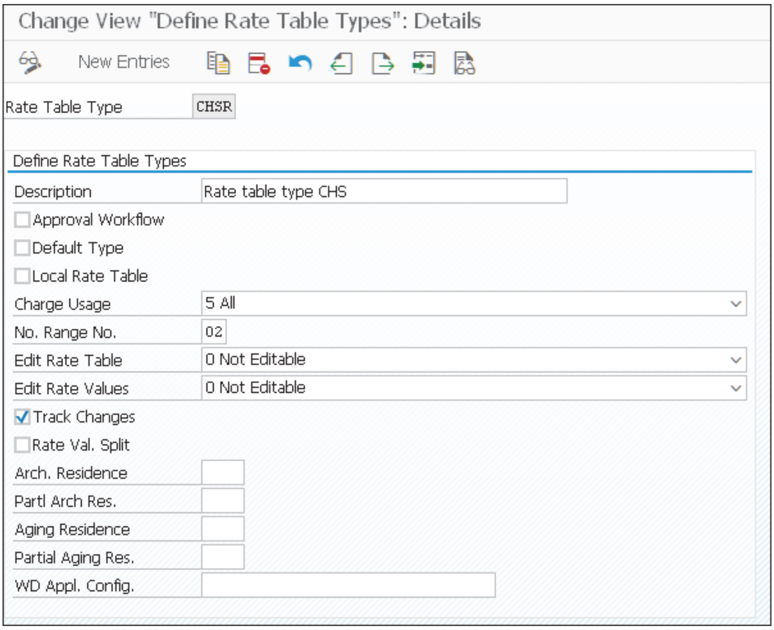


Figure 9.9 Rate Table Type

The rate table has a **General Data** section, as you can see in Figure 9.10. A rate table can be used to store selling, buying, or internal rates. As a result, you need to maintain the **Charge Usage** as a mandatory field. You can set the **Charge Usage** for one or more purposes. Another important section is the **Charge Type Settings** area, where you need to maintain the charge type for which the rate table will be used. If you generated the table from the calculation sheet, the charge type is automatically pulled from the calculation sheet item. The **Multiple Charge Types Allowed** checkbox enables the use of one rate table for multiple charge types. In this case, you can maintain the charge type as its own dimension (scale).

The dimensions for storing the rate values can be very different for each charge type. Therefore, the most important section in the **General Data** tab is the **Scales** area where you design the layout (rows and columns) of the rate table. The scales can best be described as the dimensions of a rate table. In the example, three scales are maintained, meaning the rate value will be determined based on three different criteria. The first scale is based on countries. The **Calculation Base** defines which country should be relevant for the determination of the rate in a cross-border transport. In Figure 9.10, the source country is defined as the relevant country. The second scale is based on the equipment type, and the third scale is based on weight. Because different types of weight also can be relevant for pricing (gross weight, net weight, dimensional weight, etc.), the calculation base is used to define which one should be used to determine the correct rate value. For each scale, several attributes can be defined, such as whether a match is required in the scale items of a scale (**Item with No Value Allowed**) or whether a **Minimum Value** or **Maximum Value** should be defined. The maximum number of scales that you can define in a rate table is 14, but to manage and maintain rate tables efficiently, you should use more rate tables with fewer dimensions instead of one with too many dimensions.

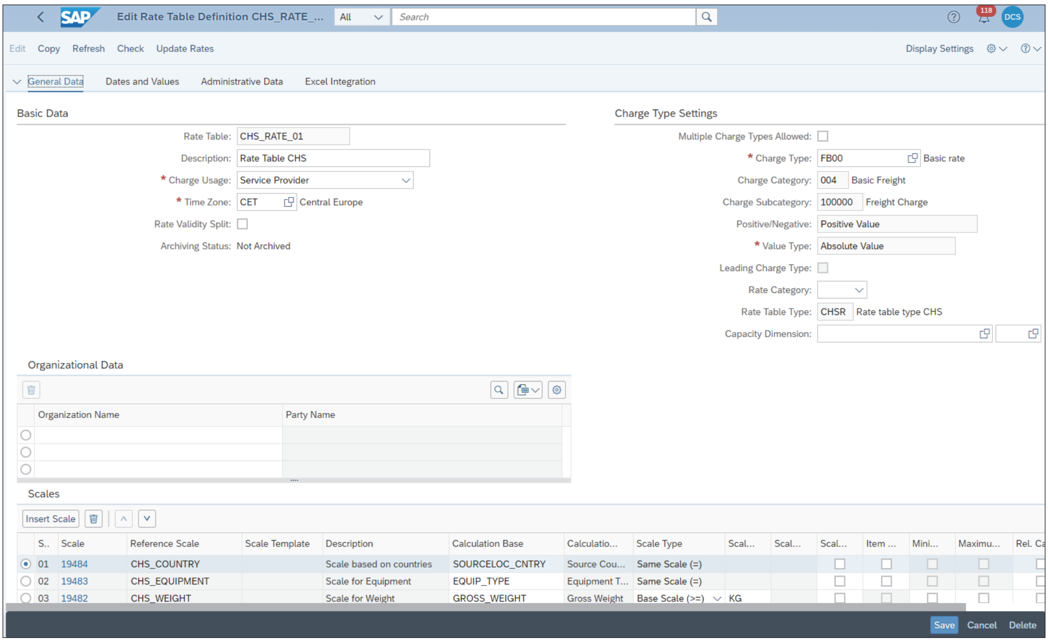


Figure 9.10 Rate Table General Data

The **Dates and Values** tab shown in Figure 9.11 contains the actual rate values for one or more different validity periods. You need to create an entry in the header item table with a valid-from date, valid-to date, and currency before you can maintain rate values. Afterward, the specified dimensions in the form of the rate table scales will become visible in the lower part of the screen. Each validity period has a **Life Cycle Status**. Initially, the **Life Cycle Status** is **In Process** and needs to be changed to **Released** before the rate values of the validity period can be used for charge calculation. To prevent fraud, the authorization to release a rate table validity period can be assigned to a user, and an approval workflow can be triggered to this user after a second user has maintained the rate values.

In the lower part of Figure 9.11, the rate values for the selected validity period are shown along the three dimensions that have defined the rate table structure on the **General Data** tab. Here you can maintain rate values, which are then used in charge calculation. You have the option to toggle between different layouts of the rate table and to display or hide descriptions and notes. You can easily imagine how rate tables can grow, so you can use the filter functionality to display only a specific set of rows.

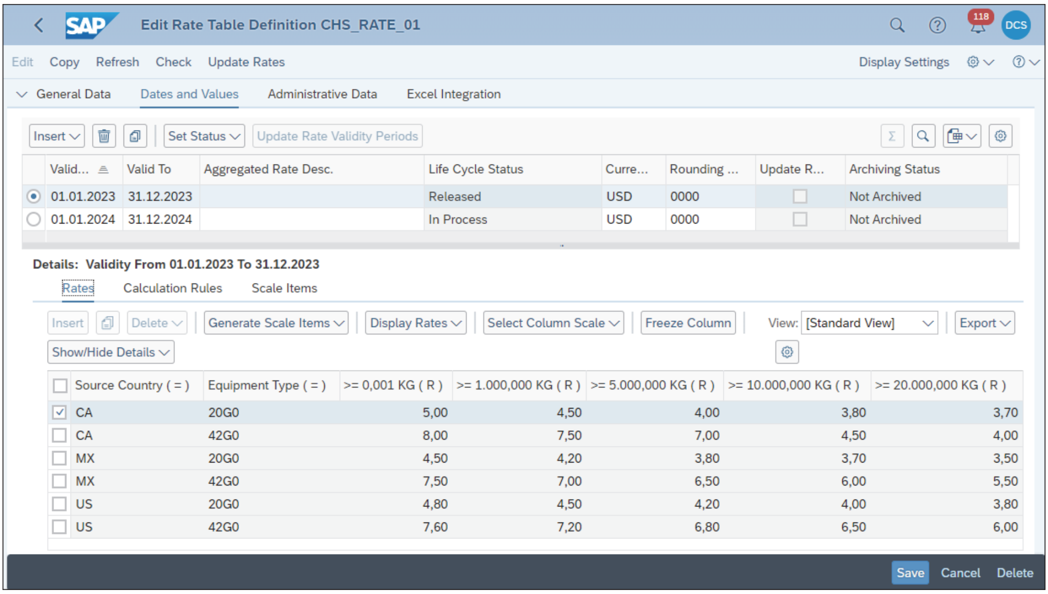


Figure 9.11 Rate Table Dates and Values

If you need to update a few rates only but want to avoid creating a new validity period, you can use rate level–specific validity periods. You can switch on this function on the **General Data** tab of the rate table by selecting **Rate Validity Split** (refer to Figure 9.10). Afterward, you can define an individual validity period for each rate as required. Note that once selected, this function can't be turned off again for a rate table.

The **Scale Items** tab defines the actual characteristic values of each scale. The example rate table in Figure 9.11 will be used for transports originating in North America because the scale items for the source country have been maintained as **CA** (Canada), **MX** (Mexico), and **US** (USA). Scale items can be entered directly row by row in the **Rates** tab of the rate table using the **Insert** button, or you can maintain the entire list of scale items in the **Scale Items** tab. Scale items may be different in each validity period of the rate table. The scale items for source country and equipment type will be compared for exact matches, indicated by the **(=)** next to the scale description. This is reasonable for alphanumeric fields such as countries, cities, or equipment. For numerical values, a smaller or equal **(<=)** comparison or a larger or equal **(>=)** comparison should be used. In the example, different weight breaks have been defined for gross weight, so that different rate values can be specified depending on the gross weight of the transported container.

Section 9.1.2 explained that you can maintain a calculation rule in the calculation sheet or directly in the rate table. Recall that a calculation rule is used in the charge calculation logic to multiply a retrieved rate value from the rate table with a certain data field.

The calculation rule in Figure 9.12 specifies that the rate values from Figure 9.11 are the amounts in USD for each 100 kg of gross weight.

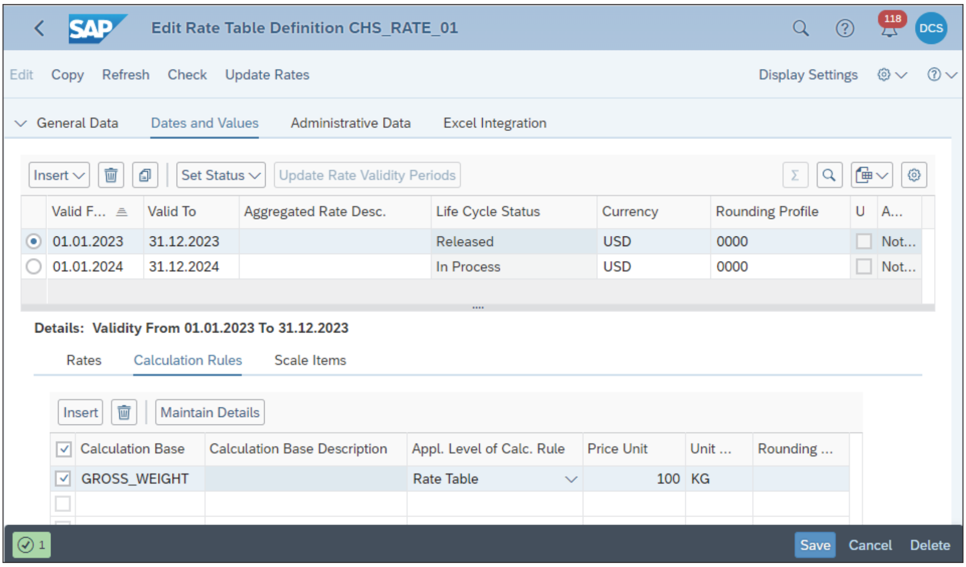


Figure 9.12 Rate Table Calculation Rule

Maintenance Tools

The manual creation and maintenance of large rate tables can be a very tedious process. Especially in the environment of large LSP or carrier contracts, a rate table can contain tens of thousands of entries. Two options to ease this maintenance process are offered in the system, but a certain level of manual effort may still be required.

The first option is the **Update Rates** function, which is available via a button in the Edit Rate Table Definition app. In Figure 9.13, you can see that it allows you to increase or decrease rate values by an absolute amount or a percentage. Rate value changes can be applied to a certain validity period, limited to a combination of scale items, or both. Additionally, it's possible to create new validity periods with this function. The same functionality is also offered using report /SCMTMS/RATE_MASS_UPDATE or from the master data cockpit.

Second, **Excel Integration** is offered for entire rate tables on a separate tab (refer to Figure 9.12). You can download one, multiple, or all validity periods into a Microsoft Excel file where a separate sheet is created for each validity period. Then you can maintain the rate values and even change the scale items in the spreadsheet to take advantage of all the capabilities of a Microsoft Excel spreadsheet that aren't available in TM. The spreadsheet will be protected in such a way that you're not able to change its structure because, otherwise, it couldn't be uploaded again. When you upload the file, the system validates the newly added or changed scale items against the master data. You can also use report /SCMTMS/TCC_RATE_MASS_CREATE to download rate table templates for later maintenance in Microsoft Excel or upload Microsoft Excel files in the background.

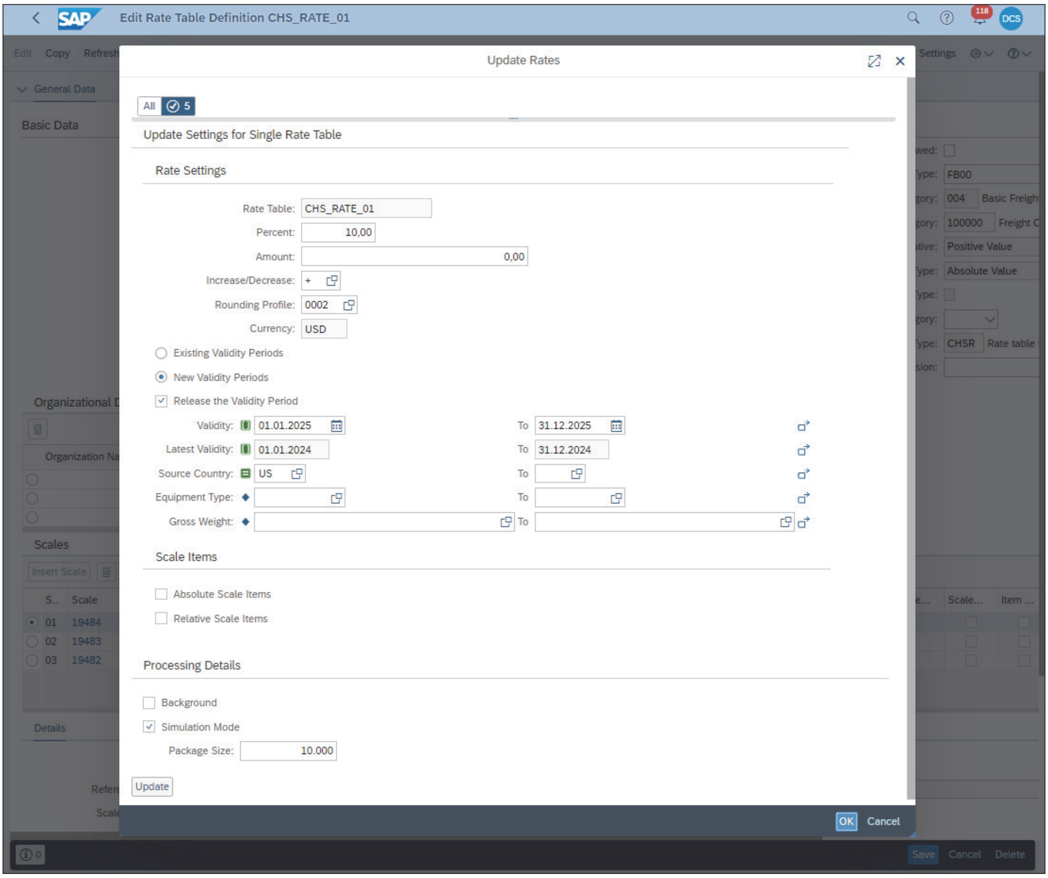


Figure 9.13 Update Rates

In the freight industry, it's a common business practice to regularly (e.g., quarterly) adjust freight charges and surcharges with batch updates. In ocean freight, these are called *general rate adjustments* (GRA). Such mass updates of rates usually impact multiple rate tables across numerous agreements. Other industries have similar requirements. Report /SCMTMS/RATE_MASS_UPDATE supports mass updates for such use cases. In the mass update report shown in Figure 9.14, you can select numerous rate tables and apply a markup or deduction.

Unfortunately, it's not possible to specify the scope for a mass update by limiting the updates to specific scale items. If this is required, the update must be done for a single rate table at a time with the **Update Rates** function described earlier.

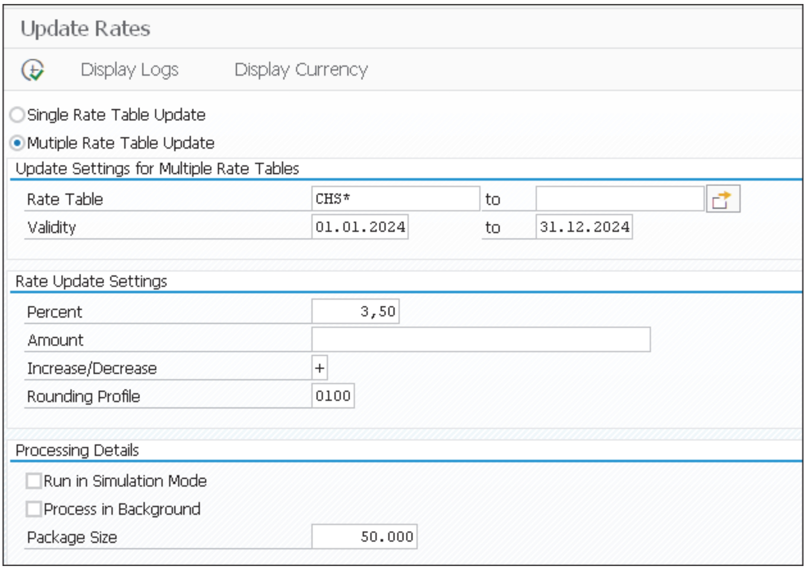


Figure 9.14 Report /SCMTMS/RATE_MASS_UPDATE

Release Your Agreements and Rate Tables

It's easy to forget this small step when setting up transportation charge management, which leads to there being no results in the rating. Therefore, remember that both agreements and rate table validity periods must be released before they can be used. This contingency prevents you from using rates while they are still in negotiation or setup. Always change the **Life Cycle Status** of the rate table validity periods and the agreement header to **Released** after the maintenance is completed. You can also release both the agreement and all of its rate tables directly from the agreement header.

9.1.5 Scale

Scales are a prerequisite for maintaining a rate table. They are the lowest layer of master data for transportation charge management. A scale itself is always generic, and you have to associate a calculation base to it to refer to the correct data element for charge calculation. The configuration of scales and their assignment to a rate table must follow the steps shown in Figure 9.15:

❶ **Define the scale base in Customizing**
The scale base is the scale's technical foundation where you define its description and the technical field assignment a scale value is stored in. Furthermore, you define whether a scale is a numerical value, whether a currency is required, whether a unit of measure is required, and which dimension needs to be maintained for the unit of measure (mass, volume, density, etc.). You can customize the scale base via menu

path **Transportation Management • Basic Functions • Charge Calculation • Data Source Binding • Define Scale Bases**.

❷ **Specify the calculation base in Customizing**
While a scale base only defines the basic data element, the calculation base defines its context. For scale base WEIGHT, the calculation bases CHRG_WEIGHT for chargeable weight, DIM_WEIGHT for dimensional weight, and GROSS_WEIGHT for gross weight exist, among others. You've learned already that calculation bases are used within calculation rules. Calculation bases are also used in the scale definition of rate tables to specify in which context the rate value should be determined.

Calculation bases are defined in Customizing via menu path **Transportation Management • Basic Functions • Charge Calculation • Data Source Binding • Define Calculation Bases**. Note that you need to assign a scale base to any calculation base. Additionally, you can specify whether the calculation type is absolute or relative. **Relative** can only be chosen if the underlying scale base is numeric. It defines whether the obtained rate value is used as maintained in the rate table (absolute) or whether it needs to be calculated from the referenced relative scale (relative). Other attributes of the calculation base are technical settings, such as those that specify database fields.

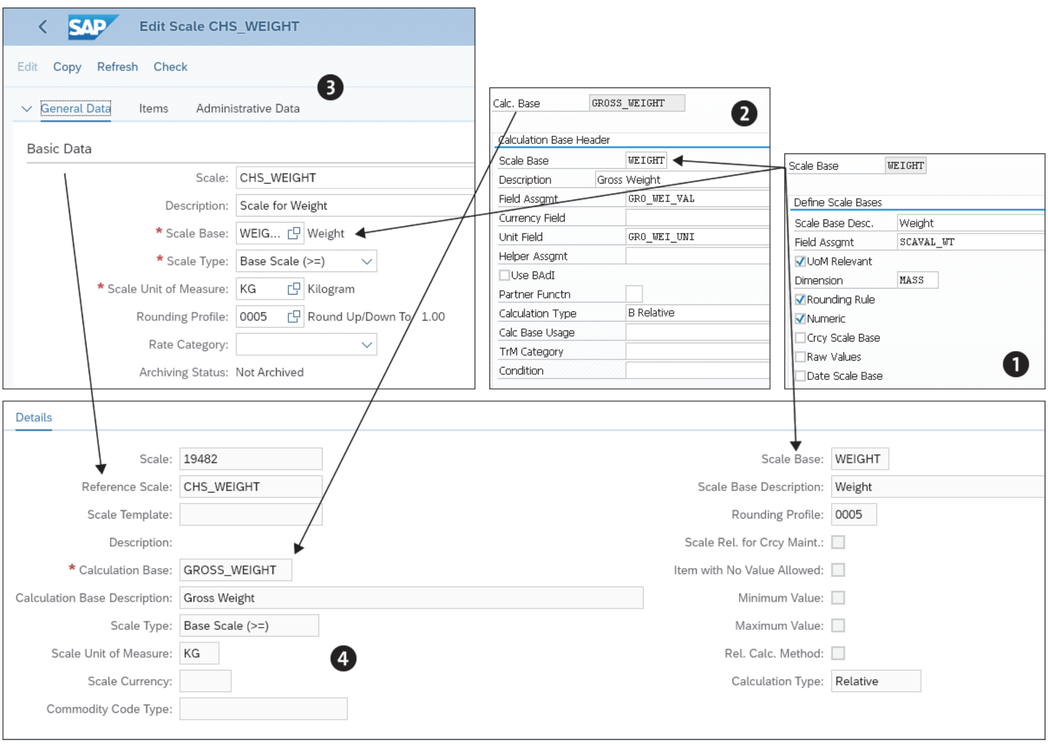


Figure 9.15 Configuration of Scales and Their Assignment

❸ **Define the reference scale (optional)**
You can create a standalone scale with the Create Scale app that you find in the **Charge Management** folder and assign it later as a reference scale in a rate table. Scales can be created from scratch or based on a scale template. When you define a scale, you must specify its scale base, scale type, unit of measure, and rounding profile. Three different scale types exist: **Same Scales** are used for alphanumeric values, whereas **Base Scales** or **To Scales** are used for numeric values depending on whether you want to define rate values *from* a certain scale value or *up to* a certain scale value, respectively. On the **Items** tab, you can define the individual scale items. Scale templates can be defined as master data in **Charge Management • Create Scale Template** or as Customizing via menu path **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Templates • Define Scale Templates**.

❹ **Embed the scale in the rate table**
Finally, a scale is embedded as a dimension into a rate table. As shown in Figure 9.15, the association to a calculation base is mandatory. All settings specified in the calculation base are populated into the dimension of the rate table, especially the **Scale Base** and **Calculation Type**. Optionally, you can assign a reference scale to prefill certain fields from the reference scale, such as a scale unit of measure, scale type, or even the scale items. Obviously, the scale base of the calculation base and the scale base of the reference scale must match.

Because there are limits on how many scales/calculation bases can be embedded in a rate table, it's possible to embed a condition into a scale to increase the flexibility of rate tables. When such a scale/calculation base is determined in a rate table to look up a specific rate, you can run through an entire Business Rules Framework plus (BRFplus) condition table as part of the rate value determination. For this process, you can use calculation base `CONDITION` with scale base `CONDTN`, and assign it to a scale. The actual condition can then be entered in the **Rates** section of the rate table for each entry.

After establishing all relevant master data elements for charge calculation, let's focus now on how these get determined in a transactional document.

9.2 Contract Determination

The creation of master data allows you to store and manage your carrier and LSP contracts. The real added value is raised when you use the integration of this master data into your transactional documents to automatically calculate the charges of freight orders, freight bookings, consignment orders, and service orders based on the contract determination logic. This functionality is the key to automatically finding and determining an appropriate contract with your business partners. There are numerous ways to set up this determination logic because it's tremendously flexible and can serve all industries and modes of transport.

Contract Determination versus Charge Calculation Logic

It's important to highlight the key difference between the contract determination in this section and the charge calculation logic in Section 9.3: contract determination finds a correct agreement, agreement item, calculation sheet, and charge type. As soon as this level is reached, the charge calculation logic determines the actual value from a rate table of a charge type and how to use this value in charge calculation.

9.2.1 Contract Determination Logic

The contract determination logic is triggered with the charge calculation for a transactional document (e.g., a freight order) either explicitly by clicking the **Calculate Charges** button in a freight order or worklist, by running background report /SCMTMS/TOR_CALC_BATCH, or implicitly by executing save strategy `CALC_CHARGE` when a freight document is saved. It follows this process:

1. Determine appropriate freight agreements.
2. Determine the relevant items of the appropriate agreements.
3. Check all qualifying calculation sheets.

Let's walk through header and item determination.

Agreement Header Determination

First, the appropriate freight agreement header is determined based on the involved parties (purchasing organization and business partner). Both parties must match in the freight agreement with the corresponding parties in the transactional document by considering hierarchies. In addition, the calculation date in the freight document must be within the validity period of the freight agreement, and the freight agreement must have agreement status **Released**.

Additional Agreement Parties

Typically, a freight document is settled between the purchasing organization and the carrier. Thus, the agreement determination logic is executed for these two parties. In some scenarios, the settlement may be required not only between the purchasing organization and the carrier but also with the purchasing organization and an additional party, for example, a service provider that was responsible for preparing export documents or fumigation. In this scenario, the service provider can be maintained as an additional agreement party on the **Business Partner** tab of the freight document. This will trigger a second agreement determination for these two parties. If an additional agreement party is used in a freight document, the calculation level will be at the header level for all parties.

Note that you must not have defined overlapping services in this scenario, for example, a charge for fumigation with the carrier and the additional agreement party, because it would be calculated twice, once for each party, as there is no mechanism to allocate a specific service to one party only.

If multiple agreements qualify based on a similarity in the described attributes, there are several ways to identify the appropriate agreement:

- The simplest approach is to specify a freight agreement or freight agreement item manually for a freight order (stage). In this case, the charges are calculated based on the specified freight agreement or freight agreement item, and no other agreement gets determined.
- Another approach requiring manual interaction is to enable the manual selection by choosing **Display All Agreements** in the **Agreement Det. Type** dropdown list of the corresponding calculation profile. In this case, the system calculates the charges based on all appropriate agreement items and displays the results in a popup window for the user to decide. This option is valid only for manual and interactive charge calculation. If charge calculation is triggered in the background or from a worklist, charge calculation will fail, and the calculation status will be set to **Automatic Charge Calculation Failed**.
- If the **Agreement Det. Type** in the calculation profile is set to **Minimum Charges** or **Maximum Charges**, the system calculates the total for all appropriate agreement items and selects the one with the lowest or highest charges. The calculation profile and its impact are explained in Section 9.2.2.
- The appropriate agreement can be selected via an agreement determination rule, if one is maintained in the calculation profile.
- The appropriate agreement and relevant agreement items can also be selected via the leading charge type. Only those agreement items that include at least one leading charge type are used in the evaluation, and only those agreement items in which all included leading charge types can determine a valid rate are considered. The leading charge type is only considered in the selection of the appropriate agreement if the **Evaluate All Agreements** checkbox is selected in the charges profile, which is explained in Section 9.2.2.
- An agreement can only be selected for charge calculation if its **Exclusion Rule** doesn't prevent its usage. The exclusion rule is assigned on the **General Data** tab of the freight agreement.
- If after all these checks, there are still several potential agreements available for charge calculation, the agreement priority, which is defined on the **General Data** tab of the freight agreement, can be used as a tiebreaker. The freight agreement with the highest priority (lowest number) will be selected.
- Finally, if none of the previous criteria helped to identify one freight agreement and its relevant items, the choice will be random, which you should avoid.

Agreement Item Determination

The determined agreement can contain multiple agreement items. Before checking the assigned calculation sheet in detail, the system needs to find out how many agreement items it's looking for. This depends on the calculation level, and there are three options:

- **Calculation at the header level**
  The contract determination logic runs only once on the header of the transactional document and identifies exactly one agreement with one matching agreement item (calculation sheet).
- **Calculation at the item level**
  The determination logic runs once per each main cargo item in the freight document. One agreement item is determined for each cargo item, and charges are calculated separately for each cargo item of the transactional document.
- **Calculation at the stage level**
  The determination logic runs once for each stage in a freight order or freight booking. One agreement item is determined for each stage, and charges are calculated accordingly.

A frequent use case is the combination of charge calculation both at the stage level and at the header level. These two calculation levels can coexist. To configure this use case, you must select **Calculation at Stage Level** as the relevant calculation level in the calculation profile to calculate charges for each stage. In addition, you need to flag one agreement item in your freight agreement as a **Header-Level Charge**. This agreement item will then be used for the calculation of the header-level charges.

It's important to note that charge lines from different calculation sheets can't be combined within one transactional document other than using this concept of calculation levels.

Furthermore, to check the relevance of an agreement item, the attributes of the agreement item must match the same of the transactional document for which the determination logic has been triggered. The following attributes can be used:

- Shipping type (e.g., less than container load [LCL], full truckload [FTL], or unit load device [ULD])
- Transportation mode (e.g., sea, air, rail, or truck)
- Stage category (e.g., pre-carriage, main carriage, or on-carriage)
- Stage type (e.g., pickup or delivery)
- Service level, such as those of a carrier (e.g., express, standard, cold chain, or fumigation)

After one or multiple agreement items have been determined, an appropriate calculation sheet needs to be identified and validated. This can be influenced by the leading charge types contained in the calculation sheet and by preconditions.

An agreement item with an assigned calculation sheet that contains a leading charge type can only be selected if a valid rate can be determined for this leading charge type. As a rule of thumb, you should always try to use just one leading charge type per calculation sheet (e.g., the basic ocean freight charge, the main air freight charge, or the basic freight charge, depending on your mode of transport).

Preconditions can be based on BRFplus (see Chapter 2, Section 2.3) for more complex condition expressions. In the next section, we elaborate more on the use of these preconditions for contract determination. Additionally, there are also standard preconditions available. These are either assigned in Customizing to freight agreement types (**Transportation Management • Master Data • Agreements and Service Products • Define Freight Agreement Types**) or freight agreement item types (**Transportation Management • Master Data • Agreements and Service Products • Define Freight Agreement Item Types**). These standard preconditions relate to attributes such as transportation mode, shipping type, or stage category. Furthermore, trade lanes or business partner roles can be used as preconditions and assigned to the agreement items.

If you want to deviate from the standard logic to determine the agreement items, you have the option to define a calculation sheet determination rule in the calculation profile.

9.2.2 Configuration of Contract Determination

There are essentially two pillars in the configuration of the contract determination logic. The first one consists of the calculation profile and charges profile defined in Customizing, and the second one is the charge calculation rules. We'll discuss both in the following sections.

Calculation Profile and Charges Profile

The calculation profile is defined in Customizing via **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Define Calculation Profile**. One of the most important settings of the calculation profile in Figure 9.16 is the calculation level explained in the previous section. An agreement determination rule (**Agr. Det. Rule**), a calculation sheet determination rule (**Calc Sheet Det. Rule**), and the agreement determination type (**Agreement Det. Type**) are also defined here.

Furthermore, the calculation profile contains the calculation date type (**Calc. Date Ty.**), which specifies the date to use to check the validity of an agreement and calculate the charges. Possible calculation date types include the system date, the order (creation) date, the order start date, or order end date. If charges need to be calculated in multiple currencies, it's also important to define how the exchange rate date is determined. The exchange rate date type (**Exch. Rate Date Type**) can be the same as the calculation date or defined differently.

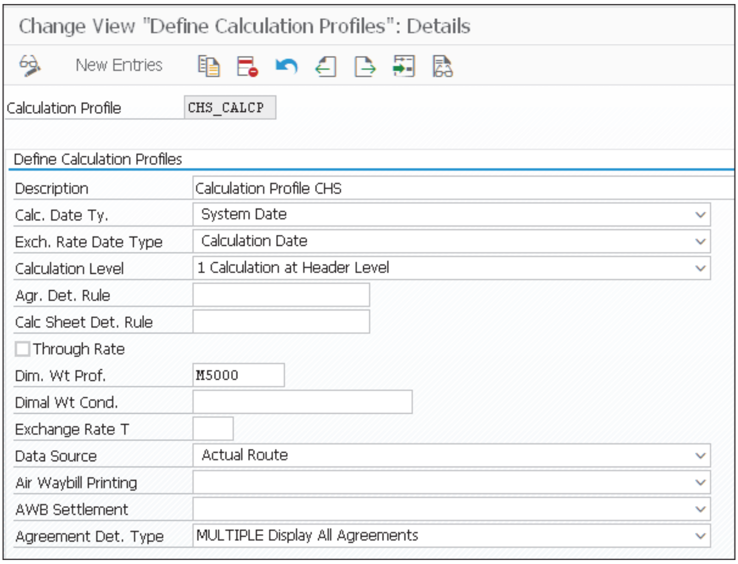


Figure 9.16 Calculation Profile

The calculation profile is assigned either to a carrier in the business partner master data or to the charges profile. The charges profile itself can be assigned to an organizational unit. Thereby, you default a calculation profile via the charges profile for a purchasing organization except for cases in which a calculation profile is defined for a carrier business partner explicitly.

Besides the calculation profile, the charges profile in Figure 9.17 contains the links to the settlement profile and the cost distribution profile, which we'll introduce in Chapter 10. The charges profile is defined in Customizing via **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Define Charges Profile**.

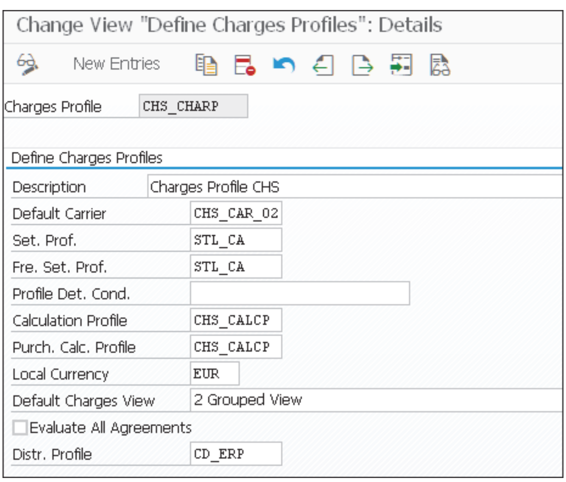


Figure 9.17 Charges Profile

In the charges profile, you can select the **Evaluate All Agreements** checkbox to allow the system to evaluate all agreements that have an appropriate business partner and organization for valid rates based on the leading charge types and priorities as it has been explained in the previous section. Finally, you define whether item-based charges should be displayed in a grouped or ungrouped view in the **Default Charges View** dropdown.

Let's conclude with the second pillar of the contract determination logic: charge calculation rules.

Charge Calculation Rules

To enhance the flexibility of both the contract determination logic and the charge calculation logic itself, you can specify charge calculation rules and conditions based on BRFplus. The basic principle is identical for all BRFplus-based conditions: all attributes in a transactional document—such as the freight order or freight booking—can be used to design a condition and for validation against a BRFplus decision table. If an attribute is stored on a line-item level (e.g., a rate table line item), it must be available as a calculation base. Attribute values are retrieved via data access definitions. They are then used as columns in a decision table and for the validation between transactional data and the table structure. Figure 9.18 shows a calculation sheet determination rule as an example for a BRFplus based condition using a decision table.

In this example, the determination is based on three criteria: mode of transport, dangerous goods (DG) indicator, and the bill-to-party. The decision table is evaluated sequentially row by row until the first row matches the attributes of the transactional document. Typically, the last row can be used to default a result (here, calculation sheet **CHS_DEFAULT**) by not specifying any attribute value to match, as shown in Figure 9.18.

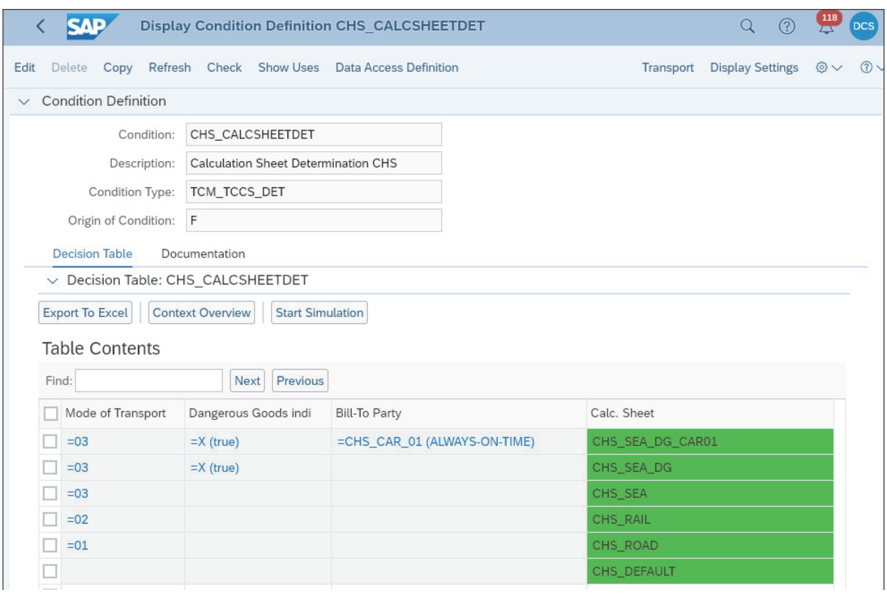


Figure 9.18 Condition for Calculation Sheet Determination

Business Add-Ins versus Charge Calculation Rules

There are various enhancement spots in charge management where a business add-in (BAdI) can be implemented. You can find the available BAdIs in Customizing via menu path **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management • Master Data • Agreements/Rate Table/Calculation Sheets** and **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management • Basic Functions • Charge Calculation**.

The actual logic developed in a BAdI has a slight performance advantage compared to charge calculation rules using BRFplus. On the other hand, a condition is much easier to implement because it's configured purely in decision tables and can be flexibly maintained without hard-coding values. Whether to enhance transportation charge management via a BAdI or a charge calculation rule is an individual decision based on the complexity and required flexibility of the enhancement.

Charge calculation rules can be based on conditions or based on custom code (BAdIs). Wherever charge calculation rules can be assigned, a condition can also be assigned directly. Charge calculation rules are defined only on the classic SAP GUI via path **Logistics • Transportation Management • Master Data • Maintain Charge Calculation Conditions**. In this transaction, charge calculation rules can be defined for the following use cases:

- **Agreement Determination Rules–Standalone**
- **Agreement Determination Rules–Exclusion**
- **Calc. Sheet Determination Rules–Standalone**
- **Calc. Sheet and Calc. Sheet Item Precondition Rule**
- **Grouping Rules for Resolution Base**
- **Rules for Rate Table Determination**
- **Rules for Charge Calculation by Formula**

For the area of contract determination, only the first four use cases are relevant:

- **Agreement determination rule–standalone/exclusion**
  The entire logic of how to perform the contract determination can be bypassed using an agreement determination rule–standalone. That way, you can define your own custom logic. Alternatively, you can still use the standard contract determination logic but apply an additional filter that takes the form of an exclusion rule.
- **Calculation sheet determination rule–standalone**
  A calculation sheet determination rule defined as a condition in Figure 9.18 can be used to determine a calculation sheet.
- **Calculation sheet (item) precondition rule**
  Precondition rules can be assigned on the level of agreement items to help select the

right calculation sheet or on the calculation sheet item level to check the applicability of a specific charge line item as described in Section 9.1.2.

The remaining charge calculation rules are relevant for the actual rate retrieval and calculation. They are explained as part of the calculation logic in the next section.

9.3 Charge Calculation Logic

In the previous section, you learned how one or multiple agreements are automatically determined for charge calculation. In this section, we focus on the pure logic of how charges are calculated per charge type in a calculation sheet. The charge calculation process can vary wildly in different industries, for different types of charges, and for different modes of transport. In ocean freight, for example, there can be hundreds of surcharges that are all calculated differently, such as bunker adjustment factors based on a formula, a charge for out-of-gauge cargo, or country-specific surcharges. Similarly, in air freight, there are complex requirements for charge calculation, such as a charge calculation for ULD ratings with pivot rates. In trucking, there can be charges such as fuel adjustment factors based on index values.

The general principles of how charges are calculated are explained in Section 9.3.1. In Section 9.3.2, we describe some special capabilities in truck and rail transportation. Section 9.3.3 deals with event-based charge calculation, and, finally, Section 9.3.4 discusses how to analyze your charge results and estimate charges. TM's strong capabilities to manage air freight charges, sea freight charges, and LSP-specific scenarios will be covered in Chapter 11 and Chapter 12.

9.3.1 Basics

Charges can be calculated for any freight order or service order, freight booking, consignment order, forwarding order, quotation, settlement document, or freight unit. You need to ensure that charge calculation is enabled in the relevant transactional business document type in Customizing. You can calculate the charges manually by selecting **Charges • Calculate Charges** in the top panel of any transactional document, from a worklist, or in the transportation cockpit. In addition, you can enable automated charge calculation in the document type Customizing. Furthermore, a background report allows you to mass-calculate charges (/SCMTMS/TOR_CALC_BATCH). Finally, charges are also automatically calculated when you generate a settlement document (depending on the strategy for settlement documents in Customizing; refer to Chapter 10) or recalculated in credit memos.

In this section, we'll discuss calculation processing logic, rules, and methods.

General Processing Logic

Let's rewind for a moment. The result of the contract determination logic is one agreement item per calculation level (e.g., per stage or item) and a corresponding calculation sheet. Now each charge line item of the calculation sheet is evaluated, as follows:

1. Each charge line is checked regarding whether it's required for the calculation. You can maintain preconditions for this purpose. Standard preconditions include trade lane, service and business partner, and complex preconditions rules based on BRFplus as explained in the context of the contract determination logic (calculation sheet item precondition rules).
2. The instruction type of the charge line gets evaluated. Instruction type **Standard** points to a normal calculation of a rate amount, whereas other instruction types initiate some special logic. **Sum** will calculate an intermediate sum of all charge lines that are defined hierarchically below this charge line. **Line Item Selection** will evaluate the subordinate charge lines and choose its highest or lowest value based on its defined operator (**Highest Value**, **Lowest Value**) or the first charge line to return a value (**Check in Sequence**).
3. The rate amount is determined for charge lines with instruction type **Standard**. The rate amount can be a fixed amount, or it can be determined from a rate table. The rate table is either assigned to the charge line or determined via a rate table determination rule. In a scenario where charges are maintained on a regional or country level, you can assign each country its own rate table and determine the appropriate one via a charge calculation rule for rate table determination. After the rate table is found, the correct rate amount is retrieved from the relevant validity period of the rate table. To retrieve the rate amount, the calculation bases for each dimension (scale) of the rate table are evaluated.

The three most important settings that influence the retrieval and calculation of the rate amount are the resolution base, the calculation method, and the calculation rule. These have been introduced briefly in Section 9.1.2 and will be explained in more detail here.

The resolution base can optionally be maintained for each charge line in a calculation sheet. The calculation resolution base determines on which level a rate needs to be applied. Therefore, it defines how often the charge line of the calculation sheet will occur in the result of charge calculation in the **Charges** tab of the transactional document. If a freight booking includes three containers, and a charge line of the relevant calculation sheet has calculation resolution based defined as **Container**, then three rates need to be determined, one for each container. The following are the most important resolution bases:

- **Root**
  This is the default. Only one charge line will be the result with this resolution base. It can be used for charges that are calculated once on the document header level only, such as a documentation fee, bill of lading charges, or air waybill charges.

- **Container**
  The resolution base **Container** generates one row in the **Charges** tab for each container in a freight order or freight booking. It's the most common resolution base for air freight and ocean freight charges. In air freight, it can be used for ULDs. Because multiple containers with different attributes—such as weight, volume, commodity, equipment type, and so on—can be contained in a freight document, the determined rates can vary per container.
- **Package**
  A charge line is generated, and the rate is calculated for each package in a transactional document. This resolution base can be used for charge types, such as commodity handling, loading and unloading, and less than truckload (LTL) charges.
- **Product**
  You can generate a charge line for each product to differentiate product-dependent transportation charges.
- **Service**
  When you work with service items, you can apply the calculation resolution base **Service** for charge types that are mapped against service types. One charge line per service will be created.
- **Stage**
  One charge line per stage will be created, and a corresponding rate will be calculated.
- **Active and passive resource**
  Especially in trucking and for railways, the calculation based on resources is a common business practice. For example, you can maintain the resolution base **Passive Resource** to calculate a charge for each trailer or rail wagon individually.

The calculation level introduced in Section 9.2.1 has a strong impact on the resolution base. If the calculation level is chosen as an item level, but the resolution base of a charge type in the calculation sheet is selected as root (header), then the charge is still applied for the item (e.g., a container) and not the header (freight order). This means that the calculation level takes precedence over the resolution base; that is, the resolution base is applied based on the selected calculation level. Resolution bases can't be customized but are provided as part of the standard functionality.

Grouping rules are charge calculation rules that allow you to cluster different elements with the same resolution base to calculate a consolidated rate. Let's assume you want to calculate charges for a train that consists of 10 rail wagons of type A and another 10 rail wagons of type B. Calculation resolution base **Passive Resource** allows you to retrieve 20 rates, one for each wagon. However, you can't calculate the cost advantage from using several wagons with identical types. This is possible by using the wagon type in a grouping rule to only retrieve two rates, one for each wagon type. In a collective freight settlement, document grouping can be done across transactional documents by selecting the **Group Across Orders** flag in the grouping rule.

Because the resolution base can be defined differently for each charge line, it's also possible to combine them in one calculation. Let's assume you calculate charges for a road freight order that delivers packages from your warehouse to several customers:

- A waybill fee is charged with the resolution base root.
- A destination-based fee is charged with the resolution base stage for each destination.
- A handling fee is charged with the resolution base package for each pallet.
- An equipment-based charge is calculated for the truck and trailer based on the active resource and passive resource resolution bases.

Calculation Rules and Methods

In the charge calculation logic, the calculation rule greatly influences how a rate is calculated. To construct a calculation rule, you need to define three components: the calculation base, price unit, and unit of measure.

From Section 9.1.4 and Section 9.1.5, you learned that many calculation bases are available, such as source location, equipment type, and gross weight. When constructing a calculation rule, you can use only calculation bases with a numerical value (e.g., gross weight) because its value needs to be multiplied with the price and divided by the price unit. For example, to maintain a charge line with the calculation base actual distance and a price of 0.45 EUR per kilometer, you can enter the amount 45 with currency EUR, the price unit would be 100, the calculation rule unit of measure KM, and the calculation base actual distance. For a freight order that travels 2,000 kilometers, the calculation logic would divide this value by 100 and multiply with 45 to determine 900 EUR as a final rate.

In a rate table, you can maintain multiple calculation rules to model more complex business scenarios. For each calculation rule in a rate table, you must define its application level. This can be either maintained as **Rate Table**, if you expect to apply the rule for the full rate table, or you can define calculation rules with different price units per scale item. In this case, the application level for the calculation rule is **Scale Item**, and you must maintain the corresponding price unit for each scale item in the **Scale Items** tab.

Calculation methods are relevant for the correct interpretation of the values retrieved from a rate table. Several calculation methods are available, but you can also develop your own calculation methods and assign them in Customizing (**Transportation Management • Basic Functions • Charge Calculation • Enhancements to Charge Calculation Engine • Define Calculation Methods**) to become available in the calculation sheet. The most common calculation methods are the following:

- **Standard**
  This is the simplest calculation method. The standard calculation method multiplies the rate retrieved from the rate table (e.g., 0.45 USD per mile) with the corresponding

value from the calculation base (e.g., 100 miles) to compute the final amount (here, 45 USD). If you don't maintain a calculation method in the charge line, this calculation method is used by default.

- **Clipping**
  A calculation method that is also frequently applied is clipping. When you're working with tiered rates in a rate table, the clipping method takes a value that is relevant for the charge calculation (e.g., weight) and applies each tier until the total is reached or exceeded. At the same time, the clipping method is accumulating the calculated charge.

  Let's compare calculation methods standard and clipping by an example: The calculated charge will be based on gross weight, and the total gross weight to be charged for is 11 tons.

  Based on the rate table in Table 9.1, the standard calculation method would identify the relevant rate as 14 USD per ton and therefore return 11 × 14 = 154 USD as a final amount. In contrast, the clipping calculation method would return 209 USD because it would have calculated different amounts for the first ton, second to fifth ton, and so on, as outlined in Table 9.1. Thus, the same rate table can yield different results based on the applied calculation method.

Scale	Rate	Calculated Amount	Value
Up to 1 ton	35 USD absolute	35 USD	1
Up to 5 tons	20 USD per ton	80 USD	4
Up to 10 tons	16 USD per ton	80 USD	5
Up to 15 tons	14 USD per ton	14 USD	1
Sum		209 USD	11

Table 9.1 Rate Table and Clipping Results

- **Break-weight**
  The break-weight calculation method deals with an undesired anomaly of the standard calculation method. Based on the rate table in Table 9.1, the standard calculation method calculates 90 USD for a gross weight of 4.5 tons (4.5 × 20 = 90 USD) but calculates only 81.60 USD for a gross weight of 5.1 tons (5.1 × 16 = 81.60 USD). Thus, a higher weight would result in a lower charge. To avoid this anomaly, the break-weight calculation method calculates two values: (1) the same as the standard calculation method and (2) the entry price of the subsequent scale item. Then it compares these two values and returns the lower one. For a gross weight of 4.5 tons, the break-weight method will first calculate 90 USD (per the standard calculation method), then calculate 80 USD (lowest price in the subsequent scale item), and finally return 80 USD (the lower value).

- **Deficit weight rating**
  Deficit weight rating is a calculation method used especially in US land transportation. If you have a tiered rate table, and the weight of a cargo item isn't high enough to reach the tier with cheaper rates, the system sums up the weight of similar cargo from different freight classes and rounds up the weight to reach the next available tier. The charges for all cargo items are calculated based on this cheaper tier. The deficit that was added is rated with the cheapest freight class rate in the appropriate tier and added to the total rate.

  Table 9.2 and Table 9.3 show an example of the deficit weight rating. The weight of freight class A is 350 kilograms, and the weight of freight class B is 600 kilograms. As depicted in the rate tables, the total rate with the standard calculation method is 20,200 USD (7,000 + 13,200). With the deficit weight calculation method rating, the total rate is 18,000 USD (5,250 + 750 + 12,000) USD because the total weight is rounded up by 50 kilograms to 1,000 kilograms to achieve the next-cheapest tier. Each freight class is rated in its individual tier (350 × 15 = 5,250 and 600 × 20 = 12,000). In addition, the deficit weight of 50 kilograms (1,000 – 950) is rated with the cheapest rate in all tiers across the two freight classes (50 × 15 = 750).

  In the transactional document, a new charge line called *deficit charge* concatenated with the charge type description is automatically created. This additional charge line will show the deficit weight and deficit rate-related information corresponding to the charge type.

Tier	Rate	Standard	Deficit Weight Rating
Up to 500 kilograms	20 USD per kilogram	7,000 USD	
Up to 750 kilograms	19 USD per kilogram		
Up to 1,000 kilograms	15 USD per kilogram		5,250 USD 750 USD (50 × 15)

Table 9.2 Rate 1 with Freight Class A: 350 Kilograms

Tier	Rate	Standard	Deficit Weight Rating
Up to 500 kilograms	25 USD per kilogram		
Up to 750 kilograms	22 USD per kilogram	13,200 USD	
Up to 1,000 kilograms	20 USD per kilogram		12,000 USD

Table 9.3 Rate 2 with Freight Class B: 600 Kilograms

- **External system**
  The external system calculation method allows you to call an external rating engine, such as SMC3. In this case, the rates are retrieved from the external system without being calculated in TM.

9.3.2 Mode-Specific Calculation for Road and Rail Freight

Each transportation mode has its peculiarities when calculating charges. While specifics for sea, air, and forwarder businesses are discussed in Chapter 11, road and rail freight are addressed here.

Parcel Freight Charges

The transportation of freight with courier, express, and parcel (CEP) services requires specific functionality to calculate charges accordingly. A key difference from all other charge calculation scenarios is that, in this scenario, charges are retrieved already in the freight unit that represents a parcel or package. This process is called direct shipment, which must be enabled in the freight unit type Customizing (**Transportation Management • Planning • Freight Unit • Define Freight Unit Type**) by selecting either **Automatic Determination of Direct Shipment Options** or **Manual Selection of Direct Shipment Options Enabled** as the direct shipment option (DSO) type. In this case, each applicable freight agreement is determined for the freight unit as well as the available services each carrier offers. A user can choose the best DSO in the freight unit based on the charges for various service levels. For the setup of these kinds of charges in agreements, it's crucial to maintain the service levels of each carrier for CEP services as agreement items. This allows you to differentiate charges for an overnight versus a three-day delivery service, for example. Each such agreement item can use additional dimensions as a precondition, such as weight, height, or length of a parcel. The retrieved charges per service are displayed on the **Direct Shipment Options** tab of the freight unit.

Charge Calculation for Road Freight

In most economies, much of the freight volume is still transported via road. Compared to rail transport, truck transports are typically faster but also more expensive. The following criteria are typical for charge calculation in road freight:

- **Number of stops**
  To enable a charge that is dependent on the number of stops in the freight order, you can use calculation base `NUMBER_OF_STOPS` that counts all stops of a freight order or calculation base `NO_OF_INT_STOPS` that only counts the number of intermediate stops without the initial start and the destination stop. You can multiply this figure with a fixed stop charge or use it in a rate table.

- **Fuel surcharges**
  To model fuel surcharges you can use index-based rate tables. This is very typical for many truck carriers to apply flexible surcharges depending on a fluctuating fuel index. A special calculation method type (**Fuel Surcharge Calculation**) and calculation method (FUEL_SURCHARGE) is available for this scenario. Two flavors of this calculation are offered: either the system retrieves the latest fuel index to look up the relevant rate in a regular rate table based on the order date, or the system compares the fuel index on the order date against a fuel index for a base date and multiplies it with a percentage or the actual fuel surcharge value.

  To configure the first variant of index-based charges, you must maintain a corresponding charge line in your calculation sheet and use calculation base FSC (fuel surcharge) in a regular rate table assigned to this charge line. This (regular) rate table holds the rate amounts depending on the index value. A second rate table, from which the index value is retrieved, needs to be maintained in the same charge line in the **Index Rate Table** field.

  In the second variant, two charge lines are required. The first charge line holds the regular rate table. The second charge line holds the index rate table, the index base date, and the reference line number to the first charge line. The index rate table is defined like the first variant, but instead of using the actual rate amount, the system determines the value for the scale item that is valid on the date specified in the **Index Base Date** field. An index value is calculated and used in conjunction with the amount or percent specified in the relevant (first) line item in the calculation sheet to determine the fuel surcharge amount.
- **Active and passive resources**
  Another useful functionality for road freight is to base charges on the vehicle resources used. This allows you to apply different charges, depending on whether a truck, trailer, or specific combination thereof has been used. The calculation resolution bases ACTIVE_RESOURCE and PASSIVE_RESOURCE are available to influence whether a charge such as a fuel surcharge is only applied for the truck or for both truck and trailer.
- **Postal codes**
  Frequently, charges in road transportation are based on transportation zones or postal codes. Because using individual postal codes for the definition of freight charges can lead to rather large rate tables, the wildcard operator * can be used in place of numerals of the postal code. The most specific rate value will be retrieved with this setup. In the rate table in Figure 9.19, the value 30 would be retrieved for transporting a dangerous good to postal code 64625, whereas 38 would be retrieved if the same item were sent to postal code 68900 (6*).

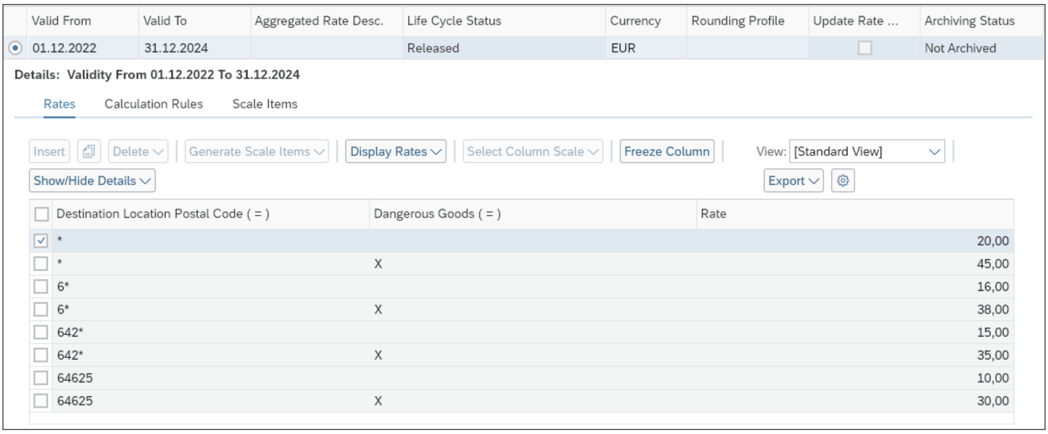


Figure 9.19 Charge Calculation Based on Postal Codes

Charge Calculation for Rail Freight

Like road transports, rail transports also have their transportation mode-specific calculation logic:

- **Interline shipments with rule 11**
  The railway network in different countries or even within large countries such as the United States is divided among several rail carriers. If a shipper wants to transport goods across a railway network, it's very likely that multiple rail carriers will be involved in executing this transport. Rule 11 is the rail industry regulation governing interline shipments with one tender and multiple service provider invoices. A rail freight order will typically have one stage for each of the different rail carriers involved in the transport. However, to simplify the contractual relationship, a shipper might have a freight agreement with only one (or a subset) of all rail carriers involved in the transport. In this kind of scenario, the system will retrieve the relevant freight agreement based on the *invoicing carrier* that will be maintained in the corresponding rail freight order against each stage. The invoicing carrier can therefore be different from the executing carrier of a stage and is determined based on rail routing.
- **Railcar charge calculation with day-of-week pricing**
  It's possible to maintain rates in absolute numbers or markups in percentages depending on the delivery date. Especially in rail transportation, the charges often deviate depending on the weekday. Calculation base `WEEKDAY` may be appropriate to use in these cases.

  This can also be relevant for the determination of rail fuel surcharges. If the order date isn't used to look up the fuel index, but the in-gate date (e.g., the end date of main carriage) is used instead, then you should specify the calculation date type in the calculation profile accordingly.

- **Railcar-specific charges**
  Like road freight, the calculation resolution bases ACTIVE_RESOURCE and PASSIVE_RESOURCE are frequently used to differentiate charges applied to either the locomotive or individual rail wagons. Calculation base NO_OF_AXLES can be used to determine axle-based charges for rail wagons of different sizes and types.

9.3.3 Event-Based Charges

Any company managing freight in containers will have experienced detention and demurrage charges. These fees are charged if containers are released or returned to the provider of the container, mostly freight forwarders or ocean carriers, later than agreed. Demurrage charges usually apply if a shipper or consignee (e.g., a manufacturing company) picks up the container from the port of discharge too late. These charges are meant to cover the cost that occurs for the service provider when storing the container in a port or terminal. Detention fees follow the exact same principle. They apply for extra days the empty container isn't returned after it has been delivered to the consignee. The rationale is that the provider of the container has an opportunity cost if the provider can't use this container for another customer. Detention and demurrage charges can even apply for entirely chartered ocean vessels. Especially for bulk transportation, it's common to charter an entire vessel for a transport (e.g., of oil or iron ore). The carrier charges detention and demurrage fees for the late release of the vessel from its service.

Detention and demurrage fees are the most prominent but certainly not the only example of where a charge is applied upon the occurrence of a certain event. Other examples include accessorial charges in the railway business (e.g., storage services or diversions), service charges in the ocean carrier industry (e.g., reissuance of documentation, detention in transit, or container cleaning charges), or any other conditional charges that aren't known prior to the execution.

Event-based charge calculation allows you to use event information in the charge calculation process. That way, charges can be retrieved depending on whether certain events happen and the deviation of time between the planned and actual event time or between the actual time and a reference event. Depending on the individual contractual agreement, a service provider usually grants some number of free days prior to starting to charge. If we apply this capability to detention and demurrage fees, this means that during the tracking of the delivery of the container and its empty return to the container depot in SAP Event Management, this information can be provided to the charge calculation logic. During charge calculation, the system retrieves the total days between full container delivery and empty container return and subtracts the free days to derive the chargeable delay days. This number is then multiplied with the detention/demurrage fee per the charge line/rate table.

Limitations of Event-Based Charge Calculation

Managing detention and demurrage charges can be increasingly complex. Depending on the exact contractual commitment, LSPs might have stringent clauses when the count of delay days goes up. Some contracts exclude, for example, force majeure or other incidents from counting toward detention/demurrage days. If there is, for example, a labor strike in a port of discharge that prevents the consignee from picking up its container, the corresponding days might not count as demurrage-relevant days. In addition, the free day commitments can be very granular and different per each port-pair and equipment type.

Another important aspect of basing charge calculation on actual event dates is the accuracy of how this event information is captured. If reported event dates and times aren't accurate, charge calculation based on this inaccurate information will be wrong from the beginning.

To enable event-based charge calculation, you need to create an event profile and map charge types to events in Customizing via menu path **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Define Event Profiles**. Figure 9.20 illustrates the creation of an event profile. In this example, three charge types are maintained, which are based on different events. When these events are reported, for example, via SAP Event Management (see Chapter 7, Section 7.2) the corresponding charge type is added to the execution document (e.g., a freight order or freight booking), and charges are calculated.

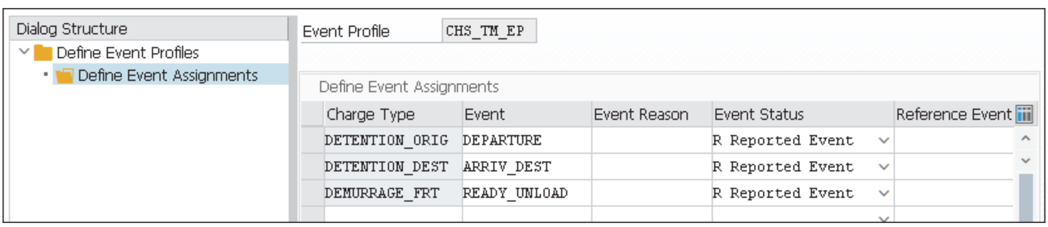


Figure 9.20 Event Profile for Event-Based Charge Calculation

Notice that the event profile is influencing only whether and when a charge type is applied in a transactional document. The charge calculation logic still resides in the calculation sheet. For the detention/demurrage calculation, you still need to maintain the appropriate charge types in the calculation sheet. To model the logic to apply a threshold of free days into the calculation, you can use calculation base DELAY_TOT (delay days) and unit of measure as DAY in the calculation rule of the appropriate charge line and assign in Customizing the calculation base GRACE_DAYS as a related calculation base to calculation base DELAY_TOT. This allows you to maintain the number of free days directly in the calculation sheet.

So far, we've put a lot of emphasis on the options for how to configure the contract determination and charge calculation logic. Finally, let's look at the result and the options for analyzing it.

9.3.4 Charge Calculation Analysis and Charge Estimation

After a successful calculation of the charges, you can find the results in the **Charges** tab of your transactional document. How you can read and understand this information, especially if the result doesn't match your expectation, is the focus of the remainder of this section.

Figure 9.21 shows an example of calculated charges for a road freight order. The freight order consists of two stages (from **CHS_SAP_1** via **CHS_SAP_2** to **CHS_SAP_3**) and includes three items (**MATERIAL 1**, **MATERIAL 2**, and **MATERIAL 3**). From the **Logistical Reference**, you can see that the basic freight of the first charge line has been calculated on the header/root level, whereas the stop-off charge has been calculated on the stage level, and the handling charges have been calculated on the product level. This has been achieved by using the different calculation resolution bases (ROOT, STAGE, and PRODUCT) for the corresponding charge lines in the calculation sheet. On this overview, you can also see the following for each charge result line:

- The rate amount that has been determined from the rate table or calculation sheet
- The price unit and unit of measure
- The logistical quantity
- The calculation base

This information is used to compute the calculated amount for each charge line as well as the final amount.

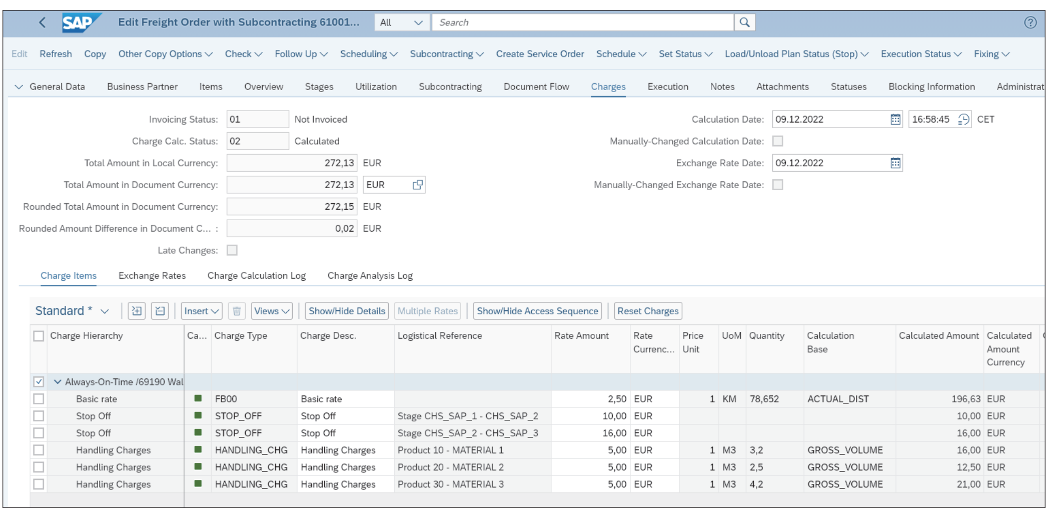


Figure 9.21 Charge Calculation Result in a Freight Order

To increase the transparency of the calculation, you can display details for each charge line. You can toggle between the display of this information or hide it using the **Show/ Hide Details** button. Figure 9.22 and Figure 9.23 show some of the details that are displayed when this function is turned on. The details show systematically how the charges have been determined. They are always displayed for the charge line that is currently selected.

More specifically, Figure 9.22 and Figure 9.23 show the details for the stop-off charge for the second stage from **CHS_SAP_2** to **CHS_SAP_3**. In Figure 9.22, you can see that freight agreement **AGR_CHS_01** with **Calculation Sheet 11317** and **Rate Table CHS_ZIP_RATE** has been used to retrieve a rate amount of **16 EUR**. Figure 9.23 shows the logistical data that has been used to retrieve this value from the rate table. The **Data Source Value** for DG was empty, such that also the empty value has been retrieved as **Scale Value**. For the postal code, the value retrieved from the freight order was **68900** (**Data Source Value**). Because no such value exists among the scale items in the rate table shown earlier in Figure 9.19, the postal code that comes closest, that is, **6***, is used as a **Scale Value** to retrieve the rate amount.

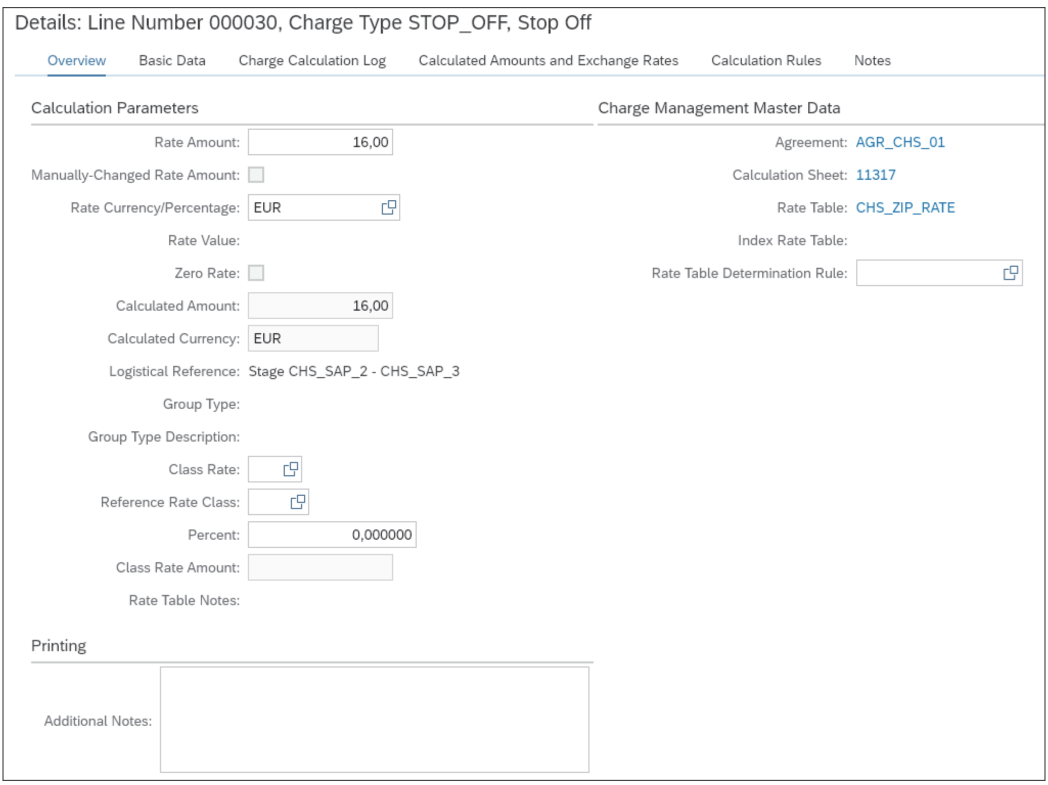


Figure 9.22 Charge Calculation Analysis: Overview

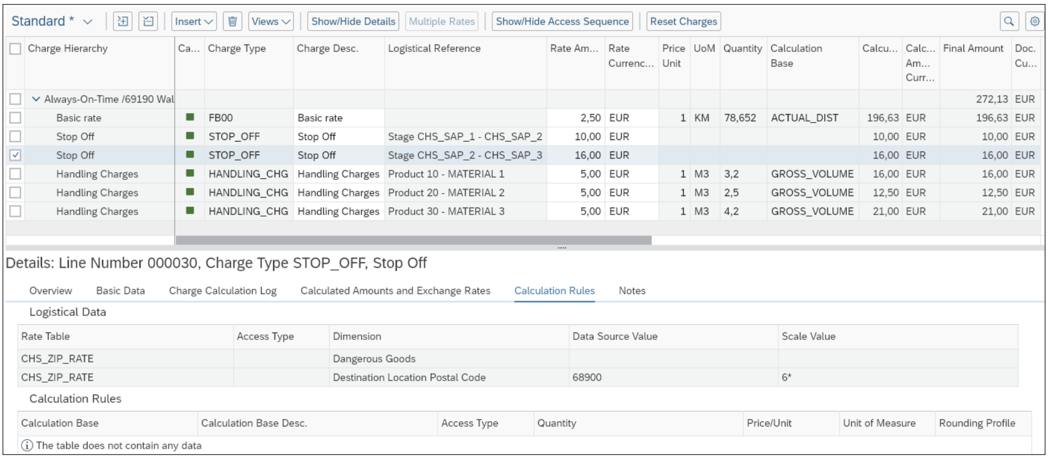


Figure 9.23 Charge Calculation Analysis: Calculation Rules

If manual changes or additions are required, you have the option to change calculated rates or add charge lines by choosing **Insert • Charge Line**. For manually inserted charges, you need to specify the charge type and rate amount. The system will flag any inserted or manually changed rates as manually changed rate amount. Manually changed rates are kept when the charges are recalculated, and the same freight agreement and calculation sheet are retrieved. If you use the **Reset Charges** button, manual changes are reverted.

Charge Calculation Log

The **Charge Calculation Log** tab shows additional details about how the system has calculated the charges. These details aren't stored in the freight document, but get redetermined whenever you trigger charge calculation. Whether the charge calculation log is created or not depends on the user parameter /SCMTMS/CLOG, which you need to specify as X for your user.

If no freight order or freight booking exists, but an estimate of freight charges is required, this can be done with the Estimate Freight Charges app available in order management. This app can support you in estimating the transportation cost without generating a transactional document. Technically, the object used in this process is like a freight order, but the results can't be persisted and saved. Furthermore, you can skip entering certain information that may be unknown at the time. The UI of this app is a simplified freight order screen, as shown in Figure 9.24.

Let's change our focus now from an operational view to a more strategic perspective. In the next section, we introduce the available capabilities around strategic freight procurement. While we started this chapter with manually creating freight contracts, the next topic is to show their automatic creation via a streamlined quotation process.

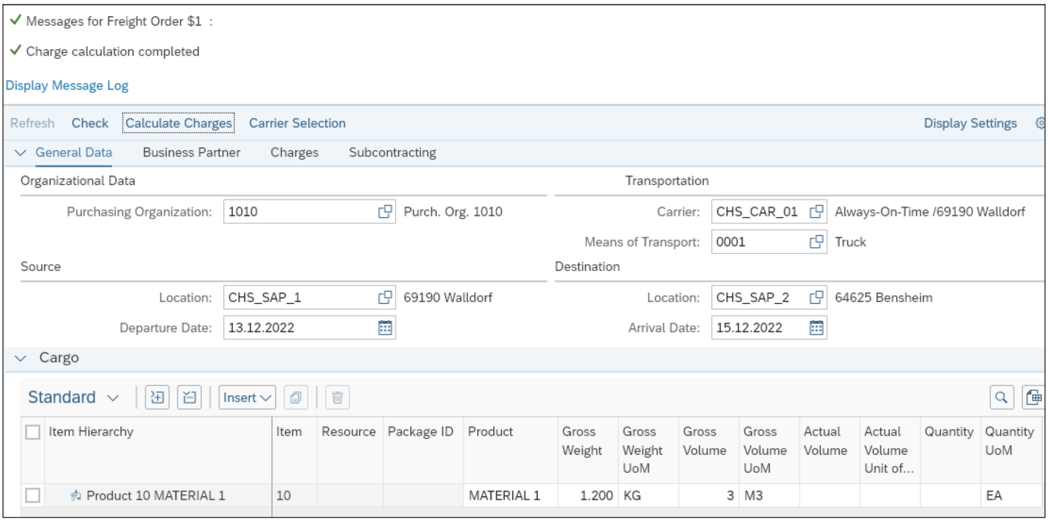


Figure 9.24 Estimate Freight Charges App

9.4 Strategic Freight Procurement

TM offers capabilities for long-term procurement and selling decisions. In this section, we summarize the capabilities of strategic freight procurement, which is part of strategic freight management. We introduce a comparable functionality for strategic freight selling in Chapter 11, Section 11.5. Strategic freight procurement is relevant for shippers and LSP businesses, as most parties need to subcontract freight services to external vendors.

Figure 9.25 shows the high-level architecture of strategic freight management. In terms of freight service contracting, the architecture shows a clear distinction between strategic freight selling (customer contract management) and strategic freight procurement (vendor contract management), symbolized by the sections on the left and the right.

On the right side of Figure 9.25, you can see the capabilities for a strategic freight procurement (also known as vendor contract management), which we focus on in this section. This includes integration with SAP S/4HANA embedded analytics to analyze historical activities and derive forecasting information. You can generate a freight agreement quotation, which serves as an RFQ to one or many vendors, shown in the center-right.

It's possible to perform a carrier ranking and carrier analysis directly from the freight agreement quotation. You can generate multiple vendor RFQs for publishing and collect various responses. In addition, you can compare answers from your vendors, both manually and via an optimizer engine, to award carriers. Finally, you can generate a freight agreement as a new contract from a freight agreement quotation.

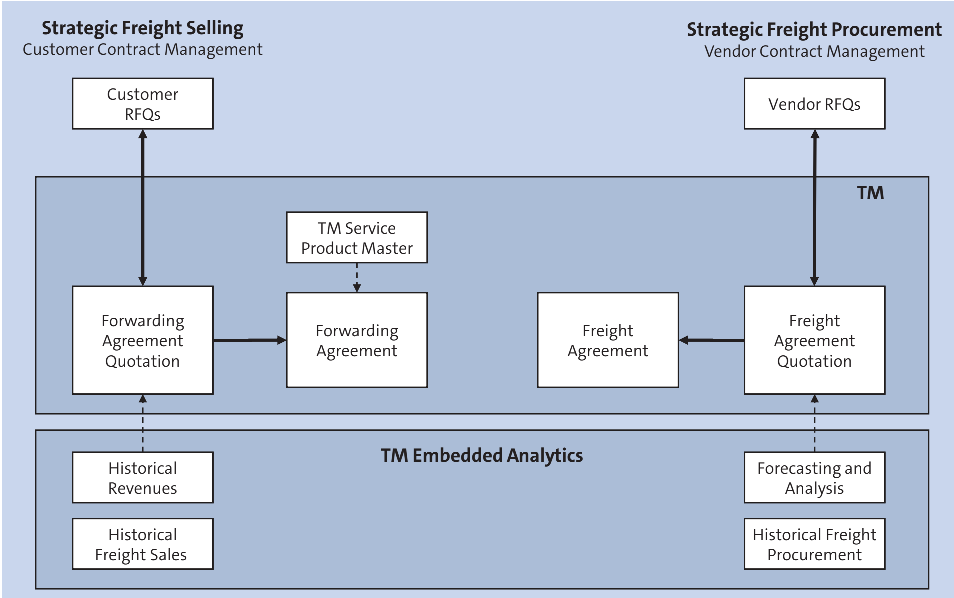


Figure 9.25 Architecture of Strategic Freight Management

Use of Analytics Functions in Strategic Freight Management

Concerning analytics usage in strategic freight management, there is a difference in availability of analytics functions and analytics integration between TM in SAP S/4HANA and previous SAP NetWeaver–based versions of SAP TM. Functionality based on SAP Business Warehouse (SAP BW) is no longer included in the standard scope of TM in SAP S/4HANA, as this release has its own analytics technologies and views. Many analytical reports that are available based on SAP BW may still be used in SAP S/4HANA, even if there is no separate content section in SAP Help. For more information, refer to Chapter 12, Section 12.1.4. As of SAP S/4HANA release 2022, SAP BW still offers the broadest support in terms of analytical data for agreements, as embedded analytics and SAP Analytics Cloud mainly concentrate on order, executional, or cost/invoice analysis in the TM standard.

Let's walk through strategic vendor contract management functionality for procurement and see how to create and manage RFQs.

9.4.1 Functional Overview

Strategic freight procurement supports a streamlined management of RFQs from the perspective of a shipper or LSP, requesting capacities and rates from a carrier or freight forwarder. The TM functionality for strategic freight procurement focuses on mid-term and long-term planning and procurement decisions. The intention is to support and enable a quotation and contract management process to establish freight agreements.

The strategic freight procurement process begins by analyzing and planning future demand based on historical data. A forecast is the foundation for procurement decisions about freight capacities. After capacities are forecasted and planned, the actual vendor selection and quotation process can be executed.

The freight order and freight booking tendering functionality is limited to single shipments only, as discussed in Chapter 6, Section 6.6. Strategic freight procurement supports the RFQ process from creating an RFQ, determining the best vendor combination based on responses up to awarding the vendors and creating the contracts. We differentiate between two functional processes, as shown in Figure 9.26:

- **Planning and analytics**
  This process is either executed using the embedded analytics of SAP S/4HANA, SAP Analytics Cloud, or SAP BW. The basis for procurement planning is the historical shipments from TM: Freight orders and freight bookings and their analytical data. These historical demands are the foundation for generating forecasts by using strategies such as trending and smoothing. After you've successfully derived a volume forecast, you can use this information for the freight agreement quotation process.
- **Freight agreement quotation process**
  You can generate freight agreement RFQs to subcontract freight capacities and agree on rates. You can use the forecasted volumes as an input to define capacities you want to request from your vendors. The freight agreement RFQ allows you to define scope, requested capacities, charge structures, and service products that you intend to contract. A carrier ranking tool allows you to short-list potential carriers and forwarders. You can generate vendor RFQ documents and publish them individually to providers. To award a carrier or service provider, you can use a comparison optimization tool and then generate freight agreements.

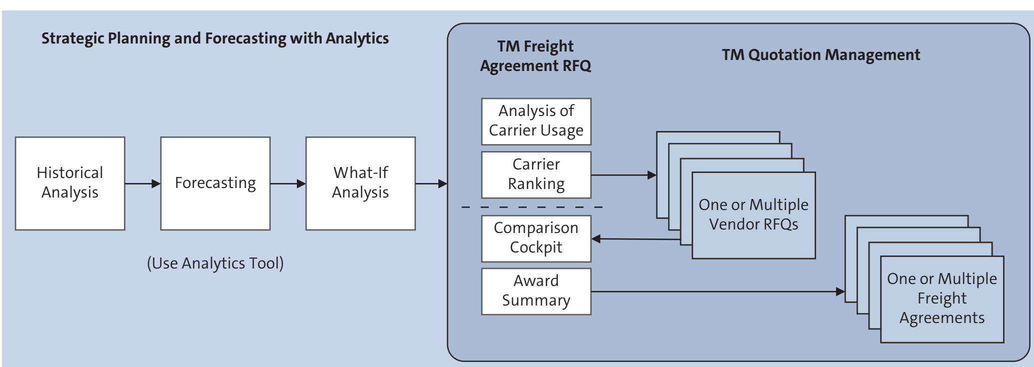


Figure 9.26 Overview of Strategic Freight Procurement

9.4.2 Freight Agreement RFQ Process

In the previous section, we gave you some hints on tools for analyzing historical demands and generation or calculation of a capacity forecast. Knowing your future demand is a key input for making strategic procurement decisions. In this section, we use both capacity information and past shipment data to issue an RFQ to short-listed vendors. The goal is to sign a long-term freight agreement with the highest-ranked and cheapest service providers. This process is driven mainly by the freight agreement quotation, which is needed to start a new RFQ process.

Create Freight Agreement RFQ

You can find agreement quotations in the launchpad by following **Contract Management • Freight Agreements or Create Freight Management RFQ Master**. You're prompted to enter an RFQ type. The RFQ type is a new Customizing setting that you can find in TM Customizing via menu path **Transportation Management • Master Data • Agreement RFQs and Quotations • Define Freight Agreement RFQ Types**. The RFQ type specifies number ranges, activates approval workflows, and contains important settings for carrier ranking and the comparison cockpit, as we describe in the following sections. After you've generated the freight agreement RFQ, you can specify basic header information, such as the purchasing organizations responsible for the RFQ, validity dates, deadline for the quotation, and desired contract duration, as shown in Figure 9.27.

The **Carriers** tab within the **Items** section is used to define the list of vendors you want to consider for the quotation. It doesn't represent the short list to which you're submitting the RFQ, but instead shows the long list of possible vendors. To specify the scope for your RFQ, you need to generate RFQ items. An RFQ item can, for example, resemble different geographical trade lanes, a different set of commodities, or different service products you want to request. You can also maintain a budget against each agreement quotation line to limit your maximum expenditure.

TM offers a ranking functionality for your vendors based on a configurable carrier key performance indicator (KPI) profile. You can set up a profile in TM Customizing and assign it as the default profile to the freight agreement RFQ type. Alternatively, you can select it in the RFQ header or line item directly.

After you've successfully short-listed your vendors based on the KPI analysis and carrier ranking, you can proceed to the quotation preparation. An important step in the preparation is to define the surcharge structure with which you want your vendors to comply. As with a regular freight agreement, you can assign a charge sheet to each line item and add charge types. The list of charges you select is used for submission to the vendors and dictates the charge structure the carrier is expected to reply to. To define the scope of your RFQ with detailed request line items, generate a rate table for each charge type in TM. For charges where you expect a fixed lump sum across all line items, you don't need to assign a rate table (e.g., a currency adjustment factor). Usually, you generate a rate table for at least the basic freight charge and key surcharges, depending on your mode of transport. You can enter the scope for the RFQ by adding lines in the rate table (e.g., per origin, destination, equipment type, and commodity). The rate table structure is flexible; you can use various scales and calculation bases to model the rate table for the scope of your RFQ. The rate table for the basic freight charge is the central input tool for your vendors to reply with a rate for each request line item. Each rate table you assign to a surcharge generates output that your vendors need to fill in.

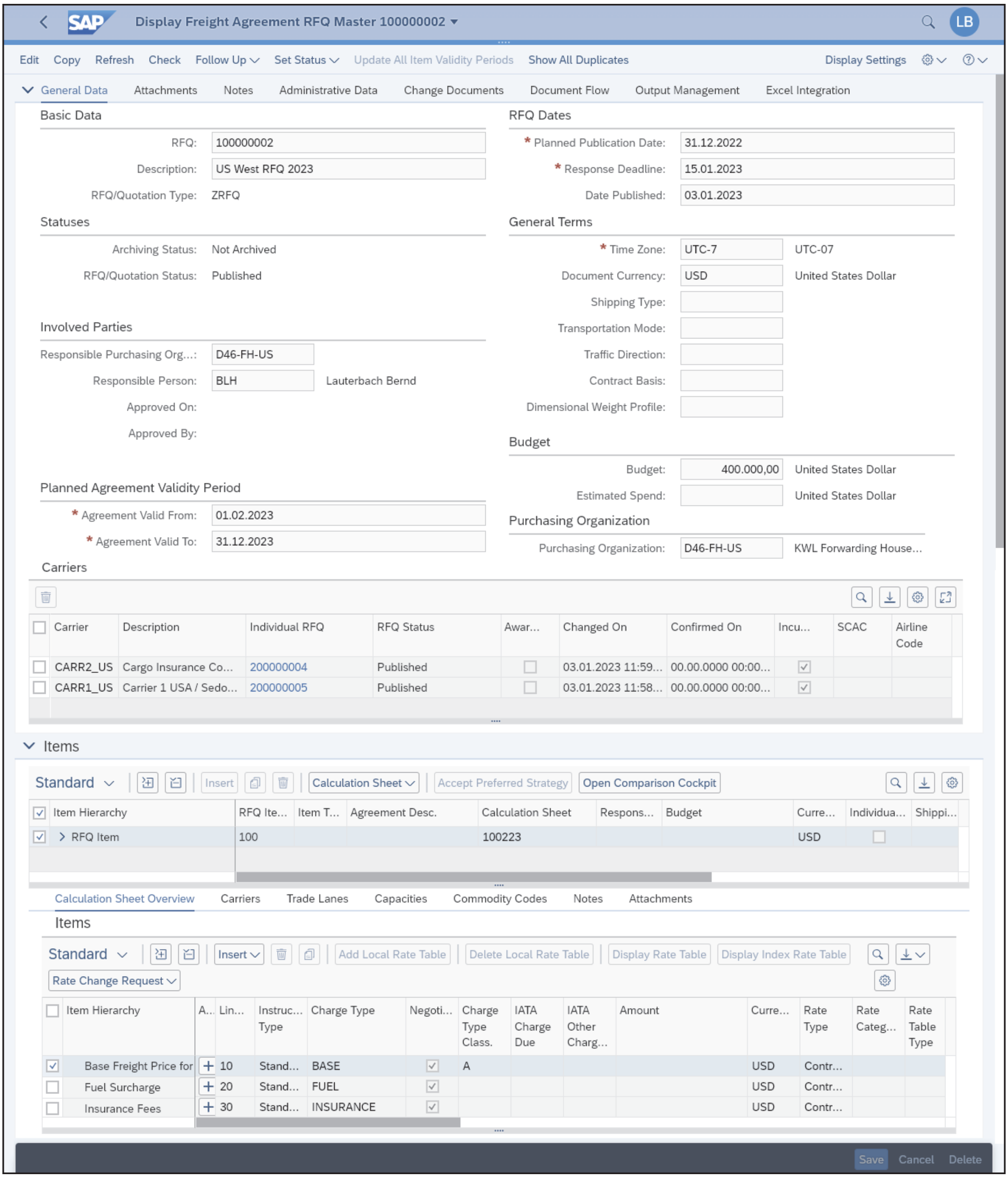


Figure 9.27 Freight Agreement RFQ Master

In addition to rates and surcharges, another important piece of information about the freight agreement RFQ is requested capacity. In the previous section, we mentioned a demand forecast, which corresponds to the requested capacity. After you've decided which capacities to request, you need to enter your decision in the freight agreement RFQ. You can request capacities both by RFQ line item and in the more granular rate table lines. In the RFQ line items, you can specify your requested capacities in various types, perhaps per weight, volume, or TEU per defined time bucket (e.g., per month or per year). A vendor can respond with promised capacities and, after a negotiation, with a confirmed capacity that can be agreed upon. In addition, you can enter requested capacities for each origin–destination pair in the more detailed rate table items. The rate table lines were enhanced in TM to store requested, promised, and confirmed capacities.

In addition to the capacity you request for transport, you can also specify a range of target rates. This is a very common business practice for freight RFQs across various modalities. In ocean freight, for example, a shipper is likely to publish requested target rates. This puts the carrier under pressure to match the expectations of the potential customer and be competitive. Consequently, shippers use this functionality to achieve cost savings. Target rates in an RFQ in TM can be added in both the calculation sheet for each charge type and, more importantly, in the rate table lines. You can also specify tolerances (e.g., 4%), which may be quoted by the carrier or LSP. Enable this functionality in the freight agreement RFQ type by choosing the **Publish Target Rates** checkbox.

Communication of Requests for Quotation

After you've successfully prepared the RFQ but before you publish it to your vendors, TM supports a standard approval workflow that you can enable in the freight agreement RFQ type; it generates a vendor RFQ document for each carrier that you included in your short list. Each vendor RFQ has a similar layout and UI as the master RFQ. It inherits all RFQ line items, the charge sheet for each line item, and the rate tables. Only one carrier is stored in the header of the vendor RFQ because it's unique for each vendor. The vendor RFQ document is used mainly to either upload it or input the carrier responses. The fields for promised capacities and offered rate values are editable for input only in the vendor RFQ. You can use the standard TM output management functionality that is enabled for RFQs to generate output files. In addition, you can use the rate table Microsoft Excel integration to generate RFQ spreadsheets and submit to your vendors. It's also possible to download the entire freight agreement RFQ into a Microsoft Excel spreadsheet for publishing with a carrier or LSP. A specific Customizing setting allows you to define which fields in the spreadsheet are editable and can be changed by the carrier: **SAP Transportation Management • Transportation Management • Master Data • Agreement RFQs and Quotations • Define Editable Fields in TM-Formatted Excels**.

In Figure 9.28, you can see the individual freight agreement RFQ, where a carrier can fill in the offered rate for a requested response item. Two important details need to be provided to successfully submit the RFQ response:

1. The **Responded** checkbox in the response item needs to be set (it may not be displayed).
2. The offered capacity per item needs to be entered on the **Capacities** tab of the item.

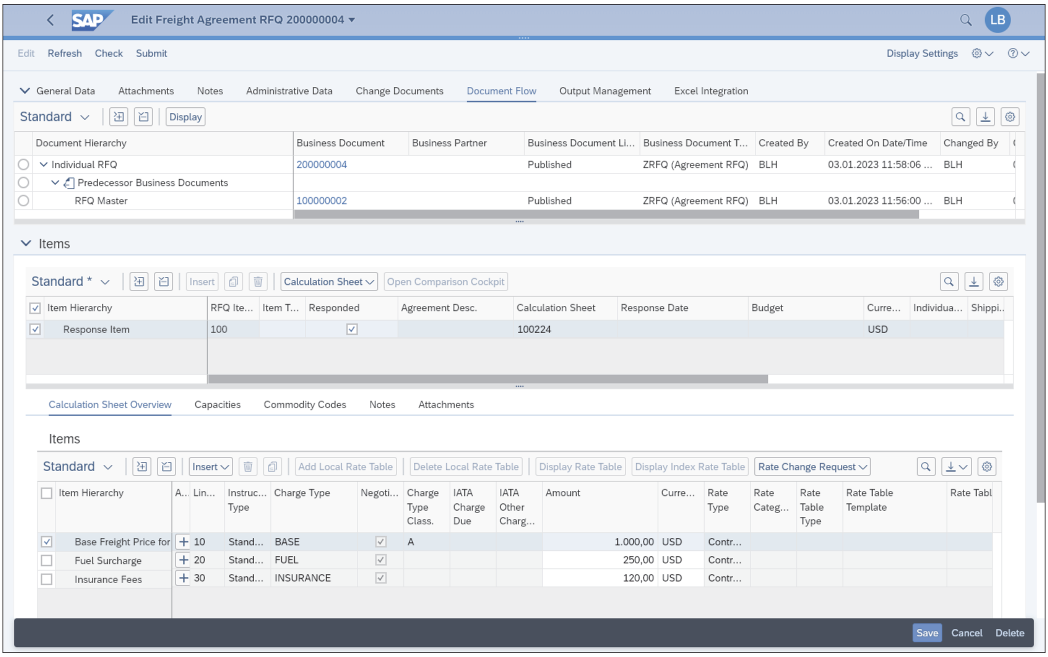


Figure 9.28 Individual Freight Agreement RFQ with Rates Filled in by Carrier

After the carrier has replied, you can load the information directly into your master freight agreement RFQ in TM to proceed with the RFQ evaluation. It's also possible to upload delta changes. Therefore, if a carrier provides additional rates after a first submission, the delta of the rates can be pulled into TM. You can use report /SCMTMS/UPLOAD_RFQ_RESPONSE in Transaction SE38. Besides the pure bid structure, it's also possible to attach any legal requirements, such as terms and conditions or a boilerplate that the carrier must comply with.

A useful functionality is the list of all the existing agreements in the Freight Agreements menu. This can further support the communication with the carrier. The actual TM freight agreement is available for download and viewing as a Microsoft Excel spreadsheet. Figure 9.29 shows the Microsoft Excel file, which represents the same individual freight agreement RFQ item and which can be used to transfer information back from the carrier to the requesting company.

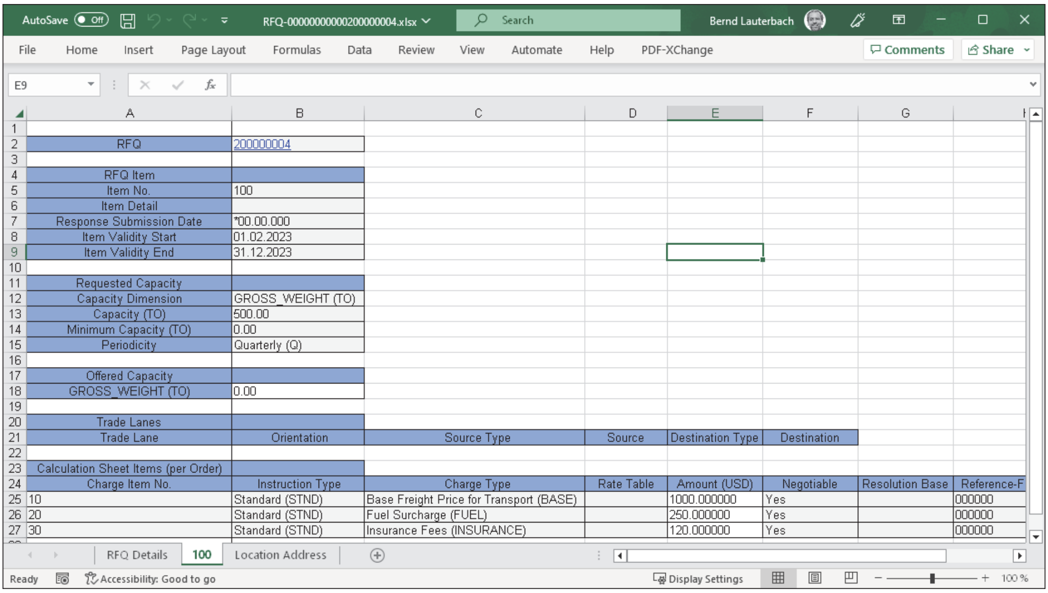


Figure 9.29 Example for Individual Freight Agreement RFQ Responses in a Microsoft Excel File

You can use the Microsoft Excel integration to upload all results into your vendor RFQ documents manually. After a successful upload or manual entry, mark each agreement RFQ line item as **Responded**, and click the **Submit** button in each vendor RFQ to make the rates and capacities available in the initial master RFQ so you can analyze and compare the results. In the master freight agreement RFQ, you can see the status of each vendor RFQ in the document flow, as shown in Figure 9.30.

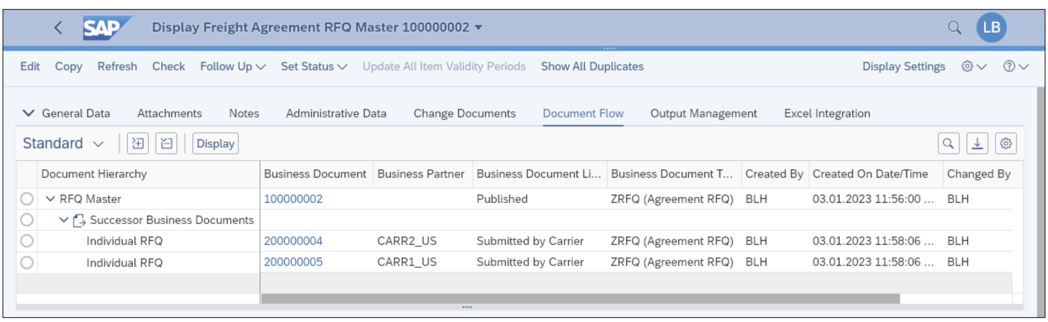


Figure 9.30 Status of Vendor RFQs in the Document Flow of the Related Master RFQ

Request for Quotation Evaluation and Awarding

A key functionality in the RFQ process is the comparison of the results of the vendors to help you choose the capacities you're going to source for each vendor. In the master RFQ, you can select a single line item and click the **Open Comparison Cockpit** button.

The comparison cockpit is divided into four sections, which are shown in Figure 9.31.

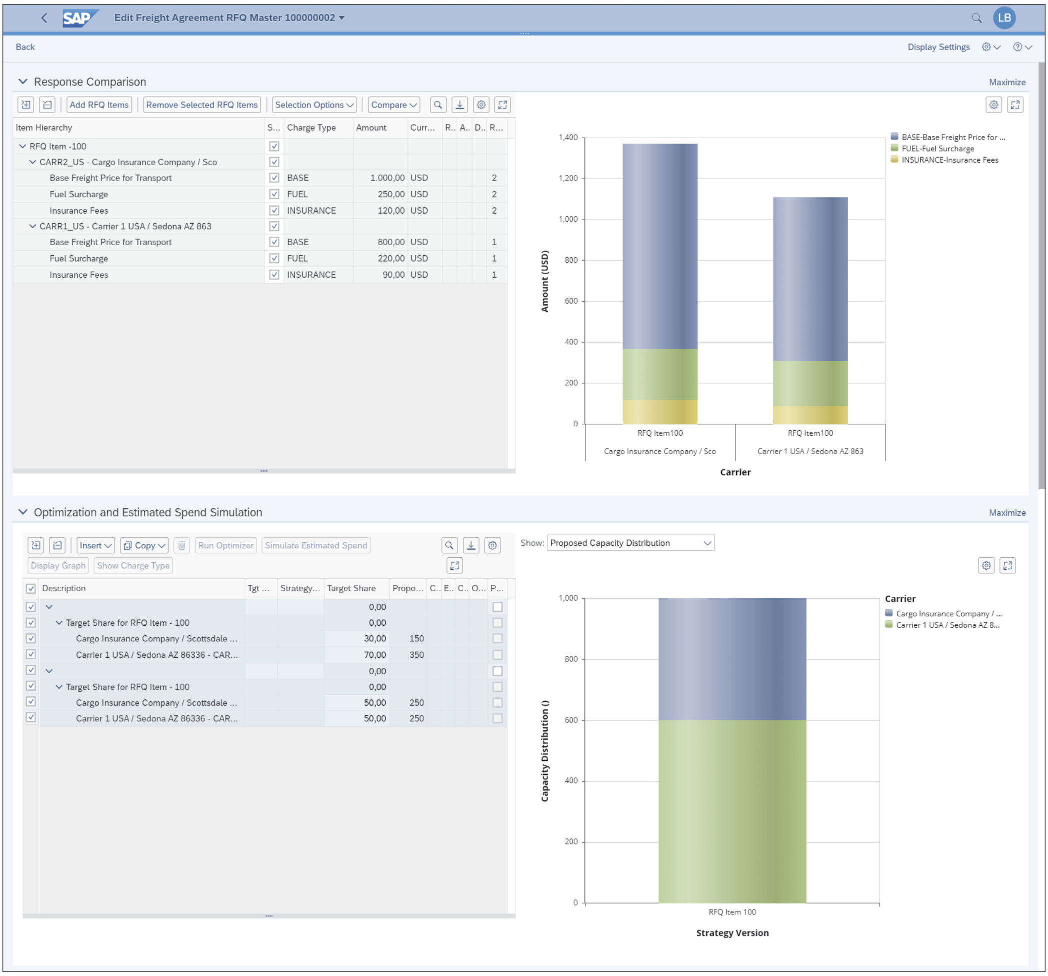


Figure 9.31 Comparison Cockpit

There are two ways to compare the vendor offers:

- **Manual response comparison**
  With manual comparison, you use the **Response Comparison** section and **Response Comparison Graph** to select the vendors that have replied and submitted their responses. You can see the breakdown of their charges with amounts. Alternatively, you see rate tables assigned to each charge type if those are maintained. You click the **Selection Options** button to select multiple charges of the same type for each carrier to compare them. When you select **Compare**, the graph in the right section is compiled, and you can switch among multiple chart types to help you make your decision. You can also add RFQ line items for comparison. TM doesn't support the analysis of amounts stored in rate tables or the display in a graph for comparison. If any charge type has a rate table assigned to it, the charge type doesn't appear in the graph. You can use the rate table comparison functionality to automatically

generate one consolidated rate table in Microsoft Excel and list the offered rates for each carrier against each line item in the table. Select **Compare • Rate Tables in Microsoft Excel** to compare the rate tables.

- **Automated comparison (optimization)**
SAP offers the functionality to automatically suggest the cheapest option via an RFQ optimizer based on defined conditions that must be met (e.g., a minimum of two carriers must be awarded). You can add these conditions before running the optimizer. Alternatively, define a target share strategy in Customizing, and assign it to the agreement type via the menu path **Transportation Management • Master Data • Agreement RFQs and Quotations • Define Target Share Strategies**. The outcome of the optimizer run is a suggestion of a target share as a percentage of the required capacity for each vendor. When you select **Simulate Estimated Spend**, the expected cost is calculated based on the provided rates and given capacities. You can compare multiple strategy versions displayed in the graph in the right section.

The automated comparison contains multiple useful functionalities to steer a decision for strategic procurement and influence the target share. A crucial part of the automated comparison is to project the future estimated spend. This will eventually allow you to choose the best carrier. The automated RFQ optimizer has different possibilities for how to influence the estimated expenditure to derive the suggested capacity allocation to the tendered carriers:

- **Estimated spend per carrier share**
The basic concept of the RFQ optimizer is to simulate the estimated future expenditure by multiplying the capacities tendered in the RFQ with the responded rates from the carrier. The settings as part of the target share strategies can then influence the capacity split across carriers—for example, by defining minimum/maximum quantities a certain carrier must be allocated.
- **Carrier performance**
As part of the RFQ optimization, it's crucial to consider not just quantitative factors, such as the quoted rates. You should also consider the performance of carriers. With every shipment you execute with carriers and LSPs in the past, you collect data concerning their performance (e.g., historical on-time delivery). With the bonus–malus functionality, TM applies penalties or rewards on the quoted rates of the LSPs. This results in cheaper or more expensive rates and impacts the target share TM suggests. You can activate the **Enable Bonus-Malus** checkbox in your target share strategy. After you've applied the bonus-malus, you can change the calculated values, which influence the carrier ranking in the **Carriers** tab.
- **Historical expenditure**
Another very important factor to consider is the historical expenditure with carriers. When you specify an RFQ, there is only limited knowledge of how many freight orders you're going to have on each trade lane or per origin–destination pair. As a

consequence, it's possible to estimate the future expenditure by using the quoted freight charges and historical freight orders. This improves the accuracy of the RFQ optimizer. This functionality is called the historical spend analysis.

- **Transit times**

  The last influencing factor on the RFQ optimizer is transit times. It can be an imperative part of your freight agreement RFQ to get a commitment of the carrier/LSP concerning the transit times for your shipments. Regardless of whether it's for air or ocean, or even trucking or rail freight, the transit time is a crucial KPI for shippers.

  It's therefore possible to specify your expected transit time (e.g., in hours) both on a charge item and per individual rate table line item. The carrier/LSP is obliged to reply. You can use the deviation of the carrier committed transit time to mark up or reduce the offered rates of the carrier. For example, you expect a carrier to transport your shipment from Singapore to Hong Kong in 168 hours via ocean freight. You expect an indirect service where the cargo might be co-loaded onto another vessel. The carrier offers you a direct service that takes only 120 hours. You can apply a discount of, say, 5% for each 10 hours of reduced transit time. This consequently benefits carriers that have attractive transit durations and penalizes carriers that don't comply with your requested transit times. You need to implement the following BAdI to define the penalty/reward rule based on transit times: **Transportation Management • Business Add-Ins (BAdIs) for Transportation Management • Master Data • Agreement RFQs and Quotations • BAdI: Specification of Transit Time for Optimizer**.

The final step in the freight agreement RFQ process is the awarding and creation of the contracts. You can choose one strategy as your preferred option and choose **Accept Preferred Strategy** in the RFQ line-item table. The **Award Summary** tab is available to compare the business share between the vendors and your budget against the actual cost. Last, you can create new agreements for the awarded carriers or amend existing agreements with the new rates and capacities.

With the successful generation of a new freight agreement based on a carrier RFQ, you've concluded an entire walkthrough of strategic freight procurement.

9.5 Summary

This chapter shifted the focus from a pure operational view to a strategic view of procuring freight space and freight-associated services. The process supports you as shipper or LSP in configuring and using freight agreements as well as requesting RFQs from third-party vendors. After looking into the details of rating and vendor contracts, we'll continue with details on freight settlement for shippers, carriers, and LSPs with external vendors in Chapter 10. We'll explain how to generate, verify, and process carrier invoice verifications.

Chapter 10

Charge Settlement

This chapter introduces the basics of charge settlement for vendors, integration with logistics transportation management (TM) processes, and financial enterprise resource planning processes in SAP S/4HANA billing and invoicing, as well as cost distribution. You'll learn how to monitor, settle your third-party freight charges, and manage disputes.

The previous chapter introduced the capabilities of TM charge calculation and strategic vendor contract management. With this background, you can dive into the process of charge settlement with vendors of freight services, such as forwarders or carriers. We'll focus on charge settlement with logistics service providers (LSPs) in Chapter 11.

Settling of charges comes with three different concepts that we need to differentiate:

- **Settlement of supplier freight services**
  Regardless of whether you work as a shipper or freight forwarder, you always procure transportation capacities with incurring costs. Both shippers and LSPs procure transportation capacities from airlines, ocean liners, railways, and trucking companies. Even for carriers, it's common to procure complementary transportation services (e.g., trucking or railway services). Similarly, costs can occur when you work with agents or alliance partners from a carrier perspective and with freight forwarders as shippers.
- **Settlement of customer charges**
  The settlement of customer charges is an important factor for all companies selling professional logistic services because billing customers for transportation services is part of the core business model. You'll read about this process and its implementation in Chapter 11, Section 11.3.
- **Internal settlement**
  An LSP's or shipper's logistics department might bill other internal departments to settle costs that need to be reimbursed internally for activities that contributed to the overall services. This common business practice will also be explained in more detail in Chapter 11, Section 11.3.5.

Before we describe the different sections, let's clarify the overarching principle and commonality across the three methods of charge settlement. If you want to use this capability of TM, you can use either SAP S/4HANA or SAP ERP as the backend system, regardless of whether you're working as a shipper with order integration or as an LSP or carrier. The standard TM solution uses the existing capabilities of SAP S/4HANA (or SAP ERP, although SAP S/4HANA will continue to be our base system) sales and distribution for billing and materials management for invoice verification and payment. In either case, it's always required to calculate freight charges based on TM's charge calculation functionality before triggering a settlement.

In the following sections, we'll introduce you to the charge settlement for vendor charges (Section 10.1) and the cost distribution (Section 10.2).

10.1 Charge Settlement and Billing

We've highlighted how the settlement process for billing resembles invoice settlement. For both billing and invoicing, a standard integration with a backend system is required. You can find more commonalities when you look at the architecture. Figure 10.1 illustrates the standard integration and flow of documents between TM, sales and distribution, and materials management as part of SAP S/4HANA.

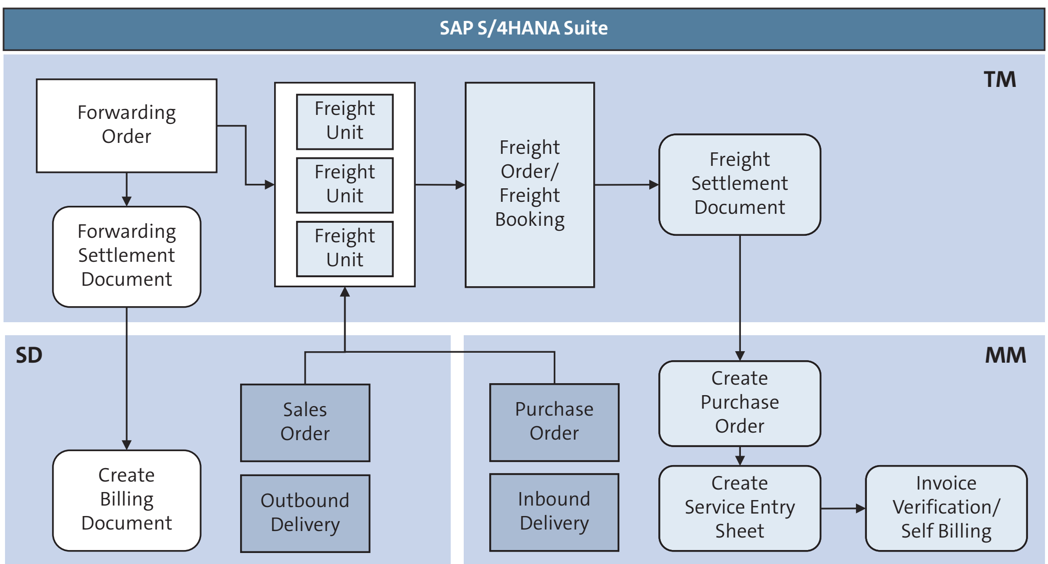


Figure 10.1 Integration of TM to Sales and Distribution/Materials Management for Charge Settlement in SAP S/4HANA

The diagram is applicable for both shippers and LSPs or carriers. The dark boxes are the documents you use as a shipper and that resemble your transportation requirements created based on SAP S/4HANA orders. The white boxes show the forwarding order document that is relevant for you as a freight forwarder or carrier (recall both options from Chapter 4). The gray boxes are the common documents relevant for both freight forwarders and shippers that are required for the settlement process. For both the billing of freight charges to your customers and the settlement of procured services, you generate a TM *settlement document*. The settlement document contains all billing- and invoicing-relevant information, such as the invoicing parties, calculated charges, and currencies. It can be considered as a draft invoice/bill.

Two business objects differentiate between the customer settlement and the invoicing of service providers: the forwarding settlement document and the freight settlement document. For the billing side, the forwarding settlement document directly generates a billing invoice in SAP S/4HANA sales and distribution. The freight settlement document triggers the creation of a purchase order in materials management in SAP S/4HANA, as well as a *service entry sheet* (SES). Both documents are generated in the background to enable posting of accruals, invoice verification, or self-billing.

SAP S/4HANA versus SAP ERP

The process works similar when an SAP ERP system is used as the backend instead. The main difference is that the settlement information must be transmitted via an XML interface from SAP TM 9.6 to SAP ERP.

From Section 10.1.1 to Section 10.1.3, we explain freight settlement and invoicing via the materials management functionality. You'll also learn about the TM self-billing process for LSPs. In Section 10.1.4, we'll describe use of the Collaboration Portal for billing and continue with the embedded dispute handling capability in Section 10.1.5. Finally, in Section 10.1.6, we introduce TM credit memos for corrections of settled amounts.

10.1.1 Creating Freight Settlement Documents

The functionality of freight settlement is used by any company procuring freight-related services, regardless of whether you work as a shipper, forwarder, or carrier. The invoicing of supplier/service provider bills always originates from your freight documents, that is, a freight order, freight booking, or service order in TM. The freight settlement document can be described as the draft invoice that is generated in TM. It's used to store all invoicing-relevant information from your freight orders, freight bookings, and service orders. The freight settlement document is the document that triggers the interface to the backend system for verifying the actual invoice. You'll see many similarities in the process of the forwarding settlement document.

Functional Process Flow

To create a freight settlement document, start by navigating to your freight documents (e.g., a freight order), and select **Create Freight Settlement Document**. The system can create the settlement document from a personal object worklist (POWL) or from the user interface (UI) of an individual freight document. Alternatively, you can call the Web Dynpro application from the launchpad by selecting **Settlement • Create Freight Settlement Document**. Finally, you can use the standard batch job for mass creation: /SCMTMS/SFIR_CREATE_BATCH. You can find it in the SAP GUI under menu **Logistics • Transportation Management • Administration • Background Processing • Create Freight Settlement Documents**.

When creating freight settlement documents, you need to determine how many settlement documents are created when you trigger the generation. In a standard scenario, the system creates one freight settlement document for a freight order, service order, or freight booking. The reason for this is that each freight order or freight booking can have exactly one supplier who performs the services. Therefore, it's expected that you receive one invoice per freight order, service order, or freight booking from this supplier. After the successful generation of a freight settlement document, the invoicing status of the originated freight document is updated.

Alternatively, perhaps you have more than just one service provider as part of a freight order or freight booking. Besides the pure transportation service from a carrier, additional services might be performed by a customs broker or a provider of container cleaning or fumigation. You can capture such additional parties in the **Business Partner** tab in your freight order or freight booking. When you trigger the settlement document creation, you can select one or multiple parties in a popup window. You can create the freight settlement document for the carrier, one or more additional parties, or both. The charge calculation determines a freight agreement and a charge calculation sheet per party. If you store the charges for the different services in two separate charge calculation sheets, the system can automatically calculate the charges and uses one charge calculation sheet per party. The only restriction applies if a business partner plays a hybrid role with two freight agreements (one for main carrier rates, one containing rates for specific services). If a service provider plays a role as the main carrier in a first freight booking but interacts as an additional agreement party in a second freight booking, there is no determination rule available to decide which of the two freight agreements to use.

You can also create collective freight settlement documents from the POWL. TM combines all selected freight orders or freight bookings based on splitting criteria into one or multiple freight settlement documents. The key criteria that need to be equal among the different freight orders or freight bookings include the carrier, invoicing party, payee, payment term, and document currency.

Basic Customizing

The essential Customizing in TM includes the following steps to enable the freight settlement process:

- **Freight settlement document type**
  You can define the freight settlement document type in TM via Customizing menu path **Transportation Management • Settlement • Freight Settlement • Define Freight Settlement Document Types**. The type contains the number range that is being assigned to newly created freight settlement documents as well as enablement of cost distribution. You must assign the freight settlement document types to your freight order and freight booking types.
- **Settlement profile**
  The settlement profile defines a rule that can be used for forwarding and/or freight. It allows you to define split rules, recalculation options, collective settlement, dispute settings, or, for example, change processes. You need to assign the settlement profile to a business partner or, alternatively, to a charges profile.
- **Process controller**
  As an optional step, you can implement an alternative way to create and group or split freight settlement documents in the creation process. SAP provides a standard method, but you can also develop your own methods and strategies, which you can assign to your settlement profile.

10.1.2 Structure of Freight Settlement Documents

The freight settlement document has a very similar structure to the forwarding settlement document. It stores the invoice-relevant information inherited from the freight order, service order, or freight booking.

The **General Data** tab shows the sum of the invoicing amount, the payment terms, and the organizational data, such as the purchasing organization that was responsible for procuring the services. You can also see the expected invoicing date, which you can change manually. After invoice creation and verification, the settlement document shows the verified invoice amount in the freight settlement document.

In the **Charges** tab, you see the list of all charge items inherited from the corresponding freight order. If you collectively created a freight settlement document for multiple freight orders or freight bookings, you'll see the sum of the charges per freight order. The view depends on your settings in the calculation profile in transportation charge management. If you calculated the charges with calculation-level stages, the details of cost per order and cost per stage are displayed. You can see an example of the freight settlement document **Charges** tab in Figure 10.2.

The settlement document shown lists the charges from the associated freight order. Figure 10.3 shows a different example, where stage-based charges are listed.

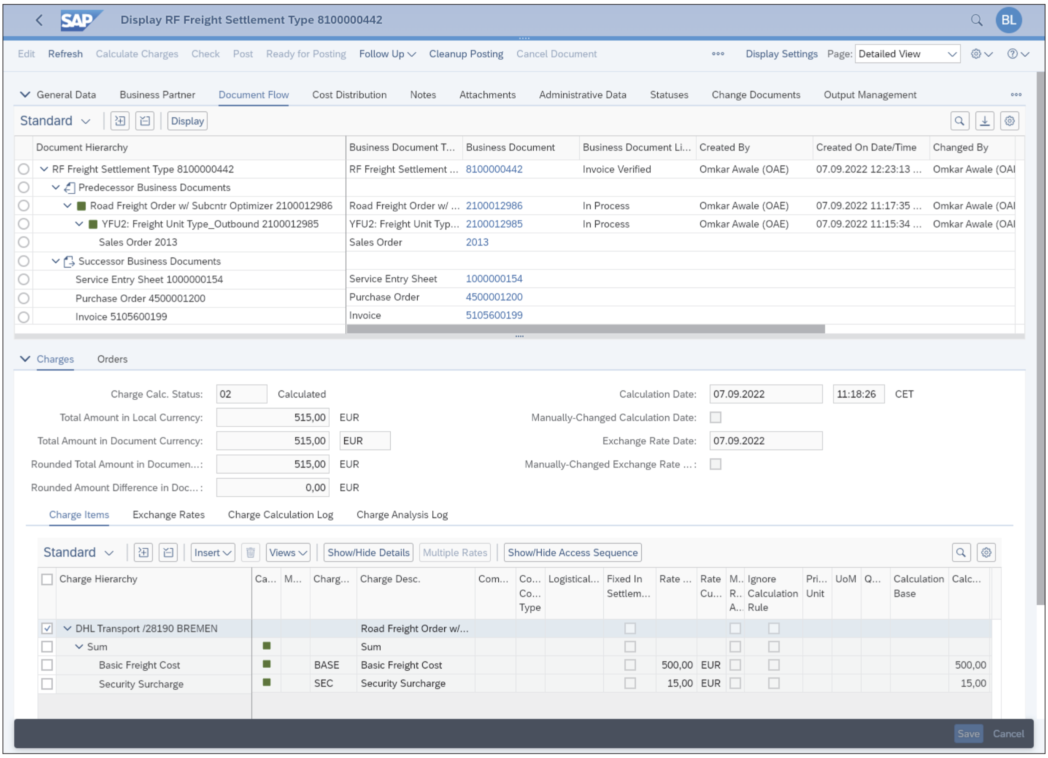


Figure 10.2 Charges Tab in a Freight Settlement Document

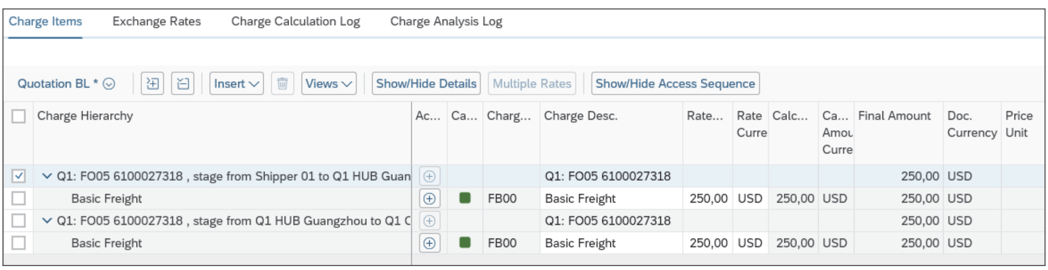


Figure 10.3 Details of Charges per Stage in a Freight Settlement Document

Here, the charges are grouped per transportation leg (stage) of an ocean freight booking. Two stages are visible and expanded to show the details of the applicable charges and surcharges per leg.

The **Business Partner** tab lists all relevant parties for invoicing. For the settlement process, you require at least the invoicing party and a payee. You can include other parties in the settlement document, such as the carrier, which is automatically inherited from the freight order. An assigned business partner determination profile in your freight settlement document type allows you to steer the correct assignment of involved parties to the freight settlement document.

Depending on how the freight settlement document was created, it might reference multiple freight orders or freight bookings that are grouped into one settlement document for joint invoice verification and payment. All such orders are listed in the **Orders** tab. If you create a settlement document for each stage based on a freight order with nonlinear stages and have selected the **Stage Split** checkbox in the settlement profile, you'll see the freight order and the stage details of the invoiced stages. This is determined by the calculation level of your calculation profile.

The **Document Flow** tab in the freight settlement document always gives you an overview of the related predecessor and successor business documents of the settlement document, such as the freight order or freight booking for which it was created. This is especially valuable in the integration scenario, where TM is operated with a financial SAP backend. The document flow shows the generation of the succeeding materials management documents, such as the SES and the purchase order, as it also captures cross-system document relations. The freight settlement document includes other tabs as well:

- **Notes**
  Allows you to enter information as free text.
- **Administrative Data**
  Gives you an overview of the users, dates, and changes.
- **Change Documents**
  Shows more details on individual changes.
- **Attachments**
  Allows you to attach a variety of documents.
- **Output Management**
  Enables you to print, for example, pro forma invoices.
- **Statuses**
  Shows the latest lifecycle and confirmation statuses, which again, support the cross-system integration.
- **Cost Distribution**
  Supports a scenario for shippers with integration for order management. We describe the details of this functionality in Section 10.2.

10.1.3 Integrating Freight Settlement Documents with Materials Management

The freight settlement process is integrated into the materials management functionality in SAP S/4HANA. SAP decided to integrate with an existing application for invoice verification and the actual posting of accruals and cost, instead of designing a new invoice verification as part of TM. The advantage is a higher consistency in usage of financial processes throughout the system. However, it comes to you with the drawback of requiring a second application (materials management) to be able to verify incoming invoices instead of doing this inside TM.

In the following sections, we highlight the required Customizing settings for the integration, the functional process flow, and some technical basics. In SAP S/4HANA, it's essential to create both an SES and a purchase order.

Technical Foundation for Integration

There are several ways that TM freight settlement documents can be transferred and thus integrated with the invoice verification process in SAP S/4HANA. If you're using a standalone TM system with a separate financial backend (SAP S/4HANA or SAP ERP), the systems can be technically integrated via SAP Integration Suite, which is part of SAP BTP. Alternatively, the traditional SAP Process Integration can also be used. SAP provides a standard integration scenario that needs to be enabled in the SAP Integration Suite. Four messages are supported for the integration between TM and the backend:

- `TransportationOrderSUITEInvoicingPreparationRequest` sends a request to create or change a freight settlement from TM and receive it in the backend system.
- `TransportationOrderSUITEInvoicingPreparationConfirmation` sends the confirmation of received supplier invoices from the backend and receives them in TM.
- `TransportationOrderSUITEInvoicingPreparationCancellationRequest` sends a request to cancel a freight settlement document from TM and receive it in the backend system.
- `InvoiceNotification` sends the invoice notification from your backend system and receives it in TM.

In an embedded environment, where TM and materials management are running on the same instance, the integration can be simplified, as it's done without SAP BTP transfers, but either with asynchronous background remote function calls (bgRFC) or, in some cases, in synchronous mode. There are three different methods of communication between TM and materials management:

- You post the information transfer from TM freight settlement document to materials management via the UI; that is, within the freight settlement document, you trigger a function related to data transfer.
- You trigger the transfer from a worklist, where it can be done for a single freight settlement document but also for multiple selected freight settlement documents.
- You use a batch report to select one or multiple freight settlement documents according to a selection profile, which will then be used to trigger the posting.

Table 10.1 shows how an embedded SAP S/4HANA system transfers the information from TM freight settlement documents to materials management purchase orders and SES.

Action	From Freight Settlement Document UI	From Worklist	Via Batch Report
Post freight settlement document	bgRFC	bgRFC	Synchronous
Cancel freight settlement document posting	bgRFC	bgRFC	Not available
Reverse freight settlement document posting	Synchronous	bgRFC	Not available
Cancel materials management purchase order	Synchronous	bgRFC	Not available
Reprocess document after failure	Not available	Not available	Synchronous

Table 10.1 Integration Modes for Actions between Freight Settlement Documents and Materials Management Documents

Basic Customizing for Service Entry Sheet and Purchase Order Creation

To set up your integration between TM and the materials management functionality, there are a few essential Customizing steps to generate an SES and a purchase order. A purchase order is created to provide an order reference in your SAP system. The SES comprises all the individual services provided by your service provider. It also contains additional information, such as descriptions of your services. An SES is generated with reference to the purchase order.

We focus on the essentials to enable vendor invoicing by integrating TM with materials management. A service master for the transportation services needs to be created. The service master in SAP is a standardized list containing all items that a company might procure in materials management. You must maintain the service master as master data and map your TM charge types to the service master in Customizing. The valuation class on the service master can optionally be used in general ledger account determination.

You can find the Customizing activity for charge type mapping by selecting **Integration with Other SAP Components • Transportation Management • Invoice Integration • Invoicing • Definition of Transportation Charge Types • Define Charge Types**. You can also define category and subcategory codes and assign them to the mapped charge types. Next, you must assign your charge types to service master records and account assignment categories in SAP S/4HANA. You must make sure that you've maintained entries in your service master record, as described previously. Navigate to Customizing menu path **Integration with Other SAP Components • Transportation Management • Invoice Integration • Invoicing • Assignment of Transportation Charge Types • Assign Service Master Record and Account Assignment Category**. Based on this setting, the system can relate your TM-specific charges to actual procurement service master records, which you can create via Transaction AC01. The account assignment category also plays an important role in the determination of accounts, cost objects, and, eventually, SAP financial postings. In Figure 10.4, you can see the assignment of charge types to the service master (the top screen) and creation of the service master record (the bottom screen).

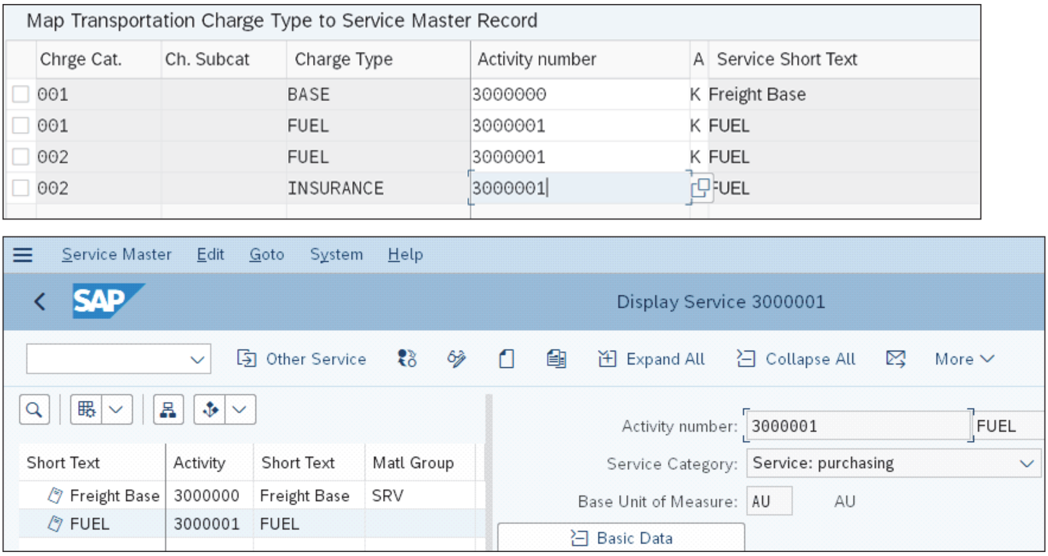


Figure 10.4 Assignment of Charge Types to Service Master and Service Master Definition

Another required setting is the assignment of your TM freight settlement document types to the purchasing characteristics in materials management. You can find the settings by following Customizing menu path **Integration with Other SAP Components • Transportation Management • Invoice Integration • Invoicing • Mapping of Organization Units • Assign Purchasing Information for Posting**. The purchasing information on the materials management side impacts account determination and invoice verification in SAP S/4HANA. In addition to the mapping of organizational units, you can map the TM purchasing organization against internal orders or cost centers. This setting is very important for posting freight costs to the correct internal cost centers.

Basic Customizing for Invoice Verification and Automated Postings

The previously mentioned settings allow you to generate the SES and purchase order in an existing SAP S/4HANA system. You can also allow automated posting of accruals and invoice verification via message integration with the TM freight settlement document. To enable these functional components in the materials management and controlling functionality in SAP S/4HANA, additional Customizing settings are required. Here, we'll provide you with a quick overview of the key Customizing settings.

To enable the automated account assignment, you need to first define a mapping for your impacted company code, cost elements, and cost centers. Navigate to Customizing and follow menu path **Controlling • Cost Center Accounting • Actual Postings • Manual Actual Postings • Manage Default Account Assignment**. The next important step is to configure the automatic postings so that your SAP system is capable of automatically posting to the correct general ledger accounts. This must be maintained per impacted *chart of accounts* in the SAP S/4HANA system of each company code. Navigate to SAP Customizing via menu path **Materials Management • Valuation and Account Assignment • Account Determination • Account Determination without Wizard • Configure Automatic Postings** to enable inventory postings (Transaction GBB) for your impacted chart of accounts.

Functional Process Flow

After you've configured your SAP S/4HANA system and—if used—the integration for the freight settlement process, you're almost ready to transfer a generated document from TM to the materials management functionality in SAP S/4HANA. In Figure 10.5, you can see the different statuses of a freight settlement document.

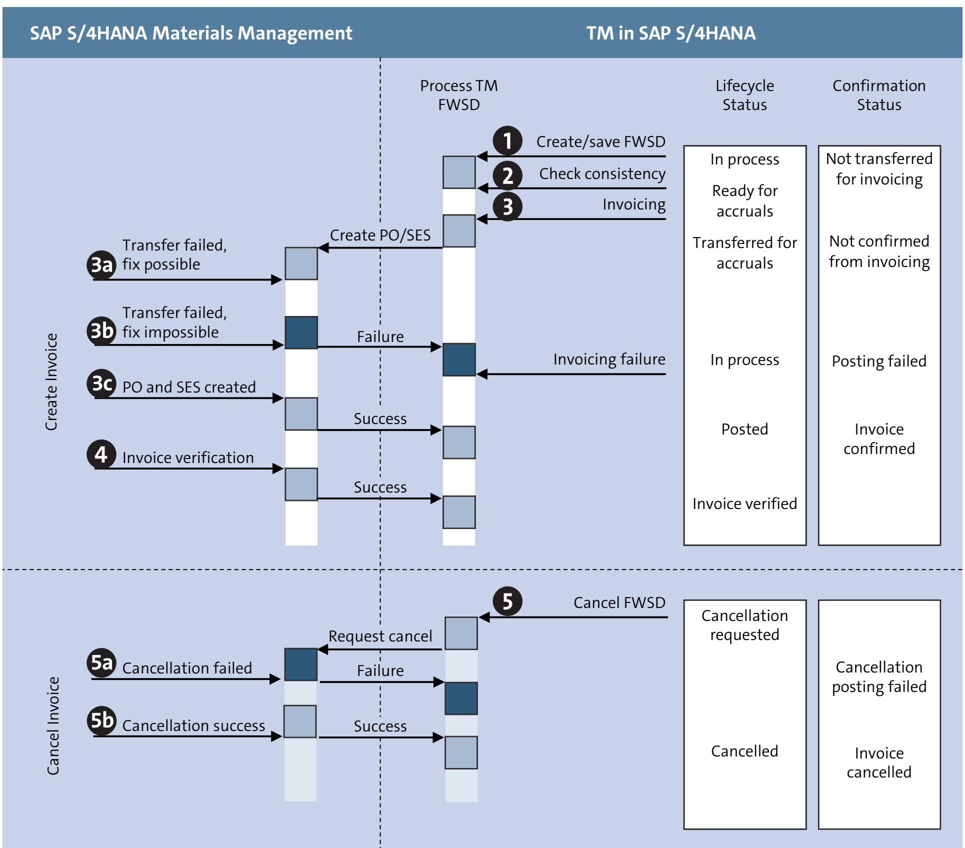


Figure 10.5 Statuses in the Freight Settlement Document

After you've created a settlement document, the lifecycle status is set to **In Process** ❶. Before transferring it to invoicing in materials management, you can perform an automated consistency validation by clicking the **Check** button on the top panel in the freight settlement document ❷. If no inconsistencies are detected, the lifecycle status is automatically changed to **Ready for Accruals**. It's always required to have charge items in the settlement document; otherwise, you can't transfer the freight settlement document to materials management.

If you generated your freight settlement documents collectively with a batch job, the system automatically performs the consistency check. In the batch program, you can also generate and transfer the freight settlement document in one step. In a more manual approach, you can click the **Save and Transfer** button in the freight settlement document or from a POWL and trigger the interface to materials management. The corresponding lifecycle status is **Transferred for Accruals**, and the confirmation status is **Not Confirmed from Invoicing** ❸.

If all settings are correct, the system automatically performs three actions in materials management:

- Generate a purchase order in materials management.
- Create an SES based on the purchase order.
- Post the accruals based on the purchase order and SES.

The purchase order is required for purely technical reasons. The SES enables the posting of accruals and invoice verification in materials management. Figure 10.6 shows a freight settlement document including charges, the document flow, and the related purchase order in materials management.

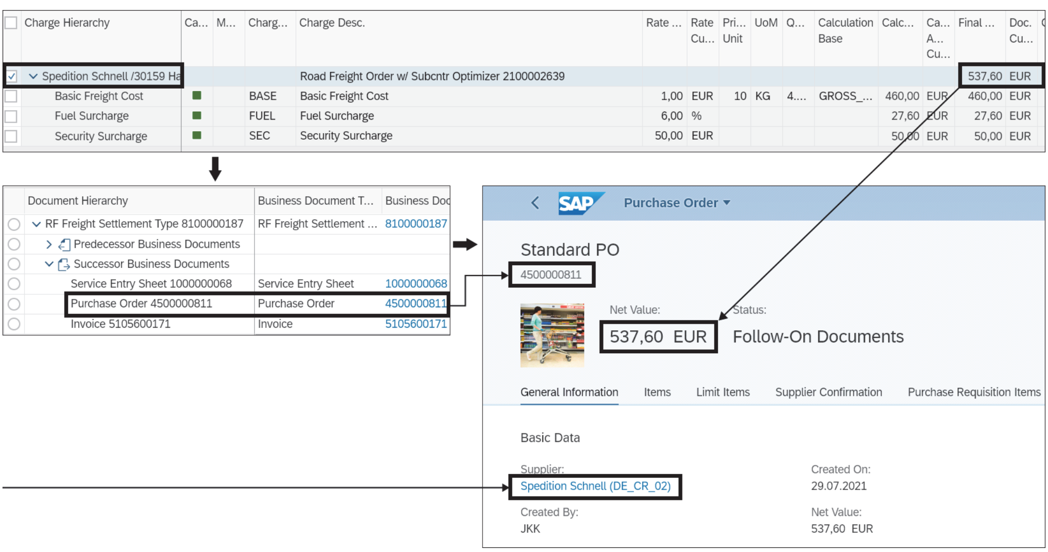


Figure 10.6 Creation of a Purchase Order from a Settlement Document

The document flow in the freight settlement document (the bottom left screen) shows the generated purchase order, SES, and invoice after the document has been verified. The purchase order contains all the charge types as service line items based on the mapping introduced in Customizing: the carrier, statuses, and other references from the freight settlement document.

If the accruals haven't been posted, the lifecycle and confirmation status in the freight settlement document stay unchanged unless an error can be corrected in the materials management side. While the lifecycle status is **Transferred for Accruals**, it's no longer possible to manipulate any data in the freight settlement document in TM (refer to Figure 10.5 3c). If the failed accruals posting can't be fixed, the lifecycle status is automatically updated to **In Process**. The confirmation status indicates **Accruals Failed**. If no discrepancies are detected, the lifecycle status is changed to **Accruals Posted** 4, and the confirmation status to **Invoice Verified**.

After you've successfully transferred your freight settlement document to materials management, and the lifecycle status shows **Accruals Posted**, it's possible again to manipulate the data in the freight settlement document in TM. Any changes require a retransmission of the freight settlement document to materials management, which triggers a few additional steps. First, the SES posted earlier is reversed. Second, items of the SES and purchase order are deleted. Last, the regular process flow is similarly followed as described earlier; a new purchase order and SES are created, and the accruals are posted again. After the actual invoice from the supplier is received, you can perform the invoice verification in materials management via Transaction MIRO, usage of the new SAP Fiori invoice management apps, or customer self-billing (refer to Figure 10.5 4). After the invoice verification has been performed, the TM freight settlement document is updated with a corresponding lifecycle status of **Invoice Verified**. The purchase order and SES in materials management are locked for any manual changes or manipulation. You can issue a credit memo to correct the charges in case of any discrepancies.

You can cancel a purchase order and SES from TM only by canceling the freight settlement document itself. Keep in mind that even this doesn't work in all statuses of the freight settlement document: **Transferred for Accruals** or **Invoice Verified**. The cancellation action triggers another status change in the TM freight settlement document (refer to Figure 10.5 5a). If the cancellation request isn't successful, the freight settlement document is updated with confirmation status **Invoice Cancellation Failed in SAP ERP**. For a successful cancellation, the status changes to **Invoice Canceled** 5b.

Settlement Scenarios for Air Freight

In the air freight business, cargo is often handled through a freight forwarder or booking agent. To standardize the billing process, most airlines outsource their billing services to the International Air Transport Association (IATA). The IATA has introduced the Cargo Accounts Settlement System (CASS) as the clearinghouse for this purpose. Airlines send their air waybills together with other settlement-relevant data to CASS.

Based on the air waybill data, such as weights, volumes, charges, and cargo details, CASS generates a monthly or bimonthly billing cycle and lists all charges and credits per air waybill for each freight forwarder. This billing document is called the *cargo sales report* (CSR). A freight forwarder can download the report or introduce an interface via Electronic Data Interchange (EDI) (message `CARGO-IMP FCI`). The CSR is used by the forwarder for invoice verification, which can be done manually or electronically.

When an error is detected by either side (i.e., the freight forwarder or the airline), and a billed amount is too high or too low, corrections are required. Because the IATA billing cycle happens monthly or bimonthly, corrections can be made only for an already-paid invoice in the subsequent billing cycle. In this case, the IATA supports airlines with two documents:

- Cargo charge correction advice document (CCAD)
- Debit credit memo (DCM)

Cargo Charge Correction Advice Document

The CCAD is a different category of freight settlement document, but technically it's the same object. You can't create a CCAD if you haven't yet generated the freight settlement document or if it doesn't yet have the **Accruals Posted** status. Before reaching a status where the freight settlement document has been generated and the accruals posted, you can still include all corrections in the first settlement document.

Let's consider an example. A freight forwarder has been invoiced for the weight of its cargo. The airline detects that the actual cargo weight is higher than originally stated. As a result, the airline issues the deviation to the IATA and submits a cargo CCAD. The CASS includes the correction amount as part of the new billing cycle in the CSR to the freight forwarder. The old amount paid is reversed (comparable to a credit memo process), and the corrected amount is added.

Cargo Accounts Settlement System

Since IATA introduced CASS in 1999, more than 200 airlines and ground handling companies have joined the CASS billing system. Today, the total billing value handled through CASS exceeds $32 billion every year.

TM offers some support for this billing process for freight forwarders. You can generate one collective freight settlement document for the same airline for all freight bookings in one month and thereby simulate the CSR in your system. The integration with your invoicing system follows the standard settlement process. A purchase order and SES are created that contain the appropriate charges. After the receipt of the CSR from IATA, in your SAP S/4HANA system (specifically, the materials management functionality), you can perform the invoice verification of the accrued charges versus the received invoice amounts and pay the settled amount.

In case of a discrepancy after the forwarder has made the payment, the airline triggers the CCAD to the IATA. As a result, the forwarder receives the corrected settlement amount with the next cargo settlement report. To reflect this discrepancy in your system as the freight forwarder, you should follow these steps:

1. Navigate to your originally created and already-completed freight booking that generated the miscalculated air waybill.
2. It's possible to correct the freight booking despite its status. You might change the weight of the cargo to the correct weight per your agreement with the airline.
3. Because the freight settlement document has already been generated for the freight booking, you can't correct or change the existing freight settlement document. You can generate your own cargo correction advice document instead. The CCAD serves as a simulation of the actual CCAD and contains the originally posted amount from your old freight settlement document, the delta amount that needs to be corrected, and the final billing amount.
4. The CCAD needs to be transferred to the materials management functionality in SAP S/4HANA, where a new purchase order is generated. The purchase order stores both the old settlement amount with a reverse indicator and the corrected amounts.
5. Based on the new purchase order, two SESs are generated:
   - The first SES posts the initial erroneous settlement amount with a reverse indicator.
   - The second SES posts the accruals for the fully corrected settlement amount.

You're now ready to perform a new invoice verification based on the actual cargo settlement report from the IATA.

10.1.4 Collaboration Portal Access

We've already introduced how to create freight settlement documents and how to verify and pay invoices in the materials management functionality in SAP S/4HANA. This process assumes a classic communication with a carrier or freight forwarder, where you receive hard copies of invoices and pay them after verification. The disadvantage of this process is that the responsibility to detect any errors as well as the workload lies with you as the customer.

If you've already been a user of SAP TM 9.5 or 9.6 and still hold an SAP Business Suite license (see SAP Note 2858217), you may use the Collaboration Portal to manage this process more efficiently and to push the responsibility to the LSP's side. In addition, you can manage dispute cases with LSPs.

The new alternative from SAP to the previous Collaboration Portal invoicing functionality is now available as part of SAP Business Network Freight Collaboration. We cover this public cloud solution in Chapter 12, Section 12.6. If you don't hold an SAP Business Suite license for SAP TM but started with any release of TM in SAP S/4HANA, using the Collaboration Portal isn't suitable for you due to licensing reasons. In this case, SAP Business Network for Logistics is the provided way to go offered by SAP.

10.1.5 Dispute Management

Whenever a carrier invoice deviates from your freight settlement document, TM can automatically create a dispute case, which can then be processed by a user in TM. You can enable an approval workflow to inform relevant users of the dispute. The dispute document is also published in the Collaboration Portal for the carrier to review it. After you process the dispute case, it's immediately updated for the carrier to review the requested changes. This process can have multiple iterations until a consensus is achieved. After any changes have been agreed upon, you can directly update your freight settlement document and the materials management documents. Most of the settings for dispute management can be found in the following section of TM Customizing: **Transportation Management • Settlement • Freight Settlement • Freight Settlement Dispute Management**. The key settings required in Customizing are as follows:

- Define the tolerance rules for disputes, which steer the behavior when TM automatically creates a dispute case and escalates charge deviations to a user. You can maintain tolerance groups and even assign them to individual charge types. Tolerances can be maintained as absolute values or percentages. The tolerance rules are assigned to the settlement profile.
- Maintain reason codes for the communication of dispute cases.
- A new freight settlement category is available that is used for the dispute document. Maintain the dispute type to influence text types, number ranges, and more.
- Use the approval workflow to define approval levels and user roles, that is, who will be informed via email about the disputes.

10.1.6 Credit Memos for Freight Orders

Billing customers and settling supplier invoices may not always be straightforward. Sometimes bills to your customers have errors, and invoices from your suppliers can be too high or too low, perhaps because the cargo measures, weights, or volumes deviate between an order and the actual amounts. In addition, any delays in the transportation chain can cause errors or exchange rate adaptions and require you to decrease your bills or receive deductions from your suppliers.

The *credit memo* is a document in TM that you use to post corrections of incorrect settlement amounts. A credit memo can be generated for the forwarding settlement document to give a credit to a bill-to party for incorrect billings. You can also generate a credit memo for a freight order or freight booking to trigger a deduction of an invoiced amount from your supplier. As settlement documents can't be changed after they reach a certain lifecycle status, you can still use the credit memo for any corrections, especially from a document process flow and audit visibility point of view. The same behavior is relevant for the freight settlement document. The following describes credit memos for freight orders. Concerning forwarding orders, you'll find the details in Chapter 11.

With a credit memo for freight settlement documents, you can correct payments to your service provider, freight forwarder, or carrier, in case they charged you too much for transportation services. The credit memo can come from your original freight order, booking, or service order, and it can include any changes in the document. If your freight forwarder charged you based on weight, but the cargo items weren't as heavy as listed in the freight booking, you can correct the weight directly in the freight booking. The credit memo automatically reverses the payment for the initial amount and posts the new, reduces amount via a new freight settlement document. In Figure 10.7, you can see the initial posting of a freight settlement document, the subsequent posting of a credit memo and final posting of a revised freight settlement document.

To create the credit memo, select **Follow Up • Create Credit Memo** in the top panel of the document. TM generates the credit memo automatically. Like the CCAD, every credit memo generates a new purchase order in materials management. In contrast to the CCAD process, the purchase order has only one line as the returns item with the correction amount. Based on the purchase orders, an SES is created that posts the corrected amount.

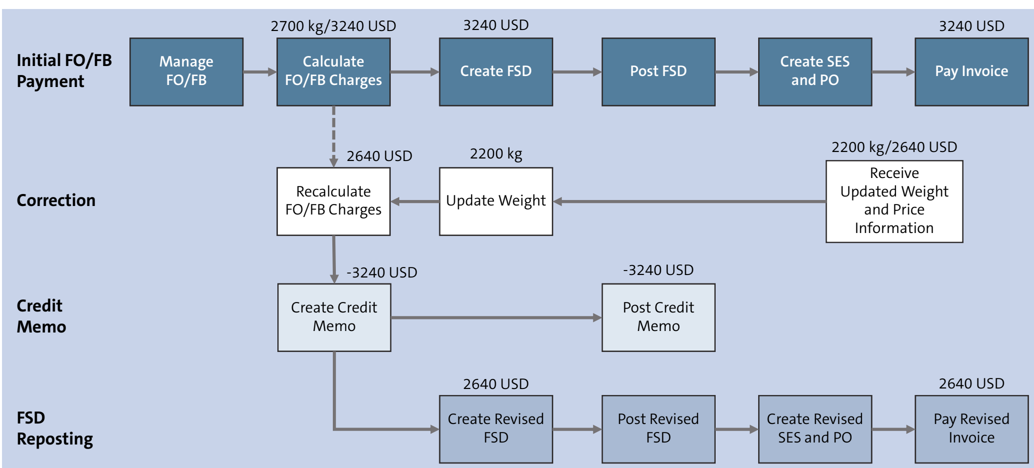


Figure 10.7 Posting of Credit Memo and Reposting of a Revised Freight Settlement Document

In the Customizing for credit memos on the freight settlement side, you need to create a credit memo type and reason codes. The credit memo type for freight settlement can be created via Customizing menu path **Transportation Management • Settlement • Freight Settlement • Define Credit Memo Reason Codes and Types for Freight SDs**. In the credit memo type, you can define how changes in the invoicing status of the freight order, freight booking, and service order should be handled. The invoicing status of the documents changes automatically to **Completely Invoiced** as soon as you've successfully generated a freight settlement document with the full amount, as calculated for the charges. You can activate the **Influence Invoicing Status** checkbox in the credit memo type. When you generate a new credit memo, the invoicing status of a freight order, freight booking, or service order is reset to **Not Invoiced**. If you deselect the **Influence Invoicing Status** checkbox, the creation of a credit memo doesn't have an impact on the invoicing status. In the same Customizing path, you can maintain reason codes and assign them to the credit memo.

10.2 Cost Distribution

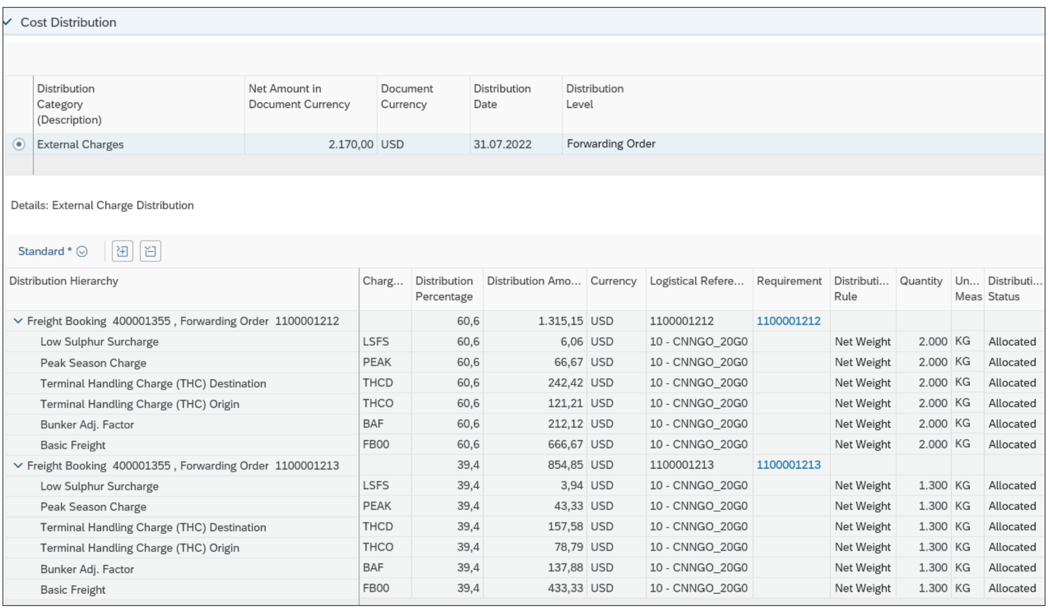
Working as a shipper or LSP, you might encounter challenges in apportioning transportation costs to the correct organizational units, accounts, or sales orders. TM offers two capabilities to support automated distribution of transportation charges and the settlement of these between different organizations. In this section, we'll explain cost distribution. The second method of apportioning is the internal settlement for LSPs, which is described in Chapter 11, Section 11.3.5.

The TM cost distribution functionality supports both shippers and LSPs. It gives you the capability to distribute incurred costs from freight orders and freight bookings in TM to the individual originating forwarding order items. You might have, for example, a freight order for trucking that contains several pallets as items from multiple forwarding orders. The cost distribution ensures an apportionment of the cost for the entire freight order down to each individual cargo item. You can use different apportionment rules (e.g., based on the weight or volume of each cargo item). Looking at this functionality, we need to differentiate between shippers and LSPs:

- **Cost distribution for shippers**
  First, you can manage your transportation costs for inbound deliveries by assigning charges to the materials valuation component in your SAP S/4HANA system. This enables calculations with actual costs from your TM freight order or freight booking documents. Second, you can gain better visibility of your sales order profitability by assigning transportation charges for outbound deliveries to the correct orders and company codes. In profitability analysis in SAP S/4HANA, you have the capability to include any transport-related charges in your sales order profitability analysis.
- **Cost distribution for LSPs**
  You can distribute incurred costs from your procured transportation services and capacities (freight orders or freight bookings) to other organizational units. The distribution can be performed completely in TM, and this enables an internal settlement process. Cost distribution outcomes are the input for the **Order-Based Profitability** tab in the forwarding orders, which allow an LSP to judge the margin related to a single customer order.

The concept of apportioning cost is similar in shipper and LSP scenarios, but how we use the cost information is different. In either case, you break down the cost of a freight order or freight booking to the order document items (e.g., sales order items and forwarding order items). A shipper can use the cost distribution for inbound shipments to perform product costing and pricing. The transportation cost is automatically used in materials management materials valuation. For all outbound shipments, the distributed cost can be used for profitability analysis. This allows improved visibility regarding actual profitability. For an LSP, the distributed cost can be used as the basis for an internal settlement process. The apportioning of cost is always done per delivery or cargo item.

For a shipper, the freight settlement document contains the distributed cost and offers visibility in its own tab, as you can see in Figure 10.8. The transportation cost is split and broken down into each individual item of an order. You can also see the distribution percentage that was assigned to each item. The cost distribution is executed for every charge type. In this example, the distribution rule is the net weight of the items. Other rules are available, which can be set in Customizing.


Cost Distribution

Distribution Category (Description)	Net Amount in Document Currency	Document Currency	Distribution Date	Distribution Level
External Charges	2.170,00	USD	31.07.2022	Forwarding Order

Details: External Charge Distribution

Standard *

Distribution Hierarchy	Charg...	Distribution Percentage	Distribution Amo...	Currency	Logistical Refere...	Requirement	Distributi... Rule	Quantity	Un... Meas	Distributi... Status
Freight Booking 400001355 , Forwarding Order 1100001212		60,6	1.315,15	USD	1100001212	1100001212				
Low Sulphur Surcharge	LSFS	60,6	6,06	USD	10 - CNNGO_20G0		Net Weight	2.000	KG	Allocated
Peak Season Charge	PEAK	60,6	66,67	USD	10 - CNNGO_20G0		Net Weight	2.000	KG	Allocated
Terminal Handling Charge (THC) Destination	THCD	60,6	242,42	USD	10 - CNNGO_20G0		Net Weight	2.000	KG	Allocated
Terminal Handling Charge (THC) Origin	THCO	60,6	121,21	USD	10 - CNNGO_20G0		Net Weight	2.000	KG	Allocated
Bunker Adj. Factor	BAF	60,6	212,12	USD	10 - CNNGO_20G0		Net Weight	2.000	KG	Allocated
Basic Freight	FB00	60,6	666,67	USD	10 - CNNGO_20G0		Net Weight	2.000	KG	Allocated
Freight Booking 400001355 , Forwarding Order 1100001213		39,4	854,85	USD	1100001213	1100001213				
Low Sulphur Surcharge	LSFS	39,4	3,94	USD	10 - CNNGO_20G0		Net Weight	1.300	KG	Allocated
Peak Season Charge	PEAK	39,4	43,33	USD	10 - CNNGO_20G0		Net Weight	1.300	KG	Allocated
Terminal Handling Charge (THC) Destination	THCD	39,4	157,58	USD	10 - CNNGO_20G0		Net Weight	1.300	KG	Allocated
Terminal Handling Charge (THC) Origin	THCO	39,4	78,79	USD	10 - CNNGO_20G0		Net Weight	1.300	KG	Allocated
Bunker Adj. Factor	BAF	39,4	137,88	USD	10 - CNNGO_20G0		Net Weight	1.300	KG	Allocated
Basic Freight	FB00	39,4	433,33	USD	10 - CNNGO_20G0		Net Weight	1.300	KG	Allocated

Figure 10.8 Distributed Cost in Freight Settlement Document

For a freight forwarder, the cost information of the freight settlement document is less relevant, as no material valuation is required, which targets only shippers. Profitability analysis, however, may be of interest to LSPs, as the slicing and dicing of freight charges and forwarding revenues related to logistical parameters such as trade lanes or container types has significance.

A key question at the beginning of the cost distribution process is how cost is distributed to the order items in the freight order or freight booking. You can define different rules for how to distribute the charges. SAP offers four methods of distribution: gross weight, net weight, gross volume, and distance times weight. You can define your own logic via a business add-in (BAdI): `/SCMTMS/TCD_DISTRIB_RULE`. This BAdI allows a lot of flexibility, so you can implement your own methods for cost distribution.

The distribution rule must be added in a mandatory *distribution profile* in TM. This profile contains both the distribution rule and the level, which must be the order item for shippers or the forwarding order for freight forwarders. You can configure the profile in TM Customizing via menu path **Transportation Management • Basic Functions • Cost Distribution • Define Cost Distribution Profiles**. The cost distribution profile needs to be assigned to a charge profile, just like any other profile relevant to the settlement or charge calculation process in TM Customizing. To do so, follow menu path **Transportation Management • Basic Functions • Charge Calculation • Basis Settings • Define Charges Profile**. In addition, you need to enable cost distribution in your corresponding freight settlement document types. Freight forwarders are required to select the **Cost Distribution** checkbox in the freight order or freight booking types.

The cost distribution settings described before are related to cost distribution in TM and allow an apportioning of cost for the purpose of calculating appropriate profitability in the forwarding order. To achieve a correct cost distribution and allocation also on the ERP and finance side, you can use an agency business document (ABD), which is an object that links sales and purchase activities. ABDs represent the values of sales or purchases, but don't do any postings. However, they can be used to transfer the corresponding values with related characteristics into profitability analysis.

In Figure 10.9, you can see the process flow when using ABDs. The deliveries representing the transportation demand are transferred to TM and create freight units ❶. Once the freight order is created ❷, and the freight costs are calculated, cost can be split by delivery and will also be available to split by delivery in the cost distribution of the freight settlement document ❸. The purchase order and SES created in SAP S/4HANA ❹ refer to the full amount as they represent the value to be settled for the whole freight order. However, the ABD ❺ can represent the cost split of the transport charges for the deliveries and are used to transfer the values to profitability analysis.

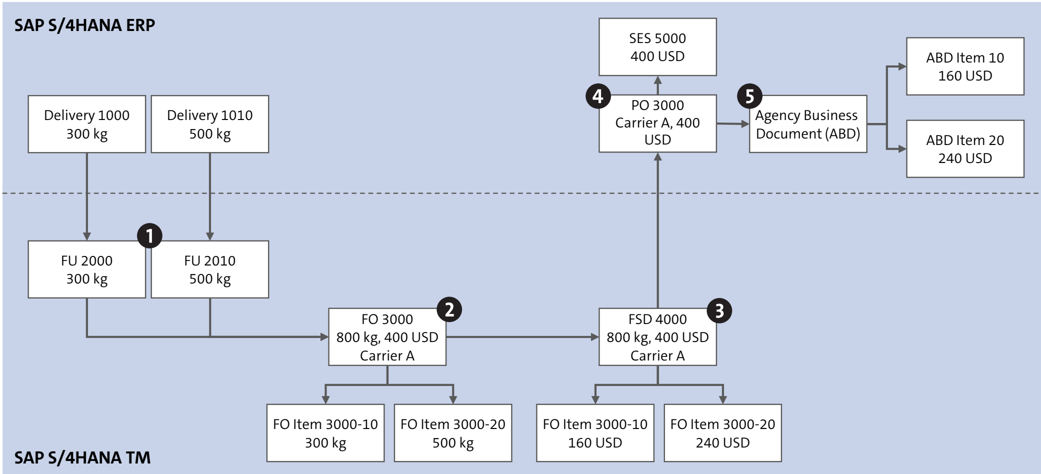


Figure 10.9 Cost Distribution in TM and in SAP S/4HANA (ABD)

10.3 Summary

In this chapter, we provided an overview of charge settlement, integration to invoicing, and cost distribution for vendor settlement. In the next chapter, we'll explain the charge calculation for the buying side, which is interesting for service providers, who are selling freight services and must settle this kind of charge with customers.

Chapter 11

Charge Calculation and Settlement for Logistics Service Providers

As discussed in previous chapters, transportation management (TM) differentiates between buying transportation services and selling them. Regarding charge calculation and settlement, we've so far only focused on the functionality from a buying perspective. Now we'll start selling services and charging customers for these services.

In the previous chapters, you've learned how the TM functionality calculates accurate transportation charges and settles those against service providers. However, as you know, TM can also be used by logistics service providers (LSPs) that use the TM system to capture customer orders. When capturing customer orders, the goal is to obtain revenue from the transportation services sold to customers. In this chapter, we'll look at how to use the charge calculation and settlement functionality to *sell* transportation services to customers and what other functionalities in this area help LSPs stay profitable in their business.

In a similar fashion as we did for the charge calculation and settlement for shippers, we'll start with examining the specific master data required (Section 11.1), before delving into the charge calculation logic (Section 11.2). We'll then look at the billing and settlement process (Section 11.3) and specifically with SAP Billing and Revenue Innovation Management (Section 11.4). Finally, we'll cover strategic customer contract management in Section 11.5.

Note

This chapter will only delve into the specifics of charge calculation and settlement for the selling side that is different from the functionality on the buying side. It's therefore essential to understand the basics of charge calculation and settlement described in Chapter 9 and Chapter 10, respectively, before going into this chapter.

11.1 Charge Calculation Master Data

In Chapter 9, we examined the freight agreement as the contract between the purchasing organization and the carrier that is selling the transportation service to us. Now that we sell transportation services to customers ourselves, we'll use the following sets of master data:

- **Forwarding agreements**
  Forwarding agreements serve as customer contracts and contain charges and rates, as well as capacity commitments, optionally based on service products.
- **Internal agreements**
  Internal agreements represent rate agreements among your own internal organizations for the internal settlements process. You can maintain standard costs for intercompany and intracompany charges.

Agreements can represent both short-term and long-term relationships between your company and business partners.

Furthermore, transportation charge management allows you to maintain a configurable *service product catalog*. You can set up your own service products based on individual service items, which can represent value-added services or customer-specific services. Using service products when you set up agreements and order documents is optional. You can assign standard operating procedures (SOP) to the service products to operationalize them.

11.1.1 Forwarding Agreements

First, let's differentiate a forwarding agreement from a freight agreement, as follows:

- The *forwarding agreement* represents a customer contract, which is highly relevant to all LSPs.
- The *freight agreement* represents a carrier contract with the rates of your vendors, which is relevant for both shippers and LSPs. We already discussed freight agreements in Chapter 9, Section 9.1.1.

You can create a forwarding agreement by navigating to the Create Forwarding Agreement app in the **Contract Management** tab of the SAP Fiori launchpad. You need to specify a forwarding agreement type, which is to be defined in Customizing, and then assign the agreement to one or multiple sales organizations.

In Chapter 3, you learned the essentials of the organizational structure. The sales organization represents a customer-facing organization that issues forwarding orders. If you work as a freight forwarder, your individual freight stations might have autonomous agreements with your customers. Alternatively, you can maintain multiple sales organizations for an agreement. Besides the sales organization, you need to store the business partners who are permitted to use the contract. You have two options:

- Define exactly one business partner (your contracting party).
- Maintain a list of business partners in a table format. All parties are permitted to book forwarding orders under this contract, unless they are excluded from an item of the forwarding agreement.

Last, it's mandatory to maintain the validity dates of a contract.

Another attribute on the header of a forwarding agreement is the version number. This functionality both supports regulatory filings and keeps track of changes in agreements. You can generate new versions of an agreement by clicking the **Generate New Version** button. A deep copy of the entire contract with all rates is generated. A history of the different versions is also available.

Figure 11.1 shows an example of the general header information of a forwarding agreement. This contract is maintained for one business partner only but is valid for three sales organizations. To prevent use while agreements are in maintenance, you must activate each agreement. As a result, you see **In Process** in the **Agreement Status** field.

Items in the agreement line differentiate the scope inside an agreement. Figure 11.2 shows an example of agreement line items. There are a few important requirements to take into consideration here. You must assign one calculation sheet to each agreement item, and each forwarding agreement must have at least one line item. When you execute the charge calculation for forwarding orders, the system picks up the rates from a line item in the determined agreement only if the defined scope between your forwarding order and the agreement line item match. We call this scope for an agreement item a *precondition*.

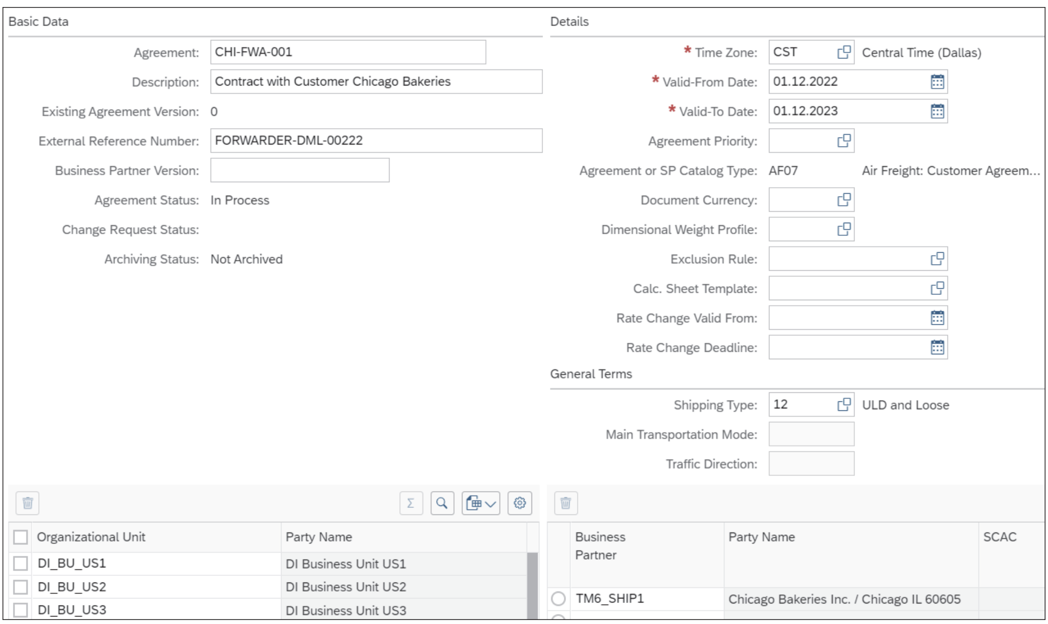


Figure 11.1 General Data of a Forwarding Agreement

Consider these examples of agreement line items and preconditions:

- Maintain only one line item per transportation stage category (e.g., pre-carriage, main carriage, and on-carriage, as shown in Figure 11.2). As a result, an item would only be used to determine trucking charges for an individual stage (pre-carriage) in the forwarding order.

- Agreement items can also represent service products; we discuss this further in Section 11.1.3.
- Mode of transport, movement type, and service level are examples of preconditions. If you don't want to maintain services as proper master data, note that the service level is a simplified concept of a service product catalog. Service levels are also used to describe services of courier, express, and parcel providers (e.g., an overnight service).

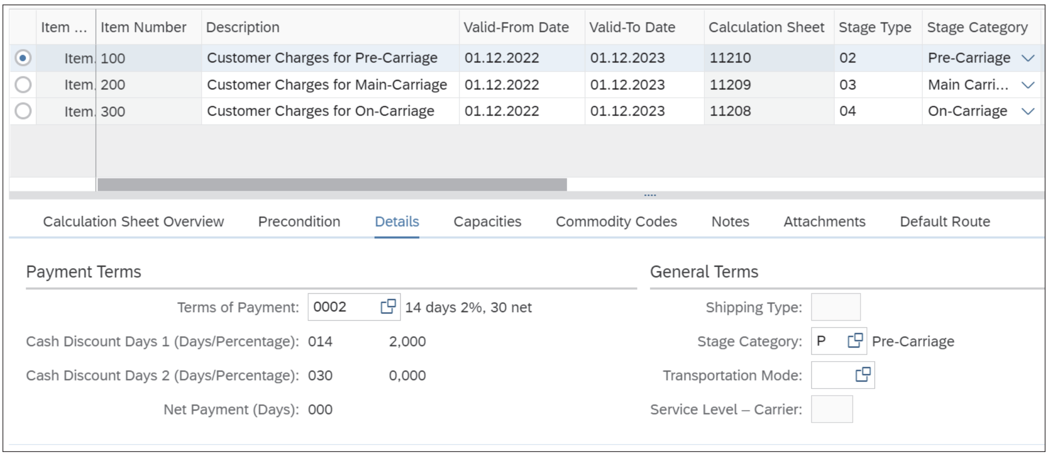


Figure 11.2 Items of a Forwarding Agreement

You can enhance agreement item preconditions through Customizing. On the forwarding agreement line items, you can also maintain the **Settlement Basis**. This setting determines how your settlement documents are generated (e.g., if you want to generate an invoice based on all goods loaded on a resource). The standard setting is **Per Forwarding Order**. We already discussed details of the settlement process in Chapter 10.

The tabs in the forwarding agreement item, such as the **Details** and **Calculation Sheet Overview** tabs, provide more information. In the **Calculation Sheet Overview** tab, you can see the information from the calculation sheet after it has been assigned to the item. The **Precondition** and **Commodity Codes** tabs allow you to store more conditions for the calculation sheet determination, which we detail in Section 11.2. Last, you can maintain capacities that you've agreed upon with a customer. It follows the same concept as for agreed capacities with carriers maintained in freight agreements that we already discussed. TM can't yet maintain space or capacity allocations from forwarding agreements to customers of, for example, a freight forwarder or ocean carrier. The capacities in the forwarding agreement are used mainly for reference purposes and in the request for quotation (RFQ) process for strategic freight selling, as described in Section 11.5, but they aren't used operationally yet.

Both the agreement header and items have other useful tabs, such as **Notes**, where you can maintain free text clauses and other text elements. You can also upload any document to the agreement, such as a signatory page or a legal filing confirmation.

For proper contract management, you need to be able to print agreements and define other output modes, such as email or fax. For this, define the settings for output management as part of the Post Processing Framework (PPF) in Customizing via IMG path **Cross Application Components • Processes and Tools for Enterprise Applications • Reusable Objects and Functions for BOPF Environment • PPF Adapter for Output Management • Maintain Output Management Adapter Settings**. We covered this in Chapter 2, Section 2.3.3.

After you've configured output management for agreements, you can generate actions in the **Output Management** tab by selecting **Generate • Actions Including Condition Checks**. Figure 11.3 shows one example of configured actions for agreements.

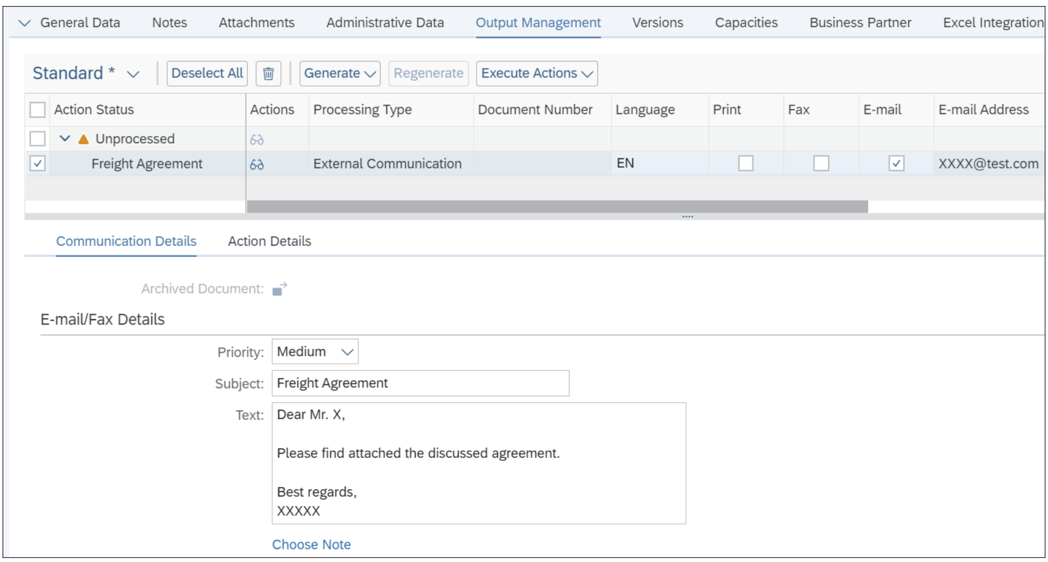


Figure 11.3 Output of a Forwarding Agreement

Let's highlight the key Customizing settings required for using a forwarding agreement. The forwarding agreement has its own type, which you need to configure. You can maintain the type in Customizing via IMG path **Transportation Management • Master Data • Agreements and Service Products • Define FWA and Service Product Catalog Types**.

The agreement type is a key setting; for example, it controls the user interface (UI) layout. You can select the **Multiple Parties** checkbox to maintain more than one business partner and organizational unit, as shown earlier in Figure 11.1. In the same Customizing section, you can specify preconditions for the agreement items, such as the stage category, movement type, and so on, as just described.

The forwarding agreement items have their own type; you can maintain them by following menu path **Transportation Management • Master Data • Agreements and Service Products • Define FWA and Service Product Item Types**. The forwarding agreement item types need to be assigned to the forwarding agreement type.

Let's turn our attention to another agreement—the internal agreement—which represents your contracts within the LSP or carrier.

11.1.2 Internal Agreements

The internal agreement is important to the management of internal settlements. For example, a freight forwarder can use internal agreements to maintain the internal rate agreements between freight stations and purchasing organizations. Each purchasing organization could have its own independent standard rates, which would be charged internally to the sales organizations generating the revenue. A manufacturing or retail company might similarly have a separate in-house logistics department that cross-charges other business units (BUs) for managing their transportation.

Alternative Use of Internal Agreements

In implementation projects, the internal agreement has been modeled differently from the internal charge settlement process. Companies decide to maintain internal agreements to store their internal standard cost of shipments. The standard cost contains many more components than just the purchasing charges for the transportation service. Such additional cost components can contain the cost of operations of the company's fleet, container repositioning, or other overhead costs that aren't directly related to a shipment. Because this data flows into the profitability analysis of the forwarding order, it gives an even more precise insight into the margin.

The structure of the internal agreement is almost the same as the forwarding agreements and freight agreements. In the header section, you maintain the purchasing organization that is offering internal services to other organizations.

The unique aspect of the internal agreement is that you also need to maintain the agreement partner. For example, a purchasing organization grants the same internal rates to all sales organizations in the same country but different rates to stations in other countries. As a result, a table is provided to maintain the involved parties for each internal agreement.

The internal agreement items are very similar to forwarding agreement/freight agreement items. Functionalities such as preconditions, commodity codes, notes, and attachments are supported. Capacities can't be stored on the items, assuming that internal organizations wouldn't negotiate on capacities that need to be consumed by internal sales organizations or other lines of business. You need to assign a calculation sheet or determination rule to each agreement item.

You need to define an internal agreement type before you can use this functionality. Maintain internal agreement types by following menu path **Transportation Management • Master Data • Agreements and Service Products • Define Internal Agreement Types**. You also need to configure the internal agreement item types and assign them to internal agreements: **Transportation Management • Master Data • Agreements and Service Products • Define Internal Agreement Item Types**. The configuration of internal agreement types and internal agreement item types is similar to the configuration of forwarding agreement types and forwarding agreement item types described in the previous section.

11.1.3 Service Products and Standard Operating Procedures

The professional services industry, which includes marketing, consulting, and the business to consumer (B2C) service industry, has been kicking around the concept of packaged service products for a long time. For LSPs, especially carriers and freight forwarders, the concept of modular and packaged service products is increasingly prominent. Offering nonfreight-related, complementary services can provide multiple benefits for an LSP, such as increasing revenue potentials, achieving cost savings due to standardization, and establishing a unique selling proposition.

With TM, you can maintain service products and service items as master data. A *service item* is a granular component that can be combined with a basic freight transportation service, such as container fumigation or reduced cutoff hours in a port of loading. A *service product* is a bundle of multiple service items (e.g., expedited air freight or cold-chain services). You can define a service product catalog and use it when setting up agreements and generating orders. TM can also operationalize the production of services with SOP.

Let's look into these options now.

Services in Agreements and Orders

You can maintain service product catalogs to create service products as bundles of multiple service items. You can use these service products as the basis to generate customer contracts representing service agreements. Remember that a service agreement is nothing more than a forwarding agreement or freight agreement that contains service products. In the case of a forwarding agreement, it represents the service offerings to your customers. Freight agreements with service items represent the services you choose from your LSPs. When setting up your agreement with services, you can choose whether a service will be considered as **Mandatory** or **Flow Service**. Both can be retrieved to an order, but the latter can be removed again—not so with the mandatory services.

You can work with service products and service items in your transactions in two ways:

- **Generate a forwarding order/freight order directly from a service agreement**
  The new forwarding order/freight order automatically inherits all service items, which are bundled under the service product in the service agreement.
- **Generate a forwarding order/freight order manually and insert service items**
  You can enter the carrier in the freight order to limit the input help values of service items from that carrier. You can also enter agreement, item, and version, and TM automatically retrieves the services to the order.

It's not mandatory to maintain a service product catalog. A limitation is that you can't insert an entire service product, only service items.

Now let's introduce the creation of a service product catalog. You can generate a service product catalog in the SAP Fiori launchpad by choosing the Create Service Product Catalog app on the **Contract Management** tab. In the structure, the catalog is like a forwarding agreement, but you don't maintain any validities or capacities. Most important, you can create service products in the item table. Select **Insert • Service Product**, and assign a service product item type as specified in Customizing (see Figure 11.4).

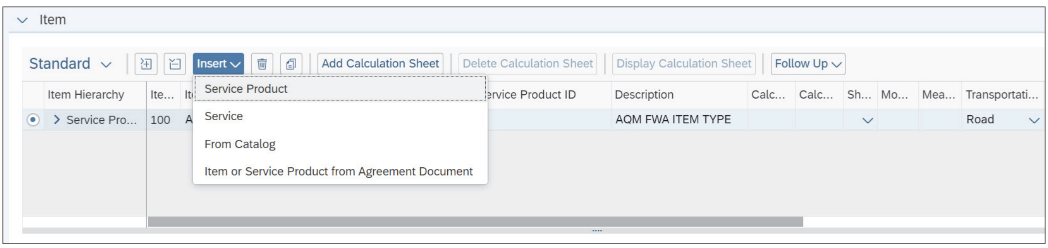


Figure 11.4 Insert a Service Product in a Service Product Catalog

You can now give the product its own ID and bundle service items under the product by selecting **Insert • Service**. You can directly assign a calculation sheet to each service product. In the calculation sheet, you can include all the charge types that are relevant to calculate the charges for the individual service items. However, you can't assign a charge type directly to a service product (e.g., to offer a price for an entire bundle).

You can maintain more than one service product catalog to distinguish the scope of service products with preconditions in Customizing. In a service agreement, you can insert a service product in the item table. You can search through your repository of service products for each service catalog and select a suitable product. All service items and charge types are pulled into the agreement when selected in a service agreement.

When generating a freight order or forwarding order, you can enter service items in the item table. You can assign services either to single containers only or to all containers as a header service. After you execute the charge calculation, the rates for service items are calculated based on the maintained amounts in the service agreement.

Settings for Services in Transportation Management

To generate a service product catalog and use services in orders, you need to define a repository of service types in Customizing, together with various other settings, as follows:

- **Service types**
  You need to set up your individual repository of service types, such as fumigation, providing generator sets, customs brokerage, container cleaning, expedited delivery, and GPS cargo tracking. To do this, navigate to the Customizing IMG path **Transportation Management • Basic Functions • General Settings • Define Service Types**. Service types are the most granular items (e.g., value-added services that can be bundled under a service product or that are particularly used in orders).

- **Forwarding order and freight order item types**
  Recall from Chapter 4, Section 4.2, that in the forwarding order, you can use item types mainly to enter cargo items, containers, railcars, and trailers. To also enter service items in the forwarding order and freight order item table, you need to maintain a new item type in Customizing by following IMG path **Transportation Management • Forwarding Order Management • Define Item Types for Forwarding Order Management**. The same is required for freight order item types. Maintain at least one entry with the item category **Service**, and assign this item type to your forwarding order type in Customizing by following IMG path **Transportation Management • Forwarding Order Management • Forwarding Order • Assign Item Types to Forwarding Order Types**.

- **Service product item types**
  Besides the granular definition of your individual service types, you need to establish a repository of your service products to generate the list of all the service products you want to offer. You can establish the repository by following IMG path **Transportation Management • Master Data • Agreements and Service Products • Define FWA and Service Product Item Types**. In this setting, you can define the description for your service product, such as guaranteed on-time delivery, expedited services, or temperature control deluxe.

  It's crucial now to assign the list of granular service types to the service product item type, under which it could be bundled. Note that this isn't the actual bundling of services, which happens in the master data.

  Optionally, you can specify preconditions that influence whether a service product can be used with the scope of an order or agreement.

- **Service product catalog type**
  The service product catalog is technically a forwarding agreement object, so you need to generate a service product catalog type that influences the number ranges and UI design and contains templates and defaults. You can create a service product catalog type in Customizing via IMG path **Transportation Management • Master Data • Agreements and Service Products • Define FWA and Service Product Catalog**

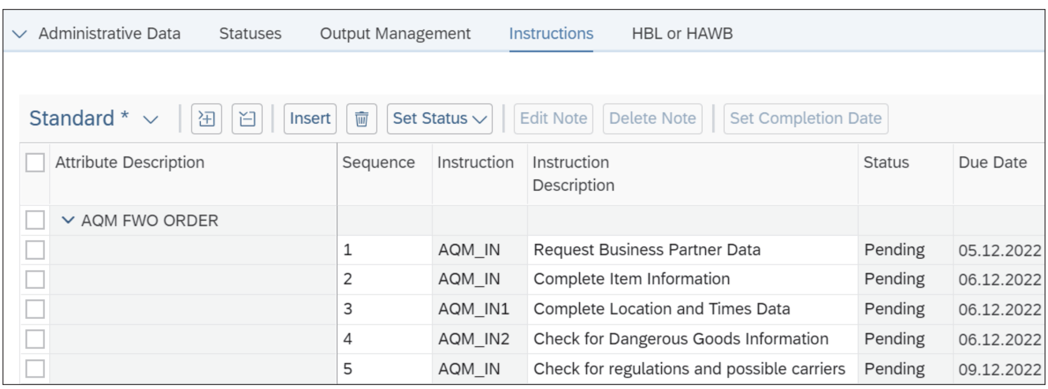
Types. To enable the use of service products in the service product catalog, you need to assign the possible service product types to the catalog types in the same Customizing path.

You've now made the basic Customizing settings to enable service products in TM. To allow a charge calculation for services in forwarding orders, you need to map your service types to charge types. You must maintain at least one charge type per service type, but, alternatively, you can map a service type to multiple charge types. Navigate to Customizing to maintain the mapping **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Assign Charge Types to Service Types**.

Standard Operating Procedures

Imagine an end-to-end transportation process of an LSP, freight forwarder, or carrier. You'll find that numerous tasks and actions need to be performed to execute a single shipment. Such tasks can include anything from taking and validating an order, planning and executing the transportation, issuing transportation documentation, performing customs clearance, and then finally invoicing a customer. In addition, specific agreements in customer contracts might outweigh the standard handling of a shipment and require additional services.

SOP support consistent and structured handling of all such tasks by generating instructions to be executed from user-specific worklists, which ensures process standardization, compliance, and clear guidance for staff. Figure 11.5 provides an example of instructions for one forwarding order. The SOP list can be considered as an individual to-do list for a user that needs to be completed daily.



Attribute Description	Sequence	Instruction	Instruction Description	Status	Due Date
AQM FWO ORDER					
	1	AQM_IN	Request Business Partner Data	Pending	05.12.2022
	2	AQM_IN	Complete Item Information	Pending	06.12.2022
	3	AQM_IN1	Complete Location and Times Data	Pending	06.12.2022
	4	AQM_IN2	Check for Dangerous Goods Information	Pending	06.12.2022
	5	AQM_IN	Check for regulations and possible carriers	Pending	09.12.2022

Figure 11.5 Instructions on a Forwarding Order

In TM, you can define instructions to represent executable tasks for a user, such as arrange fumigation, generate customer invoice, verify shipping instructions, perform cargo screening, and so on. The example in Figure 11.5 is about the customer's request for transportation of dangerous goods (DG) and therefore includes tasks such as completing location, times, and item data, and checking for possible carriers.

For each instruction, you can also define which user role needs to execute this task and provide notes and descriptions. To bring these instructions in the proper sequence and context, you need to group them in *instruction sets*. Instruction sets serve as a framework to define due dates for tasks to appear before or after a specific event. You can define, for example, that a task needs to appear in a user's worklist 12 hours before cargo cutoff. You can also define time-dependent alerts for a user in case a task hasn't been executed in time. After an initial setup, TM automatically generates instructions in a user's worklist after a forwarding order has been generated, depending on the scheduled time. You can generate instructions and instruction sets in Customizing via IMG path **Transportation Management • Basic Functions • Instructions • Define Instructions and Instruction Sets**.

Instructions are always stored on the forwarding order, where you can find the entire list of relevant instructions in the **Instructions** tab that was depicted on Figure 11.5. You have four options for how to assign an instruction set to ensure it's appropriate for the forwarding order:

- **Forwarding order type**
  The most generic assignment allows you to assign instruction sets to forwarding order types. Whenever you use the specific forwarding order type, the instructions are pulled into the forwarding order.
- **Item type per forwarding order**
  The instruction set is based on the item type in the forwarding order.
- **Stage type**
  An instruction set is pulled into a forwarding order if a specific stage type is used.
- **Service type**
  When you work with the service product catalog, you can assign an instruction set to each service type. This ensures the compliant execution of services you sold to a customer.

The assignment of instruction sets is performed in Customizing via IMG path **Transportation Management • Basic Functions • Instructions • Assign Instruction Sets**.

11.2 Charge Calculation Logic

In Chapter 9, we introduced the concept of charge calculation and how the TM functionality makes use of the master data defined. Charge calculation for forwarding orders follows the same principles as calculating charges for freight orders or freight bookings. The only difference is that we're now using a forwarding agreement instead of a freight agreement to draw rate tables and calculation sheets. When calculating charges on the forwarding order, the system determines a forwarding agreement that is valid for the combination of sales organization and sold-to party and fulfills all potential preconditions defined for the agreement itself as well as for the item. Because this is the only difference, we won't delve into the basics of charge calculation again. Chapter 9 covers this part, even though it's primarily focused on purchasing transportation services instead of selling.

This section will look at particularities that LSPs will require the charge calculation to cover that go beyond the basic charge calculation features.

11.2.1 Charge Calculation for Air Freight

Transportation charge management offers comprehensive capabilities for the calculation of air freight charges for freight forwarders or shippers. There are multiple methods and variants for calculating charges in air freight. Because this book focuses on the bigger transportation management picture, we don't cover the details of the pure air freight charge calculation or attempt to cover all available functions and setup; instead, we aim to convey a general overview of the capabilities in TM.

TM supports two ways of calculating air freight charges: rating based on the International Air Transport Association (IATA) or rating based on individual contract rates. The IATA globally standardizes processes in air freight and acts as a service organization for most airlines for charge calculation and settlement processes. One of the services the IATA offers is to calculate and manage cargo rates in its own database, representing more than 100 airlines.

We'll discuss both options in this section, including insight into additional air freight capabilities and configuration activities.

IATA-Based and Contract-Based Charge Calculation

TM can use the same methods and tools that the IATA uses for charge calculation to determine the cost for a freight forwarder. The core principle is that as a freight forwarder, when setting up agreements with your customers, you can configure your own forwarding agreements or base them on the IATA logic. Similarly, when maintaining contracts with airlines, you can be charged based on IATA or individual contract terms. For both IATA and contract rates, three rate categories are supported: unit load device (ULD) rates, special commodity rates (SCRs), and general cargo rates (GCRs).

Upload of TACT Rates

TM has the capability to upload the Air Cargo Tariff (TACT) rates into TM database tables to enable a charge calculation based on IATA. TACT rates represent a generic tariff available to any customer of an airline.

You can upload TACT rates via a report in TM. Navigate to Transaction SE38 in the SAP GUI, and run report /SCMTMS/TACT_RATE_UPLOAD. You can select a file containing the TACT rates. TM generates the appropriate entries in the database with report /SCMTMS/TACT_RATE_PROCESS.

Air Freight Calculation Logic

A common way of calculating rates is to have different weight tiers with flat charges per ULD type. This rating logic can be used both by the IATA and if rates are contractually agreed upon. If the chargeable weight exceeds a weight tier, an over-pivot rate is applied and added. TM calculates the chargeable weight of a ULD and applies the flat rate of the next higher weight tier. This rate is compared against the flat rate of the next lower weight tier, plus the delta in chargeable weight, multiplied by the over-pivot.

Let's illustrate this using the simplified example shown in Table 11.1.

ULD Class	Weight Tier for Chargeable Weight	Rate
04	300	$20,000
04	400	$22,000
04	500	$25,000
–	Over-pivot	$40

Table 11.1 ULD Rating Example

Let's say that the ULD in a forwarding order has a chargeable weight of 450. The flat rate would be $25,000. The lower weight tier rate is $22,000 plus the over-pivot rate of 50 × 40 = $2,000, which results in $24,000. The lower rate of $24,000 is rated. IATA provides the weight tiers for each ULD class and the flat rates/over-pivot rates for each carrier. The rates are normally dependent on the source and destination IATA cities. This logic is implemented in TM via the air freight break-weight calculation method.

Pure commodity rates are rarely used in air freight. They can be maintained as rates per chargeable weight and are simply multiplied by the chargeable weight of the cargo with a similar commodity class (see example in Table 11.2). You can also apply tiers for the commodity rates, but no over-pivot or comparison logic is applied. A pallet of chocolate on a flight from Frankfurt to Singapore has a chargeable weight of 350. The rate calculated would be 350 × $5 = $1,750.

Origin	Destination	Weight Tier for Chargeable Weight	Commodity: Chocolate	Commodity: Gold
Frankfurt	Singapore	>100	$6	$30
Frankfurt	Singapore	>300	$5	$25

Table 11.2 Commodity Rating Example

Finally, the GCR is always used if no specifically discounted ULD or SCR is found. Three rate classes are used for the calculation: minimum charge, normal rate, and quantity rate (see example in Table 11.3). The logic is that a normal rate is multiplied by the chargeable weight of the cargo. If it's lower than the minimum, the minimum rate is applied. If the chargeable weight of the cargo is higher than the normal rate weight, the quantity rate of the appropriate tier is used. For example, a piece of cargo on a flight from London to Newark has a chargeable weight of 80. The calculated rate is 80 × $8 = $640.

Origin	Destination	Class	Weight Tier	Rate
London	Newark	Minimum	–	$124
London	Newark	Normal	<50	$9.50
London	Newark	Quantity	>50	$8.00
London	Newark	Quantity	>100	$7.00

Table 11.3 General Cargo Rating Example

When creating an air freight booking, for example, you can specify which rate category to use. TM can also automatically determine the rate category with a specific sequence.

Nature of Goods

You can enter the *nature of goods* against each charge line in the air waybill view. The nature of goods is used in air freight to give more detailed cargo information, such as concerning quantities, dimensions, DG, or live animals. It's often printing relevant in several documents (e.g., manifest and air waybill). The nature of goods can be entered in any execution document (e.g., forwarding order or freight booking) and is inherited by the predecessor documents.

The charge calculation logic is implemented based on two calculation methods: the air freight break-weight rating and air freight standard rating, which can be used for all scenarios. It's also possible to combine the ULD and GCR rate categories, which you might do for mixed loose cargo and ULD cargo scenarios:

1. If you're transporting ULDs, the booking needs to contain a ULD with weight and volume information. TM checks for a ULD rate based on chargeable weight.
2. If no rate is found, or the cargo is loose/packages (but not consolidated in an air freight ULD), the SCR is calculated. The commodity code in the booking for the cargo is required.
3. If no specific commodity-based rate is maintained, the generic rate calculation is used as a fallback option.

When you work with contract rates, you can flexibly change this sequence. You can enter specific handling codes in air freight bookings that can indicate, for example, that a cargo screening is required, DG are being transported, or other services need to be performed. Handling codes can be used to determine additional charge types that need to be included in the calculation.

Additional Capabilities for Air Freight

An option for charge calculation in air freight is to derive the charges of a direct shipment by pulling the cost calculated in the main air freight booking into a forwarding order (use the calculation method `AIR_COST`). Such an IATA direct shipment means that one order (house air waybill [HAWB]) equals to one air booking (air waybill). No order consolidation happens, for example, in a ULD with other customer orders. This is relevant particularly if LSPs have agreed upon rates based on actual cost plus a markup, or simply the actual cost. By choosing the `COST_PULL` calculation method in the forwarding agreement, you can choose both the source (e.g., air waybill charges) and the strategy for cost pull. The `Active_Copy` strategy determines whether charges pulled to the forwarding order are editable. Very important in the behavior of the cost pull functionality are the Incoterms in the forwarding order and the *freight terms* in the freight booking. Freight terms specify which of the freight forwarder's organizational units will pay the carrier. Depending on the selection of the freight terms, the cost pull might happen from the export, the import, or both the export and import freight booking.

When you work with an airline as a shipper or freight forwarder, you might deal with a sales agent in particular countries. Instead of having your freight agreement defined directly with the airline, you might have it with the airline's agent. This is common practice especially in small countries or countries whose airline has low service offerings. The possible behavior of TM is to first check for an agreement with the sales agent and, if none is found, to check for an agreement with the airline as a fallback. Remember from Chapter 9 that this is a specific behavior. You can enable this feature by maintaining the airline in the **Vendor Data** tab of the sales agent business partner. Make sure to also establish a business partner relationship between the two business partners with relationship category **Is Agent Of**. Furthermore, you can use a weight-to-volume ratio for charge calculation. This very common way of using a chargeable weight is described in more detail in Chapter 9, Section 9.3. Specifically, in air freight, a volumetric weight factor is often crucial to calculate the actual chargeable weight.

Configuration Highlights

To configure transportation charge management according to air freight charges, you need to apply a few settings. In Customizing, the following configurations are required. Let's highlight the core differences from a regular charge calculation, as described in Chapter 9:

- TACT rates:
  - ULD rate types are maintained and mapped against ULD types: **Transportation Management • Basic Functions • Charge Calculation • Air Freight Settings • Define ULD Rate Types** and **Map ULD Types to ULD Rate Types**.
  - TACT rates are uploaded.
- A calculation profile is maintained with the calculation level **Header** and the air waybill printing and air waybill settlement definitions. The calculation profile is assigned to a charges profile of an organization or business partner.

- A dimensional weight profile is assigned to the calculation profile or the agreement/agreement item.
- The charge types you use have the transportation mode category **Air**.

Besides pure Customizing, it's essential to set up your agreements, calculation sheets, and rate tables accordingly. Consider this summary of the possible settings:

- The agreement contains a dimensional weight profile. Alternatively, it's stored on the calculation profile.
- The charges in the calculation sheets are set up for air freight:
  - The rate categories are maintained as **ULD**, **SCR**, or **GCR**.
  - The rate type is selected as either **Contract** or **TACT**.
  - Charge type classifications and IATA charge-due definitions are maintained.
- One of the two air freight calculation methods—air freight break-weight or air freight standard—is assigned to the charge types.
- Rate tables contain the appropriate rate category for a corresponding charge type.

You can also use other functionalities, such as a multirate hit or minimum/maximum rates, as well as working with preconditions in the air freight charge calculation.

11.2.2 Charge Calculation with Freight Forwarders

In this section, we highlight charge calculation capabilities specific to freight forwarders or when you, as a carrier or shipper, have contracts with a freight forwarder. Crucial to mention at the beginning is that freight forwarders provide air freight services. In this chapter, we now focus on other capabilities freight forwarders can use in the context of air, ocean, trucking, or rail charges.

Charge Calculation Based on Chargeable Weight

In the freight forwarding industry, especially in air freight and less than container load (LCL) ocean cargo, it's a very common business practice to maintain rates not per weight or volume but per chargeable weight. The chargeable weight is a combination of weight and volume based on a specific factor. For the calculation of rates, it's common to use the higher value out of weight versus chargeable weight.

Let's look at an example. In air freight, the space of an aircraft and the weight that a plane can carry are limited. Consequently, the perfect piece of cargo to meet both the total volume and weight limits of the plane weighs 1 kilogram (kg) per 6,000 cubic centimeters (cm^3). In Example 1 in Table 11.4, the chargeable weight used for rating is 83.33 kg. In Example 2, the chargeable weight is 47 kg.

Example	Volume (in cm3)	Divided By	Dimensional Weight	Actual Weight
1	500,000	6,000	83.33 kg	60 kg
2	240,000	6,000	40 kg	47 kg

Table 11.4 Air Freight Weight Scenarios

You can maintain dimensional weight profiles to store the specific weight-to-volume ratios in the TM Customizing via IMG path **Transportation Management • Basic Functions • Charge Calculation • Data Source Binding • Define Dimensional Weight Profiles**. You can assign the dimensional weight profile to a calculation profile or on the header/line items of an agreement to use it for the charge calculation and even in the charge details.

Through Rates, Cross Rates, and Uncontrolled Shipments

In a regular rating scenario for customers of a freight forwarder, you can calculate charges per transportation leg. TM checks for a rate for each start location and destination location for each leg when using the resolution base **Stage**.

In the ocean freight industry, however, it's a common business practice of carriers to charge a freight forwarder an end-to-end rate from origin to final destination. This is called the *through rate*. Alternatively, any other combination of stage-dependent rating is possible based on *cross rates*, meaning that one rate is maintained for the pre-carriage, another rate for the main carriage, and a third rate for the on-carriage.

To pass this concept on to customers of the freight forwarder, TM supports the through rate/cross rate calculation logic for forwarding orders and forwarding quotations. This calculation logic always tries to find the most direct rate with as few individual stages as possible. If no through rate is found, the logic systematically breaks up the end-to-end route into pieces of mixed stage categories (pre-carriage and main carriage) to find cross rates, including two-stage categories. If no cross rate is found, the logic checks for a rate for each stage category. If a rate isn't maintained for each stage category, then each start–destination pair is analyzed for a rate. Figure 11.6 shows how TM breaks down the legs of the tour.

The trip starts with a charge calculation, which checks the rate table for a rate from A to F. If no rate is found, a second call to the rate table (Rating 2) is performed to check for a rate from A to D and from D to F, and so on. To enable the through rate/cross-rate calculation logic, you need to select the **Through Rate** checkbox in the calculation profile in Customizing (refer to Chapter 9, Section 9.2.2). The calculation level needs to be maintained as the stage level. Note that if a rate isn't found for specific legs, TM performs a partial determination, where a rate is determined (e.g., only for main carriage and on-carriage).

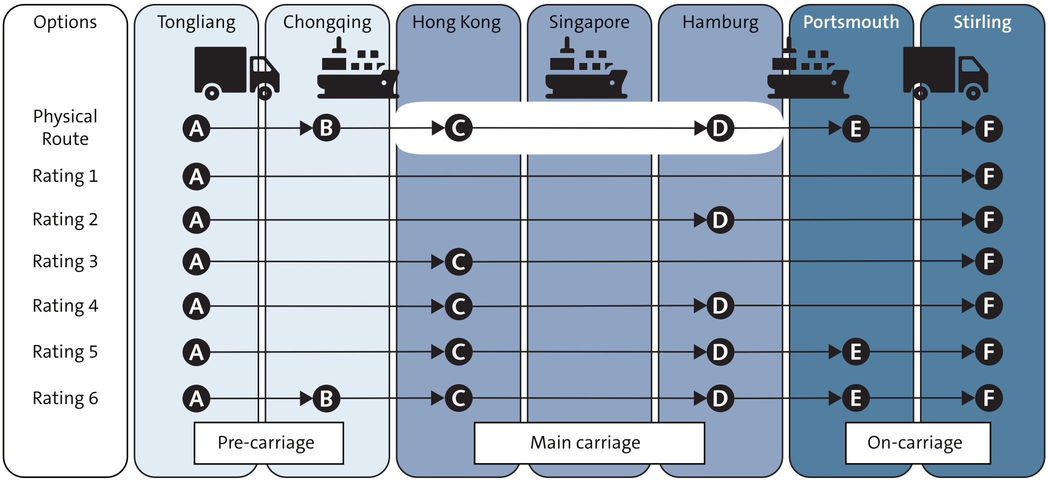


Figure 11.6 Through Rate and Cross Rate Concept

A common business scenario for a freight forwarder is to handle uncontrolled shipments. A customer uses rates for the main carriage that are directly agreed upon with the carrier. A forwarder can be requested to perform invoice verification for the carrier. Consequently, the charge calculation for both the forwarding order and freight booking are still performed by the forwarder to validate an invoice received. You can maintain a forwarding agreement item, deactivate the **Controlled** flag, and enter both the carrier and external agreement ID. In the freight agreement with the carrier, you need to mention the uncontrolled agreement party and the external agreement ID.

Customer Charge Calculation Based on Cost Pull

A very useful functionality in TM is the cost pull capability, through which you can pull the actual transportation cost from a freight order or freight booking into a forwarding order for customer charge calculation. We briefly introduced this in Section 11.2.1 for air freight. For example, you can maintain markups in percentages that are applied on top of the transportation cost when you calculate the customer charges. As you saw in Chapter 10, Section 10.2, you must configure the cost distribution before you can use this functionality.

When setting up your calculation sheets in the forwarding agreement, you need to enter a line item with the new instruction type **Cost**. In the basic data of this line item, assign the calculation method **COST_PULL**, which enables the underlying logic of retrieving cost information from a freight document and using it for charge calculation on the forwarding order side. You can specify whether all charge types or only dedicated charge types from a booking are retrieved, as well as whether they are applied as an aggregated lump sum or shown individually as in the booking. To apply a markup, you can enter additional charge types under the cost line item in the calculation sheets with percentage values.

You can retrieve internal charges from a freight order to the forwarding order. This is particularly important if an LSP has multiple organizations that are involved in the execution of a shipment, typically an export and import organization. In this case, an internal agreement between the export and import organization applies internal charges to the freight booking or freight order—for example, from the export side to the import side. This is very common for an LSP, as we explain in more detail in Section 11.3.5. To enable the internal cost pull, you need to add a specific charge type in your calculation sheet of the forwarding agreement. Maintain the **Charge Source** field in the **Basic Data** tab as **Internal**. A similar calculation method and instruction type as described earlier are needed.

11.2.3 Charge Calculation for Container Management

For an LSP such as a freight forwarder or an ocean carrier, it's common to provide containers to customers as an additional service to the actual transportation of the freight. A shipper might provide its own container, and provisioning isn't required. In other examples, the customer might require only an empty container but no transportation service. In TM, you can manage these different provisioning and return processes of containers. TM introduces container units, which can optionally be created during freight unit building. Refer to Chapter 4, Section 4.2.1, for more details on the order processing of such containers. It's essential for your profitability that you invoice relevant fees for container provisioning and return. For this purpose, you can maintain a container-specific charge type, that is, maintaining values for the **Empty Provisioning** or **Empty Return** attributes in the **Basic Data** tab of a charge type in a calculation sheet. For both empty provisioning and empty return, you can choose any of three options, as depicted on Figure 11.7:

- **Requested**
  An empty container is provided to the shipper/returned from the ship-to party. The cargo transportation of the container is managed as the main service.
- **Not Requested**
  The shipper has its own container, and only the cargo transportation is requested from the LSP.
- **Provisioning Only**
  The shipper/ship-to party doesn't need the actual cargo transportation, just the provisioning/return of an empty container.

Figure 11.7 Applying an Empty Container Provisioning or Return Charge Type

If a forwarding order is created, and a container provisioning or empty provisioning only (no cargo movement) is requested for the container items, the relevant charges from the calculation sheet are retrieved. You can use a resolution base container to retrieve the corresponding charge types for each container.

Technical Container Object

When you offer all three container options (cargo movement, container provisioning/return with cargo movement, and only container provisioning/return) to a customer, you must pay attention to the charges setup. If you, for example, maintain separate charge types for the cargo movement, the container provisioning/return, and the empty provisioning/return, TM applies each applicable charge type per container item on the forwarding order. Remember that the resolution base is `Container`. This might result in an overcharging of the customer because TM creates technical container units in the background. Such a container unit is created for the empty container leg and *additionally* for the leg of the cargo movement. If a forwarding order, for example, has two containers—one requires provisioning and cargo movement, and one container is needed only for empty provisioning—TM creates three container units: one for the provisioning of the cargo container, one for the cargo movement, and one for empty provisioning. In reality, only two containers exist. In this case, the charge to provide only empty provisioning is also applied for the technical container created for the empty provisioning of the cargo movement.

This section walked through the specific capabilities offered in TM for managing forwarding contracts and charges, and it demonstrated the different ways of deriving rates for eclectic use cases and transportation modes.

Now, we need to make sure the charges calculated against our customers are also paid. To facilitate this, we need to create customer invoices. The next section will focus on the functionality TM provides to create invoices based on the charges calculated in forwarding orders.

11.3 Billing and Settlement

When talking about settlement in TM, we usually differentiate between settlement toward a transportation service provider and settlement against a customer. Chapter 10 already dealt with freight settlement, which will serve as a basis for this section. This section will now take a closer look at the following types of settlement:

- **Settlement of customer charges**
  The settlement of customer charges is significant for LSPs and carriers (e.g., railways, trucking companies, and ocean liners). Billing customers for the provided transportation services is part of the core business model. This can be a very straightforward process or become increasingly complex. The settlement of charges depends greatly

on the Incoterms of a shipment. The Incoterms define whether freight charges need to be paid by the shipper or the ship-to party. Consequently, different settlement documents and invoices are sent to the involved shippers to pay for prepaid charges, and the involved ship-to party or parties to pay the collect charges, according to the agreed Incoterms. Certain customers have preferences about how to split and group invoices, which can become a challenge for logistics companies. The logistics departments of shippers can benefit from the same functionality if they act as an LSP/carrier to external customers. However, as a shipper, your logistics department is probably a cost center and doesn't bill customers.

- **Internal settlement**
  A shipper's logistics department might bill other internal departments—let's call them internal customers—for transportation services. For freight forwarders and trucking companies, this is a very common business practice. LSPs usually organize themselves in such a fashion to increase operational efficiency. They have gateways and hubs that are responsible for the optimization of costs for procurement and generating a profit through consolidation services. In such situations, LSPs tend to operate as internal service providers for their own BUs. Incurred cost and profit is commonly settled/shared across the organizations. A selling branch/booking office of an LSP might sell transportation services to a customer, but multiple hubs and gateways are responsible for procuring and providing capacities along the global supply chain.

In the next sections, we'll look at how forwarding settlement—the settlement of customer charges—is performed, meaning how we create settlement documents, what these documents look like, and how these are integrated with the billing functionality in SAP S/4HANA. We'll also dive into internal settlement and profitability analysis.

11.3.1 Creating Forwarding Settlement Documents

During this section, you'll notice that the high-level process of creating and processing forwarding settlement documents is similar to the way we created and processed freight settlement documents in Chapter 10, Section 10.1. The forwarding settlement process, however, is highly integrated with and dependent on the way we calculate the charges in the forwarding order. You'll quickly see that a multitude of scenarios and requirements have come from LSP customers concerning how their invoices are created and structured. As a result, TM supports a variety of functionalities to serve specific scenarios. We'll introduce the different scenarios step by step, including both the business background and the most important Customizing settings.

Incoterm-Based Forwarding Settlement Documents

Our process starts with creating the forwarding settlement document, if we've already generated and executed a forwarding order. There are generally three ways to generate a forwarding settlement document:

- Navigate to a forwarding order, and select **Charges/Settlement • Create Forwarding Settlement Document** from the top navigation panel.
- Run a batch report, which periodically generates forwarding settlement documents.
- Collectively or individually generate forwarding settlement documents from a personal object worklist (POWL) by selecting **Create Forwarding Settlement Document • Individual**, **Collective** or **Use Default Settings**.

Mass Creation of Forwarding Settlement Documents

TM offers a standard report that you can run manually or automatically in the background to mass-create forwarding settlement documents. Navigate to Transaction SE38 in SAP GUI, and run report /SCMTMS/CFIR_CREATE_BATCH.

The first question to answer is how many forwarding settlement documents are generated when the creation is triggered. For a freight forwarder, customer invoices are generated based on global Incoterms. From Chapter 4, you learned how to maintain and use Incoterms in a forwarding order, and you've seen that Incoterms can significantly influence the way we calculate charges. Now we'll show you how Incoterms influence the generation of forwarding settlement documents. Figure 11.8 shows an example of a settlement process based on Incoterms.

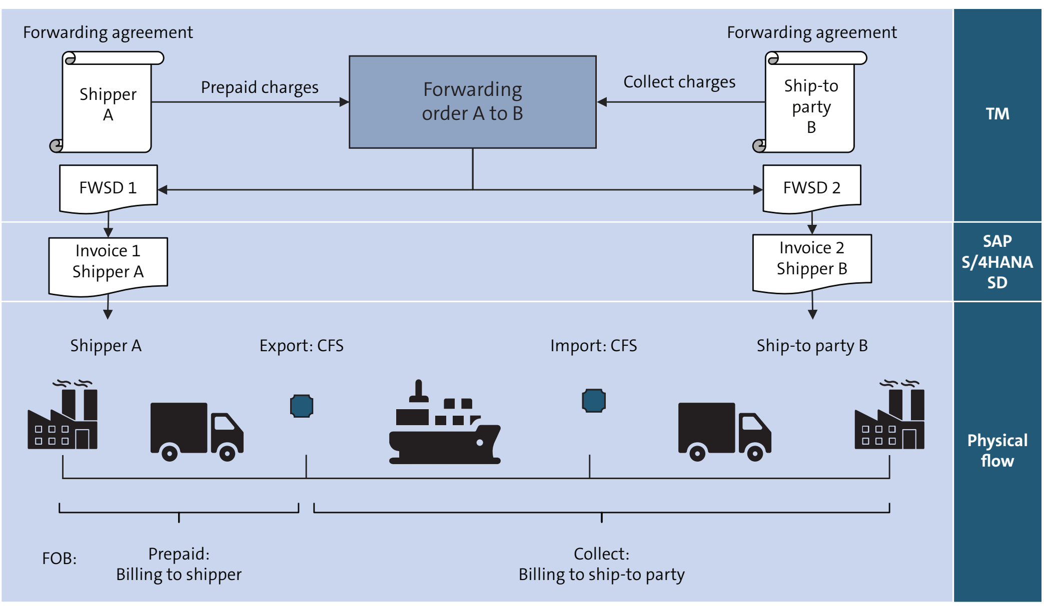


Figure 11.8 Settlement Process Based on Incoterms

Let's assume you have a forwarding order with the Incoterm free on board (FOB). The shipper is responsible for paying all charges until the port of loading, including the export customs declaration. The ship-to party pays all charges from the port of loading to the final destination, including insurance and import customs. We have two forwarding agreements in place, one with the shipper and one with the ship-to party.

The definition of which agreement party is responsible for paying which part of the forwarding order is defined on the **Actual Route** tab of the forwarding order (or the **Ordered Route** tab if the charge calculation is performed based on the ordered route). As you can see in Figure 11.9, the forwarding order in our example is an ocean transport from the Dallas metropolitan area to Germany. The prepaid agreement party will pay for the stage in the United States, while the collect agreement party will pay for the main carriage and the road stages in Germany. Note that the **Agreement Business Partner** is automatically determined from the **Business Partner** tab of the forwarding order, where a business partner was assigned to an agreement partner function.

Stage Description	Stage Type	Mode of Transp...	Source Location	Destination Location	Agrmt Prtnr Function
Route			TM9-CU-DLS1	TMA_CUST	
Stage 1	02 (Pre-Carriage)	01	TM9-CU-DLS1	TGE_CFS_USEWR	Prepaid Agrmt. Party
Stage 2	03 (Main Carriage)	03	TGE_CFS_USEWR	TGE_CFS_DEHAM	Collect Agrmt. Party
Stage 3	04 (On-Carriage)	01	TGE_CFS_DEHAM	TMA_CUST	Collect Agrmt. Party

Figure 11.9 Assigning Agreement Parties to Transportation Stages

Assuming we've made all the required settings, you should see the following system behavior after navigating to the forwarding order and selecting **Charges/Settlement • Create Forwarding Settlement Document**. The system prompts you with a user selection to define which forwarding settlement document to create (see Figure 11.10).

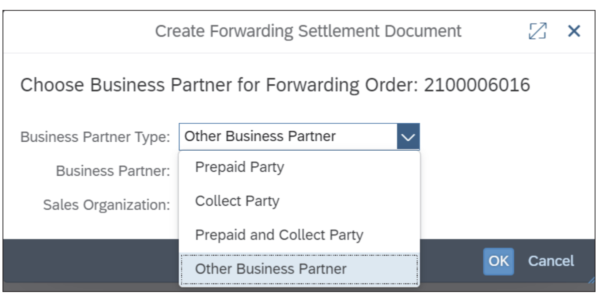


Figure 11.10 Selecting the Agreement Party for Forwarding Settlement Document Creation

The system recognizes that two forwarding settlement documents will be created based on our configuration settings. The first business partner represents the prepaid agreement party, as maintained in the **Business Partner** tab in the forwarding order. The second business partner is the collect agreement party that must pay the charges from the port of loading. You now choose whether to create just one settlement document for either business partner or both at once.

Note

If you create a forwarding settlement document for only one business partner in this step, not all charges of the forwarding order will be settled, as the charges against the other business partner will remain pending settlement.

When choosing **Prepaid and Collect Party**, a minimum of two settlement documents are generated in total from the forwarding order because both the ship-to party and the shipper pay a proportion of the overall charges. The first forwarding settlement document contains the charges of the shipper who is responsible for paying the prepaid charges from origin to port of loading. The charges are calculated for each transportation stage.

The second forwarding settlement document contains the collect charges to be paid by the ship-to party. The invoicing status in the forwarding order is updated to **Partially Invoiced** if not all settlement documents have been generated. The status changes to **Invoiced** after all forwarding settlement documents have been generated. After the successful creation of multiple forwarding settlement documents based on Incoterms, you see an item table of forwarding settlement documents that contains all the settlement documents that were created. You can now select each document to drill down into the details, which we cover in Section 11.3.2.

Additional Forwarding Settlement Documents

You can create additional forwarding settlement documents manually by selecting **Other Business Partner**. This functionality has been developed for exceptional and unplanned cases only, where a user wants to bill a customer manually for charges that weren't retrieved from the customer's forwarding agreement or services billed to another business partner that is neither the prepaid nor collect agreement party. These additional settlement documents don't impact the invoicing status of a forwarding order, and the charges for these settlement documents need to be calculated on the settlement document directly.

It's important to mention that in an export/import scenario, the settlement of customer charges can be based on two forwarding orders for one shipment: the export forwarding order and import forwarding order. As you learned in Chapter 7, Section 7.1.3, TM can generate an export and an import forwarding order for international shipments. As a result, the export organization of a company in the exporting country might be responsible only for settling the prepaid charges to a shipper. The responsible import organization consequently settles the collect charges with the ship-to party. Depending on the Incoterm, you generate one forwarding settlement document to the shipper from the export forwarding order and a second forwarding settlement document to the ship-to party from the import forwarding order. In addition, you can cross-charge the incurred transportation cost between the export and import organizations for an equal split. We detail this scenario of internal settlements in Section 11.3.5.

If a customer cancels a forwarding order, it's still possible that costs occurred, and, consequently, the charges need to be applied. You can create a forwarding settlement document for forwarding orders that are in the **Canceled** lifecycle status. You must create the forwarding settlement document manually because it's not yet possible with the standard TM installation to calculate the charges automatically for canceled orders. As a result, you must manually add them in the settlement document, which is created as an empty shell. After you've entered the charge types and actual amounts, you can follow the standard settlement process flow.

Basic Customizing in Transportation Management

Let's look at the basic settings required to achieve this system behavior. For the creation of forwarding settlement documents, you need to take a few basic Customizing steps in the forwarding order management and charge calculation areas. You need to have defined the Incoterms and maintained the default agreement party roles for stages, where a stage type is assigned a default agreement party role. The forwarding order you created stores the actual Incoterm. In addition, you need to have defined the resolution base as **Stage** in your calculation profile (see Chapter 9), as the charge split between prepaid and collect agreement party is usually done on a stage basis.

The following Customizing settings are required in charge settlement:

- **Settlement document type**
  When using TM settlement functionality, you must define at least one forwarding settlement document type in Customizing and assign it to your forwarding order type by first following IMG path **Transportation Management • Settlement • Forwarding Settlement • Define Forwarding Settlement Document Types**. The forwarding settlement document type specifies the number range, output profile, and multiple default settings. The assignment of the forwarding settlement document type to the forwarding order document type is done in IMG path **Transportation Management • Forwarding Order Management • Forwarding Order • Define Forwarding Order Types**. More details about this Customizing activity are provided in Chapter 4, Section 4.2.
- **Settlement profile**
  You need to maintain a settlement profile via IMG path **Transportation Management • Settlement • Define Settlement Profile**. Figure 11.11 shows a standard settlement profile in TM. The settlement profile is the key configuration that influences the behavior of a forwarding settlement document. A settlement profile can be directly assigned to a business partner. Alternatively, it can be assigned to a charges profile that is mapped to an organizational unit, in our case, the forwarding house or sales organization.

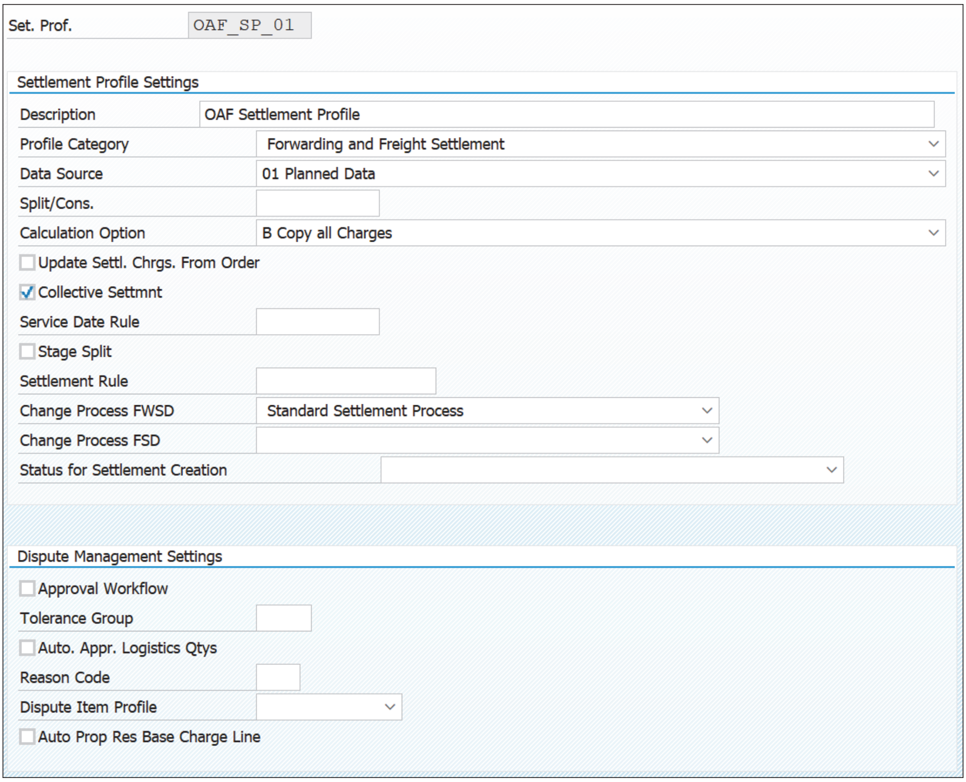


Figure 11.11 Settlement Profile

In the following Customizing path, you need to assign your settlement profile to a charges profile: **Transportation Management • Basic Functions • Charge Calculation • Basic Settings • Define Charges Profiles**. If the settlement profile is assigned to both the business partner and the charges profile, the priority lies with the business partner. The settlement profile is used for both freight settlement documents and forwarding settlement documents, unless the profile category in Figure 11.11 restricts the usage to only freight settlement or forwarding settlement. An additional capability of the settlement profile is the **Stage Split** checkbox. As an alternative to the described Incoterm scenarios, selecting this checkbox causes a forwarding order to generate one settlement document per leg for the entire transportation process, independently of the Incoterm and involved parties.

- **Process controller**
  You must set up the process controller for creating settlement documents. TM offers two standard methods for the settlement process: either split the forwarding order based on Incoterms to generate multiple forwarding settlement documents or consolidate multiple forwarding orders to generate one settlement document. In addition to the TM standard capabilities, you can develop your own process controller methods and assign them to a strategy that will be used in the charge settlement

process and steer the creation process of a forwarding settlement document. Custom logic won't replace the standard methods.

Collective Creation of Forwarding Settlement Documents

In addition to the generation of settlement documents based on Incoterms, which allows you to split a forwarding order and generate multiple settlement documents, you can also create one forwarding settlement document across multiple forwarding orders. You can select multiple forwarding orders in a POWL and create a collective forwarding settlement document. One document is created for your selection if the basic settlement data is the same. You can configure your own strategies to determine the attributes that have to be similar across forwarding orders to generate a common forwarding settlement document. Examples of such attributes are bill-to party, payer, sold-to party, payment term, credit segment, and source or destination location. To activate this grouping logic, you don't need to assign a split/consolidation strategy in the settlement profiles. A default logic is available in standard TM. A customer-specific logic can be optionally assigned to the settlement profile, which runs in addition to the default in standard TM (refer to Figure 11.11).

Trailer-Based and Route-Based Settlement

Billing the customer based on the distance traveled between origin and destination is a common business practice in the trucking industry. Recall from Chapter 5, Section 5.4.2, that a trailer can be used to pick up multiple forwarding orders across different origins and drop off the cargo at multiple destinations. In this case, you can invoice one bill to your customer for multiple forwarding orders that are transported on the same trailer. This gives you an alternative way of generating one forwarding settlement document for multiple forwarding orders.

A key aspect of the trailer-based settlement is that the charge calculation logic is different from a regular rating scenario. The charges are calculated for the entire group of forwarding orders in a trailer, not per individual order. They are treated as one virtual forwarding order document, and the consolidated weights, volumes, and so on are used for the charge calculation. Consequently, you can use a trailer-based settlement process to generate one settlement document per trailer document per customer.

In cases where the trailer contains forwarding orders from multiple customers, multiple forwarding settlement documents are created. The settlement document has a slightly different layout of the **Orders** section than regular forwarding settlement documents, as shown in Section 11.3.2. You can see the trailer document used for the settlement creation as a line item. Select the line item to see the forwarding orders that were loaded on the trailer on the line-item details. These scenarios are also referred to in a similar fashion as execution-based settlement because the cargo execution information plays a vital role in the settlement process.

For you to enable trailer-based charge calculation and creation of settlement documents, one additional setting is required: the **Trailer-Based Settlement** indicator needs to be selected in the line-item details of your forwarding agreement that you want to use to calculate the charges of the corresponding business partner. This automatically serves as the main item for charge calculation; use of a specific resolution base isn't required.

Trailer-Based Settlement

For a trailer-based settlement process, you can only use the calculation levels **Header** and **Stage** as possible settings for the charge determination. From Chapter 9, you know that the calculation level, which is maintained on the calculation profile, defines how many forwarding agreements are used when resolving the charges. The calculation-level item would not make sense in this business context because the system would try to retrieve one forwarding agreement per item (e.g., per package of an order).

In the trailer scenario, the opposite is the case. We want to settle all the packages collectively from one customer that are loaded on the same trailer, based on the distance a trailer has traveled. Consequently, there is no need to use a different forwarding agreement for one package or another because the agreed-upon rate based on the distance would be stored in one forwarding agreement of the business partner only.

Another functionality of TM is to generate forwarding settlement documents based on the freight order they are loaded to (which is called route-based settlement). It's similarly targeted at trucking companies. TM allows you to generate a forwarding settlement document for all forwarding orders on the same freight order. The distinctive feature we want to highlight here is that you can use your freight document (and the data contained) as the basis for the settlement to your customers. This bypasses the individual settlement of forwarding orders, such as a trailer-based settlement. For example, you could combine the route-based settlement with trailer-based settlement in a scenario where a forwarding order is transported on a first stage in a freight order without trailer assignment and for a second leg in a trailer object. Consequently, two forwarding settlement documents are generated per customer—one for the stage of the freight order and one for the stage of the trailer. You can activate this functionality by selecting the route-based settlement basis in the line-item details of your forwarding agreement.

11.3.2 Structure of Forwarding Settlement Documents

The forwarding settlement document contains all billing-relevant information inherited from a forwarding order. Think back to Chapter 4, Section 4.2, about forwarding order management and to Chapter 9 about transportation charge management; a lot of the fields and information will already be familiar to you. Therefore, we now want to highlight the most crucial information with respect to the billing process.

The **General Data** tab contains the type of your settlement document, which determines, among other things, the screen design (Web Dynpro application configuration, as described in Chapter 2, Section 2.2). In addition, this tab contains the sales organization, which is determined based on the sales organization from the forwarding order. The Incoterms are available based on the forwarding order, as well. They can have a major impact on the creation of the settlement document, as we discussed in the previous section. There is also a screen area listing the payment terms from the customer's forwarding agreement. Payment terms can be maintained in Customizing via IMG path **Sales and Distribution • Master Data • Business Partners • Customers • Define Terms of Payment**. In addition, there is the invoice date. You can manually change some information in the forwarding settlement document, such as the invoice date and payment terms.

To be able to issue a bill to your customers, maintain at least the bill-to party and the payer. The business partners for these two partner functions are defaulted from the forwarding order. You can use business partner determination rules to automatically determine which parties will be maintained for which partner function. For more details on how to maintain and use business partner determination profiles, refer to Chapter 4, Section 4.2. You can overwrite the address of a bill-to party in the forwarding settlement document if you want to send the invoice to a different address. In this case, the settlement and invoice creation in SAP S/4HANA considers the different address to generate the billing document.

The forwarding settlement document is created based on actual forwarding orders. As a result, you can always see which forwarding orders were settled in a forwarding settlement document. You might see only one forwarding order assigned to the forwarding settlement document, but remember that we described how to settle multiple forwarding orders collectively in one settlement document. Therefore, the **Orders** tab provides you with the list of all forwarding orders you grouped into a settlement document. For a trailer-based or freight order-based settlement, you'll see the freight orders or trailer documents in the **Orders** tab, which contains the forwarding orders as line items. If you resolve the charges based on the calculation level of forwarding order items, you can see the list of forwarding order items in the **Orders** tab.

In the **Orders** tab, you might notice the *service date*; this can be different from order to order. When settling the charges to a customer, you're probably confronted with a legal taxation requirement to activate only your revenues when a service has been rendered. TM supports this requirement with the service date. It allows you to set up flexible rules to define at what time you consider the service of a forwarding order fulfilled. The date is transferred with your settlement document for the actual billing (mapped to the *service rendered date* in sales and distribution billing). You can define such rules in the TM Customizing by following IMG path **Transportation Management • Settlement • Define Service Date Rules and Rule Prioritization**.

TM offers you the choice between multiple transportation-related dates that are stored in your forwarding order and even in the freight order (e.g., expected start date of first stage main carriage or actual end date of loading). You can maintain multiple dates that are considered as the service date and assign priorities among them if a date isn't available in a forwarding order. You can assign the service date rule to a settlement profile, and it will be converted to the relevant time zone. For further flexibility, a business add-in (BAdI) is offered to plug in your own service date rule (`/SCMTMS/BADI_FCP_SRV_DATE` of enhancement spot `/SCMTMS/ES_FCP`).

The **Charges** tab contains the core information on the forwarding settlement document, which gives you the comprehensive overview of all charges that need to be billed to a business partner. All charges are retrieved from your forwarding order; however, they can be recalculated in some cases, such as collective order rate lookup where the charge is, for example, determined based on the aggregated weight of multiple forwarding orders that are collectively charged on one forwarding settlement document. Which charge items appear in the **Charges** tab depends on how you've configured the charge calculation and settlement process.

You have the same ability to switch the view of the charges and display them grouped or ungrouped as described in Chapter 9 for the charge calculation of the forwarding order. If you use a collective forwarding settlement document to settle multiple forwarding orders, then the charges appear as a sum for each charge type across all forwarding orders. In a standard settlement scenario based on Incoterms, the charges are calculated per stage. As a result, you see a breakdown of the charges per stage in each settlement document (for both the shipper and ship-to party). You can see two forwarding settlement documents that were created to bill the charges to the prepaid and collect party based on Incoterms in Figure 11.12.

The first settlement document ❶ is for the shipper—the prepaid agreement party. In our example, this is a party in Dallas, TX. The second settlement document ❷ is for the ship-to party (the collect agreement party) who is a customer in Germany.

After successful generation of a forwarding settlement document, the actual billing process and posting to sales and distribution in SAP S/4HANA still must be accomplished. The **Statuses** tab gives a comprehensive overview of the various process steps from creation of a forwarding settlement document until the final billing in sales and distribution. Two statuses ensure visibility of the progress of the entire settlement process. We provide you with example values of both statuses as we describe the posting to SAP S/4HANA:

- **Life Cycle Status**
  This status describes what step was performed last, along the entire billing process. After the initial creation of a new forwarding settlement document, the status is set to **In Process**.
- **Confirmation Status**
  Based on the interaction between the TM functionality and sales and distribution, multiple activities are performed when transmitting a settlement document to sales and distribution. Hence, a separate status is provided that meticulously tracks the

interaction between the two modules. The initial status after the creation of the forwarding settlement document would be **Not Yet Posted** in sales and distribution.

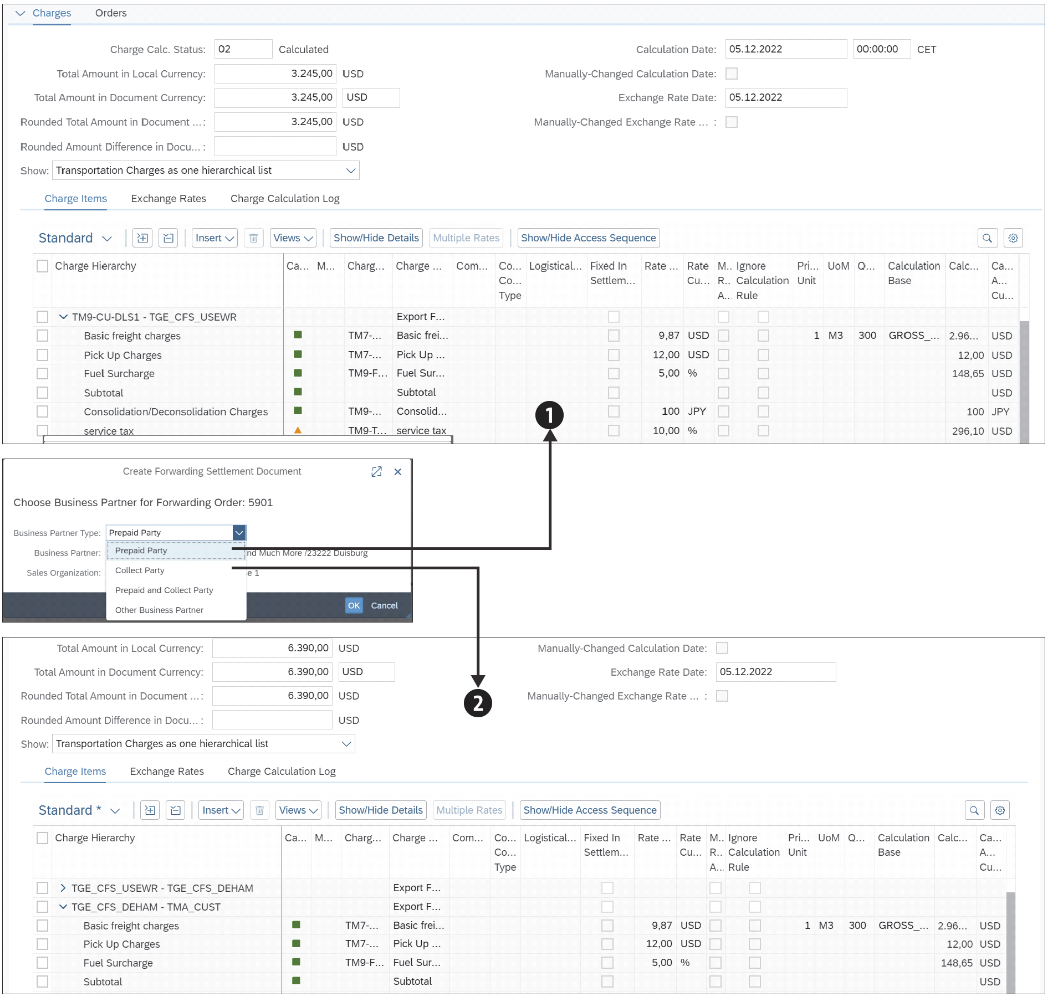


Figure 11.12 Forwarding Settlement Document Charges for Prepaid and Collect Agreement Party

11.3.3 Integrating Forwarding Settlement Documents with Sales and Distribution in SAP S/4HANA

You've learned throughout this chapter that TM uses the sales and distribution billing application in SAP S/4HANA to invoice customers. In Section 11.4, we'll highlight an alternative way of invoicing your customers by integrating TM with SAP Billing and Revenue Innovation Management.

For now, let's dive into the details of the interaction of TM and the sales and distribution functionality for billing.

Basic Customizing in SAP S/4HANA

To enable the TM to sales and distribution communication, you must customize your sales and distribution billing functionality. Moreover, you're required to set up mapping rules between TM and sales and distribution billing. Let's start with the essential settings in sales and distribution in SAP S/4HANA billing:

1. As a first step in sales and distribution billing, you need to maintain *condition types*. Condition types are used to steer the logic of how the charges for a sales document are retrieved and calculated. In the communication with TM, you must define a condition type for each charge type used in the TM documents. In sales and distribution Customizing, follow IMG path **Sales and Distribution • Basic Functions • Pricing • Pricing Control • Define Condition Types • Set Condition Types for Pricing**.
2. You must create a *pricing procedure*. You're required to assign the condition types to the pricing procedure that you've just defined. The pricing procedure is responsible for defining which condition types are used when creating an invoice. You can maintain hundreds of different condition types, but when you generate a billing document, only the ones that were assigned to a pricing procedure are picked up. You can group the condition types in a pricing procedure logically (e.g., by origin port charges, sea freight charges, and destination port charges in an ocean freight scenario). You can maintain multiple pricing procedures because they are assigned for each sales organization or customer. In Customizing, follow IMG path **Sales and Distribution • Basic Functions • Pricing • Pricing Control • Define and Assign Pricing Procedures • Set Pricing Procedures**.
3. Last, you need to assign your pricing procedure to a sales organization. A sales organization can be assigned multiple pricing sequences. Navigate to Customizing by selecting **Sales and Distribution • Basic Functions • Pricing • Pricing Control • Define and Assign Pricing Procedures • Set Pricing Procedure Determination**.

Now let's focus on the mapping between TM and sales and distribution billing:

1. First, you need to assign the forwarding settlement document type to a sales and distribution billing document type and assign a pricing procedure, item category, and sales document type to it. You can do this in IMG path **Transportation Management • Settlement • Forwarding Settlement • Settings for Posting Forwarding Settlements • Assign SD Information for Posting**.
2. Navigate to the following Customizing IMG path to perform the mapping of the TM charge types and the sales and distribution condition types: **Transportation Management • Settlement • Forwarding Settlement • Settings for Posting Forwarding Settlements • Assign Condition Types**.
3. In addition to the mapping of charge types, you need to map your sales organizations as defined in TM to sales organizations in sales and distribution. Recall from Chapter 3, Section 3.1.1, that the organizational structure defined in the TM functionality differs from the organizational structure defined for sales and distribution and

materials management, which is defined in Customizing. Therefore, to post sales and distribution billing documents from forwarding settlement documents, you need to map the sales organization defined on the forwarding settlement document to the sales organization that is to be used on the sales and distribution billing document. As you can see in Figure 11.13, the ID of the sales and distribution sales organization is entered into the **BSG Org. Unit** field in Transaction PPOME.

If the organizational structure in TM was created based on the integration report, this field is already prepopulated.

Integrating TM with SAP S/4HANA

If you want to transfer forwarding settlement documents from TM to SAP S/4HANA, the assignments mentioned in the preceding are configured in IMG path **Integration with Other SAP Components • Transportation Management • Invoice Integration• Billing • Settings for Posting Forwarding Settlements**.

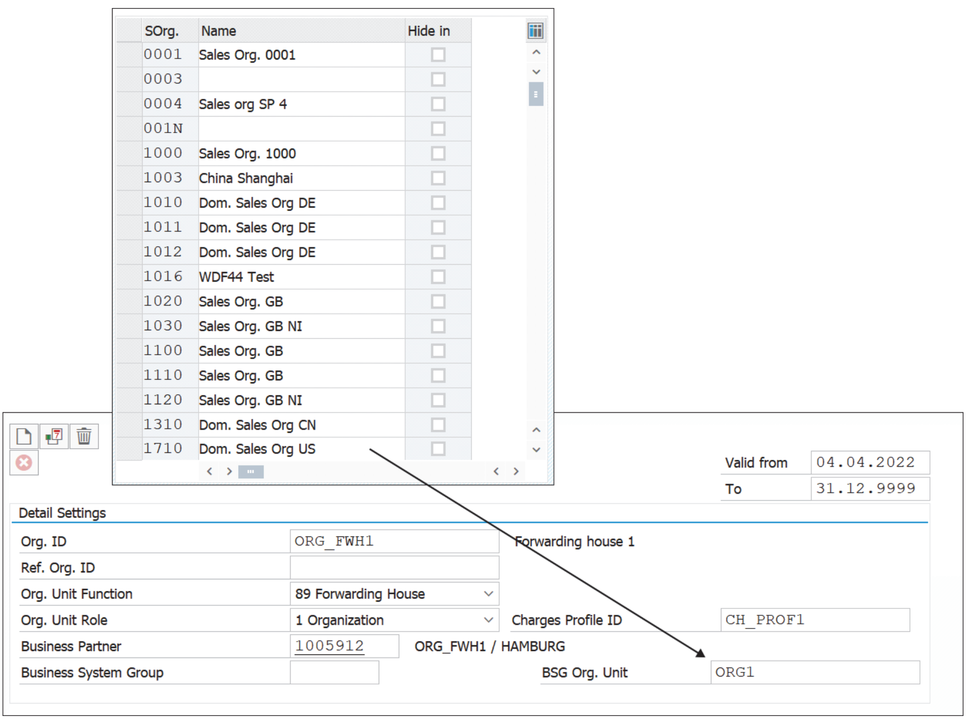


Figure 11.13 Mapping a TM Sales Organization to a Sales and Distribution Sales Organization

Functional Process Flow

After you've successfully created the forwarding settlement document in TM, you can execute a billing simulation in TM before posting it to sales and distribution in SAP S/4HANA. The charm of this capability is that you combine the logistical information from TM with the tax data available in SAP S/4HANA. Click the **Preview Invoice** button in the top panel of the forwarding settlement document. TM communicates the relevant logistical information to sales and distribution. Sales and distribution, in turn, generates a PDF output file that you can view in TM for each forwarding settlement document. This synchronous processing isn't visible to users. When you select the preview functionality, the actual PDF output file is visible immediately.

To enable this feature, you need to set up the corresponding output types in Customizing via menu path **Sales and Distribution • Basic Functions • Output Determination • Output Determination • Output Determination Using the Condition Technique • Maintain Output Determination for Billing Documents • Maintain Output Types**.

Because the logic of billing simulation is active and implemented in standard TM, it doesn't require any particular Customizing. It's possible for you to enhance the logic (e.g., if you have additional TM fields that need to be sent to sales and distribution). A provided BAdI on both the sales and distribution and TM sides is available for such enhancements. On the sales and distribution side, use the enhancement implementation `TM_BIL_IMPL01` for enhancement spot `BADI_SD_BIL_PRINT01`. In TM, the BAdI `/SCMTMS/BADI_FWSD_PRINT_SIM` needs to be implemented for enhancement spot `/SCMTMS/ES_FWSD`. This is the same enhancement spot used for the regular printing of sales and distribution invoices.

After the forwarding settlement document is consistent and ready to be posted to sales and distribution, you can click the **Post** button in the top panel of the forwarding settlement document. Alternatively, you mark multiple forwarding settlement documents and execute the action from a POWL. You can also use a batch job to post the data to sales and distribution.

Mass Posting of Forwarding Settlement Documents

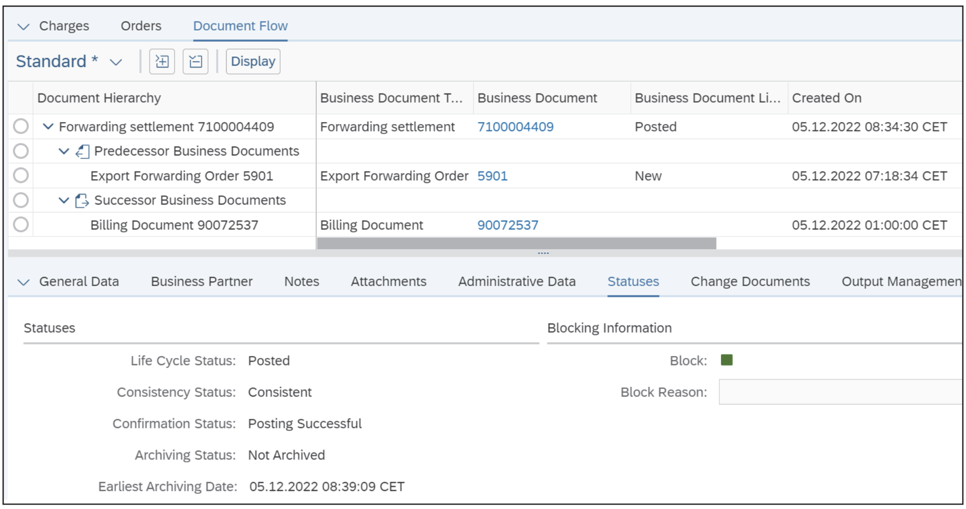
TM includes a standard report to mass-create forwarding settlement documents. You can use the same report to post your created forwarding settlement documents to sales and distribution in SAP S/4HANA billing en masse. Navigate to Transaction SE38 in your backend system, and run report /SCMTMS/CFIR_CREATE_BATCH.

A billing document is created directly in sales and distribution as depicted in Figure 11.14. Depending on your charge calculation level in TM, the corresponding billing items are generated in sales and distribution. If you did a header calculation of charges, the corresponding billing document in sales and distribution contains one billing item. If you calculated the charges per transportation stage, one billing item is created per stage.

Integration of TM in SAP S/4HANA with an External SAP S/4HANA System

As mentioned in other sections of this book, this book concentrates on TM *in* SAP S/4HANA. Therefore, we've only described the process of posting a forwarding settlement document that is created in SAP S/4HANA.

However, we can still use the forwarding settlement functionality in a separate SAP S/4HANA TM system. In this case, we need to configure the integration with an SAP S/4HANA system to transfer the forwarding settlement documents. The processing of these documents in the sales and distribution functionality of SAP S/4HANA is equivalent to the process we described in this section.



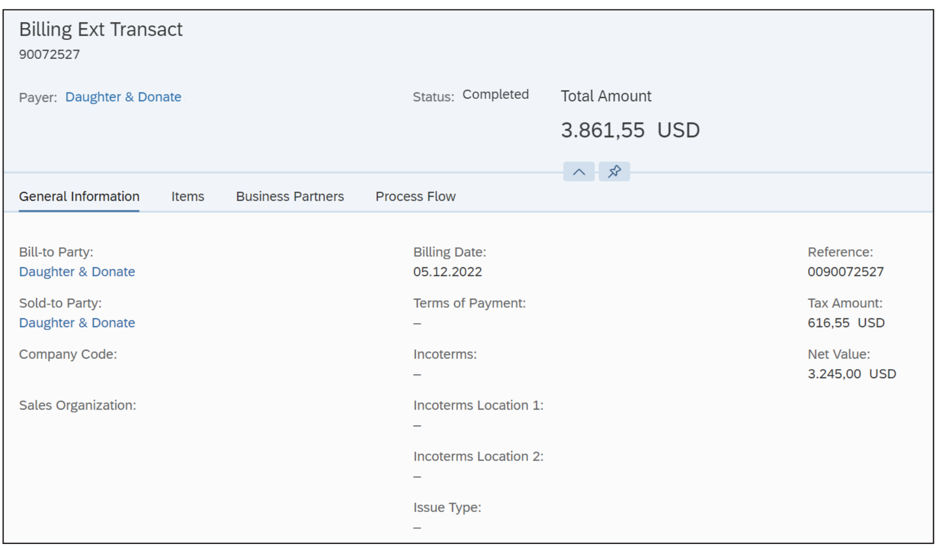


Figure 11.14 Posted Forwarding Settlement Document and Sales and Distribution Billing Document

In Figure 11.15, you can see the overview of the most important statuses of a forwarding settlement document. After a forwarding settlement document has been created and saved in TM in step ❶, the lifecycle status is set to **In Process**. As we've mentioned, you can change certain information in the forwarding settlement document—such as an alternative address for a business partner—without causing inconsistencies. If you change billing-relevant information in the forwarding order, the two documents won't be consistent anymore. This might happen if, for example, the route of a forwarding order needs to be changed due to a missed cutoff, such as a missed aircraft or vessel departure, and it results in a recalculation of charges.

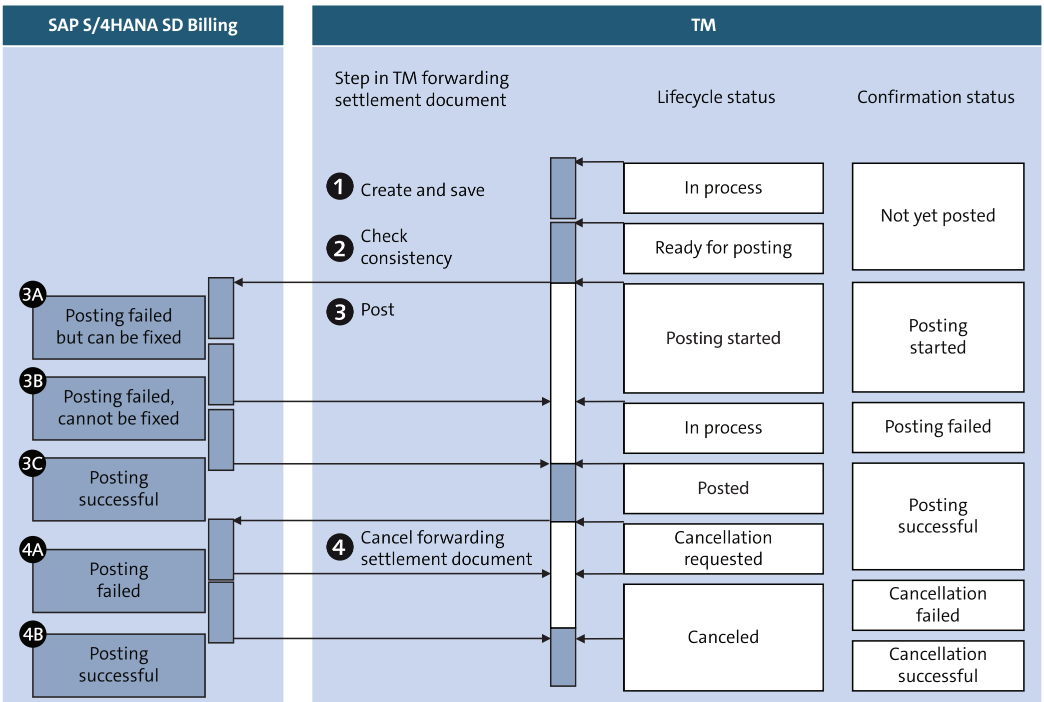


Figure 11.15 Functional Process of TM to Sales and Distribution Billing Integration

Only if the document is consistent is the lifecycle status updated to **Ready for Posting** ❷. Without consistency, you can't trigger the posting to sales and distribution, and the forwarding settlement document is marked with an **Inconsistent** flag in the **Statuses** tab. As soon as you trigger the posting of the forwarding settlement document to sales and distribution in step ❸, the lifecycle status changes. The **Confirmation Status** shows **Posting Started** until you receive a confirmation that the sales and distribution billing document is created successfully. In the event of a failed transfer, it depends on the error handling whether a message is returned to the TM functionality.

If you can fix a transfer error directly in sales and distribution—say, because of locking issues or a financial period closure—then the posting can be reprocessed in sales and distribution. Until the reprocessing, the lifecycle status and **Confirmation Status** in TM remain as **Posting Started** 3A, respectively. Only if the error can't be fixed 3B or the transfer is successful 3C are both the lifecycle status and **Confirmation Status** updated on the forwarding settlement document accordingly. Similarly, to the inconsistencies that occurred before you posted the forwarding settlement document to sales and distribution, you might still have to change invoicing-relevant data in the forwarding order.

Consequently, you can cancel the forwarding settlement document in both TM and sales and distribution in SAP S/4HANA in step 4. The lifecycle status and **Confirmation Status** are updated accordingly in steps 4A and 4B. It's still possible to cancel the forwarding settlement document by creating a credit memo.

Credit Memos for Forwarding Orders

The credit memo on the forwarding order side is used by freight forwarders and carriers to correct originally invoiced amounts on a billing document. You can generate a credit memo by navigating to your forwarding settlement document and selecting **Follow Up • Create Credit Memo**. This is also possible directly from a POWL. Remember that a credit memo can be created only after your forwarding settlement document has been posted to sales and distribution, and a billing document has been generated.

With TM, you can generate credit memos for both individual forwarding settlement documents and collective settlement documents that contain multiple forwarding orders. After you've generated a credit memo, you'll see that it has the same structure as the forwarding settlement document. The major difference is that the **Charges** tab contains three columns listing the charges. In Figure 11.16, you can see that in addition to the invoiced amount, a credit amount can be entered.

Standard *

Charge Hierarchy	Item Description	Charge Type	Line Nu...	Invoiced Amo...	Cu... - Inv...	Credit Amount	C...	Credit Remaining Amount	Curr... Credit Rem...
TM9-CU-DLS1 - TGE_CFS_USEWR	Export Forwarding Ord...		0	3.145,00	USD	3.145,00	USD		
Basic freight charges	Basic freight charges	TM7-BASIC	10	2.961,00	USD	2.961,00	USD	2.961,00	USD
Pick Up Charges	Pick Up Charges	TM7-PICK	20	12,00	USD	12,00	USD	12,00	USD
Fuel Surcharge	Fuel Surcharge	TM9-FUEL	30	149,00	USD	149,00	USD	149,00	USD
Subtotal	Subtotal		40		USD				
Consolidation/Deconsolidation Ch	Consolidation/Deconso...	TM9-CONS	50		USD		USD		USD
service tax	service tax	TM9-TAX	60		USD				
Sum	Sum		70		USD				
Documentation Charges	Documentation Charges	TM7-DOCF	80	5,00	USD	5,00	USD	5,00	USD
Packing/Unpacking Charges	Packing/Unpacking Ch...	TM7-PACK	90	10,00	USD	10,00	USD	10,00	USD

Figure 11.16 Charge Details of a Credit Memo

In the **Credit Amount** column, you can enter all deductions from the settlement amount. You can generate multiple credit memos for one settlement document. As a result, the **Credit Remaining Amount** column shows the remaining billing amount. TM validates and ensures that you can't give a higher credit than the invoiced amount.

Prior to the posting to sales and distribution, you can use the **Preview Invoice** functionality if you want to simulate a preview of the credit memo in sales and distribution together with the tax information. Like the settlement document, you must ensure consistency in the credit memo before you can transfer it. After you've successfully posted the credit memo to sales and distribution, a new document is generated of type credit memo. The lifecycle status of the credit memo is updated after it has been successfully posted to sales and distribution as **Credit Memo Posted**. It's also possible to cancel a credit memo, which changes its status to **Cancellation Requested** and **Canceled** if successful.

To use the credit memo for the forwarding settlement document, you need to perform a few Customizing steps:

1. A credit memo has its own document type that contains a number range and a reason code for a credit memo. You can define a credit memo type in Customizing in IMG path **Transportation Management • Settlement • Forwarding Settlement • Define Credit Memo Reason Codes and Types for Forwarding SDs**. The credit memo type can be assigned to your forwarding settlement document type.
2. In the same Customizing path, you can maintain reason codes and assign them to the credit memo. A description of a reason code could, for example, be **Delay in Transport** or **Deviating Cargo Measures**. The reason code generally has three characters with a free-text field for a description.
3. All other Customizing settings for the forwarding settlement document on both the TM and sales and distribution sides must be in place. In addition, you need to map the reason codes from the TM credit memo to sales and distribution order reason codes. Navigate to Customizing by following IMG path **Transportation Management • Settlement • Forwarding Settlement • Settings for Posting Forwarding Settlements • Assign SAP TM Credit Memo Reason Code to Order Reason Code**.

Technical Integration

The posting of a forwarding settlement document from TM to sales and distribution is processed via direct business logic. However, if you're using a standalone TM that isn't in the same system as the sales and distribution in SAP S/4HANA functionality, the integration needs to be done via service-oriented architecture (SOA) services. In this case, the terminology changes from *posting* a forwarding settlement document to *transferring* a forwarding settlement document. Alternatively, it's also possible to set up the connection between a TM system and an SAP S/4HANA system via Web Services Reliable Messaging (WSRM).

Standard SOA Services

SAP delivers eight standard SOA services for transactional integration between TM in SAP S/4HANA and sales and distribution in SAP S/4HANA:

- `CustomerFreightInvoiceRequestSUITERequest_Out_V1` (and `_In`)
  Send a request to create or change a forwarding settlement from TM and receive it in SAP S/4HANA.
- `CustomerFreightInvoiceRequestSUITEConfirmation_Out_V1` (and `_In`)
  Send the confirmation and status change for customer invoices from SAP S/4HANA and receive them in TM.
- `CustomerFreightInvoiceRequestSUITECancellationRequest_Out_V1` (and `_In`)
  Send a request to cancel a forwarding settlement from TM and receive it in SAP S/4HANA.
- `CustomerFreightInvoiceRequestSUITESimulate_Out` (and `_In`)
  TM offers to show a preview of an invoice in TM. Send the forwarding settlement from TM to SAP S/4HANA. Receive a PDF of the sales and distribution in SAP S/4HANA billing document.

11.3.4 Business Scenarios in the Forwarding Settlement Process

You've learned so far about the standard capabilities of the TM forwarding settlement process. However, because different companies can have entirely different billing requirements, we want to highlight specific scenarios in this section that TM supports.

Prepayment Scenario

In the freight-forwarding and ocean liner industries, it's a common business practice to grant customers a certain credit limit. To minimize risks, there are cases where customers aren't conceded any credits. A *cash customer* must pay the invoice for all prepaid charges of the transportation in advance. In such a scenario, you allow creation of a forwarding order for a cash customer but prevent it from being executed until the payment has been received. As a result, for the system to block the forwarding order, you need to indicate that the specific business partner is a cash customer.

When setting up your customer contracts, the forwarding agreements, you can maintain a **Pre-Payment** payment term. Alternatively, you can store this payment term directly in the business partner master data of your customer. In Customizing for payment terms, you can define a block reason (e.g., **Payment not Received**). Whenever you have a contract (i.e., a forwarding agreement) with a cash customer, you can assign a payment term containing the block reason **Payment not Received** to the agreement or business partner record. After a forwarding order is created for the cash customer, you can calculate the charges. Based on the charge calculation from the forwarding agreement, the payment term is retrieved into the forwarding order, and the document is automatically blocked for execution. The same behavior is invoked if you store the payment term on the business partner and as soon as you assign the business partner to the forwarding order. To still allow the settlement of this order, the creation of a forwarding settlement document is possible despite the block status of the forwarding order. As a result, you can follow the forwarding settlement process as described and create an invoice.

Unfortunately, this feature isn't yet fully integrated with the sales and distribution in the SAP S/4HANA billing component. The receipt of the actual payment from the customer in the sales and distribution functionality doesn't automatically release a blocked forwarding order. Instead, a user must manually navigate to the **Business Partner** tab in the affected forwarding order and select the checkbox for the corresponding business partner (e.g., select **Payment Received** for the shipper). As you learned in Chapter 4, Section 4.2.1, TM is integrated with the credit limit check application. TM automatically deactivates the credit limit check after the payment term is marked as **Pre-Payment**.

Settlement for Buyer's Consolidation

A buyer's consolidation is a very common service that freight forwarders and carriers offer to their customers. A buyer's consolidation is a scenario where the LSP picks up cargo from multiple origins (e.g., manufacturers in different countries). The cargo is transported to a container freight station (CFS) and consolidated into one container. From the CFS onward, the cargo travels in the same container until the final destination. It's relevant for the settlement process that a customer—in this case, a ship-to party—needs to be invoiced for the consolidated amount and not for each individual forwarding order. As a result, you can generate one forwarding settlement document for all forwarding orders in the same container in a freight booking. Each container in the freight booking (**Cargo Management** tab) can be marked with the value **B** in the **Consolidation Container** field. You can create the forwarding settlement document directly from the freight booking or from one of the consolidated forwarding orders. As a result, the combined charges for all forwarding orders that are consolidated in this container are calculated.

The actual creation of the forwarding settlement documents depends on the Incoterms: if the Incoterm is maintained as FOB, multiple forwarding settlement documents are generated for the pre-carriage legs. One forwarding settlement document per forwarding order is generated because every forwarding order has a different shipper. For both the main carriage and on-carriage, one consolidated forwarding settlement document is generated for the collect agreement party containing all forwarding orders that were consolidated in the same container in the freight booking. The freight booking is shown as a reference in the **Orders** section. In the example of the Incoterm, where the ship-to party pays all charges, only one forwarding settlement document is generated on the importing side. This document contains all charges for the precarriage based on the individual forwarding orders and the charges for main carriage and on-carriage based on the consolidation in the freight booking.

Export versus Import Forwarding Orders

Keep in mind that you always have two forwarding orders in an international shipment: one export forwarding order and one import forwarding order. You generate all settlement documents for the shippers from the exporting side and the settlement document for the ship-to party from the import forwarding order. Depending on the Incoterm, an exporting organization might settle its charges with the importing organization to be compensated for any incurred cost. This is always required when the shipper doesn't pay for pre-carriage and main carriage.

We provide a deeper insight into the settlement process between exporting and importing organizations in Section 11.3.5 for internal settlements.

The charge calculation follows a specific logic to find the correct forwarding agreement item to retrieve the charges for the forwarding orders:

1. Set the calculation level to **Stages** so that the consolidated charges are calculated only for distances the cargo traveled together in the container.
2. You can maintain your own forwarding agreement item and select the **Buyers Consolidation** checkbox for it. In the creation of the settlement document, the charges are picked up from this item in the customer's forwarding agreement for all stages that were transported in a consolidated container.
3. If no such item is maintained, TM retrieves the rates from an agreement item with shipping type full container load (FCL) or full truckload (FTL) but never less than truckload (LTL) or less than container load (LCL).

You also need to follow a specific process in the sales organization. Each forwarding order that has been consolidated into the buyer's consolidation might have been captured by a different sales organization. If all sales organizations across the forwarding orders are equal, the buyer's consolidation functionality can be used. If the organizations in the forwarding orders deviate, TM uses the purchasing organization of the consolidated freight booking. It's crucial that this organization is maintained as a forwarding house, so it can be used as a sales organization as well.

One forwarding settlement document is generated for all forwarding orders. The **Orders** tab in the forwarding settlement document lists the freight bookings where the buyer's consolidation has been marked and that contain the corresponding freight units. In the **Details** section, the container item is displayed together with the forwarding orders.

Settlement for Shipper's Consolidation

We can apply the concepts introduced in the buyer's consolidation scenario to a shipper's consolidation scenario as well. In this scenario, a shipper sends consolidated goods in a full container for both pre-carriage and main carriage. In the importing country, the container is deconsolidated, and the cargo items are separately transported to multiple ship-to parties. Depending on the Incoterms, TM generates one settlement document to group all pre-carriage and main carriage charges in one forwarding settlement document that is charged to the shipper. The charges for the delivery legs are included in the same forwarding settlement document only in the case of an Incoterm, where the shipper pays for all charges. Otherwise, separate invoices are generated for each delivery leg to settle with each ship-to party separately.

Whether multiple forwarding orders are shipped in a consolidated way as a shipper's consolidation is determined by TM. You must select the container in the **Cargo Management** tab of a freight booking to mark the container as a shipper's consolidation. This triggers the **SC** flag to be set in each forwarding order, which can also be done manually. The rest of the settings are like the buyer's consolidation. For example, you must mark at least one agreement line item as a shipper's consolidation item.

Flexible Invoicing

We've introduced various ways to generate a forwarding settlement document. Apart from the functionality introduced so far, you have even more flexibility in how to generate the settlement documents. This capability strongly supports LSPs and, in particular, rail carriers. Flexible invoicing allows you to cluster your relevant charge types into *settlement groups*. An example is that a railway company might decide to invoice all charges from the main transportation in one invoice, all accessorial services of an order in a second invoice, and, finally, any peripheral charges in a third invoice. After you create your settlement document, an enhanced popup opens. You can choose for which party and settlement group the forwarding settlement document should be created, as shown in Figure 11.17.

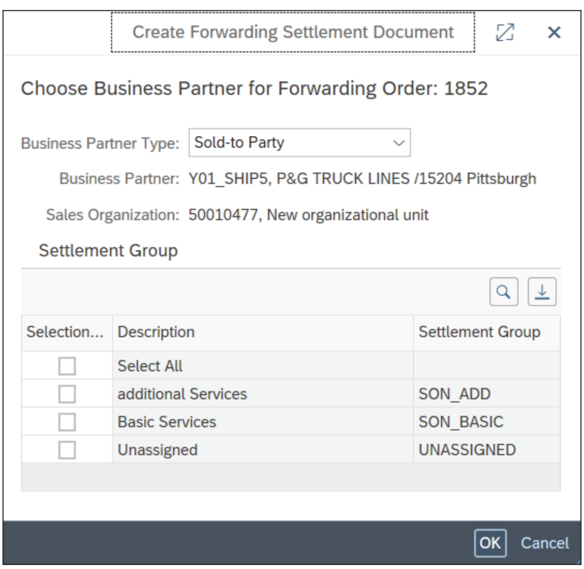


Figure 11.17 Creation of Forwarding Settlement Documents with Flexible Invoicing

You can trigger the generation of the settlement document for either of the two business partners and any group of charges individually. In addition, the batch report to generate forwarding settlement documents generates forwarding settlement documents only for a specific settlement group. You can still use the collective creation of forwarding settlement documents from a POWL. All selected forwarding orders are combined in one forwarding settlement document for the same settlement group. You can create a settlement group in Customizing via IMG path **Transportation Management • Settlement • Define Settlement Groups and Settlement Rules**. Note in Figure 11.17 that there is also a default settlement group called **Unassigned** that will collect all charge types that aren't assigned to a settlement group in Customizing. This settlement group will be displayed even if all charge types on the forwarding order are assigned to settlement groups.

Multiple settlement groups can be clustered in a *settlement rule*. In a settlement rule, you can define more time-relevant parameters for the settlement document generation, such as a billing schedule and the service date rule. To use the settlement rule, which contains the settlement groups, you need to assign it to your settlement profile.

11.3.5 Internal Settlement

In Section 11.1.2, we already introduced the master data object of an internal agreement. In this section, we'll now delve into how the internal settlement process is performed in the TM functionality and how it needs to be set up. We'll also look at different scenarios in which the internal settlement functionality is used.

In general, the internal settlement process is defined like this: a purchasing organization cross-charges the cost for a shipment to a sales organization, which generates the actual revenue with a customer. Let's consider a few examples of different business practices:

- In the freight-forwarding industry, it's very common for CFSs/gateways to procure their own capacities with ocean liners or airlines. Capacities are procured and internally provided. A CFS/gateway charges an internal rate to the exporting organization. The Incoterms play a major role because an exporting organization might only partially settle the charges with the customer.
- Importing organizations in freight forwarding are generally in charge of any inland transportation via rail or truck in the importing country. This means that an importing organization can settle the charges of the transportation cost to the exporting organization.
- In the trucking industry, it's a common business practice for a service center to own a pool of resources such as trucks and trailers. The service center provides other internal sales or planning organizations with the required capacities. In this case, the sales or planning organization is charged internally by the service center.

TM supports the internal settlement process for both intracompany and intercompany charge settlement. Intracompany charge settlement happens between branches or divisions of the same company code; for example, a gateway in Newark, New Jersey, settles the transportation cost to a freight station in New York City. An intercompany settlement takes place between legal companies with independent company codes (e.g., if a CFS and export station are in separate countries).

Internal Settlement Process for Logistics Service Providers

Let's use an example to illustrate an intracompany settlement process with a cross-company shipment execution. Section 11.3.1 covered the settlement process based on Incoterms. Now let's complicate this picture to represent an authentic example of the interaction in the settlement process among internal organizational units. We summarize the lessons learned in this chapter and include both a forwarding settlement document and freight settlement document creation.

In Figure 11.18, Shipper 1 in England transports cargo to Ship-To Party 1 in Singapore. Shipper 1 and Ship-To Party 1 have arranged the Incoterm FOB. Consequently, Shipper 1 is responsible for paying for the transport to the port of loading, and Ship-To Party 1 pays for the rest of the transportation, including customs duty. Any mode of transport and business scenario can be supported, but our example is based on ocean freight (the equivalent for air freight appears in parentheses).

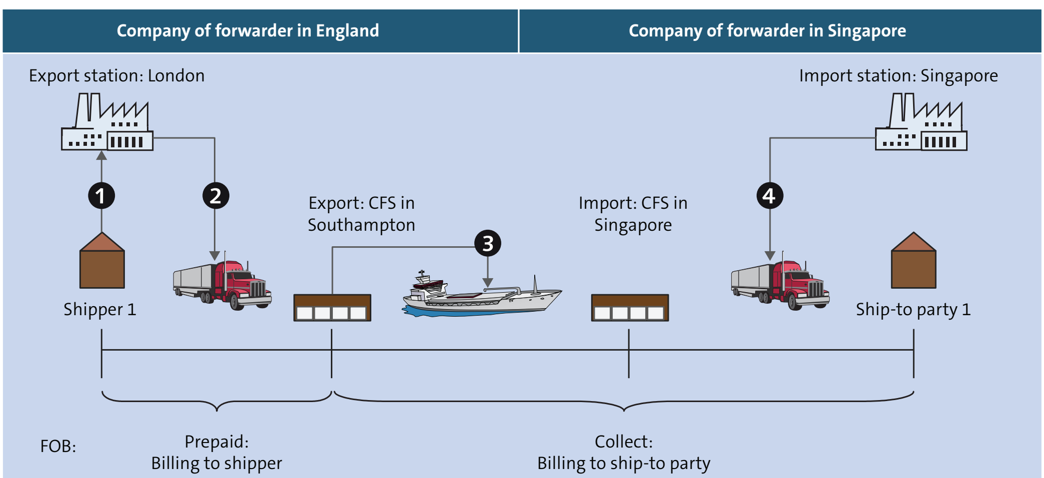


Figure 11.18 Business Scenario for Settlement Process in TM

In step ❶, you receive an export forwarding order in the export station in London. The shipper contacts the local forwarding office to arrange for the transport. Shipper 1 is listed as the prepaid agreement party. Ship-To Party 1 is listed as the ship-to party, but the importing station in Singapore is marked as the collect agreement party.

In step ❷, the export station in London arranges for a pickup service (a local trucker, perhaps) to transport the goods from the customer to the CFS (gateway) in Southampton. A freight order is generated.

In step ❸, the CFS (gateway) in Southampton has already procured capacity on a vessel (on a plane), leaving on a voyage (departure) from Southampton to Singapore with an ocean liner (airline), reflected by a freight booking. As you learned in Chapter 4, Section 4.2, the generation of an export freight booking triggers the generation of an import freight booking and consequently an import forwarding order.

In step ❹, after the vessel (plane) arrives in Singapore, the importing station is informed and generates another freight order for the pickup of the freight in the CFS (gateway) and delivery to Ship-to Party 1. In this example, a total of seven settlement documents are generated. Figure 11.19 shows the creation of the settlement documents.

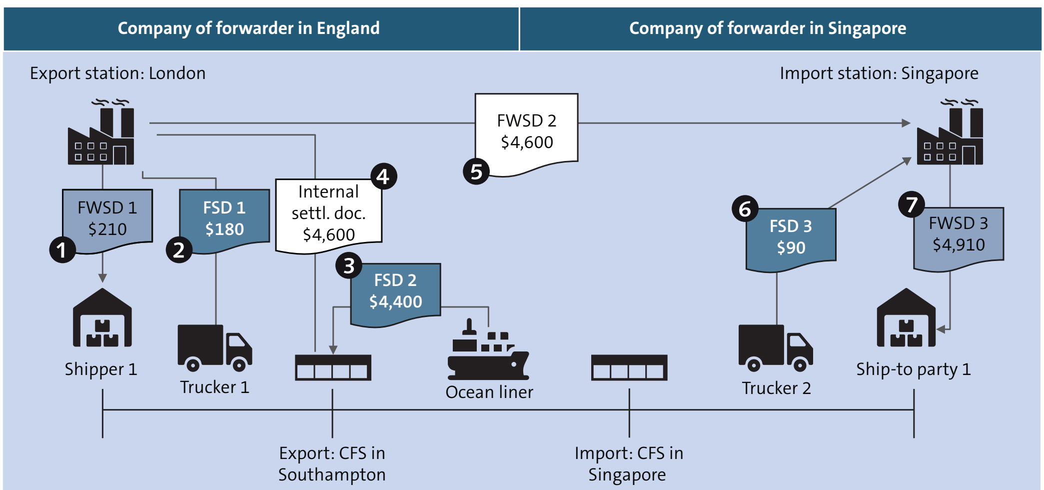


Figure 11.19 Creation of Internal Settlement Documents

Let's walk through this figure. Based on the FOB Incoterm, the exporting station in London creates forwarding settlement document 1 for the prepaid party (Shipper 1) from the export forwarding order ❶. These are the only charges the shipper must cover. The same exporting organization also arranges the pickup and must settle the charges for the trucker. Freight settlement document 1 is generated for the pre-carriage ❷. The CFS (gateway) in Southampton generates a freight settlement document to settle the main leg charges with the ocean liner (airline) ❸.

An internal settlement document (ISD) is generated between the CFS (gateway) and the exporting station, again based on the export forwarding order ❹. The intracompany settlement document recovers the cost for the procurement organization—in our example, the CFS (gateway) Southampton of the main leg. To calculate the internal charges, in the top menu of the forwarding order, select **Charges/Settlement • Calculate Internal Charges**.

The creation of the intracompany settlement document can be executed manually from a POWL that lists all freight bookings/freight orders that require intracompany settlement. To find this POWL in the SAP Fiori launchpad, navigate to the **Settlement** tab, and open the Forwarding Orders for Internal Settlement Worklist app in which you can open the query **All Forwarding Orders for Internal Settlement**. Notice that not only the forwarding orders are listed in this POWL but also the freight order/freight booking documents that are associated with the forwarding order for the internal settlement process. You can click the **Create Internal Settlement** button to generate the ISD. Alternatively, you can use a batch job for report /SCMTMS/CFIR_CREATE_BATCH to generate the ISDs.

Internal Settlement Document

The POWL shows relevant freight bookings or freight orders for the generation of an ISD only if you've specified a corresponding settlement rule. A settlement rule is defined in Customizing and determines the behavior for generating ISDs based on the execution status of a freight booking or freight order. In our example, we assume the settlement rule is **Executed**. Consequently, the ISD is ready for generation only after the freight booking of the main leg is fully executed.

In our example, the agreed-upon Incoterm is FOB. Consequently, the exporting organization transfers the cost to the importing organization in Singapore, which will bill Ship-To Party 1 as the collect payer for the main leg service (❺ in Figure 11.19). This settlement document forwarding settlement document 2 is considered an external settlement document and is generated as a regular forwarding settlement document. In step ❻, the importing organization generates freight settlement document 3 for the delivery charges. Last, in step ❼, forwarding settlement document 3 is generated based on the import forwarding order to bill the collect charges to Ship-To Party 1.

Now let's highlight the difference between the intracompany settlement process and the flow for intercompany settlements. Let's assume our CFS (gateway) is located in a different country—say, Ireland, instead of England. In this case, the sales organization in London and the CFS (gateway) in Ireland are assigned to different company codes. The internal settlement between the CFS (gateway) and the station are considered an *inter*company settlement. The major change in the process lies in the integration with the sales and distribution functionality. You would not see a difference in the actual internal settlement flow in TM.

Table 11.5 summarizes the different cost and revenue components of each organization for our intracompany settlement example.

There are generally two ways to calculate the rates that are to be settled internally. First, you have the choice to set up internal rates in an agreement between the sales and purchasing organizations. These rates represent the standard cost for a purchasing organization. The standard cost is an average price of procuring transportation services and can even include a profit margin. As a result, you can handle purchasing organizations as profit centers that compete to offer the best rates for capacities in the organization. You can maintain such rates in internal agreements, as described in Section 11.1.2.

Export Station London		Export CFS Southampton		Import CFS Singapore		Import Station Singapore	
Cost	Rev.	Cost	Rev.	Cost	Rev.	Cost	Rev.
$180 pickup charges	$210 prepaid charges	$4,400 main leg charges	–	–	–	$90 delivery charges	$4,910 collect charges
$4,600 main leg intracompany settlement	$4,600 main leg charges	–	$4,600 main leg intracompany settlement	–	–	$4,600 main leg intercompany settlement	–
–	$300	–	$200	–	–	–	$220

Table 11.5 Cost and Revenue per Organizational Unit

Recall the introduction to cost distribution in Chapter 10, Section 10.2. Based on the cost distribution functionality, you can determine the actual cost of a freight order or freight booking allocated to the forwarding order items. You have the option to use these actual costs, which need to be paid to the service provider for an internal settlement between the purchasing organization and the sales organization. The core difference from the standard cost scenario is that instead of an average of the cost, the billing-relevant amounts of the actual service provider charges are used. For consolidated shipments, the cost distribution supports the apportionment of the cost to all affected forwarding orders.

Basic Customizing and Master Data in TM

The functionality of internal settlement in TM is well integrated with and dependent upon other master data and several settings. In this section, we highlight the essentials of setting up an internal settlement process.

The basis for every settlement process is the charges and the setup of transportation charge management in TM. Refer to Chapter 9 to learn what basic settings are required. You can directly assign a calculation profile to a business partner of type sold-to party or to the regular charges profile. If both are maintained, the profile assigned to the business partner takes precedence.

As with the regular settlement process in TM, you need to define a settlement profile. You can use an existing profile from the regular settlement process that is assigned to a charges profile, as you're used to from Section 11.3.1. Remember that the settlement profile of the purchasing organization will be picked up. Like the calculation profile, you could assign a settlement profile to a business partner in the type sold-to party, which would take precedence.

Because the ISD uses the same object as the forwarding settlement document, there is no separate document type Customizing for ISDs. You need to define an ISD type in Customizing. Navigate to **Transportation Management • Settlement • Forwarding Settlement • Define Forwarding Settlement Type**. The forwarding order type needs to be enabled for internal charge calculation and settlement in Customizing.

You can define a specific time you want an ISD to be ready for generation. This is achieved by an internal settlement rule that you can assign to each stage type of a movement type. Navigate to **Transportation Management • Forwarding Order Management • Define Stage Type Sequence for Movement Types** to determine the point in time when internal settlement should be performed (e.g., only when the stage was executed).

Most important, you must have maintained an internal agreement between the purchasing organization and the sales organization. As introduced in Section 11.1.2, an internal agreement can be valid between one or many purchasing organizations and one or many sales organizations. If you want to base the internal charges on the standard cost, you must maintain charge types with amounts or internal rate tables.

Purchasing Organizations

Be sure to model your purchasing organizations with the organizational unit function *forwarding house*. The reason is that a purchasing organization interacts as a sales organization internally when settling internal charges to another organizational unit. In our example, this would be the case for the CFS (gateway) in Southampton.

To use the actual transportation cost for internal settlements, you require a slightly different setup. The way you generate your ISDs and the integration to the sales and distribution functionality are similar. You've performed the setup of the cost distribution for LSPs, as introduced in Chapter 10, Section 10.2, and all the Customizing steps. The key difference lies in the creation of an internal agreement. You still need to define an internal agreement but no rates or rate tables. Instead, you set the **Charge Usage** field of the transportation charge calculation sheet as **Internal**. In addition, you must maintain one charge type with the calculation method **9—Internal Charge Calculation**. The cost is picked up from the corresponding execution documents, freight order, and/or freight booking.

Integration with the Sales and Distribution Functionality in SAP S/4HANA

After you've successfully generated the various settlement documents, they need to be posted to the sales and distribution functionality. For the internal settlement, we need to distinguish between the intracompany and intercompany settlement documents.

The intracompany settlement document doesn't generate a billing document in sales and distribution in SAP S/4HANA; a regular forwarding settlement document does. Instead, reposting would take place in sales and distribution in SAP S/4HANA. Remember that the cost of procuring a service is always posted to the purchasing organization (in our example, the CFS in Southampton). When you post the intracompany settlement document to the sales and distribution functionality, the settled cost in the forwarding order from the corresponding freight orders or bookings is reposted from the purchasing organization (the CFS in Southampton) to the sales organization (the exporting station in London). As a result, you can map the primary cost to a cost center or an internal order. We already discussed how the intercompany settlement document has a different sort of integration with the sales and distribution functionality. It simply generates a regular billing document in sales and distribution.

Integration of TM in SAP S/4HANA with an External SAP S/4HANA System

As mentioned in other sections of this book, this book concentrates on the TM *in* SAP S/4HANA. Therefore, we've only described the process of posting a forwarding settlement document that is created in SAP S/4HANA.

However, we can still use the internal settlement functionality in a separate TM in SAP S/4HANA system. In this case, we need to configure the integration with an SAP S/4HANA system to transfer the ISDs. The processing of these documents in the sales and distribution functionality of SAP S/4HANA is equivalent to the process we described in this section.

Let's take a high-level look at the Customizing steps required to set up the sales and distribution functionality (refer to the SAP S/4HANA configuration guide for more details):

- The standard integration for forwarding settlement needs to be configured to enable the intercompany process, as described in Section 11.3.1 and Section 11.3.3. A mapping of TM sales organizations to sales and distribution organizational units is required.
- You need to map your sales organizations and purchasing organizations to the corresponding cost centers or internal orders in sales and distribution. This is required for intracompany settlements where the charges are being posted from the original purchasing organization of a freight order or freight booking to the sales organization of the forwarding order.

  Navigate to Customizing by selecting **Transportation Management • Settlement • Forwarding Settlement • Settings for Posting Intracompany Settlements • Assign Internal Order/Cost Center to Sender Organization** as well as **Assign Internal Order/ Cost Center to Receiver Organization**. In this case, the purchasing organization is the sender of the intracompany settlement document, and the sales organization is the receiver organization.

- In addition, you're required to assign your charge types to primary cost elements in sales and distribution. Navigate to Customizing by selecting **Transportation Management • Settlement • Forwarding Settlement • Settings for Posting Intracompany Settlements • Assign Transportation Charges to Cost Elements**.
- You have the flexibility to enhance the methods for intracompany scenarios based on available BAdIs. This enables you to develop a custom logic for determining cost elements, cost centers, and internal orders. The available BAdI is called `TCM_SE_CFIRSUITE_RQ` with the method `INBOUND_PROCESSING` (parameter `CS_CO_DOC`). Similarly, for intercompany settlement, you can implement a BAdI to influence the assignment of cost objects (e.g., cost centers): BAdI `TCM_SE_CFIRSUITE_RQ` and method `INBOUND_PROCESSING` (parameter `CT_KOMFKGN`).

Configuring the Integration of Internal Settlement with TM in SAP S/4HANA

When not using TM in the same SAP S/4HANA instance as the sales and distribution and materials management functionalities, the configuration of the integration will be different. The mapping of charge types and organizational units will then be performed via IMG path **Integration with Other SAP Components • Transportation Management • Invoice Integration**. In subsequent menu entries, you'll find the same Customizing activities as described earlier, but they are tailored to the scenario of integrating an external TM functionality to SAP S/4HANA.

Internal Settlement Process for Trucking Businesses

In addition to the process of internal settlements for LSPs based on forwarding orders, as described for the international shipment scenario, you can generate ISDs for resources. This functionality supports trucking companies that own trucks and trailers, for example. A procurement organization arranges a trucking service by using the truck and trailer of another organization that owns the resources. An internal agreement can be maintained between the procurement organization and the organization that owns the resources. These rates are used to generate ISDs between the two organizations. After a successful internal charge calculation, you can generate the ISD directly from the freight order by selecting **Charges/Settlement • Create Internal Settlement Document**.

The settlement integration with sales and distribution works similarly as described in the previous section. The resource-owning unit is the sales organization that sends the ISD. The purchasing organization using the truck and trailer is the receiver of the internal charges. Based on the sales organization, the system derives the purchasing organization, cost centers, or internal orders.

Group Logistics Settlement for Shippers

A very common scenario for large companies with shipping demands is to consolidate all transportation tasks in one BU. This is usually an independent BU within a shipper company that is focused only on organizing and managing transports. Such BUs often act as internal LSPs, which is why we also deal with this process in this chapter. We call such a scenario *group company logistics*. The main advantage is that, as a shipper, you can bundle the transportation demand of your company in one organization, giving it respectively more buying power to negotiate freight rates. In addition, the visibility and process standardization are improved in an organization that solely focuses on transportation.

The key difference in a group logistics scenario is that the BU that manages the transports consolidates orders from multiple other lines of business of the group. A manufacturing company might have different lines of business for the various product segments it produces. The demand for transportation of all these shippers will be consolidated by the logistics company. The transportation services are paid by the logistics branch. Because freight orders will contain goods from multiple orders, it's imperative for the logistics branch to distribute the charges back to the BUs that caused the demand. This process can be managed with internal settlements:

1. You can use cost distribution to allocate the charges from freight orders to the order documents.
2. The ISD is created for each BU that had freight involved in the transportation.
3. The ISD creates an intercompany sales and distribution billing document, which in turn creates an entry in financial accounting.

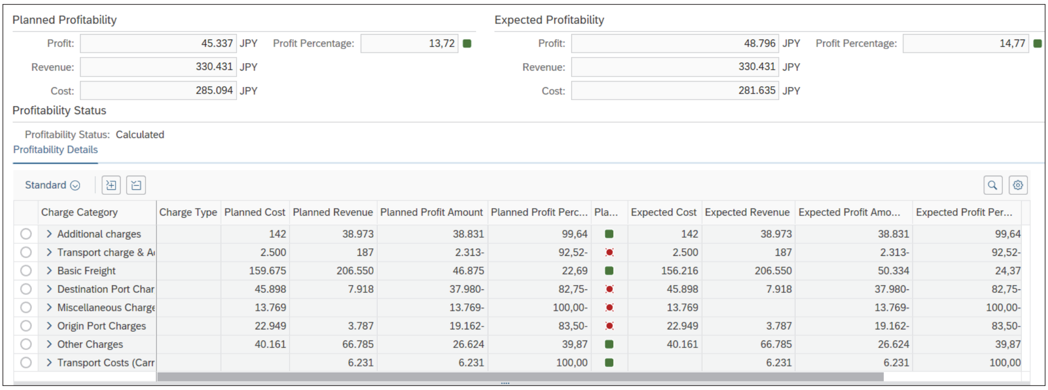
The key settings to support this process are very similar to the internal settlement process we described earlier in this chapter. The group logistics scenario is only enabled so far for a standalone TM in SAP S/4HANA system that is connected to an external SAP S/4HANA system.

11.3.6 Margin Analysis

Margin (or profitability) analysis in TM is used to provide an LSP or carrier with a view on the margin per forwarding order. It's not applicable for shipper solutions. The foundation of margin analysis lies in the transportation charge management and settlement, which was introduced earlier in this chapter and in Chapter 9. It accumulates all revenue components in a forwarding order and calculates the delta against all cost components that were incurred as part of the shipment execution to calculate the profitability of a shipment.

The forwarding order has a **Profitability** tab. You can trigger the calculation of the profitability by selecting **Charges/Settlement • Calculate Profitability**. Figure 11.20 shows an example of the results in a forwarding order with calculated cost, revenue, and profitability. Note that not only the aggregated costs and revenue is shown but the costs and revenue per charge category. Recall from Chapter 9 that charge types are assigned to charge categories to classify their purpose. This configuration is useful also in this context as we usually use different charge types for buying charges than for selling charges.

With the use of the charge categories in the margin analysis, however, we can analyze the margin per charge category, which could represent, for example, a service product.



Charge Category	Charge Type	Planned Cost	Planned Revenue	Planned Profit Amount	Planned Profit Perc...	Pla...	Expected Cost	Expected Revenue	Expected Profit Amo...	Expected Profit Per...
Additional charges		142	38.973	38.831	99,64		142	38.973	38.831	99,64
Transport charge & A		2.500	187	2.313-	92,52-		2.500	187	2.313-	92,52-
Basic Freight		159.675	206.550	46.875	22,69		156.216	206.550	50.334	24,37
Destination Port Char		45.898	7.918	37.980-	82,75-		45.898	7.918	37.980-	82,75-
Miscellaneous Charge		13.769		13.769-	100,00-		13.769		13.769-	100,00-
Origin Port Charges		22.949	3.787	19.162-	83,50-		22.949	3.787	19.162-	83,50-
Other Charges		40.161	66.785	26.624	39,87		40.161	66.785	26.624	39,87
Transport Costs (Carr			6.231	6.231	100,00			6.231	6.231	100,00

Figure 11.20 Profitability Analysis in a Forwarding Order

To calculate the profitability, you first need to calculate revenue and cost. The revenue is calculated based purely on the charge calculation for forwarding orders, which are based on forwarding agreements. The cost components are derived from three sources: freight orders, freight bookings, and internal rates. Consequently, you first need to set up the transportation charge management component as a prerequisite, as described in Chapter 9. You need to make sure that the charge calculation for forwarding orders, freight orders, and freight bookings has been executed. Both the cost distribution and internal charge calculation need to be set up and executed as described in Chapter 10, Section 10.2 and Section 11.3.5, respectively, to enable the margin analysis.

Which cost or revenue components are included isn't configurable. TM generally uses all charge types of revenue and cost for the comparison. TM calculates both a *planned* and *expected profitability*. The major difference between planned and expected profitability is that planned profitability is based on the charge calculation in forwarding orders, freight orders, and freight bookings. The expected profitability is calculated based on the settled amounts in the forwarding settlement documents, ISDs, and freight settlement documents.

11.4 Increased Flexibility in Billing and Invoice Verification

Customer billing done with the billing and financial components of SAP S/4HANA is quite flexible. It supports good control of integration and many localizations to special billing and taxation standards of a variety of countries worldwide. However, for companies selling logistics services and for some shippers, the billing flexibility of TM in SAP S/4HANA and SAP ERP may sometimes not be sufficient. Cargo and logistics customers need end-to-end solutions that allow them to execute invoice services efficiently according to service-level agreements (SLAs) defined in customer contracts.

Services need to be invoiced the way customers expect or demand in their SLAs. Additionally, an LSP often needs to deal with bad credit history, short payments and nonpayments, credit and collection issues, freight payments to be prepaid in cash before cargo moves, and disputes raised by customers. All these processes need to be handled efficiently with integration into the customer service workplace. Figure 11.21 shows the process steps and the business focus of an end-to-end process concentrating on financial tasks in customer billing (dark shaded boxes).

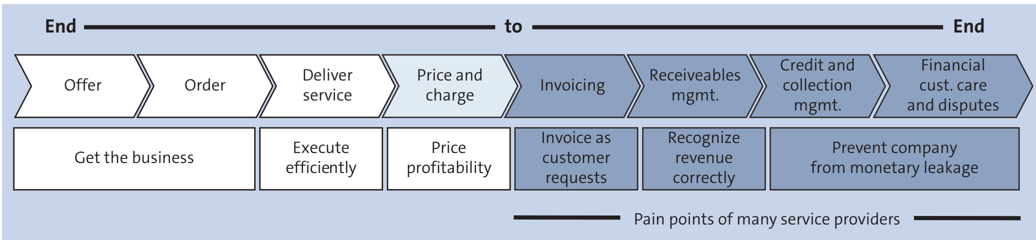


Figure 11.21 End-to-End Process with Billing Focus

A second issue for LSPs is the recognition of revenue in line with legal regulations. If shipments span multiple countries or even continents, or if payments must be made by multiple parties, you need to properly manage revenue recognition.

Usually, the revenue for a service may be recognized only upon progression of the shipment in the supply chain. Depending on local legal regulations, the following situations may occur:

- A customer orders a rail move across the United States. The payment term is prepaid. The invoice is sent to the customer five days before the pull of the railcars, and the customer pays one day before the pull. The carrier is only allowed to recognize the received revenue upon delivery of the railcar at the destination.
- A customer orders a multimodal FCL ocean shipment with truck inland haulage in the country of origin, an ocean leg, and inland haulage in the country of destination. Pre-carriage and the ocean move are prepaid by the shipper; the destination haulage is collected from the ship-to party before delivery of the containers. The carrier can recognize the shipper's revenue in multiple steps. Revenue for origin haulage can be recognized upon delivery of the container at the port of loading. Ocean carriage revenue can be recognized 50% after half of the trip is done; another 50% is recognized after the container arrives in the port of discharge. Ship-to party revenue is recognized after the container has been delivered in the destination country.

Other issues and limitations that customers are facing include the following:

- Before or while doing customer billing, order-overarching rebate calculations aren't possible in TM. If, for example, an LSP has a rule that a customer gets a 10% rebate for all shipments in a month exceeding a sum of 1000 kg, then TM can't do this kind of charge (re)calculation based on a set of historical orders and dimensions derived.

- When doing mass invoice verification for carrier invoices, TM can't properly do a mass invoice verification that directly works on and adjusts the charges determined in freight orders or freight bookings. However, is often required for handling large quantity of invoices or heavily consolidated invoices (e.g., an invoice from a carrier for road shipment from the past month).

The previously mentioned situations can be handled using SAP Billing and Revenue Innovation Management, which has a high focus on customer billing and revenue recognition. The required flexibility in billing and the ability to handle financial customer care and revenue recognition as previously described are part of SAP Billing and Revenue Innovation Management.

TM has the capability to integrate with SAP Billing and Revenue Innovation Management via its subcomponent SAP Convergent Invoicing. The technical integration was handled by a custom development project component, which is discontinued today. However, there are two integration options, which can be achieved via a custom integration. In the beginning, TM creates settlement documents from calculated charges as the basis for invoicing. When invoicing needs to be done, the subsequent financial steps can be done either via SAP S/4HANA billing or via SAP Billing and Revenue Innovation Management.

Looking at the extended billing and collection requirements of LSPs, SAP Convergent Invoicing as part of SAP Billing and Revenue Innovation Management is an important building block in their transportation processes. About 80% of LSPs using TM as a core solution for their businesses chose SAP Billing and Revenue Innovation Management as their customer billing solution. SAP Billing and Revenue Innovation Management offers a rich portfolio of services around customer invoicing and receivables management. Figure 11.22 shows an overview of the major abilities of SAP Billing and Revenue Innovation Management.

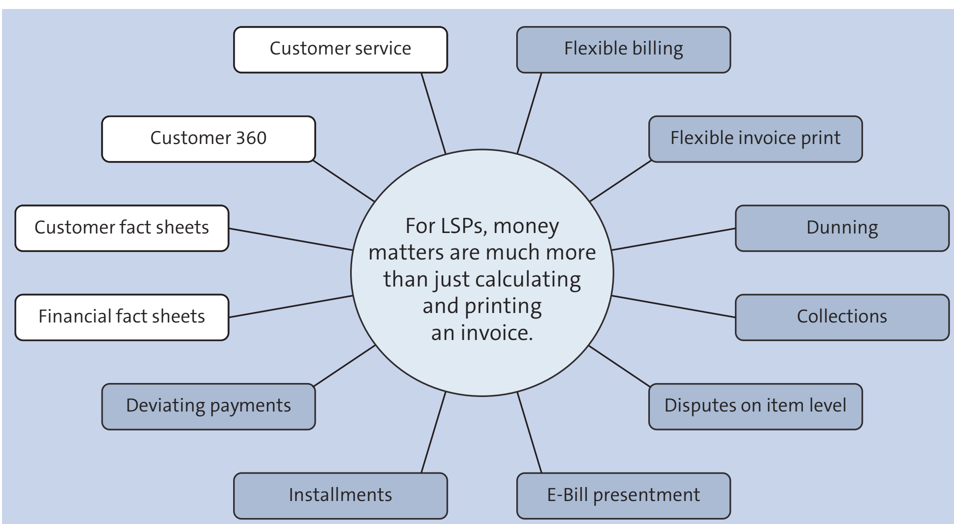


Figure 11.22 Features of SAP Billing and Revenue Innovation Management and Its Integration into Customer Service

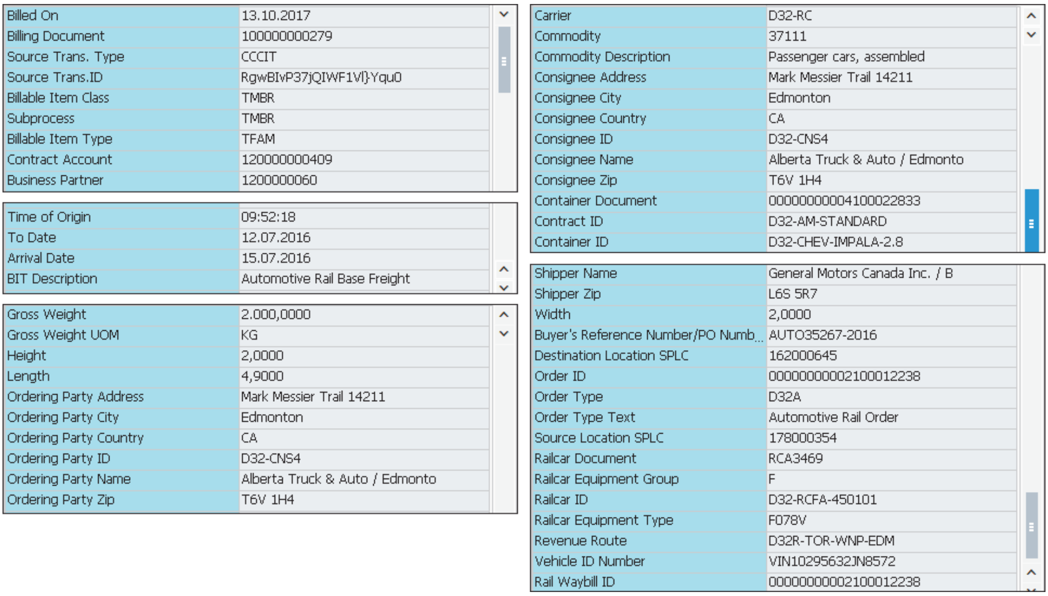
Let's walk through each of these supported functions:

- **Invoice convergence**
  TM creates settlement documents with multiple invoice items. If such a settlement document is sent to sales and distribution billing, the whole settlement document is used to create an invoice. With SAP Convergent Invoicing from the SAP Billing and Revenue Innovation Management solution, a billable item is created for each charge item of the settlement document. Subsequently, customer profiles (contract account settings) can be used to control a rules engine that assembles the individual customer invoices from the available charge items. In this case, the content of the invoices isn't controlled by agreement and settlement rules in TM, but by contract accounts in SAP Billing and Revenue Innovation Management. You can easily use this, for example, to converge fuel surcharges over a longer time while invoicing freight revenue immediately per shipment.
- **Flexible billing and invoice printing**
  Bill creation and communication (technology and paper forms) are also controlled by contract account settings, enabling you to bill according to customers' service requirements.

  The invoice may contain a large selection of logistics and customer context data. In SAP S/4HANA billing, this context data is very limited. SAP Billing and Revenue Innovation Management, however, offers a powerful concept about how any kind of logistical context data can be stored with each billable item. Examples for the logistics context are as follows:
  - Bill of lading number
  - Container number or pallet ID
  - Vehicle identification number
  - Railcar or train ID
  - Equipment type used
  - Buyer's reference number

  Therefore, you have all logistics-related data available to sort, filter, and group items for invoicing. In Figure 11.23, you can see an example of logistical context data in an SAP Billing and Revenue Innovation Management billable item (an automotive rail base freight for a Chevrolet Impala 2.8 with VIN 1O295632JN8572).

  It shows a forwarding settlement item for base freight for an automotive move by rail (finished vehicle), which has been enriched by a variety of context information from TM forwarding order, freight unit, railcar unit, and freight order.
- **Dunning and collections**
  Dunning and collection mechanisms are very flexible in SAP Billing and Revenue Innovation Management. Payment clearing rules and clearing worklists support efficient processing of open receivables items.



Billed On	13.10.2017
Billing Document	100000000279
Source Trans. Type	CCCIT
Source Trans.ID	RgwBIvP37jQIWF1Vl}Yqu0
Billable Item Class	TMBR
Subprocess	TMBR
Billable Item Type	TFAM
Contract Account	120000000409
Business Partner	1200000060

Time of Origin	09:52:18
To Date	12.07.2016
Arrival Date	15.07.2016
BIT Description	Automotive Rail Base Freight

Gross Weight	2.000,0000
Gross Weight UOM	KG
Height	2,0000
Length	4,9000
Ordering Party Address	Mark Messier Trail 14211
Ordering Party City	Edmonton
Ordering Party Country	CA
Ordering Party ID	D32-CNS4
Ordering Party Name	Alberta Truck & Auto / Edmonto
Ordering Party Zip	T6V 1H4

Carrier	D32-RC
Commodity	37111
Commodity Description	Passenger cars, assembled
Consignee Address	Mark Messier Trail 14211
Consignee City	Edmonton
Consignee Country	CA
Consignee ID	D32-CNS4
Consignee Name	Alberta Truck & Auto / Edmonto
Consignee Zip	T6V 1H4
Container Document	00000000004100022833
Contract ID	D32-AM-STANDARD
Container ID	D32-CHEV-IMPALA-2.8

Shipper Name	General Motors Canada Inc. / B
Shipper Zip	L6S 5R7
Width	2,0000
Buyer's Reference Number/PO Numb...	AUTO35267-2016
Destination Location SPLC	162000645
Order ID	00000000002100012238
Order Type	D32A
Order Type Text	Automotive Rail Order
Source Location SPLC	178000354
Railcar Document	RCA3469
Railcar Equipment Group	F
Railcar ID	D32-RCFA-450101
Railcar Equipment Type	F078V
Revenue Route	D32R-TOR-WNP-EDM
Vehicle ID Number	VIN10295632JN8572
Rail Waybill ID	00000000002100012238

Figure 11.23 Example of Logistical Context Data for a Billable Item in SAP Billing and Revenue Innovation Management

- **Invoice and dispute management and customer service**
  Invoice correction capabilities and dispute management are highly flexible in SAP Billing and Revenue Innovation Management. Integration into the customer service workplace and the interaction center of SAP CRM is provided. A customer service representative can work directly with invoices in SAP Billing and Revenue Innovation Management and manage customer disputes on the charge item level. This has the huge advantage that only the disputed part of an invoice needs to stay open, and the rest can be paid. If, for example, only one item in an invoice with 100 items is disputed, the other 99 items can be collected. This is a big relief for days sales outstanding processing.
- **E-bill presentment**
  SAP Billing and Revenue Innovation Management uses financial supply chain management functionality for e-bill presentment. Customers can directly access their bills in a portal.
- **Deviating payments and installments**
  If a customer pays an amount that deviates from the invoices or pays in installments, these payments can be easily processed against the open receivables.
- **Cash payments**
  In logistics services, especially for ocean cargo or outside of Europe or the United States, cash payments are still a common way of managing receivables. SAP Billing and Revenue Innovation Management offers a cashiering functionality for cash desk operation.

- **Customer information**
  To be fully informed about the customer, the customer service workplace offers 360-degree analytics and fact sheet functionality that gives you an overview of customer contracts, orders, payments, disputes, credit history, and other details.

SAP Billing and Revenue Innovation Management can do invoicing for TM and, at the same time, also process billing data from other systems (even legacy systems) and converge multiple receivables streams into joint invoices. You can bring freight invoice data from TM together with warehouse billing data from a legacy warehouse management system and accessorial data delivered from SAP Event Management, which is used to calculate demurrage. You can even use the SAP Billing and Revenue Innovation Management component SAP Convergent Charging to calculate additional prices before going into the invoicing step.

The process integration between TM and SAP Billing and Revenue Innovation Management is triggered from the TM side. Figure 11.24 shows how the process is executed. In TM, customer draft invoices (TM forwarding settlement documents) are created based on the charge information in forwarding orders. For a logistical context, the example shows a container shipment from Shanghai, China, to San Pedro, California. The charge items are sent to SAP Billing and Revenue Innovation Management, where billable items (BITs) are created for each charge item. Following invoicing rules, the available BITs are converging into three invoices based on certain criteria: one for freight charges, one for terminal charges, and a third for additional fees such as a security surcharge.

Accounting is finally done in SAP Billing and Revenue Innovation Management contract accounting, which is a subledger accounting system in SAP S/4HANA that integrates into the general ledger.

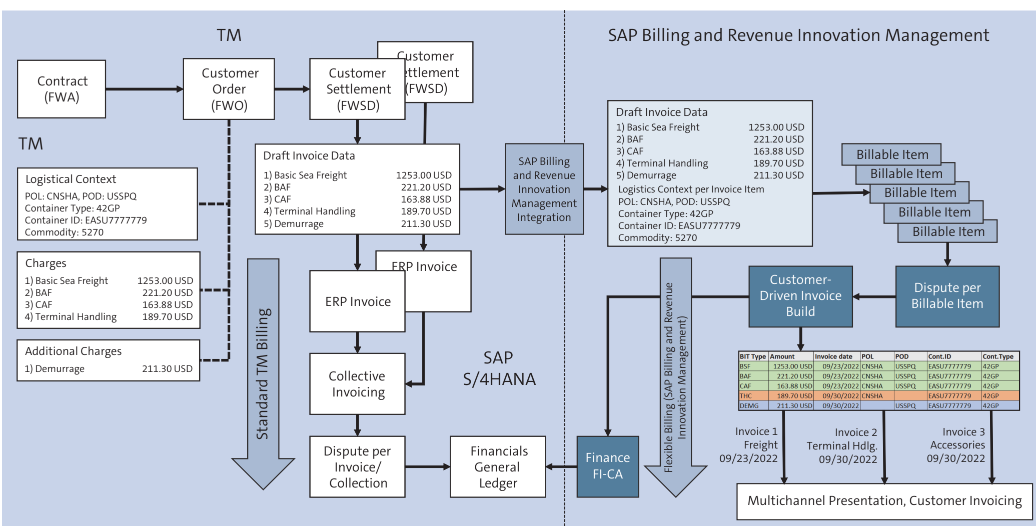


Figure 11.24 Logistics Invoice Creation with SAP Billing and Revenue Innovation Management

11.5 Strategic Customer Contract Management

We've seen how strategic vendor contract management (strategic freight procurement) functions in Chapter 9, Section 9.4, and also covered the basics of strategic freight management as a whole. In this section, we'll look at the selling side of the strategic freight management picture: customer contract management (strategic freight selling) for LSPs.

Contracts can have a wide meaning in the world of logistics because an LSP can handle the complete transport business for a manufacturer of goods. Thus, the path from initial customer contact to the contract is often quite lengthy and cumbersome. Strategic customer contract management, which is named strategic freight selling in TM, is a functionality that is usually only used by professional logistics companies, as manufacturers and shippers don't sell freight services.

The process of initiation of contracts often begins in marketing with documenting the first sales calls, resulting in leads and opportunities. For more concrete contacts, the customer often requests a quote from the LSP, which is submitted as an electronic- or file-based RFQ. The RFQ is answered by the LSP with a quotation, which corresponds to a contract offer.

Because the quotation reply of the LSP usually doesn't immediately match the customer's expectations in terms of pricing structure, price level, service details, or other conditions, multiple follow-up phases of quote adjustments may be required. Finally, if the customer decides to completely or partially accept the quotation, a contract can be created by the LSP.

11.5.1 Constraints, Expectations, and Activities in Customer RFQ Management

The process of creating a quotation that matches a customer's RFQ and expectation well isn't a simple task because customer RFQs often contain thousands of request items that need to be matched with the LSP's product offering and answered within an often relatively short time frame. A single request item is usually structured to include some of the following constraints:

- Origin and destination of cargo
- Container types and commodities of cargo
- Quantity details on number of containers or weight of cargo to be shipped within a certain time frame to get high-volume rebates
- Additional wishes for value-added services, shipment routing, or assigned carriers
- Additional wishes for rate structure and included or excluded surcharges

To respond properly to the RFQ, the LSP must do the following activities for each of the request items:

- Understand the requested items.
- Match the items with its services.

- Share the items logically among the LSP's sales teams to jointly or separately work on the items (e.g., according to customer or trade lane responsibility).
- Find appropriate existing tariffs and contracts that are applicable to the request.
- Determine appropriate price structures and prices to be offered.
- Push the processed items through various workflow stages.
- Converge the distributed items into an overall offering to be sent out to the customer.

On top of these activities, there may be a lot of commercial and trade lane analytics required to make a good decision that leaves a good margin for the LSP and doesn't overdraw the customer's allocated budget.

11.5.2 RFQ Management Process

Looking at TM, the customer RFQ management process can be split into four main sections, each involving several activities that either must be done centrally or are executed in a distributed manner among multiple departments or responsible persons. Figure 11.25 shows the phases and detailed steps of the customer RFQ management process.

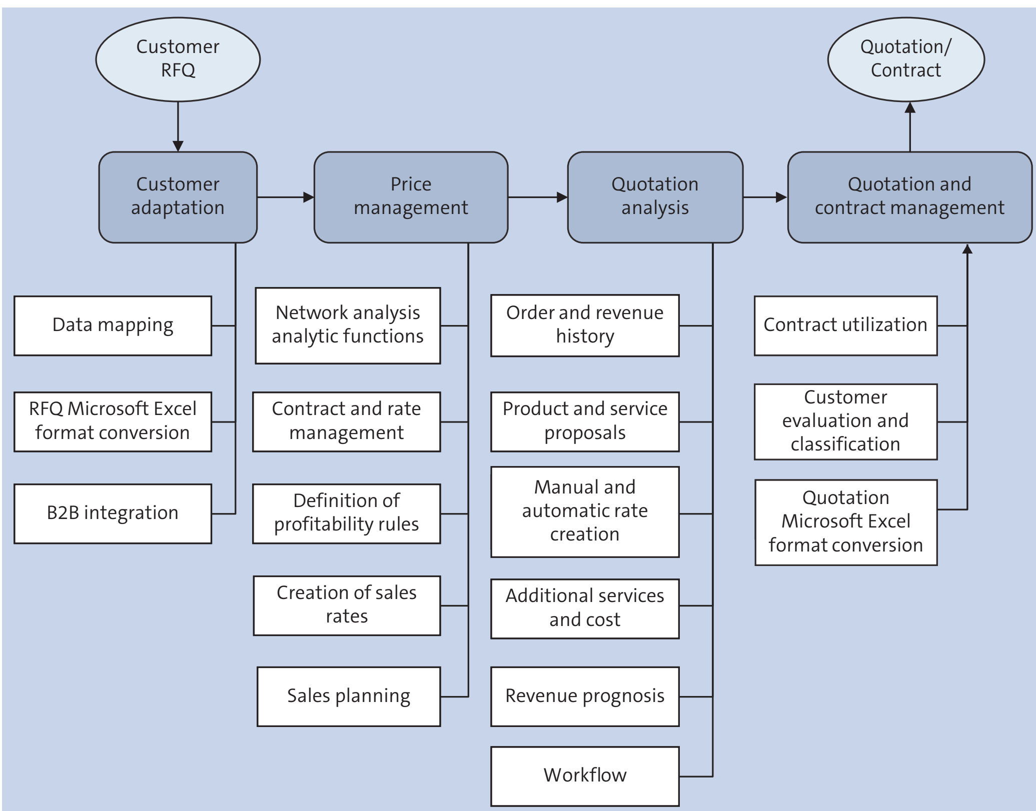


Figure 11.25 RFQ Management Process

Looking at the four phases kicked off by the RFQ, we can highlight the following activities:

- **Customer adaptation**
  Customer adaptation provides you the means of receiving RFQ data from a customer in an electronic format and converting and mapping it into a representation that TM can understand and handle. Because customers in many cases use their own Microsoft Excel templates to send the RFQ data, the Microsoft Excel document must be analyzed, and data must be either extracted and filled into an initial new forwarding agreement quotation or fitted into an existing one, which is then updated and stored as a new version.
- **Price management**
  Price management allows you to relate the RFQ data back to existing rates and tariffs, which are applicable under comparable requirements as stated in the RFQ. New sales rates can be created where required either from scratch or based on existing rates (e.g., with uplift). Analytical functions allow you to do sales planning and network analysis. For an applicability check of rates, profitability rules may be defined that allow a better judgement on appropriate sales prices. The price management phase can already be relevant for a split of the forwarding agreement quotation to several teams. For this purpose, the forwarding agreement quotation created from the RFQ is split into multiple assignments, which are technically again forwarding agreement quotation objects but usually contain only a part of the items of the original forwarding agreement quotation and can be assigned to specific sales teams.
- **Quotation analysis**
  Analysis of the quotation and its postprocessing allows you to evaluate the created offer in the context of an existing contract and sales history with the customer. You can add additional services to the offer and adjust rates as required. Approval workflows and revenue prognosis tools round up the capabilities of this phase. Again, as in price management, the quotation analysis phase can be done in a distributed or overall manner.
- **Quotation and contract management**
  After you finalize the split forwarding agreement quotation assignments in the corresponding teams, the overall quotation can be merged from the single assignments. Again, you have the option to run through an approval workflow and do further analysis and classification. The final quotation can then be converted back into the customer's data or Microsoft Excel format and be sent out to the customer.

  If the customer accepts the quotation, the LSP can directly create a contract from the last quotation version and activate it for use within TM forwarding order management.

11.5.3 Strategic Freight Selling Functions

In this section, we explain and visualize some of the important steps of strategic freight selling. You can see the Microsoft Excel upload function to load customer RFQ Microsoft Excel sheets into forwarding agreement quotations in Figure 11.26.

The upload function can be called via the FWAQ Excel 07 Integration app, which is reachable via **Launchpad • Home • Transportation – Contract Management** in TM in SAP S/4HANA. The Microsoft Excel file to be uploaded can be selected, and you can define whether you want to create a new forwarding agreement quotation or a new version of an existing one. The mapping profile determines how TM interprets the data provided by the customer and feeds it into the forwarding agreement quotation. Further parameters allow you to set validity dates or quotation types, for example.

The mapping profiles used to convert the Microsoft Excel document into an appropriate format for the upload are defined in Customizing via the path **SAP Transportation Management • Master Data • Agreement RFQs and Quotations • Define Excel and Flat View Profiles**. This takes you to a Customizing transaction where you can define which column or row of the Microsoft Excel document contains which type of data (e.g., mode of transport or destination location). Figure 11.27 shows the details of the field assignment for the Microsoft Excel upload. New Microsoft Excel layouts always require an individual profile; therefore, the LSP always tries to standardize the RFQ process with its customers.

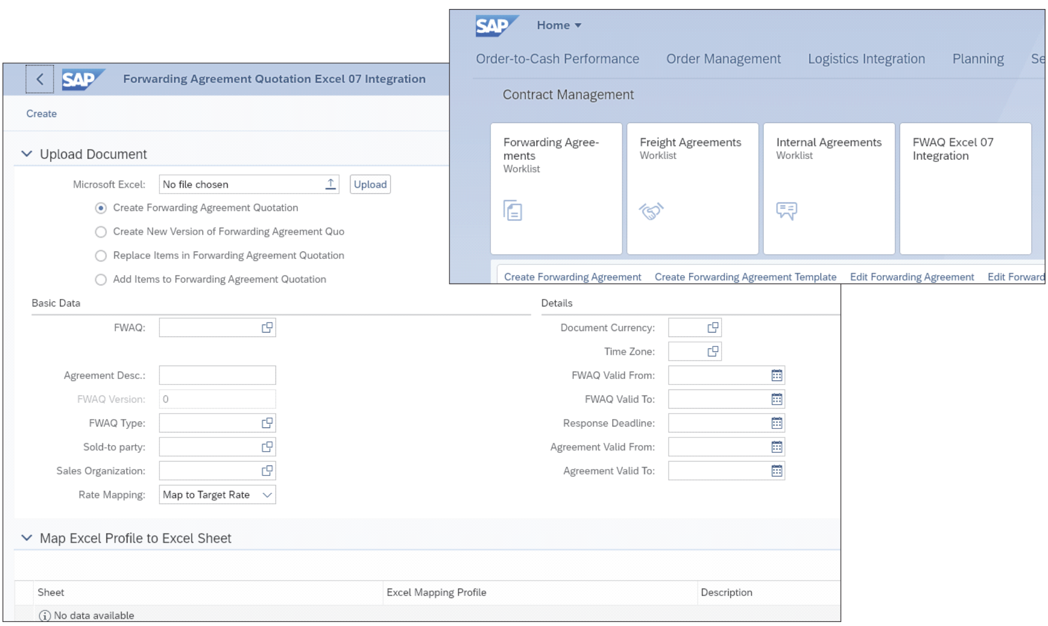


Figure 11.26 Microsoft Excel Upload Integration for Customer Quotation Requests to Create Forwarding Agreement Quotation

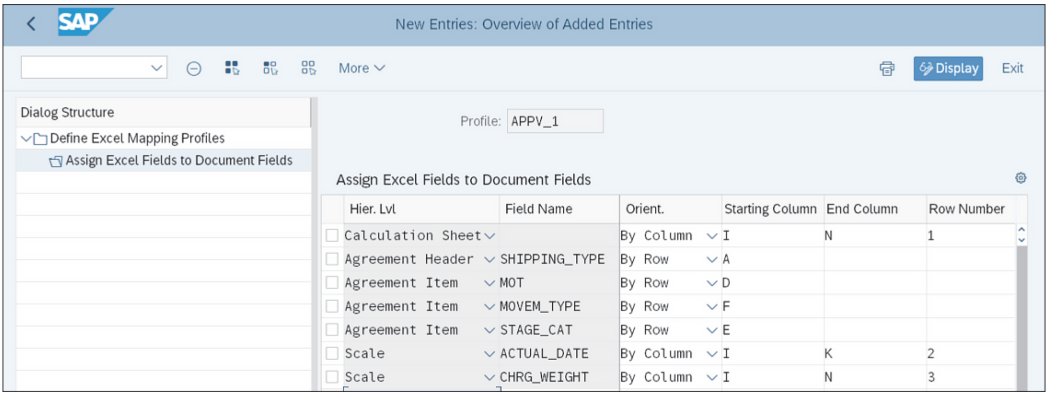


Figure 11.27 Field Assignment for Microsoft Excel Mapping

After the forwarding agreement quotation is created by upload or created manually, you can manage the quotation similarly to a forwarding agreement. If you want to distribute the work to several subteams, you can either create forwarding agreement quotation assignments with a subset of items directly from the forwarding agreement quotation (push scenario; see Figure 11.28) or create a new forwarding agreement quotation assignment and then insert selected lines of other forwarding agreement quotations into the new assignment (pull scenario). The individual team would then work with the forwarding agreement quotation assignments until they are approved and can be merged back into the original forwarding agreement quotation.

Then, rate building happens in the **Rate Builder Cockpit** screen shown in Figure 11.29, which you can start from the forwarding agreement quotation or forwarding agreement quotation assignment item by invoking the corresponding follow-up function.

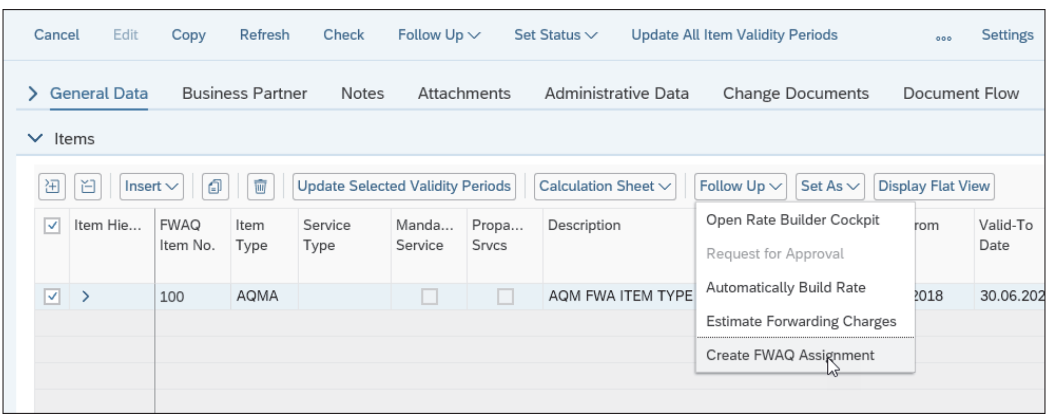


Figure 11.28 Splitting a Forwarding Agreement Quotation into Assignments

On the left side, you can see the related forwarding agreement items, and for the marked item, the breakdown into charge elements as assigned in the charge calculation sheet.

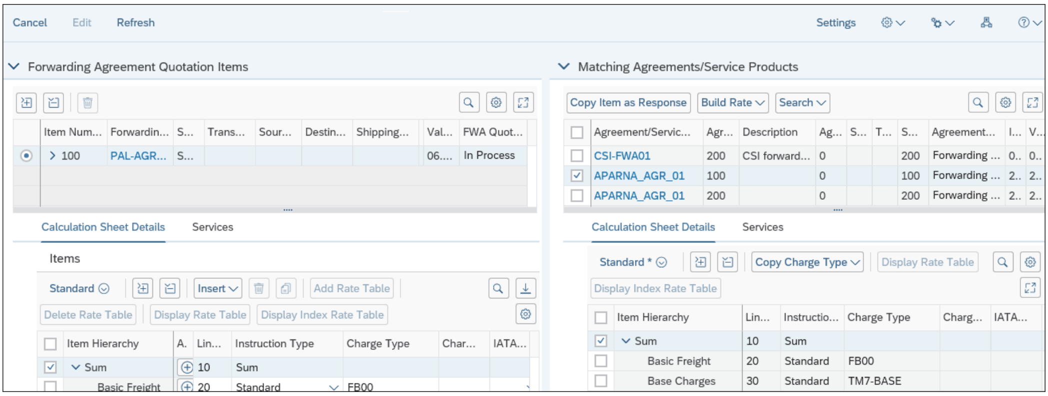


Figure 11.29 Rate Builder Cockpit

On the right side, you see the list of matching agreements and service products, which are applicable to be used as a foundation or copy source for building rates on the left side. You can either copy or assign complete items from the right side or copy and adjust charge elements and their rates from the bottom-right table to build up the calculation sheet on the left.

The flat view for rates introduces a very comfortable technique to get an overview on rates and rate structures, as well as maintain the rates in that view. You can start the flat view by marking an item in the forwarding agreement quotation and clicking the **Display Flat View** button shown in Figure 11.30.

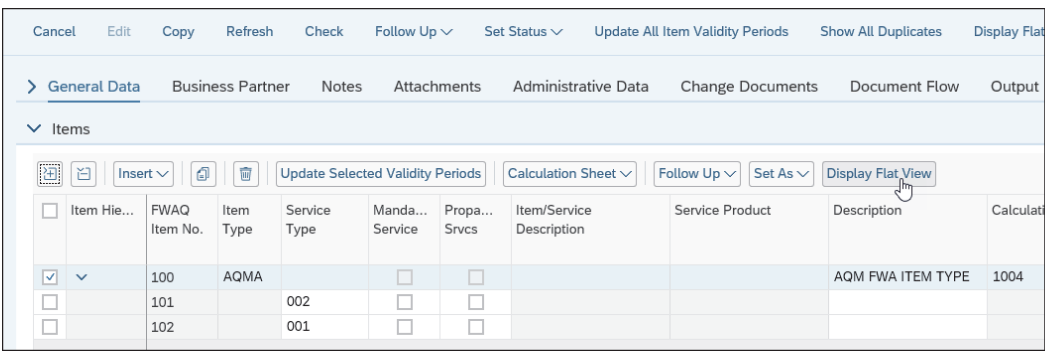


Figure 11.30 Invoking the Flat View for Rate Maintenance

This opens the flat view screen for the rates, where all rates of the calculation sheet of the forwarding agreement quotation item are displayed in a kind of table containing the characteristics columns on the left side and the various charge elements with their rates and currencies on the right side. With this table, you can, for example, get an overview on the charge element relevant to a move of cargo between certain locations and see all applying charges, without explicitly drilling down into each rate table that is related by the charge calculation sheet. Figure 11.31 shows an example of a flat view screen.

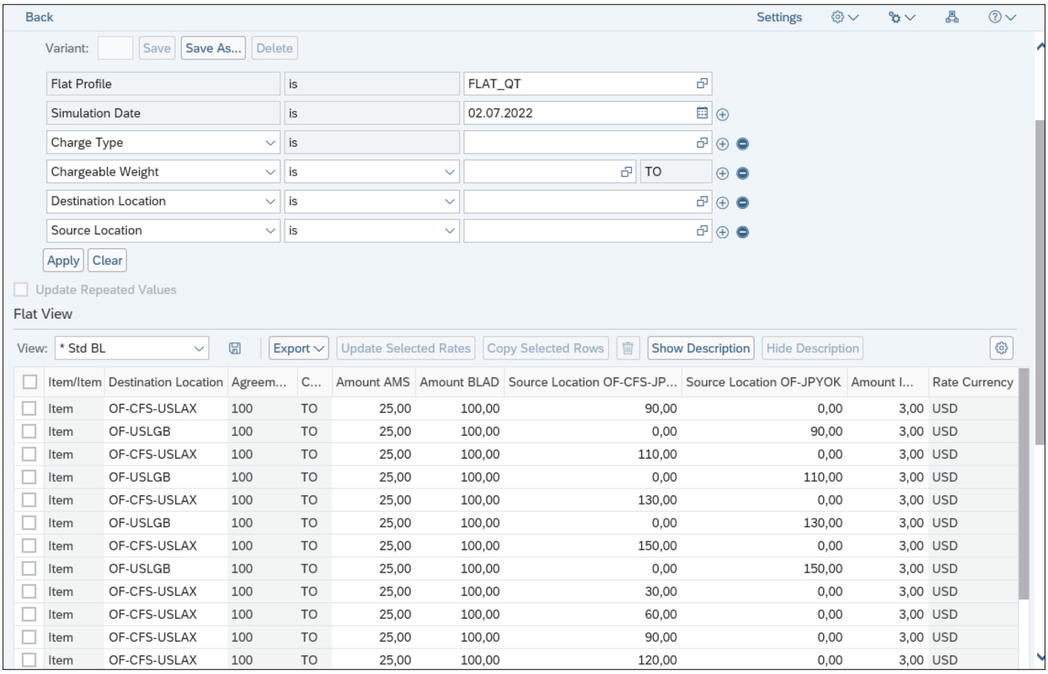


Figure 11.31 Rate Flat View

The rate flat view screen can be configured and controlled by flat view profiles. These are comparable to the Microsoft Excel mapping profiles and can also be configured in Customizing via path **SAP Transportation Management • Transportation Management • Master Data • Agreement RFQs and Quotations • Define Excel and Flat View Profiles**. When you enter the flat view screen, the flat view profile must be selected. You can instantaneously switch the view by selecting another profile. Figure 11.32 shows the configuration details of the flat view profile.

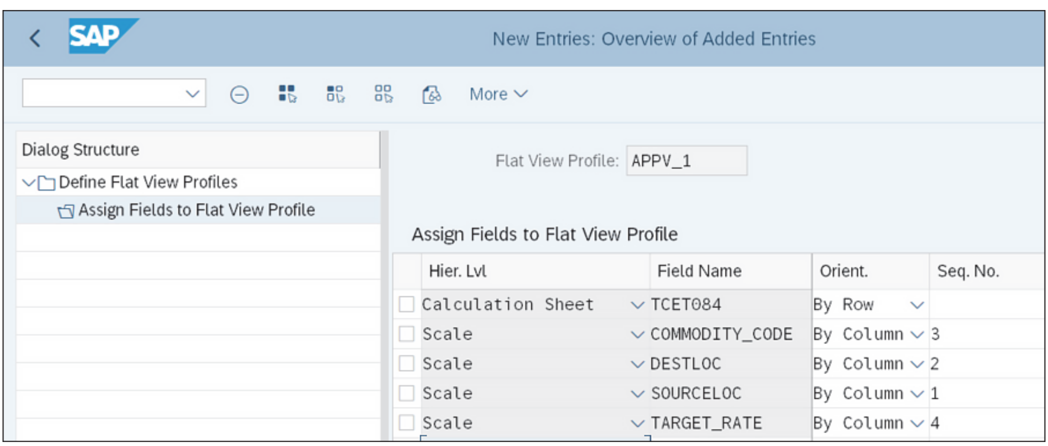
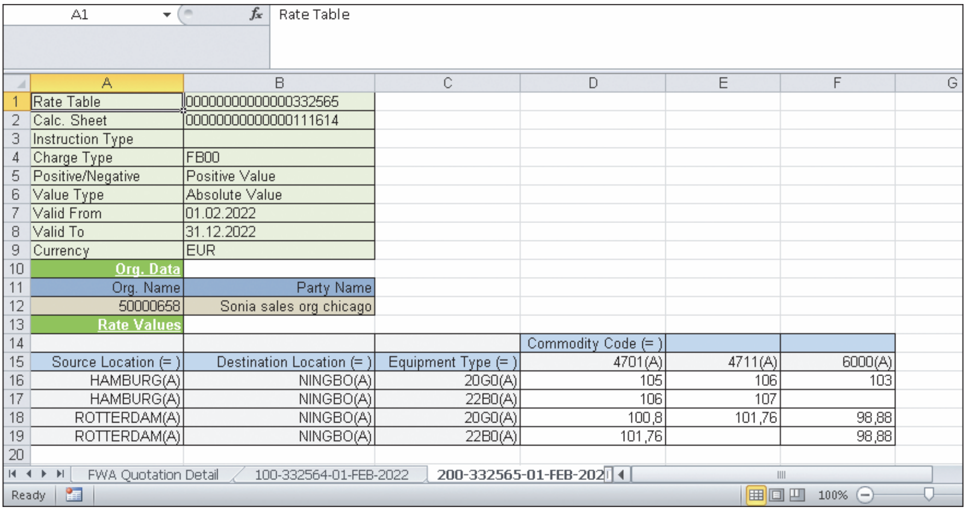


Figure 11.32 Configuration of the Flat View Profile

After all rates are properly built and the quotation is checked and approved, you can export it into a Microsoft Excel file either in an internal format or with a conversion into a customer-specific format. Figure 11.33 shows a sheet of such a Microsoft Excel table exported from a forwarding agreement quotation. The Microsoft Excel file contains a header sheet with all forwarding agreement quotation header details and separate sheets for each item with the corresponding rates.



	A	B	C	D	E	F
1	Rate Table	00000000000000332565				
2	Calc. Sheet	00000000000000111614				
3	Instruction Type					
4	Charge Type	FB00				
5	Positive/Negative	Positive Value				
6	Value Type	Absolute Value				
7	Valid From	01.02.2022				
8	Valid To	31.12.2022				
9	Currency	EUR				
10	Org. Data					
11	Org. Name	Party Name				
12	50000658	Sonia sales org chicago				
13	Rate Values					
14				Commodity Code (=)		
15	Source Location (=)	Destination Location (=)	Equipment Type (=)	4701(A)	4711(A)	6000(A)
16	HAMBURG(A)	NINGBO(A)	20G0(A)	105	106	103
17	HAMBURG(A)	NINGBO(A)	22B0(A)	106	107	
18	ROTTERDAM(A)	NINGBO(A)	20G0(A)	100,8	101,76	98,88
19	ROTTERDAM(A)	NINGBO(A)	22B0(A)	101,76		98,88

Figure 11.33 Microsoft Excel Output of a Rate Table of a Forwarding Agreement Quotation

Another comfort function is the duplicate agreement check, which allows you to verify whether duplicate agreements or items exist in the system. Checked characteristics are plenty and include stage categories, validity dates, trade lane assignment, service level, and many others.

11.6 Summary

This chapter provided an overview of charge settlement, integration to SAP S/4HANA billing and invoicing, integration to SAP Billing and Revenue Innovation Management as an alternative way of customer billing for LSPs, mass rebating and invoice verification, and strategic freight selling.

We started by looking at the master data focusing on forwarding agreements and internal agreements, as well as a service product catalog. You learned about the relationship between and integration of these items.

Additionally, we dove deep into the logic for industry-specific charge calculation capabilities and scenarios for air freight, freight forwarder business, and container management. Corresponding charge sheets with assigned rate tables are used for the actual calculation logic.

However, simply calculating costs wouldn't be sufficient to generate revenue. Therefore, we showed you the process of preparing the documents for the customer invoice. The corresponding document in the TM functionality is the forwarding settlement document. Furthermore, this chapter introduced the aspect of cross-charging costs among internal and external organizations of the LSP and calculating profitability.

In the next chapter, we offer insight into TM integration aspects such as analytics, SAP Extended Warehouse Management, SAP Transportation Resource Planning, SAP Yard Logistics, and more.

Chapter 12

Integration with Other Components

A task deemed as too hard or too complex to be solved by one person can in most cases be done by engaging a group of individuals. The same principle applies in software, where integration between individual business systems allows us to address the challenges of the digital age.

Modern supply chains are often dependent on a multitude of participants to reach the goal of a perfect delivery. Such a delivery is achieved only if the goods arrive at the right time, in the ideal quality, and at the desired place. Efficient supply chains orchestrate the participating business partners, while following another principle: efficiency. This last ideal is met when all formerly listed parameters are kept reliably and at the lowest achievable cost. Efficient supply chains are hence relying on business software to gain the transparency for measuring success, mitigating risks, and optimizing planning processes.

You already know that transportation management (TM) can map the complex business processes of logistics service providers (LSPs) and shippers. Frequently, such business processes must be represented across system boundaries. Furthermore, a large volume of data is gathered and added to the business process to satisfy the requirements of carriers, authorities, customs, and receiving business partners. Such data is imported electronically and/or automatically ascertained by the system. Today, the volume of data generated during a transportation process is immense, so it's not always easy for an end user or enterprise to draw conclusions from a success or failure at the document or aggregated level.

In this context, TM not only offers strong integration capabilities with analytics solutions from SAP but also uses the potential and opportunities of mobile devices in this regard. We cover these topics in Section 12.1.

When it comes to supply chain operations, TM offers both strong implementation capabilities with third-party solutions and seamless integration with other applications from SAP S/4HANA or SAP Business Suite. In previous chapters, we've already seen that tight integration with other SAP components is used mainly to facilitate transportation planning and execution in TM. SAP Global Trade Services (SAP GTS) is used to perform compliance checks and customs processing (see Chapter 8, Section 8.1). SAP Event Management (on-premise) and SAP Business Network Global Track and Trace (cloud) is used to track and monitor events and statuses for various business objects within the supply chain (integration with SAP Event Management is explained in Chapter 7, Section 7.2, while integration with SAP Business Network Global Track and Trace is covered in Chapter 7, Section 7.3).

From end to end, however, supply chain management goes far beyond transportation planning and execution. The fulfillment process also uses warehouse operations to source, store, and handle products within the transportation network. Section 12.2 explains the process integration with extended warehouse management (EWM) in SAP S/4HANA, and we'll cover the new topic of advanced shipping and receiving (ASR) in Section 12.3.

In a logistically connected world, the movement of resources, such as containers, is essential to allow a seamless flow of goods. Planning the provisioning and movement of resources at the right place and time is essential for disruption-free transportation. Therefore, we explain the SAP Transportation Resource Planning solution in Section 12.4.

Section 12.5 explains the SAP Yard Logistics solution and elaborates on the resource management within large areas, such as container or railway terminals.

In Section 12.6, we explain the SAP Business Network for Logistics functionality, which extends beyond tracking and tracing and provides a platform to collaborate with LSPs. It provides a technological basis for process integration across company borders without setting up and monitoring individual point-to-point connections.

For planning store visits (e.g., as it's done in consumer goods companies), executing physical deliveries, and facilitating the related settlements, we'll look at SAP Direct Distribution and its integration into TM in Section 12.7.

Available SAP Documentation

Refer to the SAP Help Portal (*https://help.sap.com/*) for a comprehensive level of detail and configuration steps to show how the current release of TM can be integrated with other components of SAP S/4HANA. The specific SAP S/4HANA documentation for TM can be found here: *http://s-prs.co/v557505*.

12.1 Analytics

Because they make fact-based decisions, enterprises can benefit greatly from detailed analyses on available data. This way, they can identify profitable and less profitable transportation and shipping routes, for example. They can use historical data as a basis for learning for the future, structuring their business differently, negotiating with new customers, or plotting shipping routes. A consolidated view of all data from day-to-day activities can give LSPs and shippers an important competitive edge.

Analyses that connect logistical data with financial data serve as an important corporate management tool in competition-intensive and low-margin logistics.

In this scenario, analysis-oriented information systems are used to support both planning and strategic processes. They provide enterprises with current and historical data. These systems are frequently based on a data warehouse in which relevant data is collected, formatted, and made available. The core of a data warehouse is a database. The latest business warehouse solutions from SAP are available both in the cloud and on premise, and they use an SAP HANA database.

Due to technical advancements both in business systems and their underlying technology, such as in-memory operations, operational analysis of data in real time is gaining momentum. Based on the SAP S/4HANA system, operational reports are represented across all functional areas as part of the core functionality to track *key performance indicators* (KPIs).

In this section, we explain how analytics and the integration with TM help decision makers answer business-related and specific questions.

Within this book, we split the analysis section into several parts:

- Embedded analytics (Section 12.1.1)
- Analytics base layer (Section 12.1.2)
- Transportation scenarios in SAP Analytics Cloud (Section 12.1.3)
- Transportation management in SAP Business Warehouse (SAP BW) (Section 12.1.4)
- Transportation management in SAP BW/4HANA (Section 12.1.5)

The embedded analytics section will give an overview of the currently available analytics scenarios within TM in SAP S/4HANA that don't require additional business intelligence (BI) solutions and are available out of the box when using TM. The section on the analytics base layer will further specify the underlying technology for TM reporting, whereas the content section will explore SAP Analytics Cloud, SAP BW, and SAP BW/4HANA consumption scenarios of the available data.

12.1.1 Embedded Analytics with SAP S/4HANA

Typically, three levels of analytics support decision-making in organizations:

- At the corporate level, analytics mainly supports the strategy concerning the direction, composition, and coordination of various business activities within a large and diversified transportation network.
- At the business level, the strategy relates to the creation of competitive advantage.
- At the operational level, analytics usually supports a combination of resources, processes, and competencies to put a strategy into effect or be competitive.

In SAP S/4HANA, the embedded analytics technology was designed to combine online transaction processing (OLTP) and online analytical processing (OLAP) on one system based on the SAP HANA database to enable real-time analysis of existing data without the need for separate reporting systems.

In this section, we'll address how this new reporting method can be used to gain valuable business insights for planning and executing transportation processes. Embedded analytics has numerous applications in the SAP S/4HANA environment. Within this book, we'll focus on the applications built and delivered as part of the TM in SAP S/4HANA software. All the functionalities shown are consumed via the SAP Fiori user interface (UI) and hence work in a mobile environment.

Business Context Viewer

The Business Context Viewer (BCV) was the classic solution in SAP TM available to address operational analytics processes. As the BCV is currently delivered with only limited standard content for TM in SAP S/4HANA, we decided to focus on the description of operational reporting on the currently endorsed embedded analytics functionality for SAP S/4HANA. For further information on the BCV, refer to the SAP TM 9.6 documentation at *http://s-prs.co/v557506*.

Within TM, several overview pages have been created that reflect contextualized KPIs relevant for freight planning and execution. Those pages are tailored to business roles, so they show KPIs relevant for a certain area in TM. Users who supervise transportation execution would hence start the day by navigating to the **Freight Order Execution Overview** page via the SAP Fiori launchpad to understand where their attention is required. As these overview pages are the cornerstone of operational TM reporting, we'll discuss them in more detail. In Figure 12.1, one such page is shown, which allows insight into the current freight order quantity KPIs.

Multiple KPIs are combined in one screen, and the individual KPI boxes are called *cards*. These cards display graphs, charts, or consolidated figures. The individual cards can be reorganized by dragging and dropping them in a different screen area.

On the upper part of Figure 12.1, the filter bar is shown, where based on criteria such as source region, carrier, purchase organization, and others, the KPIs shown in each section of the screen are being recalculated. The shown numbers and graphs are all determined in real time, allowing for decision-making based on the latest information.

Personalizing Overview Pages

You can decide which KPIs are relevant within your current role and functions, and all other cards can be hidden. This is achieved by clicking on the **User** button/picture on the top-right corner and then selecting **Manage Cards**.

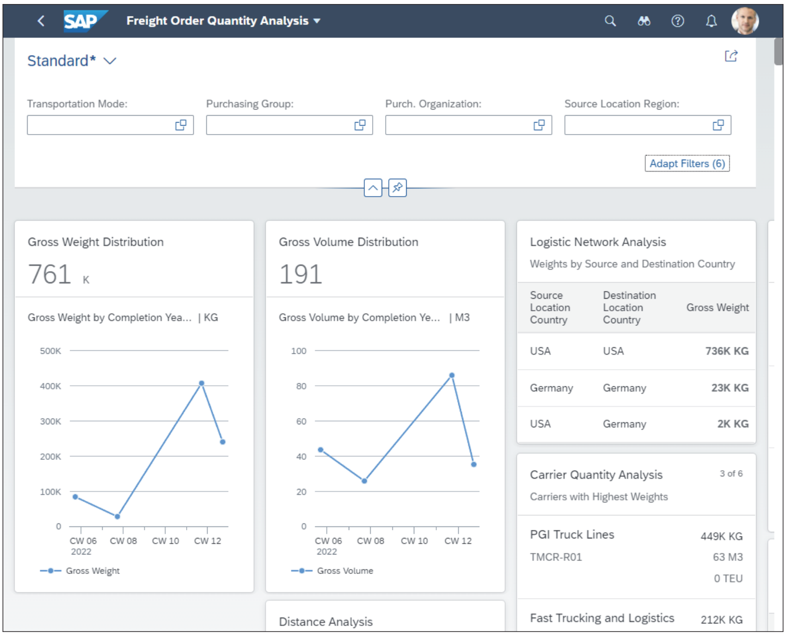


Figure 12.1 Freight Order Quantity Analysis: Overview Page

Each of the displayed cards follows the *insight to action* principle; that is, it can be clicked on for further, more detailed information as depicted in Figure 12.2.

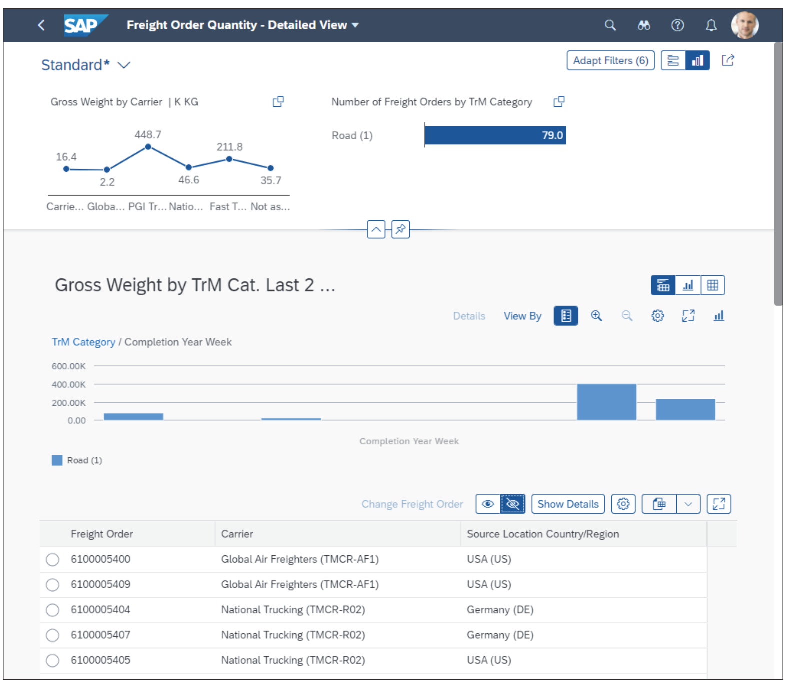


Figure 12.2 Freight Order Quantity: Analytical List Page

These *analytical list pages* show graphs and figures on the selected KPIs. By clicking on the respective area, for example, the quantities of the past week, the list on the lower part of the screen gets filtered further. Only those freight orders are shown that fall into the specific time frame.

As a final step of the analysis, individual freight orders can be opened from this screen by selecting one of the list entries on the lower part of the screen. This insight to action principle was designed to enable the end user a simple way to execute follow-up actions after getting insight in the past and current transportation situation.

The overview pages shown in Table 12.1 are currently available within TM. We also add the respective contributing core data services (CDS) views, which will be introduced in the following sections.

Overview Pages	Description	CDS View
Allocation Analysis	KPI overview of existing allocations for weight volume and amounts transported	`C_TranspAllocComplianceQ`
Business Share Analysis	KPI overview of business share fulfillment ratios	`C_BusinessShareComplianceQ`
Cost Analysis	KPI overview of costs per time frame and distributed by carrier, charge type, purchasing organization, source, and destination country	`C_FreightSettlementCostQ`, `C_TranspOrdInvcgBlockStsQ`
Freight Booking Execution Monitoring	KPI overview of the freight booking execution's status for the current and previous month	`C_FrtBkgExecuionQuery`, `C_FrtBkgExecuionStsQ`
Freight Booking Quantity Analysis	KPI overview of quantities transported with freight orders for and with certain business partners and between locations	`C_FrtBkgQuantityQuery`
Freight Order Execution Monitoring	KPI overview of the freight order execution's status for the current and previous month	`C_FrtOrdExecutionQuery`, `C_FrtOrdExecutionStsQ`
Freight Order Quantity Analysis	KPI overview of quantities transported with freight orders for and with certain business partners and between locations	`C_FrtOrdQuantityQuery`
Tendering Analysis	KPI overview about running and completed tendering processes	`C_TenderingQuery`

Table 12.1 Available Overview Pages in TM

Each of the overview pages has individual cards that lead to further analytical list pages.

Available SAP Documentation

For further information on the available content for overview pages and analytical list pages, refer to the online help at *https://help.sap.com*, search for "SAP S/4HANA", and navigate to the **SAP Transportation Management • Analytics** part of the help document.

You've now learned how to navigate the overview pages in TM. All content displayed is delivered out of the box; that is, no further configuration is necessary.

12.1.2 Analytics Base Layer

The overview pages are just one aspect of the possibilities that SAP S/4HANA offers. Within this section, we'll briefly give a glimpse into the background technologies and adaptation options for SAP Fiori tiles, reports, and overview cards.

SAP offers best practice analytics content, that is, analytical tiles that are tailored to the needs of a significant number of end customers. As analytical models need to reflect the specific business realities of a corporate environment, which can deviate from the predelivered content, additional analytical use cases can be created by reusing the CDS views, which provide access to the data stored on the SAP HANA database. These views are a curated data model to quickly provide semantically enriched data in a specific business context and are the basis for all real-time and near-real-time reporting in the SAP solution landscape. This technology forms the *analytics base layer*.

Figure 12.3 shows an overview of the SAP S/4HANA architecture.

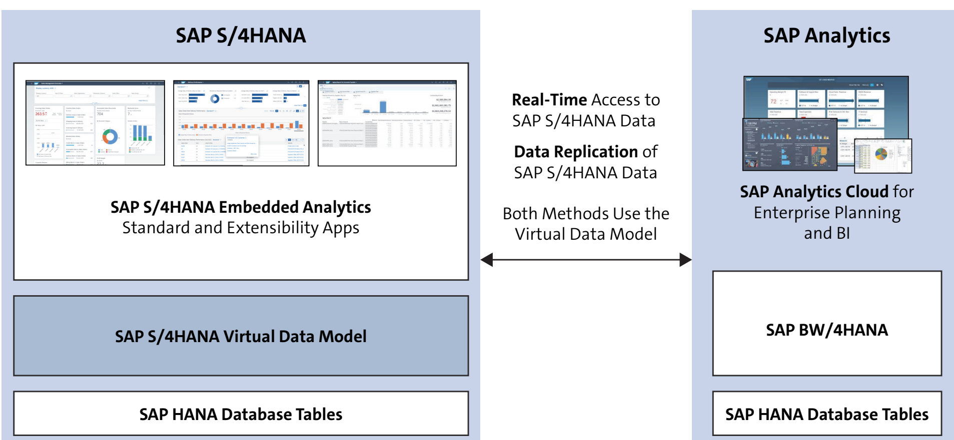


Figure 12.3 SAP S/4HANA Analytics Architecture

The SAP HANA database tables aren't read directly by the individual consuming business applications, namely embedded analytics, SAP Analytics Cloud, and SAP BW or

SAP BW/4HANA. Instead, the *virtual data model* (VDM) provides semantic views on the columnar database that represent semantic objects. Further data manipulations are then done in the respective reporting system after the data is read in real time or replicated. It's finally displayed in an SAP Fiori interface or further prepared for processing in a third-party application.

The VDM

With the emergence of the SAP HANA database, a new concept for providing and consuming analytical data was also devised. CDS was developed as a semantically enriched data model that exposes a semantically enriched view of the underlying SAP HANA database. Hierarchical consumable CDS views form the VDM. The VDM can be used to create new consuming applications, and a company's own views can be created to allow even more flexibility.

The authorization concept for CDS views is in line with the overall profile and role concept of SAP S/4HANA, so access on certain views is restricted to certain roles.

Within this book, we won't do a deep-dive into embedded analytics. For more information, we recommend checking out *SAP S/4HANA Embedded Analytics: The Comprehensive Guide* (SAP PRESS, *www.sap-press.com/5226*).

The overall analytics design of the TM application can be divided into several layers, as depicted in Figure 12.4.

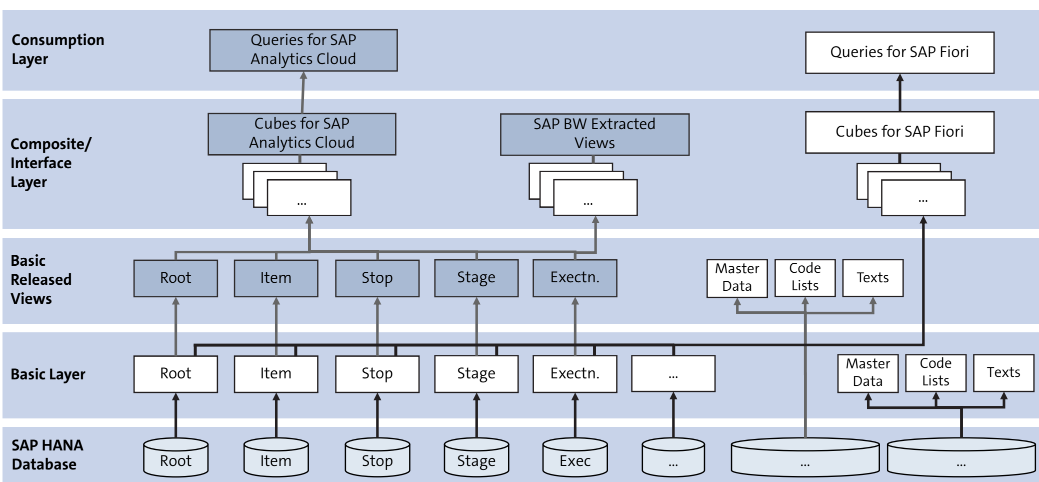


Figure 12.4 Analytical Layers in TM

The *SAP HANA database layer* holds all information of the TM application. The data is then consolidated into the CDS views that form the *basic layer* for application-internal consumption. The basic views in the basic layer (e.g., "root") are the only views that interact directly with the underlying database. The *basic released views* are stable and ready to be utilized for consumption of further applications and third-party tools (e.g., SAP Analytics Cloud or SAP BW).

In the *composite layer*, the individual CDS views can be combined through joins and associations to fetch data, perform calculations, and then produce a result set/data cube that can be exposed to consuming applications.

The c*onsumption layer* makes use of the composite layer data cubes to expose the respective data sets to consuming applications/analytics tools such as SAP Fiori apps, SAP BusinessObjects, SAP Analysis for Microsoft Office, SAP Analytics Cloud, and so on. In this layer, the data is used for reporting and visualization of analytics scenarios.

The basic layer for analytics contains several data sources, of which we'll cover the five main contributors:

- **Transportation order: Root**
  This view contains KPIs to enable you to monitor your freight orders on a header basis. It contains the current weights, volumes, and numbers being transported by each carrier, shipper, and consignee, as well as by transportation mode, source country, and destination country. The view also retrieves utilization information.

  The CDS view system name is `I_TransportationOrder`.
- **Transportation order: Item**
  This CDS view contains KPIs that enable you to monitor your freight orders on the item level. It contains the current weights, volumes, and numbers being transported by each product between shipper and consignee, as well as by transportation mode.

  The CDS view system name is `I_TransportationOrderItem`.
- **Transportation order: Stop**
  This CDS view contains KPIs to enable you to analyze and monitor your business on the stop level. It contains current dates, locations, and stop indicators (e.g., stop category, stop role).

  The CDS view system name is `I_TransportationOrderStop`.
- **Transportation order: Execution**
  This CDS view helps to analyze execution information for transportation orders. It can contain events that have been imported from an external source, set manually, or set via a status change with the freight order. The events have references to the transportation order root/header, item, and/or stop.

  The CDS view system name is `I_TransportationOrdExecution`.
- **Transportation order: Stage**
  This CDS view contains KPIs to enable you to analyze and monitor processes on the stage level. It contains references to source and destination stops and different stage attributes.

  The CDS view system name is `I_TransportationOrderStage`.

The KPIs presented in the analytics base layer can be consumed through the composite layer for analytical applications, answering business questions such as the following:

- How many freight orders are currently delayed?
- How reliable does a carrier perform on a certain transport relation?
- What is the overall weight/volume transported to a certain destination/country?

With the overview pages introduced in Section 12.1.1, the functionality for the out-of-the-box reporting in the TM system has been already introduced. Within the SAP S/4HANA application itself, there are further options for utilizing the CDS data. KPI reporting based on CDS views can be achieved without the need for programming.

For this purpose, SAP created several apps to adapt and create reports, cards, and tiles at design time. Two of these apps are View Browser and Manage KPIs and Reports:

- The View Browser app allows you to see a list of all created CDS views. The respective app views can be searched and tagged, and the included data fields can be assessed.
- The Manage KPIs and Reports app allows for the creation of custom analytical applications for key users. Data from CDS views can be visualized in chart or table format, and individual KPI tiles can be created.

Access to Analytics Apps

To access the presented apps for viewing and utilizing CDS views for analytical purposes, the role `SAP_BR_ANALYTICS_SPECIALIST` (or an equivalent of this standard role) is required for the user.

With these runtime functions, the possibility for creating new analytical capabilities has undergone a major shift toward SAP S/4HANA end users. For simple reports, which are based on the predefined CDS views, interaction with company IT specialists is no longer a must.

Self-created reports can also be published and transported throughout the system landscape to allow testing in a nonproductive environment and reuse by other users.

12.1.3 Transportation Scenarios in SAP Analytics Cloud

So far, we've described the embedded analytics part of TM in SAP S/4HANA. Embedded analytics, however, isn't a final answer to all analytical needs. Sometimes analytical scenarios require a mix with from different data sources such as other SAP S/4HANA systems, SAP BW, cloud applications, and data lakes. It might also be required to access historical data for comparing and predicting actual and future data points. These insights help to answer business questions such as these:

- How was transportation performance linked to weather events?
- How sustainable were the transports per mode?

This function is fulfilled by *SAP Analytics Cloud*, which supports users in linking data sources, creating meaningful analytics scenarios, and publishing the scenarios on multiple devices via SAP Business Technology Platform (SAP BTP). SAP Analytics Cloud is one of the strategic cloud BI solutions of SAP.

SAP Analytics Cloud Connections

For a comprehensive overview of the different data sources that can be used in SAP S/4HANA Cloud visit *http://help.sap.com* for SAP Analytics Cloud and navigate to **Data Connections**.

Like SAP S/4HANA embedded analytics, SAP Analytics Cloud also supports live connections to data to enable up-to-date insights into the current business processes.

Data manipulation features include smart insights (AI-based algorithms to make deductions from the available data) and prediction models to answer business questions like:

- What impact does the time of year have on transportation prices?
- What is the predicted volume of transports for the next quarter on a certain tradelane?

As indicated before, existing data sources can be utilized to create individual analytics stories. The CDS views explained in the previous section can be reused for this purpose. There is content already available out of the box that can be used for comprehensive transportation analysis.

In the area of transportation execution, two such dashboards are available: **SAP Business Network for Logistics – Supply Chain Network Analysis** and **SAP Transportation Management Business Performance**. Within this book, we'll focus on the latter, as it utilizes the data present in TM without relying on further input from SAP Business Network solutions.

The dashboard for transportation (technical name: `SAP__TMS_SCM_LB_BUSDSHBRDFORFREIGHTORDER`) consolidates data from multiple CDS views into cubes to produce insights on freight order performance. The content package can simply be imported through the *business content network* in SAP Analytics Cloud. The dashboard uses a live connection, so it works with real-time data directly read from the TM system (release 2020, FPS2 and up). Figure 12.5 shows the data sources utilized for this purpose. There is no further configuration in TM necessary to activate the scenario.

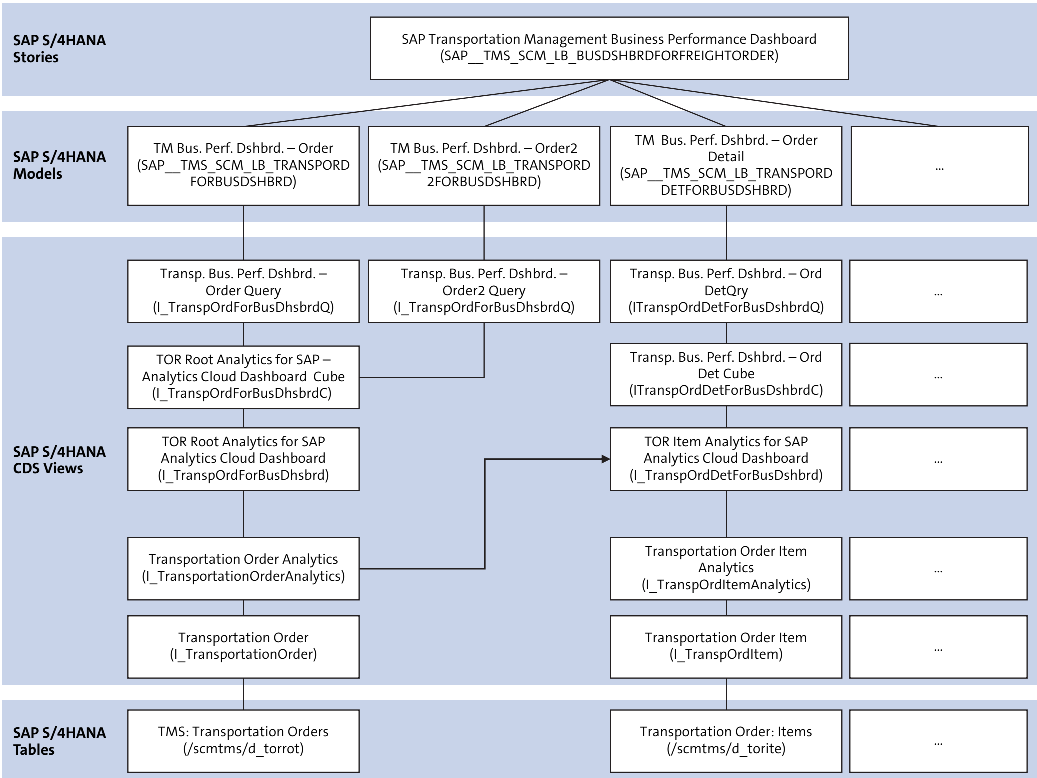


Figure 12.5 Business Dashboard Query Structure

Along the individual layers, the information from the underlying SAP S/4HANA database tables is published and consolidated into the business dashboard. The information is presented as part of an SAP Analytics Cloud story with three pages, which we'll briefly introduce:

- **Overview**

  The **Overview** page provides an overview of the current transportation status. As is customary for SAP Analytics Cloud scenarios, the screen is divided into several elements. These are used to depict the transportation data in different formats such as pie charts, bar charts, time series, tables, and so on. Some of the elements also allow interaction to filter the data or jump to a certain point in the time series for further analysis.

  The model used is `SAP__TMS_SCM_LB_TRANSPORDFORBUSDSHBRD`. A model is mandatory in SAP Analytics Cloud to produce output. It can be reused, for example, in other dashboards that are created by users.

  The underlying CDS view (query) is `C_TranspOrdForBusDshbrdQ`. It ultimately is linked to CDS view `I_TransportationOrder`. All sections in the introduced SAP Analytics Cloud business dashboard are using the data of one or more CDS views; Figure 12.5 shows schematically how the individual views are linked.

Figure 12.6 shows the **Overview** page of the available SAP Analytics Cloud scenario. The following information is made available:

- Number of freight orders by lifecycle status (bar chart), execution status (pie chart), and by creation date (time series)
- List of freight orders by transportation mode (table)
- Used carriers (multiselect)
- Max utilization ratio for weight, volume, and length (bar chart)

This page serves as the entry point for further transportation analysis. It offers further filtering options via the displayed checkboxes.

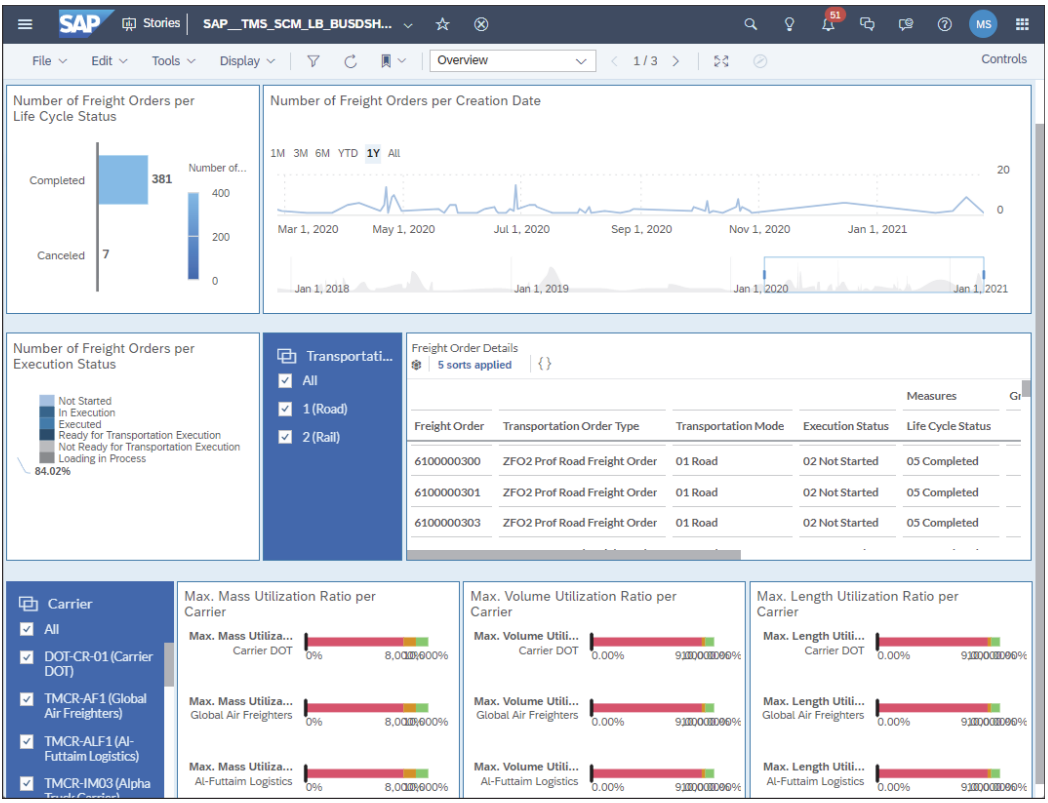


Figure 12.6 Business Dashboard Overview Page

- **Execution and Block**

  The **Execution and Block** section provides insight on the status of freight orders in the TM system and carrier performance. Like the **Overview Page** in Figure 12.6, data is represented using different visuals. In some cases, an **Explorer View** can be opened to inspect the data further.

Planned versus actual arrivals, for example, is presented as a bar chart per transportation activity (i.e., **Loading**, **Departure**, **Arrival**, etc.). This view can be further expanded into an **Explorer View** via the link shown in the top part of the screen in Figure 12.7.

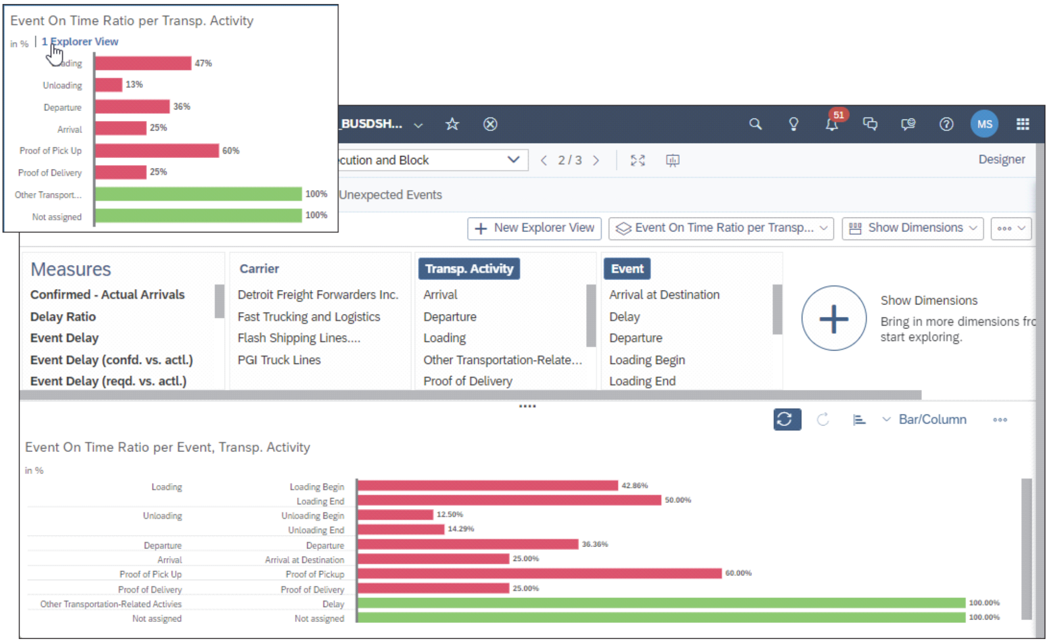


Figure 12.7 Business Dashboard Explorer View

Within this view, in the middle screen, the individual activities can be further explored by filtering on the given dimensions or adding more dimensions from the underlying data set. Each filter applied alters the appearance of the displayed bar chart (shown in the bottom screen).

In this section, business questions such as the following are addressed:

- How many freight orders are arriving on time?
- How reliable is a certain carrier?
- What are frequent reasons for blocking a freight order?

- **Transported Quantities**
  This section of the dashboard gives insight on transported quantities in relation to location as a time series, table, and bar chart. Filters help to adapt the respective output to a meaningful data set. Here, business questions are tackled such as these:
  - What weight/volume was transported inbound to a certain location?
  - When do peaks in weight/volume occur during a certain period of time?
  - Which quantities of a certain item type have been transported in relation to other item types?

As content in the SAP Analytics Cloud business dashboard is evolving, for proper implementations, further information on the content might be required. Refer to the SAP Content Package User Guide for this information at *http://s-prs.co/v557507*.

12.1.4 Transportation Management in SAP Business Warehouse

With SAP BW, SAP provides a solution that includes all required components for setting up data warehouse architecture for transportation reporting. In addition to the basic technology for data retention, the system provides all the essential components for evaluating the transportation-relevant data stored in SAP BW (i.e., reporting tools, data mining methods, and an option for a portal/SAP Fiori connection). It handles time-dependent master data and time-/version-dependent hierarchy processing.

We assume that you're familiar with the main concept of SAP BW, so we provide some further details about how this data is extracted from the source system, as well as how—and in which context—the data can be used for operational reporting.

Where to Find Help

Contrary to other SAP S/4HANA areas, all SAP BW extractors for TM in SAP S/4HANA are still working (refer to SAP Note 2500202 for further details). However, there is no separate content section on this topic in the SAP Help for SAP S/4HANA.

For operational data provisioning (ODP), as of SAP TM 9.0, most of the documentation of data sources and BI content has been moved from the BI content documentation to the SAP library for SAP TM 9.X. You'll find the description at *http://help.sap.com* (search for "Transportation Management", and then select product version 9.0 or higher).

SAP provides delivered content within SAP BW and delivered extractors for transferring data from TM to SAP BW to further analyze transportation-related data.

TM supports you in managing the physical transportation of goods from one location to another. The SAP BW–related content of TM empowers decision makers and employees with the basic data sets to evaluate, analyze, and interpret transportation-related business data.

In this section, we explain the principles of data extraction from the TM source system and data sources, as well as the content that provides the data basis and analytical foundation to support and answer daily questions:

- How much weight or volume is transported per trade lane, business share, or transportation allocation? How long was the distance or duration of individual transports on average?
- How many containers have been shipped from one location to another? What is the percentage of dangerous goods (DG) shipments compared to the overall number of shipments per trade lane?

- What are the average transport costs per trade lane, carrier, shipper, or consignee? How reliable was the shipper, carrier, or consignee?

Data Extraction Overview

In general, SAP logistics applications run either via the UI or through planning or batch reports; a data backup generally takes place before the end of the transaction. Once the backup is completed (i.e., when the transaction is obviously finished and new data has been updated), we need to extract the data relevant to characteristic and key figure determination. Figure 12.8 shows the principal integration process.

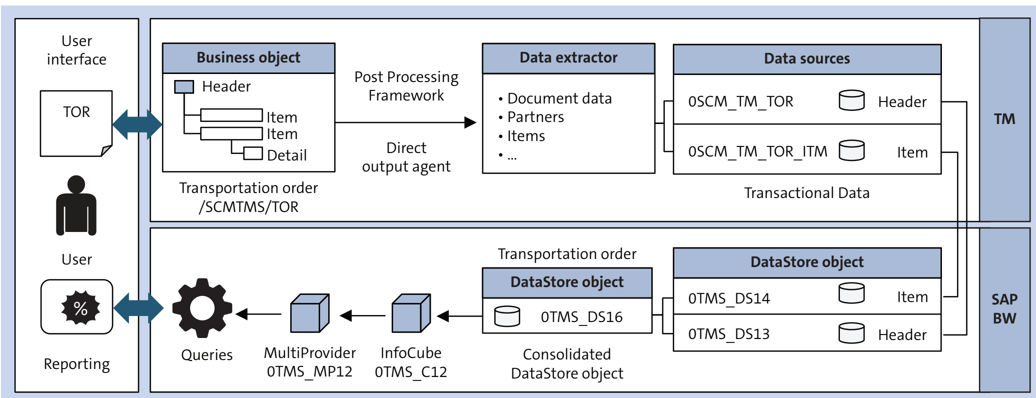


Figure 12.8 SAP BW Extractor: Overview

Let's walk through it. The data is loaded from the TM system to SAP BW into the *persistent staging area* (PSA). In SAP BW, the data source information is stored in *DataStore* objects, which then fill *InfoCubes* with information that is subsequently used by the *MultiProviders* from the various sources of data. Once the data has been made available in the MultiProvider, you can use queries to access the information in SAP BW and then combine this information with other available data, specifically for the purpose of conducting analyses.

Before it can be stored in SAP BW, the content is systematically structured based on the technical relevance of the content that is supposed to be mapped. This structure in turn determines and provisions the available options for transportation analytics.

Additional Resources

In this book, we can't provide a full introduction to the principles and fundamentals of data provisioning and modeling using SAP BW. However, to familiarize you with the core elements of data retrieval, we provide a brief overview. For a comprehensive overview, practical examples, and further insight, we recommend *SAP BW 7.4—Practical Guide* by Amol Palekar, Bharat Patel, and Shreekant Shiralkar (SAP PRESS, *www.sap-press.com/3733*).

For the standard delivery, the following business content has been integrated into SAP BW:

- Network
- Trade lane analysis
- Business share
- Transportation allocation
- Cost/revenues
- Transportation cost
- Transportation revenues
- Quantities/execution
- Transportation order
- Transportation order stages
- Transportation order execution
- Quantities
- Transportation request
- Transportation request stages

Data Extraction Setup

In the current release of TM, SAP BW integration is based on outputs that don't involve the Post Processing Framework (PPF). The framework is described in Chapter 2, Section 2.3.3. Although the configuration is still part of the PPF adapter configuration, output determination and relevance are based on the direct output agent relevance of the business object. You can maintain this relevance and direct output configuration in the PPF settings for extracting data for SAP BW in the Customizing of TM. In the IMG for TM, select **Cross-Application Components • Processes and Tools for Enterprise Applications • Reusable Objects and Functions for BOPF Environment • PPF Adapter for Output Management • Maintain Output Management Adapter Settings**. Figure 12.9 shows the Customizing screen for the delta upload configuration of a transportation order.

Before you can use SAP BW for reporting, you have to connect TM with the reporting system. You can find the relevant settings in the IMG for TM by following menu path **Integration with Other SAP Components • Data Transfer to Business Warehouse • General Settings**. Here, you enter the necessary parameters to specify the source system and the maximum size and rows of the data packages that will be transferred into SAP BW. These are mainly cross-client settings.

Before the data extraction and integration can be configured, use Transaction RSA9 to transfer the application component hierarchy. The necessary data sources are then delivered as part of the business content of TM and can be activated with Transaction RSA5. These data sources belong to the source system (here, TM in SAP S/4HANA) and contain all relevant fields that can be transferred to SAP BW.

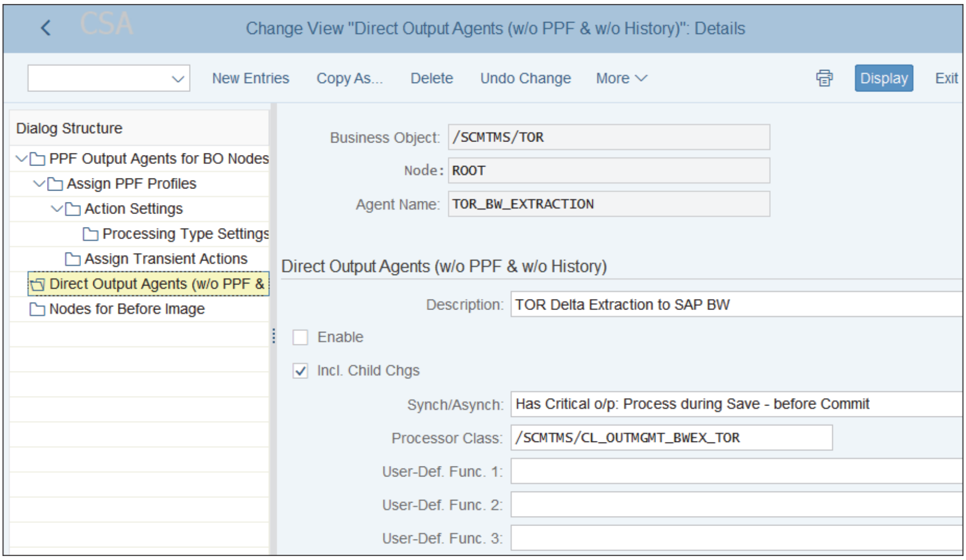


Figure 12.9 SAP BW Extractor Configuration

Figure 12.10 shows Transaction RSA5 in TM. The relevant data sources for master data, texts, and transactional data can be found under hierarchy node 0SCM_TM_DATASOURCES. In this context, we must distinguish between an initial upload or delta upload from TM to SAP BW.

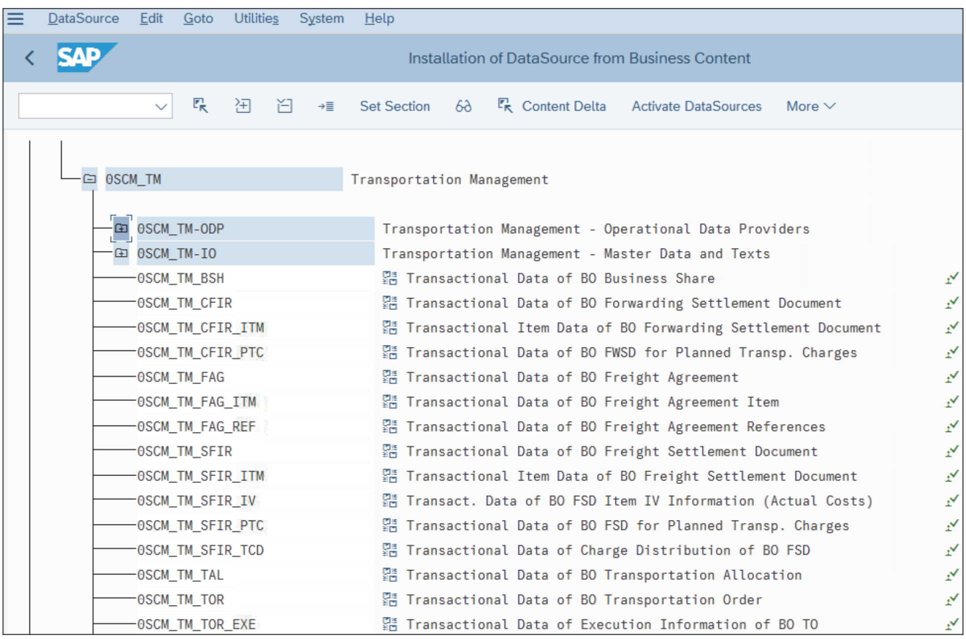


Figure 12.10 Business Content Initialization in TM

The initial upload of data to SAP BW can be initialized with or without a physical data transfer. The initial data upload of existing data with data transfer is done using setup tables in TM. Once the data in these setup tables has been deleted, they can be filled with data from the relevant SAP BW extractor. You can find the initialization of these setup tables, the relevant transactions to fill them with existing data, and the execution of the data upload into the SAP BW system in the **SAP Easy Access** menu of TM: **Administration • Initial Data Upload to SAP NetWeaver BW**.

Also visible in Figure 12.10 are the ODP extractors, mentioned earlier. They are now the strategic data connection for SAP source systems and include the possibility to connect to ABAP CDS views. SAP BW release 7.40 SP05 is required for this. ODP connection to the source allows you to skip the integration via PSA layer and load data directly into a target object, increasing performance by more than 40% (SAP lab results). For detailed information on PSAs, go to *http://s-prs.co/v557508*.

Finally, use Transaction RSA6 to perform an extraction test and display the data records of a specific data source.

Once the data from TM is integrated in SAP BW, it can then be consolidated into the previously mentioned MultiProviders/InfoCubes on which SAP BW queries are performed. Those can then be used/reused to create BI content in SAP BW or can be connected to the previously introduced SAP Analytics Cloud to create dashboards.

12.1.5 Transportation Management in SAP BW/4HANA

In the previous section, we put emphasis on integration with SAP BW systems, as a lot of SAP customers still use this software for data warehousing, so it still reflects current system realities. Since 2016, SAP BW has been replaced by SAP BW/4HANA. The main difference between the two systems being that the newly introduced application now runs on an SAP HANA database and is optimized to use SAP HANA to its fullest.

With the performance and usability improvements realized in SAP BW/4HANA, architectural simplifications also took place. InfoCubes and DataStore objects have been replaced by highly flexible and reusable InfoObjects, advanced DataStore objects, open ODS views, and CompositeProviders.

Further Resources

For a comprehensive overview of SAP BW/4HANA architecture and how to integrate, manipulate, and analyze data using the tool, we recommend *SAP BW/4HANA 2.0: The Comprehensive Guide* by Thorsten Lüdtke and Martina Lüdtke (SAP PRESS, *www.sap-press.com/4544*).

The data structures integrated from TM can then be combined with further data sources, stored as a time series, and reused again for further analytical processing in, for example, SAP Analytics Cloud.

The CDS views of the analytics base layer, which were introduced in Section 12.1.2, can be reused for integration without further configuration on the SAP S/4HANA TM side:

- Transportation order root extractor
- Transportation order item
- Transportation order stages
- Transportation order stops
- Transportation order execution

All the respective views are delta-enabled, allowing for either a live data connection to the source TM system or delta loads.

As part of the *SAP BW/4HANA content add-on 2.0*, SAP HANA-optimized business content has been made available. Transportation order root- and item-based data is being made available using the `C_TranspOrdItemAnalytDEX` data extraction composite view.

This standardized content allows for analysis on the following, for example:

- Number of transportation orders by order category and order type
- Number of transportation orders with DG
- Number of transportation orders with blocked invoicing
- Goods value of transportation orders

The respective content can be reused without adaption, adjusted as required in an implementation context, or used as template material for creating your own data models.

12.2 Integration with Extended Warehouse Management

Across all phases of process evolution in the delivery of goods, one thing remains certain: the warehouse and transportation functions of a business are its cornerstone for successful supply chain execution. Orders and deliveries serve as common logistical objects within SAP S/4HANA. They interconnect all logistics functions of the SAP software in the context of supply chain business processes. Within TM, these objects are generally used to build freight units, which represent transportation demands.

This tight connection allows TM to continuously react to changes to orders and deliveries and support the optimization of transportation costs and efforts in a flexible and optimized way. From a cargo handling perspective, the results of transportation planning have a direct impact on warehouse logistics and operations.

From a transportation logistics perspective, the results of transportation planning influence the warehouse-internal processes, such as the retrieval, staging, and provisioning of goods and cargo. In a connected warehousing and transportation process, efficiency is achieved by optimizing the cost for handling a truck, starting from its arrival at the gate to its final departure after loading and therefore using the data of both systems for planning and execution.

We introduce warehouse operations based on EWM in Section 12.2.1, and transportation unit-based integration of EWM is explained in Section 12.2.2. The integration of these systems enables smooth inbound and outbound processing with an optimized warehouse internal process according to the transportation planning result. Section 12.2.3 explains the integration with EWM from a transit warehouse perspective. Section 12.2.4 gives a brief overview of the warehouse billing process. The new ASR functionality will be covered in Section 12.3.

Note that integration guides with step-by-step introductions and process configuration are available and linked in the respective sections. In addition to these guides, we explain the relevant process flow of these integration scenarios for outbound processing. We use screenshots of a sample process to document and explain the most relevant integration points.

12.2.1 Introduction to EWM

Let's begin by moving our focus from warehouse management in general to EWM. The administration of and transparency regarding existing materials is essential to making precise statements about the availability of a material. Goods movements are usually caused by procurement, distribution, and the associated goods receipts and goods issues or through stock transfer.

SAP has been providing warehouse management functions since the release of SAP R/3 2.0. Thus, it can look back on more than 30 years of experience in warehouse management and a plethora of successful implementations. Ever since the first SAP R/3-based versions and leading right up to the current SAP Supply Chain Management (SAP SCM)–based systems, functionality has been continually expanded and adjusted according to customer demands. In addition to Warehouse Management (WM) as part of SAP ERP, in 2005, SAP introduced the considerably more efficient SAP Extended Warehouse Management (SAP EWM), which is based on SAP SCM.

Today, SAP EWM is an independent application that can be used in any warehouse environment and integrated with TM. SAP EWM was developed for complex warehouse and distribution centers with a multitude of different products and a high document volume. In contrast to WM, it offers many new and expanded functions and business objects. SAP EWM functionality is available in SAP S/4HANA as embedded EWM, which we discuss in these sections.

To better understand the TM integration scenarios and how TM documents are mapped and integrated to their corresponding counterparts in EWM, we first briefly explain the most relevant EWM documents and terminology for a standard outbound scenario. We then use this outbound scenario as the basis to elaborate on the described integration scenarios.

From the EWM perspective, the process starts with an SAP S/4HANA outbound delivery: the central document in goods issue. It typically represents a follow-up document to a sales order but can also be created directly, without reference to a preceding document. The physical shipment, which forms the completion of a goods issue procedure, thus begins with the generation of an outbound delivery document in SAP S/4HANA. Whether it's necessary to distribute this document to a decentralized EWM system or process it in EWM for SAP S/4HANA depends on the warehouse number that is allocated to a delivery item. If an outbound delivery is relevant to processing in EWM, the follow-up activities, such as picking, packing, staging, and so on, are performed in the EWM system.

Within the outbound logistical process of EWM for SAP S/4HANA, deliveries form *outbound delivery orders* (ODOs) in EWM. An ODO is a document that contains all the relevant data required for triggering and monitoring the complete outbound delivery process. This process starts with the first planning activities for the outbound delivery and extends to the loading and shipping of the goods.

Outbound Deliveries in EWM

The outbound delivery records the goods that are delivered to a goods recipient as part of a delivery. It entails the process of picking goods, reducing the storage quantity, and finally shipping the goods to their destination (determined by a ship-to party). In the SAP system, this operation is represented by the outbound delivery document that is generated during the following activities:

- Goods shipment based on a sales order
- Stock transfer order
- Goods return to the vendor

Before the introduction of EWM into SAP S/4HANA, SAP ERP inbound deliveries and outbound deliveries were always replicated to a decentralized SAP EWM warehouse system where an *outbound delivery request* (ODR) was created. This document contained basically the same information, had the same structure as an outbound delivery in SAP ERP, and it was activated upon successful replication.

With the introduction of embedded EWM in SAP S/4HANA, it was decided that this object was no longer required and that direct access to EWM on the delivery was the preferred way forward on an SAP S/4HANA system. In the outbound example, that means skipping the creation of an ODR and directly starting the process with an ODO in EWM.

Goods are typically packed and handled on pallets. In this context, the *handling unit* (HU) represents a physical unit consisting of packaging materials (e.g., boxes, containers, wire baskets, etc.) and the products they contain. HUs have a single, scannable identification number.

As soon as the materials have been packed, the resulting packages (i.e., HUs) can be loaded on *transportation units*, and the goods issue is then posted. The system can also automatically determine the staging area and door for goods issue in advance, which is typically based on the route determined when the ODO was generated.

Technically, the transportation unit in EWM serves as a special kind of HU used to reflect the truck, trailer, or container that is used for shipping. A transportation unit is assigned to delivery items and therefore contains all relevant information (e.g., carrier, license plate of the truck, and information regarding which items are supposed to be loaded on the truck). Because loading is an optional step, the goods issue can be posted without previous loading, depending on system settings. Alternatively, posting can be done after loading or, if the yard management functionality is used, at the latest after the transportation unit has left the warehouse grounds. When the goods issue is booked, EWM informs inventory management in SAP S/4HANA of the change in stock.

12.2.2 Execution Based on Deliveries and Transportation Units

SAP EWM was initially designed as a decentralized warehouse management system. Like SAP TM, which was also initially decoupled from SAP ERP, it was designed as an autonomous application of SAP SCM. Standalone SAP EWM requires integration with an SAP ERP and SAP S/4HANA system for master and transactional data. As for SAP TM, the technical link between an external SAP EWM and SAP ERP or SAP S/4HANA and such functions as the transfer of inbound deliveries and outbound deliveries between the systems takes place in real time via defined interfaces. These interfaces enable the seamless integration of both systems by distributing, altering, and returning data relevant to deliveries. Inbound and outbound processing is performed asynchronously based on the sequence stored in the inbound and outbound queues. In the event of an error, such as a missing network connection, this queue saves all transfers and allows processing to continue seamlessly as soon as the error has been located and eliminated. The queue enables the real-time and bidirectional exchange and processing of information.

Like SAP TM, SAP EWM has moved to the SAP S/4HANA core (embedded EWM), making the replication of certain master and transactional data obsolete within this deployment scenario. For systems embedded in SAP S/4HANA, many of the existing interfaces were altered or became unnecessary, such as the removed outbound delivery requests and inbound delivery requests. Refer to SAP Note 2668150 for further details.

From a technical standpoint, close integration of EWM and SAP S/4HANA is achieved via interfaces (external/side-by-side SAP EWM) or direct access within the same system (embedded EWM in SAP S/4HANA), while process integration is done primarily via organizational data. As in the case of integration of the warehouse management system, in EWM, organizational allocation of warehouse numbers is initially achieved by their allocation to specific plant/storage location combinations.

In this section, to illustrate the TM integration and processes, we assume the use of EWM for SAP S/4HANA in an embedded environment.

Direct Integration with SAP TM and TM in SAP S/4HANA

Since the days of SAP TM 9.0 (and the first edition of this book!), the integration of SAP TM with SAP EWM ran via SAP ERP using SAP ERP shipments as an intermediate step. Data wasn't sent directly between SAP TM and SAP EWM. Since release 9.1, SAP TM has supported direct integration between SAP TM and SAP EWM without creating shipments in SAP ERP. The next step in the evolution is the transportation unit-based scenario, where both EWM and TM run as part of the SAP S/4HANA system since release 1709.

The integration scenarios in this setting are still based on orders and deliveries. Shipments, however, are part of the compatibility scope of solutions in SAP S/4HANA, which have a specific end-of-life date announced. They will no longer be supported after the year 2030.

In Section 12.3, we'll cover the new integration scenarios for integrated goods movements through ASR processes. Even though this long anticipated change in TM and EWM collaboration will be of significant importance in the future, the classic method of integration via orders and deliveries is still available and relevant.

Integration Setup

For setting up the technical connection of TM and EWM, several configuration tasks must be performed. Integration profiles must be set up, freight order types configured, logical system connections defined, and so on. For a setup guide on these settings, refer to SAP Note 2933925 (for TM and EWM both embedded in SAP S/4HANA) or SAP Note 1978857 (for sidecar scenarios).

Standard Integration Scenarios

To optimize transportation costs and efforts in a flexible and optimized way, TM supports transportation planning based on either purchase order/sales order/stock transfer order requirements or inbound/outbound deliveries. As part of transportation planning, the results influence warehouse-internal processes. The integration of the TM transportation planning results into EWM processes is beneficial because it enables smooth inbound/outbound processing with an optimized warehouse-internal process according to the transportation planning result.

We now explain this direct transportation unit-based integration and process flow for the standard integration scenarios shown in Table 12.2.

	Outbound	Inbound
Order Based	Sales orders	Purchase orders
Delivery Based	Outbound deliveries	Inbound deliveries

Table 12.2 Standard Integration Scenarios

Intracompany Stock Transfer Orders

Since SAP S/4HANA release 2021 FPS01, intracompany stock transfer orders have been supported for transportation unit-based EWM/TM integration. This process creates a transportation unit for the outbound plant based on an outbound delivery as described in the sales order integration. Once the transportation unit departs from the outbound plant and the goods issue is booked, a new Lightweight Directory Access Protocol (LDAP) request creates a second transportation unit for the plant where the goods are inbound, allowing for seamless warehouse processing.

For both inbound and outbound core processes, EWM offers great flexibility to model the necessary warehouse operations and seamlessly integrates all relevant process steps with the transportation planning system.

Known Restrictions

In a direct integration scenario, where TM and EWM behave as a common execution platform, SAP S/4HANA is used to support the order integration on the TM side, as well as the standard integration with EWM. In this context, we draw your attention to SAP Notes 1984252 and 3018355, which describe the known supported functional scope and limitations of the direct integration. For implementation processes, it's mandatory to monitor this note and its changes closely to prevent any wrong assumptions for supported scope.

In addition, note that for previous integrated installations of TM and EWM, a redesign in integration architecture requires a detailed check of custom coding during update. Refer to SAP Note 3117542 for specifics.

In this section, we explain both delivery-based and order-based direct integration. For the delivery-based scenario, to make you familiar with the core functionality, we concentrate on both the explanation of the relevant warehouse activities and a documented process example with screenshots. For inbound processing, as well as order-based integration, we provide an overview and mention the main functional differences.

Outbound Planning with Warehouse Execution

According to the mentioned scenarios, a delivery-based or order-based planning process is used for outbound execution. Therefore, TM sends freight order details to EWM. Warehouse execution for outbound processes, such as picking, packing, staging, loading, and goods issue, takes place in EWM. Given the seamless integration, TM is updated with the actual dates, as well as discrepancies and quantity deviations.

SAP S/4HANA versus SAP ERP

The scenarios discussed here will work in all possible deployment scenarios:

- TM and/or EWM in SAP S/4HANA
- TM and EWM standalone in conjunction with an SAP S/4HANA system
- SAP TM and SAP EWM standalone in conjunction with an SAP ERP system

The following example, however, will be based on the latest technology and assume an execution scenario where both EWM for SAP S/4HANA and TM in SAP S/4HANA are used.

Delivery-Based Integration

The delivery-based integration scenario is an integrated warehousing and transportation process that sends ordered goods via an external carrier to external customers from a warehouse managed with EWM. Transportation is planned in TM, while warehouse activities are planned and executed in EWM. This process is based on SAP S/4HANA sales orders, and transportation requirements are based on SAP S/4HANA outbound deliveries.

Cross-Delivery HUs

HUs that contain more than one can be regarded in TM-EWM integration by creating local packages for affected freight orders with the SAP S/4HANA 2021 FPS1 release. The individual deliveries are shown in the item hierarchy of the freight unit as separate outbound delivery line items. As of the time of writing, this process only works for freight units with a single stage.

Delivery processing in SAP S/4HANA involves grouping deliveries to pick, pack, and ship, and then performing all the functions associated with the delivery process. Based on split criteria or combination indicators, you can group together entire orders, individual items, or split orders into partial deliveries. As shown in Figure 12.11, outbound deliveries are created and scheduled in SAP S/4HANA and are the basis for transportation planning in TM.

As a result of this planning, a freight order is created, which, as soon as the freight order is ready for loading and the load plan is sent, results in the creation of a transportation unit in EWM, together with the assignment of the relevant ODO.

Figure 12.11 depicts the flow of documents in the delivery-based execution using EWM and TM in SAP S/4HANA.

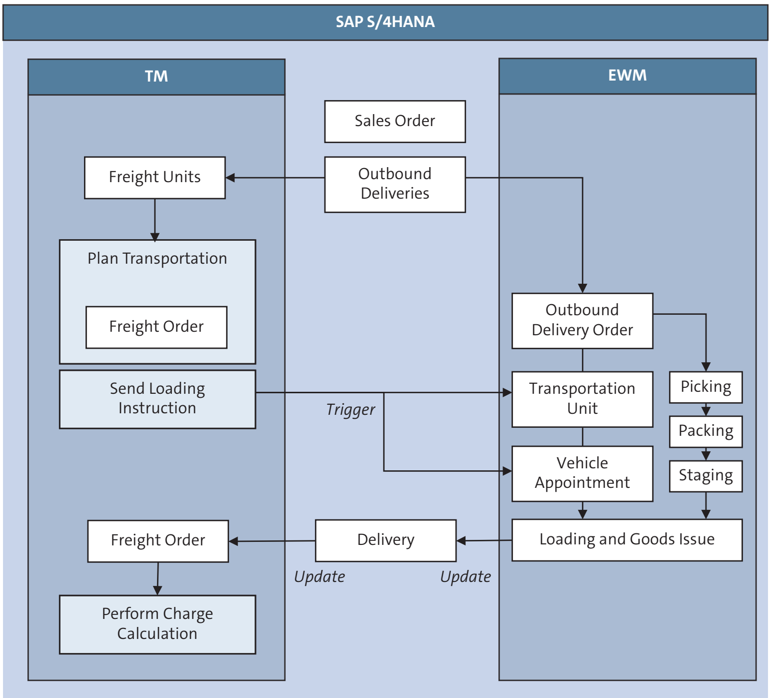


Figure 12.11 Delivery-Based Integration

Let's walk through a simple example: To replicate the demonstrated scenario, we create deliveries that are planning relevant in TM. The freight units are automatically created in TM based on the to-be-delivered items. As a reminder, TM determines the smallest logistical unit to be transported through the transportation chain and regards this during its creation. In this example, no freight unit split is performed, so each delivery leads to exactly one freight unit.

One or more delivery positions can create one or more freight units. At all times, the documents created in TM can be seen in the delivery via the document flow in the **TM Status** tab of the delivery (see Figure 12.12 for delivery **80326409**).

In the document flow, the planning and carrier assignment have already been performed. In our example, the outbound deliveries **80326409**, **80326410**, and **80326411** lead to freight units **4100008654**, **4100008655**, and **4100008656**, which are planned on freight order **6100006532**.

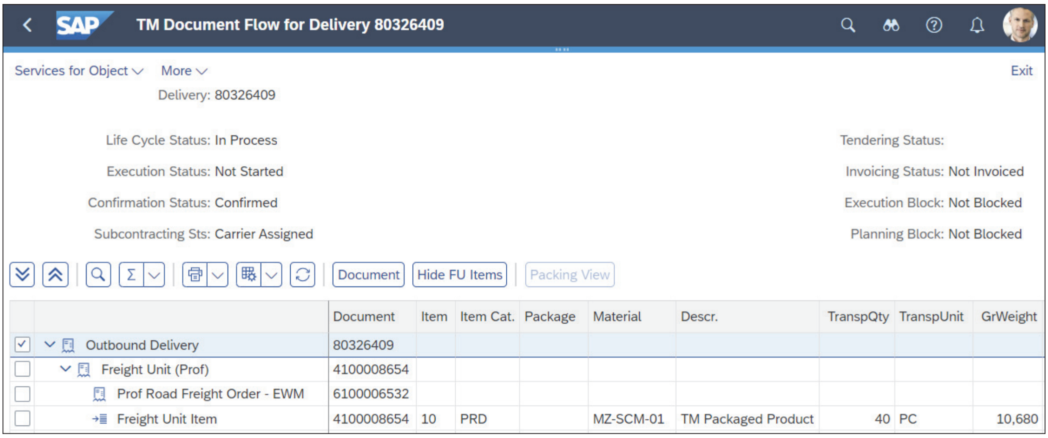


Figure 12.12 Delivery Document Flow

The deliveries are visible both in TM for transportation planning and execution and in EWM for warehouse planning and execution. In EWM, the delivery creates an ODO, which acts as the actual warehouse request and initiates processing in EWM.

Within our example, the outbound delivery **80326409** contains data assumed from the preceding document and all necessary information to start warehouse execution. From the perspective of warehouse management, ODO **17185** (see Figure 12.13) is created on its basis and represents a worklist that is completed only when the picked materials have been loaded and shipped. This process is supported by warehouse orders and warehouse tasks that monitor the individual steps performed from picking to loading.

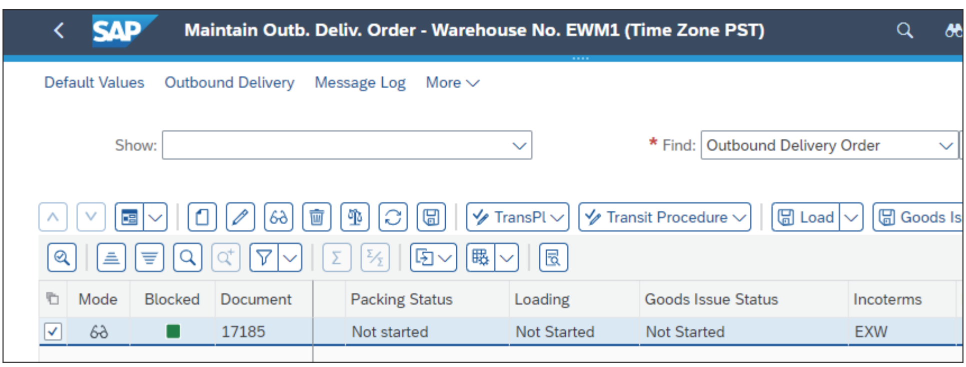


Figure 12.13 ODO after Delivery Creation

At this stage of the process, three ODOs have been created in EWM, one for each delivery. To hand over the planning and vehicle information from TM to EWM, the process needs to be initiated on the TM side. As shown in Figure 12.14, the status for the load plan on stop level (**Load Plan Status (Stop)**) is set to finalized (**Set Load Plan to Finalized**) in the freight order. TM will send a loading appointment request message to EWM. Depending on the integration profile settings, the freight order will either not be editable anymore or won't allow sending the loading instructions multiple times.

Sending Loading Instructions to EWM Only Once

Sending the loading/unloading instructions only once is especially important for warehouse-driven processes, where after the initial sending of the freight order details to EWM, no further planning or changes in the TM are to be communicated to EWM until the warehouse activities are finished.

For cases where loading instructions are sent more than once, freight order changes are possible until the EWM outbound status **Loading Completion** (respectively, **Arrival at Checkpoint** in the inbound process) is reached.

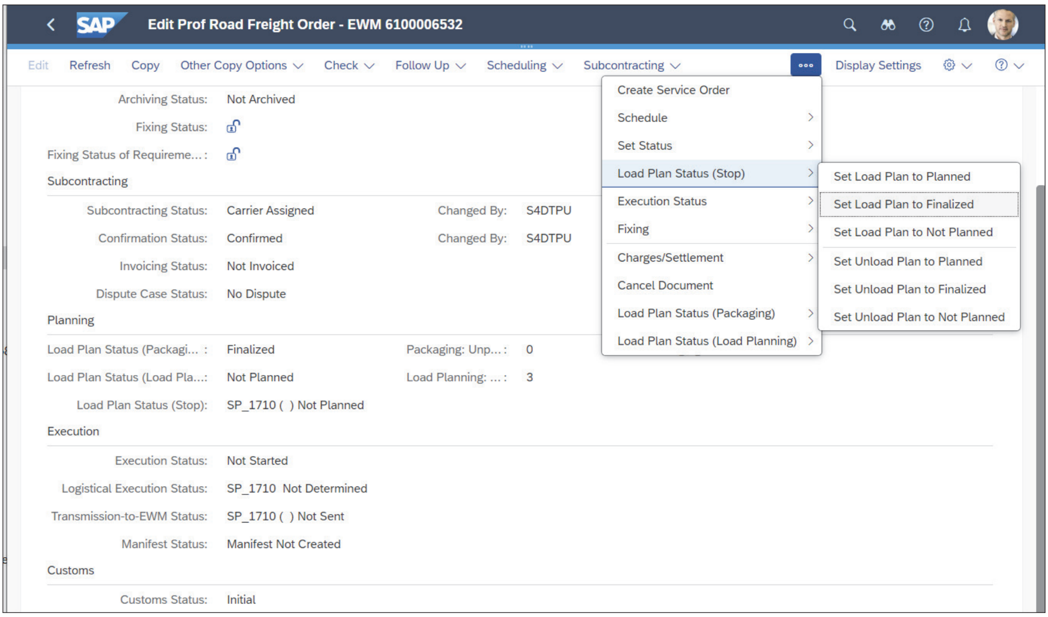


Figure 12.14 Finalize Load Plan and Trigger EWM Transportation Unit Creation

As a result of the finalized load plan, the **Transmission-to-EWM Status** changes to **Sent**. In EWM, all corresponding ODOs will be linked to a newly created transportation unit.

Multipick, Multidrop

As of the SAP S/4HANA 2020 FPS01 release, multipick/multidrop scenarios where more than one EWM warehouse is involved are also supported for TM-EWM integration. This development is restricted to shippers. Freight orders for this scenario can also be canceled, being regarded by all warehouses where stops had been planned, load plans were sent, and ODOs were created.

In this scenario, one transportation unit is created in each connected warehouse.

ODOs with transportation units are now the basis for warehouse execution in EWM. The TM freight order is represented by the transportation unit in EWM. The freight order in TM is locked for editing, until the warehouse processing is finished, and the truck is reported as checked out. Figure 12.15 shows the transportation unit in EWM with the linked ODOs. To easily identify the linked objects across systems, transportation unit and freight order share the same number.

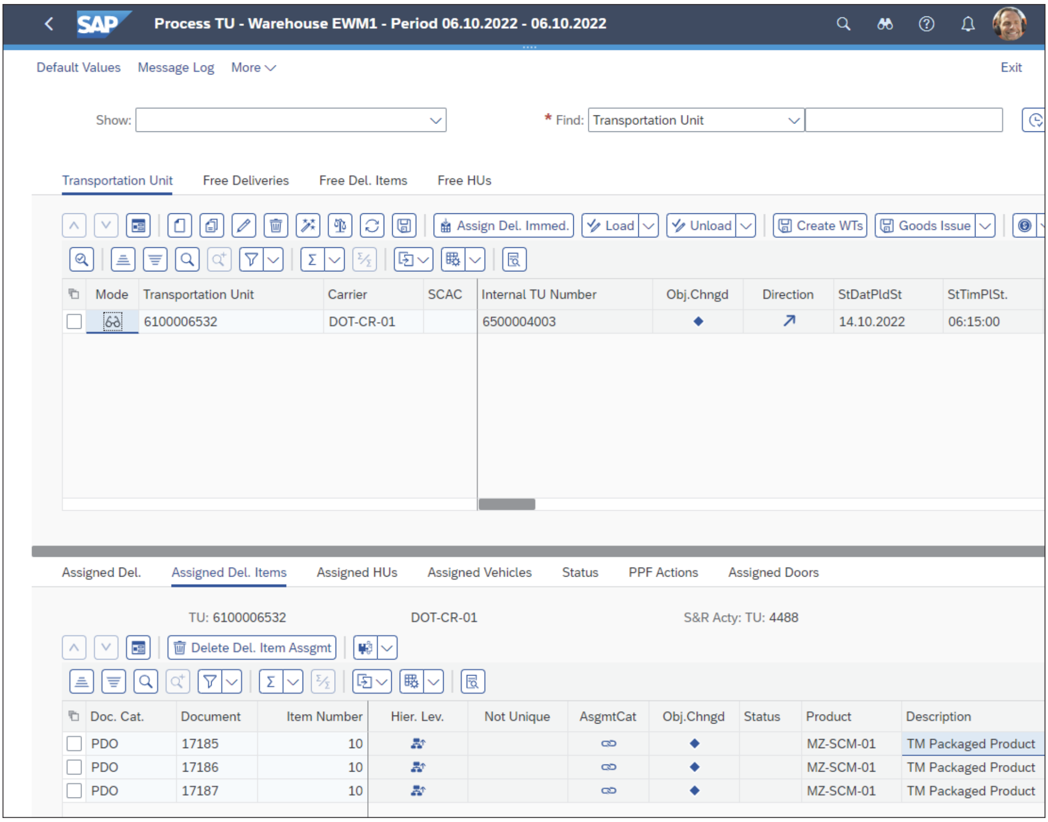


Figure 12.15 EWM Transportation Unit with Assigned ODOs

When the ODOs are created, the system can automatically assign them to waves. The warehouse internal process starts when the deliveries are unblocked, and waves are created and released. This assignment to a picking wave is based on the shipping information and an optional (as opposed to manual triggering of warehouse processes) step to optimize the picking efficiency and to monitor and track the outbound process. Together with the information of the planning in TM, wave management can regard the transportation information (truck types, arrival dates, etc.) for execution of warehouse tasks.

Picking and moving the goods to the staging area is usually carried out using a radio frequency (RF) device. If RF is used, the warehouse worker logs on as a resource and takes an empty pallet or wire basket as a pick HU. After it's assigned to an RF queue, the worker receives the first pick task for execution and is prompted to create the pick HU for the warehouse order the worker is currently executing. After the HU is created, the system can automatically print the HU label, which contains both plain text descriptions and the HU number as a barcode. The worker typically continues to the source bin and picks the requested product and quantity into the pick HU proposed by the system.

The sequence of warehouse tasks for stock removal can be determined according to various criteria, such as the shortest path. EWM and the corresponding SAP S/4HANA system are closely linked for the picking process. This allows picking specifications such as batches or batch characteristics to be considered.

When all warehouse tasks for stock removal are confirmed, the stock is removed from its source storage bin and moved to the destination storage bin. If a difference in quantity is detected in the process because the picked quantity deviates from the quantity to be picked, then another warehouse task can be created, or the quantity to be delivered is adjusted and diminished accordingly. When a second warehouse task is generated, stock removal isn't complete until the second warehouse task has also been confirmed. The warehouse worker drops the pick HU at the staging area, scans the staging bin barcode, and thus confirms this step in the system. With the last confirmation, EWM prints a shipping HU (SHU) label to be attached to the pallet.

As soon as the materials have been picked and staged, the resulting HUs are loaded, and the goods issue can be posted. As mentioned previously, the system can also automatically determine the staging area and door for goods issue in advance.

From a process perspective, if the EWM yard management functionality is used, the truck arrives at the checkpoint. It's identified by the external transportation unit number, which also represents the freight order number in TM. The truck can be automatically assigned to a warehouse door. Alternatively, the door assignment can be done manually be the checkpoint clerk or—in large yards—the shipping office.

After the truck has arrived at the warehouse and is docked to the door, the loading of the goods can begin. Loading is also supported by RF. Scanning the door starts the loading of the transportation unit. The SHU is loaded on the truck, its barcode is scanned, and the system automatically creates and confirms a corresponding warehouse task. Loading is confirmed as soon as all SHUs have been loaded on the transportation unit. When the loading is finished, delivery notes and the waybill can be printed, and the goods issue can be posted in EWM based on the transportation unit. The SAP S/4HANA outbound delivery is also updated. When the goods issue is posted, EWM also sends confirmed execution results via the `LoadingAppointmentNotification` message to TM.

Early Updates from EWM

Since SAP S/4HANA release 2020, to enable earlier printing of documents, the point in time where data is returned from EWM to TM can be set to **Finish Loading**, which will trigger an additional `LoadingAppointmentRequest` message to TM to update the freight order/freight unit item hierarchy. All connected logistics execution deliveries are also updates at this early stage.

In a scenario where early updates to TM are supported, an additional `LoadingAppointmentNotification` can be sent to TM after the **Finish Loading** status is reached in EWM.

For the monitoring and processing of these tasks, a cockpit has been created in EWM in addition to the well-known warehouse monitor, which has been used for the EWM screenshots in this book so far. As shown in Figure 12.16, the cockpit can show a list of transportation units and their respective progress in the warehouse execution.

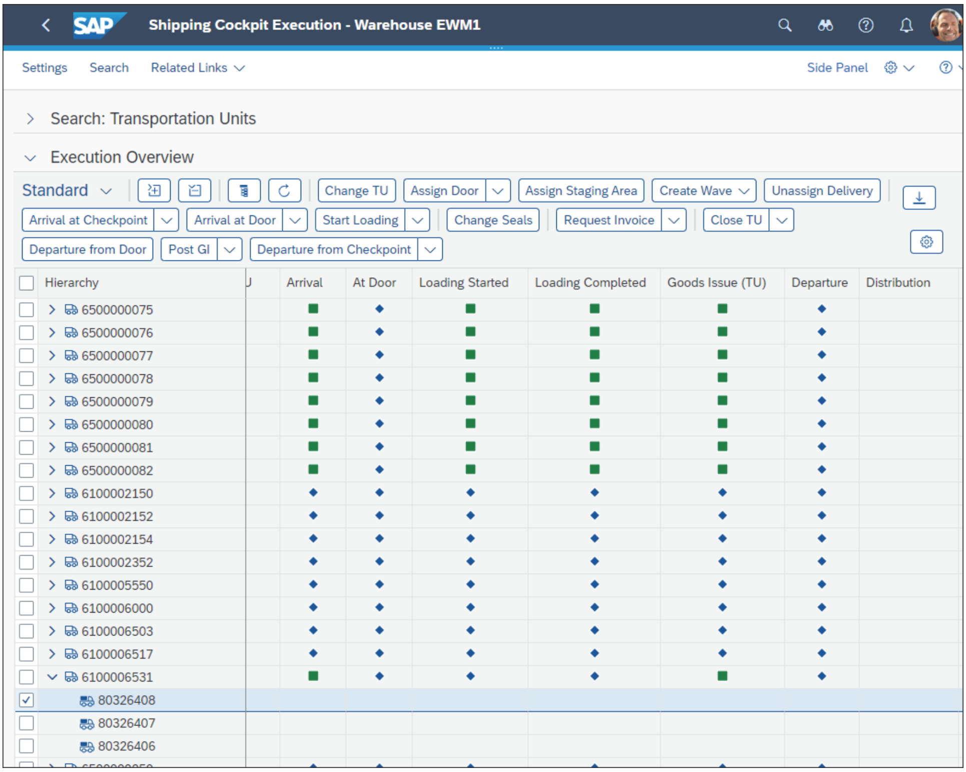


Figure 12.16 EWM Shipping Cockpit

Aside from getting an overview of the outgoing shipments, the monitor also allows for manually setting the statuses for **Loading**, **Arrival**, **Departure**, and **Goods Issue** and allows for manual processing steps, such as door and staging area assignments and seal changes. This functionality brings transparency to the transportation unit processing and is a helpful tool for outbound execution processing in the context of an integrated scenario between TM and EWM.

If an SHU is missing, the ODO can be unassigned from the transportation unit before posting goods issue. It can be manually assigned to another transportation unit or considered during the next transportation planning in TM. Alternatively, the ODO can be split.

ODOs can be manually assigned to other transportation units or considered during the next transportation planning in TM. Freight units that could not be loaded to the transportation unit in EWM are automatically unassigned from the freight order and can be considered for subsequent transportation planning in TM via delivery and freight unit splits.

After the warehouse process in EWM is finished, TM will receive an updated status as depicted in Figure 12.17.

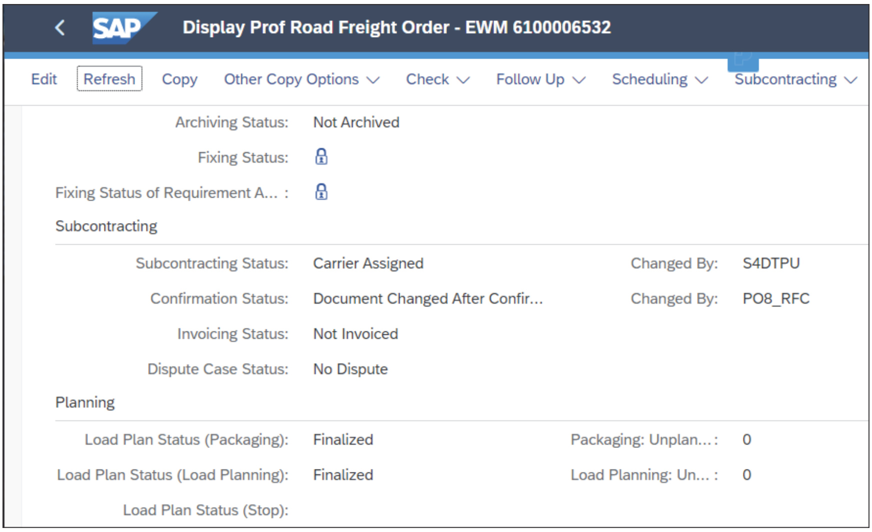


Figure 12.17 EWM Activities Finished

When the carrier confirms the arrival of the truck at the customer site, the freight order is completely executed and confirmed.

During the outbound process execution, TM is updated with all execution-relevant information and events. As shown in Figure 12.18, the EWM updates sent via the loading notification are used to set the respective event timings, allowing for full transparency on the actual status of the freight order.

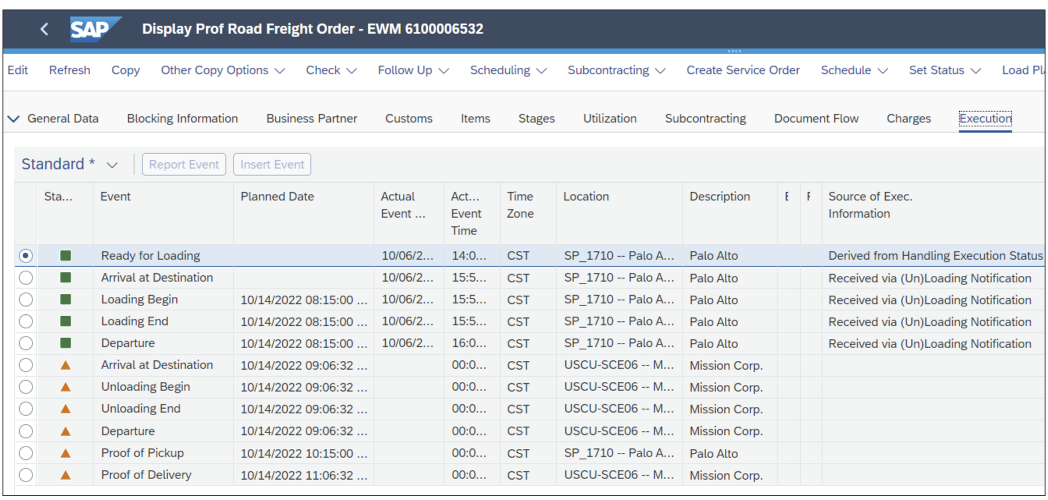


Figure 12.18 TM Freight Order Event Reporting

In addition, the actual times, item hierarchy, packaging materials, actual carrier, loaded quantities, and seals are updated in TM to consider any deviations from the initial plan that might have occurred during warehouse execution and can be reviewed in the **Items** tab of the freight order.

Order-Based Integration

In addition to delivery-based integration, EWM and TM can also work together in an order-based process. In contrast to the previous scenario, the outbound delivery is now created because of freight unit-based delivery proposals and transportation planning in TM. In the delivery-based scenario, inventory planning, and logistics execution had priority over the transportation planning process in TM, and deliveries were already created.

In the order-based scenario, TM plans transportation based on SAP S/4HANA sales orders and, as a result, proposes and creates deliveries based on the determined dates and quantities. Transportation planning results in the creation of freight orders, which are the basis for the delivery creation in SAP S/4HANA. In this context, TM considers transportation constraints, such as resource availability and transportation durations. The created deliveries are usable by EWM (see Figure 12.19). In TM, the freight order can be the basis for carrier selection and tendering (also refer to Chapter 6, Section 6.5 and Section 6.6, where these two topics are discussed).

The process flow of the order-based integration is quite like the delivery-based integration planning, so we just focus on the main differences here. The process starts with a sales order and a planned delivery date. This automatically creates freight units. These are then the basis for transportation planning and optimization in TM.

The transportation planning in TM is completed as soon as the transportation capacity of the freight orders has been fully planned and all relevant transportation requirements have been assigned.

Package Building in Freight Order

Package building when planning a freight order is available as an integration scenario from the SAP S/4HANA 2020 FPS2 release. The created packages in TM will be sent to EWM as planned shipping handling units (PSHUs) and can be regarded or ignored during the picking/packing.

After the carrier has been assigned, TM can trigger the creation of an SAP S/4HANA outbound delivery and communicate the freight order number to the selected carrier. These deliveries are based on the transportation planning results and therefore consider planning constraints, such as resource availability, distances, durations, and consolidation and dates. This step can be executed manually or automatically as a background job.

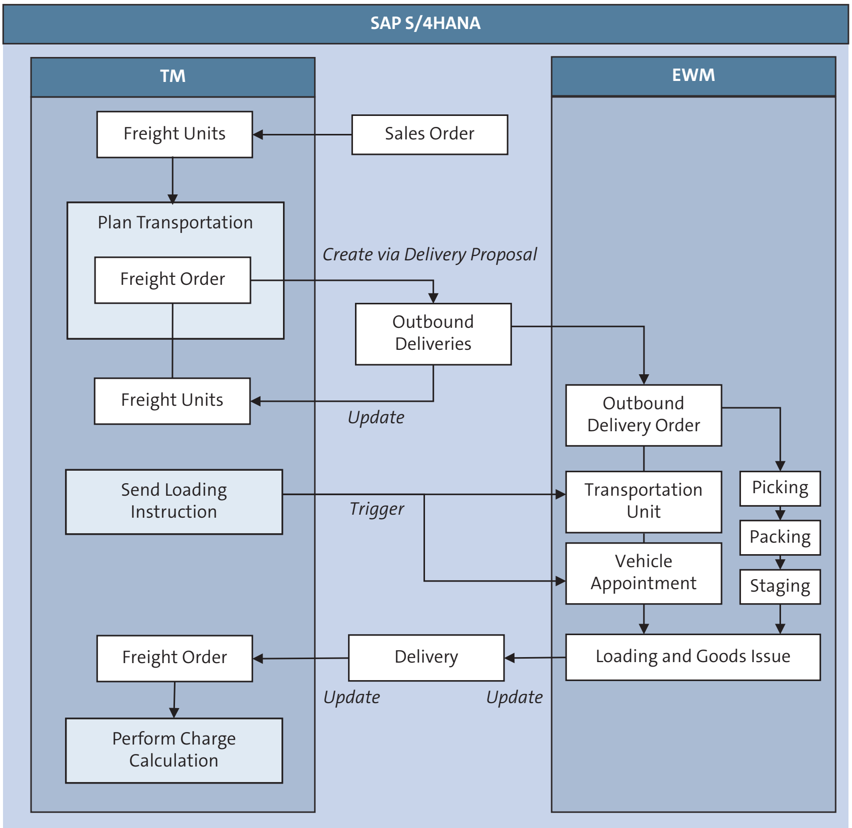


Figure 12.19 Sales Order: Transportation and Warehouse Execution

As soon as the delivery has been created, the document flow in TM is updated to show all related documents to a freight unit and freight order. In Figure 12.20, the document flow of a freight order in TM is shown. **Sales Order 69659** was initially the basis for the **Freight Unit (Prof) 4100000258**. After the creation of the **Outbound Delivery 80049967**, its number shows up in the document flow.

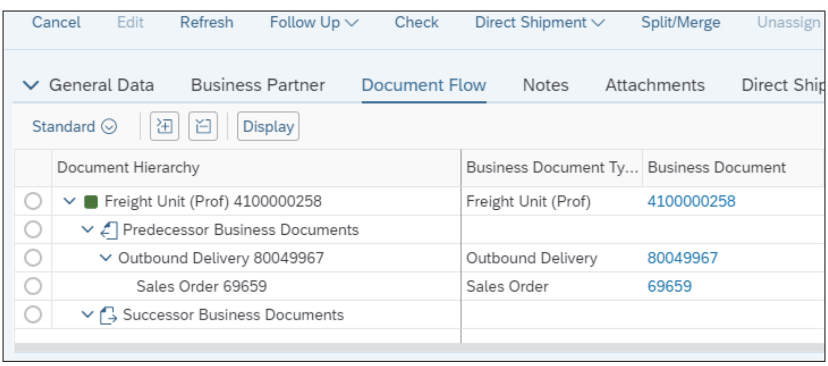


Figure 12.20 Document Flow: TM with Sales Order

When the deliveries have been created, they are visible in the EWM environment for further processing as ODOs. The SAP S/4HANA delivery is created with the proposed delivery date from TM.

If the EWM ODOs haven't been assigned to a transportation unit, these orders are locked for execution. When the transportation planning activities are finished, and the freight order status has been set to **Cargo Ready for Loading**, TM sends a loading instruction to EWM. This triggers the creation of a transportation unit in EWM.

In EWM, the transportation units are automatically assigned to the locked ODOs. With this assignment, the ODOs are unlocked and updated with the related carrier information from TM. Unlocked ODOs, assigned to a transportation unit, are now the basis for warehouse execution in EWM. As in the previous scenario, goods are typically picked by waves, put directly into SHUs, staged, and finally loaded on a truck. Posting goods issue/checking out the truck in EWM immediately adjusts the inventory in SAP S/4HANA, updating the outbound deliveries and the freight order in TM for a later freight cost settlement.

Inbound Planning with Warehouse Execution

In addition to outbound processing, the direct integration of TM with EWM also supports planning and execution for inbound processing. As has been mentioned for outbound, the planning process for inbound execution can be delivery-based or order-based. Therefore, TM sends freight order details to EWM. Warehouse execution for inbound—such as unloading and goods receipt—takes place in EWM. Given the seamless integration, TM is updated with the actual dates and quantities.

Delivery-Based Integration

The process starts with a purchase order and follow-up inbound deliveries. In EWM, the inbound delivery, which represents a warehouse request, and the starting point for subsequent activities in EWM are created.

Because of the transportation planning in TM, a freight order is created. As soon as the transportation planning activities are finished, and the freight order status has been set to **Cargo Ready for Unloading**, TM automatically sends an unloading instruction to EWM, triggering the creation of a transportation unit.

The inbound delivery, now being assigned to the transportation unit, contains all necessary information to trigger and monitor the goods delivery process in EWM. This process typically continues with the truck arriving at the yard and unloading the cargo, and finally ends with put-away of the materials in the warehouse. During unloading, the goods are moved out of the transportation unit from the door to a staging zone, consolidation zone, or work center for quality inspection, depending on operational needs. When yard management is used, the unloading process begins with the recording of the vehicle or transportation unit at the control point. Putaway in the destination storage bin completes the goods receipt process from a warehouse management perspective (see Figure 12.21).

After unloading, as soon as the warehouse worker has posted the goods receipt, the SAP S/4HANA inbound delivery is automatically updated. In TM, the relevant freight documents are updated accordingly.

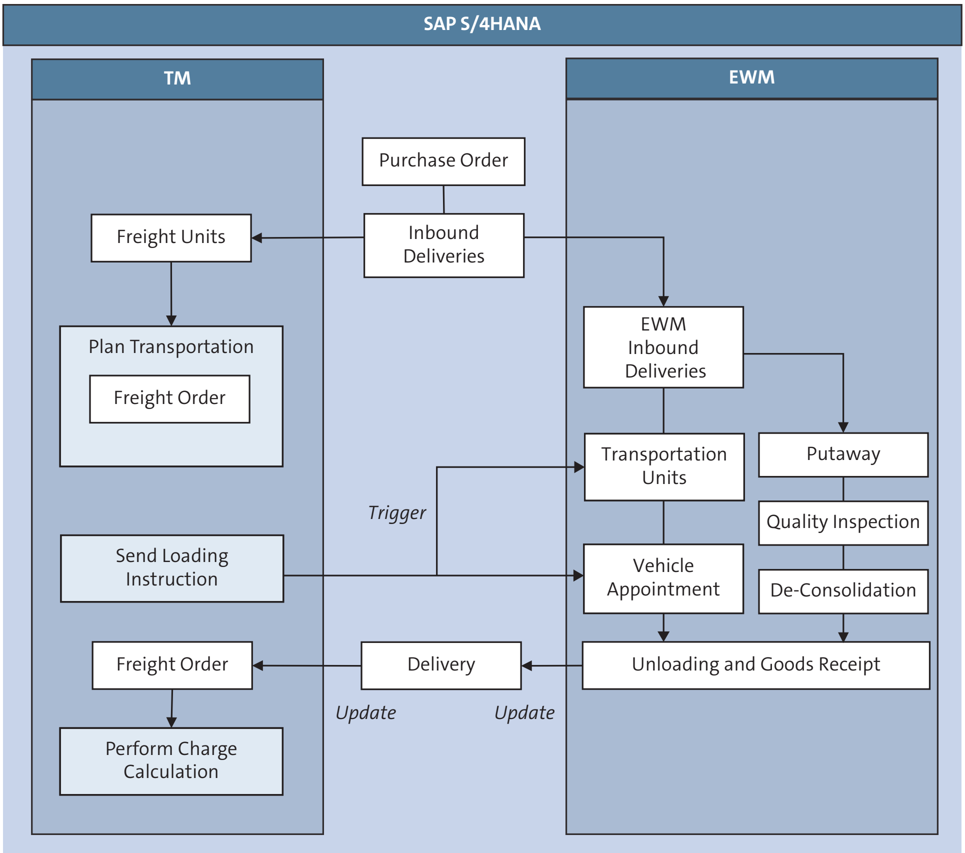


Figure 12.21 Order-Based Inbound Processing

Execution-Driven Planning

While in our example we describe how an integration based on TM planning works, there is also support for an EWM-driven approach: An empty freight order with source location, destination location, and delivery date is sent from TM to EWM based on the freight order Customizing. EWM creates an empty transportation unit to allow the warehouse worker to load the transportation unit. Upon departure, TM is updated with the loaded items and item hierarchy and assigns the corresponding freight units to the freight order accordingly.

For further details on this process, refer to *http://s-prs.co/v557509*.

Order-Based Integration

In the order-based scenario, TM plans transportation based on SAP S/4HANA purchase orders. These create freight units in TM. The freight units are planned on freight orders, and subsequently SAP S/4HANA inbound deliveries are created.

Warehouse execution is like the order-based integration mentioned previously. After goods receipt has been posted, the TM documents will be updated with the actual dates and quantities.

We've now introduced the integration of TM and EWM for SAP S/4HANA. The changes in this area have been mainly of a technical nature, whereas the process remained nearly the same compared to the previous version of this book.

Side-by-Side Integration

Note that while not explicitly mentioned everywhere, the integration of TM and EWM also still works in nonembedded scenarios, where either SAP TM, SAP EWM, or both are installed side by side with an SAP S/4HANA system. This is especially important for customers already running SAP TM or SAP EWM side by side and contemplating a conversion of their SAP ERP system to SAP S/4HANA: the integration to both systems will still be possible after the core system has been converted.

In the next section, we introduce the integration with transit warehouses based on EWM.

12.2.3 Integration with EWM for Transit Warehouses

In the previous section, we introduced the core processes and functional building blocks of warehouse operations based on EWM and gave an integrated process example based on standard integration scenarios with TM. In this context, we explained the integration and warehouse-internal processes for inbound and outbound operations for a typical distribution center scenario.

Now let's turn our attention to integration with EWM from a transit warehouse perspective. Globalization requires that products sometimes need to travel thousands of miles before they can reach a consumer. And in global transportation chains, numerous parties are connected in a supply chain and challenged to efficiently carry out logistics process going beyond transportation to involve handling, consolidation, rearrangement, staging, and other warehouse operations at intermediate locations. The general goal is to cover the physical distances and temporal periods between the location where the goods are produced and the location where they are needed efficiently.

Transshipment Operations

Freight forwarders can use TM together with EWM to solve transportation problems for their customers and efficiently manage transshipment operations at intermediate locations. These operations typically include transportation, transshipping, and storage of products in an integrated, cross-system scenario. The integration is based on execution documents resulting from forwarding orders, and it can help you organize the cargo flow over the entire transportation chain and get transparency regarding warehouse-specific data. To provide an efficient transport between two distant locations, diverse means of transport (e.g., trains, ships, trucks, or planes) are needed. The change in means of transport is called *transshipping*.

Therefore, a transshipment warehouse is used to store goods for a short period of time and generally only to transfer them to another means of transport. The focus is placed on movement processes. For this reason, the primary concern is generally not high storage capacity but rather high transshipping efficiency or high transshipping speed.

EWM provides both the functionality to consolidate, separate, and sort goods to create the most efficient transport possible and the performance and capabilities to handle transshipment operations, seamlessly integrated with TM.

Transshipments

In the previous section, we mentioned that TM is used for transportation planning and execution along the complete transportation chain, while EWM is used to manage the transit warehouses.

These transshipment locations serve as a bridge between the receipt and the dispatch of goods. From a transportation planning perspective, transshipment locations are transit warehouses in which goods are stored for a limited time and transshipped from one vehicle to another, while differences between receipt and dispatch can be addressed. As a rule, they are distribution centers, container freight stations, railway stations, gateways, or similar places where a change in transit carrier (e.g., from a truck to a plane) frequently takes place.

Integration of TM and EWM for Transit Warehousing

This section provides you with an overview of the main integration aspects of TM with EWM for transit warehousing by using an air freight scenario as an example.

Documentation

The current process description can be found at *http://help.sap.com*. Search for “SAP S/4HANA” and select the link for product assistance. Follow the path **Enterprise Business Applications • Supply Chain • Delivery and Transportation • Transportation Management • Integration • Integration with SAP Extended Warehouse Management**.

As you'll learn next, the outbound integration from TM to EWM is based mainly on LDAP requests known from the direct integration. The structure of this message is very flexible and can contain information resulting from freight orders as well as freight bookings. Supporting different scenarios, it offers a flexible structure to send context-specific information to EWM. This context is mainly specific to locations and transportation chains, and it usually varies regarding the granularity and structure of line-item hierarchies and clear instructions reflecting how capacity and cargo items are nested in a specific business context.

The following sections provide you with an overview of how this integration generally works while familiarizing you with the functional building blocks of transit warehousing.

In previous chapters, you've seen that freight documents in TM use different item categories to define the goods to be transported, as well as the capacity to do so. From an integration perspective, with EWM, we therefore need to distinguish between *cargo items* and *capacity items*. Both items can have a hierarchy where, for example, cargo items are normally assigned to capacity items (refer to Chapter 6, Section 6.1).

Capacity items are transportation resources, whereas cargo items are typically *package items* (PKG), *containers* (TUR), or the *products* (PRD) themselves. *Transportation resources* can be active or passive (refer to Chapter 3, Section 3.3). *Active vehicle resources* (AVR) are self-propelled and can drive by themselves (e.g., trucks), while *passive vehicle resources* (PVR) must be coupled to an AVR to move (e.g., trailers).

In EWM, the warehouse-specific processes are based on business documents that are created using loading and unloading instructions that are sent from TM. You can configure the warehouse layout according to the specific requirements of the transit warehousing process. For example, specific storage types are available, and a product master is no longer necessary. Further, the handling of cargo is done on the package level and not on the product level.

The integration itself starts in TM. After a transportation planner finishes planning freight orders, the execution of loading or unloading steps in a warehouse system can be triggered by setting the status for **Unload Plan/Load Plan Finalized**. TM uses LDAP requests (loading appointments based on SAP Process Integration message `TransportationOrderLoadingAppointmentRequest_IN`) to integrate freight orders with EWM. These requests are mapped to EWM, finally creating documents, vehicles, transportation units, and planned HUs for inbound and outbound processing. After the warehouse operations have been executed, EWM communicates the loading or unloading results back to TM. This LDAP notification is based on SAP Process Integration message `TransportationOrderLoadingAppointmentNotification_OUT`.

To illustrate the complete process, we'll use an air freight example for an end-to-end transshipment process as depicted in Figure 12.22.

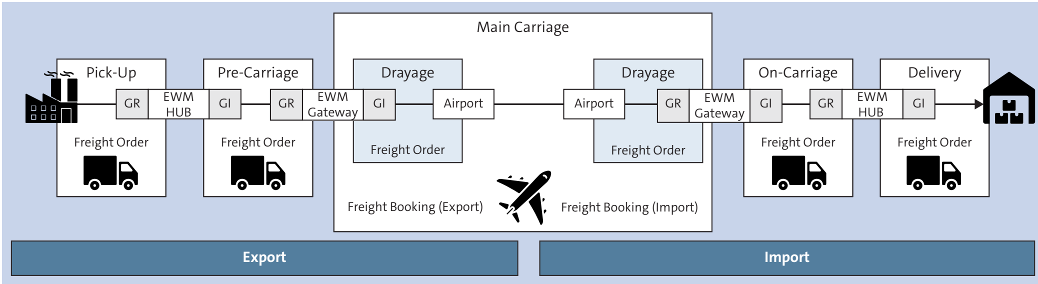


Figure 12.22 End-to-End Air Freight Transshipment

As Figure 12.22 shows and was previously described, the goods pass several warehouse locations before they reach their destination. From a TM perspective, the objects involved in the communication with EWM are freight orders and freight bookings. In each warehouse along the transportation chain, a goods receipt and a goods issue process take place. Information on incoming and outgoing trucks and planned goods to be transported is supplied by TM.

Note

Although an air freight scenario serves as our example, the same procedures can be applied to ocean freight as well.

In the next two sections, we'll discuss the inbound and outbound processes for one location in the transportation chain. We'll then proceed with an example to illustrate the process further.

Inbound Integration

In a transit warehouse, only packages are moved. Typically, the warehouse system knows the attributes of the package content, while the content itself doesn't correspond to a product master record. For EWM, that means this integration with TM doesn't support product master records. The "content" attributes and characteristics are stored at the document level and received via an LDAP request or are manually maintained in the receiving process.

The basis for the process is the creation of a forwarding order in TM, where the intended route is either entered manually, via default route, or automatically determined by the system with the help of a transportation proposal.

Constraints and Functional Scope

The described functionality focuses on freight forwarders and is currently not foreseen for shippers, so the execution of this process always relies on forwarding orders as the base document.

Corresponding freight units are then planned on a freight order, which is the object that's relevant for integration. The messaging to EWM is triggered based on the created freight order.

TM sends an LDAP request (`LoadingAppointmentRequest`) to the destination, an EWM location, after the *unload plan finalized* action is triggered. The freight order includes at least packaging items (PKG) from a shipper (see Figure 12.23). EWM then creates the corresponding transportation unit, an inbound delivery for each freight order, a delivery item for each package item, and planned SHUs for the corresponding item quantities.

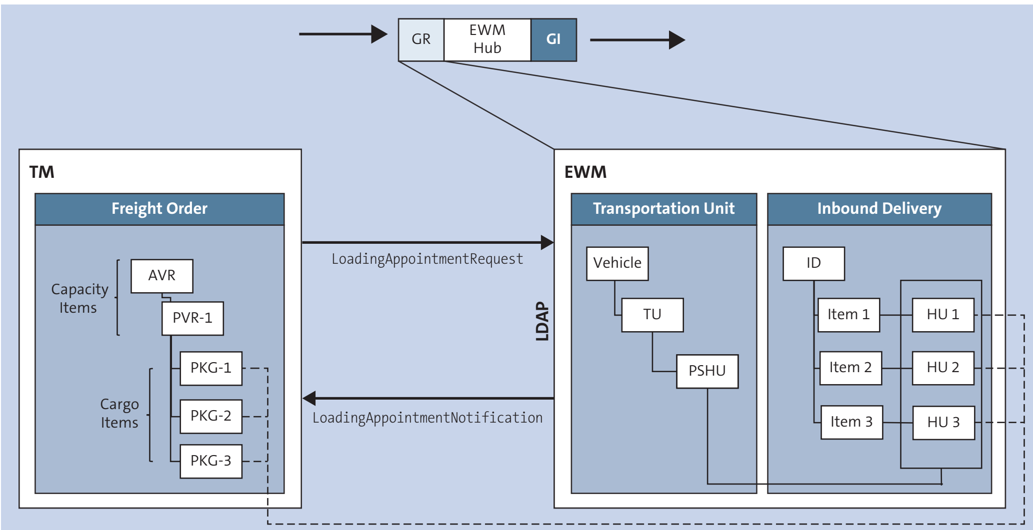


Figure 12.23 Integration in Transit Warehouse Processing: Inbound

In a standard EWM inbound process, HU items are linked to delivery items, while a top HU is linked to the inbound delivery header. This reference is lost after the delivery is put away. As we mentioned earlier, a transit warehouse doesn't need product items and therefore can't link the HU to a delivery item. In order not to lose the reference to the inbound delivery after the delivery is put away, HUs in this integrated scenario have a permanent reference to the corresponding delivery item and won't lose it after putaway. The arrival of the truck, unloading, and goods receipt is confirmed to TM via the `LoadingAppointmentNotification` message, where it updates the freight order.

After the goods receipt has been posted, the HUs change their status from **Planned** to **Existing**. Alternatively, if package items are already received in another transit location, TM sends the exact HU identification to EWM, together with the information of which HU is assigned to which vehicle resource. This typically happens in a second warehouse after the cargo is received at a previous transit location and the HU identification was sent to TM via an LDAP notification. TM can now send detailed information specifying which HU is nested in which PVR. In EWM, these HUs are also created as planned HUs with the existing HU identification from TM as an external HU identification.

For inbound processing in an entire transportation chain, the integration between TM and EWM supports both the initial receipt of cargo items at an entry location and their relationship to capacity items as soon as cargo is received at an intermediate location. Gateway locations are typically the last consolidation location before cargo is transported on the main carriage. From a system perspective, the main carriage and drayage order to physically hand over cargo from the gateway location to, for example, the ground handling agent at a departure airport, is represented by freight bookings.

These freight bookings have all the information such as which capacity items are expected in EWM for outbound processing at the gateway location. For air freight, this typically means containers or unit load devices (ULDs).

For air freight scenarios, these ULDs represent specific containers or pallets used to load freight and cargo onboard an aircraft. In this context, the LDAP request from TM contains mainly TUR items representing a container or ULD. Based on that information, EWM creates either a transportation unit for ocean freight or an HU for air freight.

Because the freight booking has no information about the vehicle bringing the container or ULD, it needs a second message to send these relevant freight order details to EWM and create a corresponding transportation unit for this drayage freight order. This order is used mainly to cover and document the short distance of the intermodal transport between the gateway and the means of transport itself.

Outbound Integration

Like the inbound integration, TM also uses LDAP requests to send outbound-relevant information and trigger the warehouse execution for packing, staging, and loading in EWM. These requests are based on freight orders containing information about the freight (SHU) that is loaded onto a freight order, as well as freight bookings containing information about HUs and TUR items that need to be packed or nested. For the intermodal transport and to finally hand over ULDs (e.g., to a ground handling agent), TM also uses drayage freight orders to specify which ULD is loaded onto which transportation unit.

We've already mentioned that these LDAP requests contain both cargo items and capacity items. For outbound processing, that means TM sends all relevant items, if needed in a hierarchy, to trigger the creation of planned HUs in EWM and to specify which of these HUs will be loaded onto which transportation unit (see Figure 12.24).

The integration typically starts with the LDAP request (`LoadingAppointmentRequest`) containing freight order information specifying the AVR and PVR being used for loading outbound processing. In this context, TM can send either rough information about cargo and capacity items or the exact hierarchy specifying which SHU must be packed in which transportation unit.

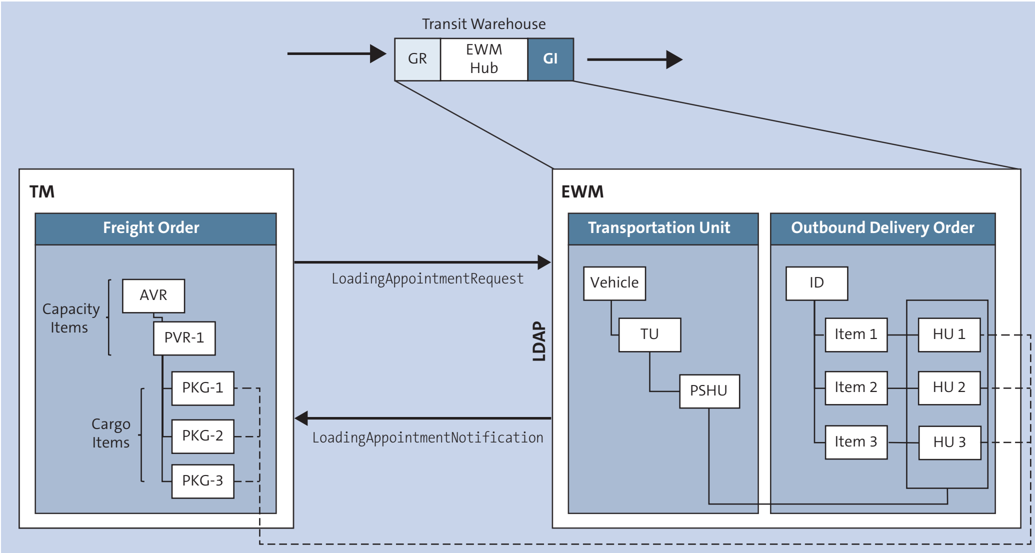


Figure 12.24 Integration in Transit Warehouse Processing: Outbound

In the case of freight bookings, as has been mentioned previously for the inbound integration, TM sends a loading appointment request. If EWM is provided with a HU container (PSHU), it packs the ULDs according to the provided PSHU. After completion, EWM sends the LDAP notification (`LoadingAppointmentNotification`) to TM. This notification is sent for each ULD and contains the actual HU, which is picked into the ULD. It updates the TM freight booking and freight units with this information.

Alternatively, TM can send less detailed information without clear instructions regarding which PKG items are nested under which TUR item. EWM then creates the transportation unit with a PSHU itself and reports the results back to TM with a `LoadingAppointmentNotification` to update the freight booking and freight units.

To finally cover and document the short distance of the intermodal transport between the gateway to the place where the goods are to be loaded on the plane, TM also sends a message to communicate details of this drayage freight order to EWM. This message creates a corresponding transportation unit in EWM and contains all ULDs that are loaded on a transportation unit to transport the ULD to the airport.

Sample Air Freight Scenario

In the previous section, we explained the main characteristics and principles of the system integration for transit warehousing. In this section, we illustrate this using an air freight scenario from shipper to consignee (refer to Figure 12.22).

Air Freight Scenario Specifics

Note that we won't describe the specifics of how to execute an air freight scenario in this section. We'll rather focus on the steps that need to be performed to allow integration into EWM for performing the transit warehousing process. For further information on air freight bookings, refer to Chapter 6, Section 6.2.2.

This sample scenario starts with a forwarding order (export) 1100009315 to ship goods from a shipper in Japan to a consignee in the United States. Figure 12.25 shows the forwarding order for this air freight export scenario in TM.

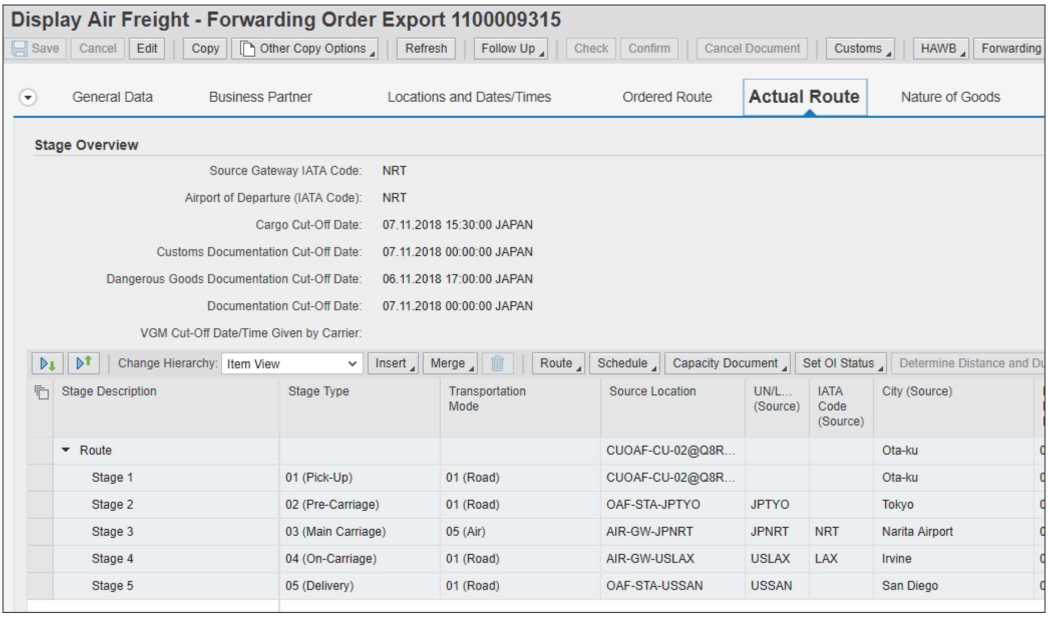


Figure 12.25 Forwarding Order in TM

For this scenario, it already contains all relevant stages (**Stage 1** to **Stage 5**), from picking up the cargo from the shipper and receiving it at the first transit warehouse location in Japan, the domestic pre-carriage to the departure airport, and the main carriage to the United States, with the on-carriage and final delivery to the consignee.

Let's walk through these stages:

1. **Pickup**

   For the first stage, a pickup freight order is created. Freight units are assigned to the respective freight order, and the cargo is picked up from the customer and brought to the EWM hub.

   After the freight order has been set to **Ready for Transportation Execution**, and the **Load Plan Status** is set to **Unload Plan Finalized**, the `LoadingAppointmentRequest` is sent to EWM.

   EWM receives the LDAP request with the inbound transportation planning result from TM. In this example, this message contains information about the truck bringing pallets from the shipper to the transit warehouse. HUs and transportation units are created in EWM.

Figure 12.26 shows the freight order that is inbound to the warehouse and the items that are reported to EWM for processing, in this case, six pallets. Changes can still be made on the forwarding order and resent to EWM via the **Load Plan Finalized** status until the cargo is reported as **On Hand**.

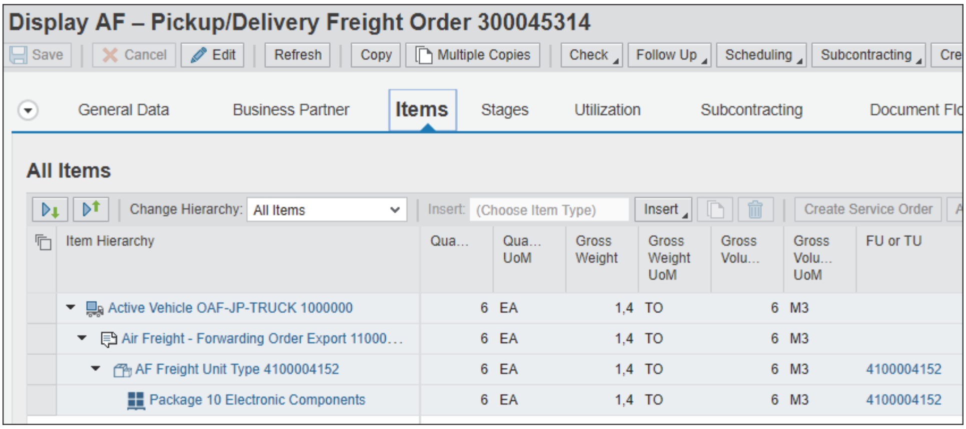


Figure 12.26 Pickup Freight Order

After the truck arrives at the warehouse yard, EWM starts sending updates to TM. The truck is unloaded, and the six pallets are received as HUs and put away in the transit warehouse. EWM posts the goods receipt for the unloaded HUs and automatically determines a putaway bin.

Several `LoadingAppointmentNotification` messages are sent for the statuses **Arrival at Destination**, **Unloading End**, and **Departure**. Discrepancies that occur during the warehousing process, such as missing or damaged goods, are also part of the EWM-TM communication and can subsequently be addressed.

Documentation

For further detailed information on discrepancy handling, refer to *http://s-prs.co/v557510*. The discrepancy handling for transit warehousing is specifically described there.

2. **Pre-carriage**
   To transport the HUs to the export gateway, TM sends the outbound transportation results to EWM. In this context, the LDAP request contains all relevant information to move the cargo from a transit warehouse **JPTYO** to a next transit warehouse (refer to Figure 12.25). This outbound process represents **Stage 2** in forwarding order **1100009315**.

For the second stage, another freight order is built, and the cargo assigned to it. From a TM perspective, the only difference in the handling of the freight order is the setting of the status **Load Plan Finalized** instead of **Unload Plan Finalized**.

The respective freight order is received in EWM, and the transportation unit with respective HUs and an ODO are created. Because the goods have already passed an EWM location, the outbound HUs are automatically linked with their unique EWM identifiers and referenced to forwarding order **1100002021**.

For loading activities and for the departure of the truck, EWM updates TM again with a `LoadingAppointmentNotification` message, based on which the statuses in TM are updated.

The same freight order is used to inform the gateway about the incoming goods via setting the status **Unload Plan Finalized**. Inbound handling happens once more, as is described in the previous explanation of the inbound process.

3. **Main carriage**

   According to the sample scenario, the truck finally arrives at the gateway location **JPNRT**, where the cargo is unloaded and staged, before it departs for the main carriage from Japan to the United States. This step, **Stage 3** in our air freight scenario (refer to Figure 12.22), requires an air freight booking.

   Figure 12.27 shows the export air freight booking **400007868**. In the **Overview** tab, TM shows the current state of the planned and executed warehouse steps, including the **Load Plan Status** and EWM transmission status for each of the stages. In addition, in the **Capacity and Cargo** tab, the expected ULDs and their content is described. After the **Load Plan Finalized** status is set in the freight booking, the `LoadingAppointmentRequest` is sent to the EWM system.

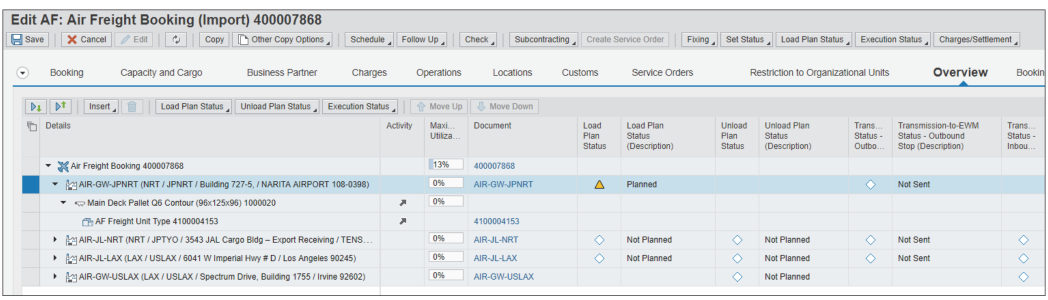


Figure 12.27 Air Freight Booking Overview

4. **On-carriage**

   To prepare loading and double-check that the outbound quantities are staged, EWM delivers its own transactions to supervise the receiving progress and prepare loading and unloading activities for freight bookings while monitoring the scheduled departure times.

   After all HUs are loaded into the respective ULDs, the process is confirmed to TM, and the corresponding freight booking and freight units are updated.

5. **Delivery**
   For the last stage, a freight order for pickup is created from the freight booking **Cargo Management** tab, as shown in Figure 12.28. The transit warehouse process for this freight order is exactly like the one mentioned in the pre-carriage step.

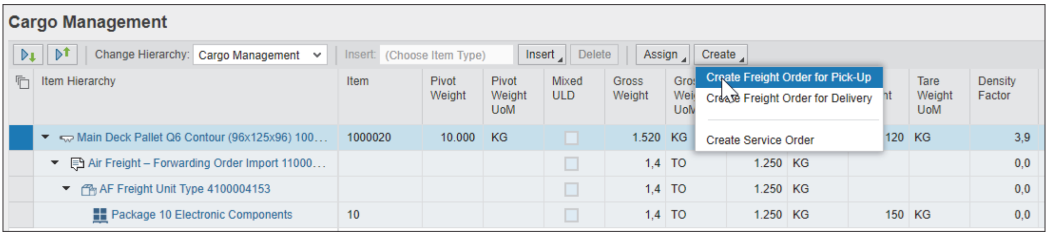


Figure 12.28 Creation of Pickup Freight Order

After loading is completed, EWM again sends the LDAP notification back to TM containing the actual quantities that have been loaded into the truck. The truck finally covers the last mile and transports the ULD from the gateway to the place of loading. With the plane departing and the execution of the main carriage occurring, the freight booking is set to **Uplift Confirmed**, the export process ends, and the import process starts at the destination airport. Export freight booking and export forwarding order are copied into the respective inbound documents, and the process continues.

The completed document flow, recorded in the forwarding order in TM, is depicted in Figure 12.29.

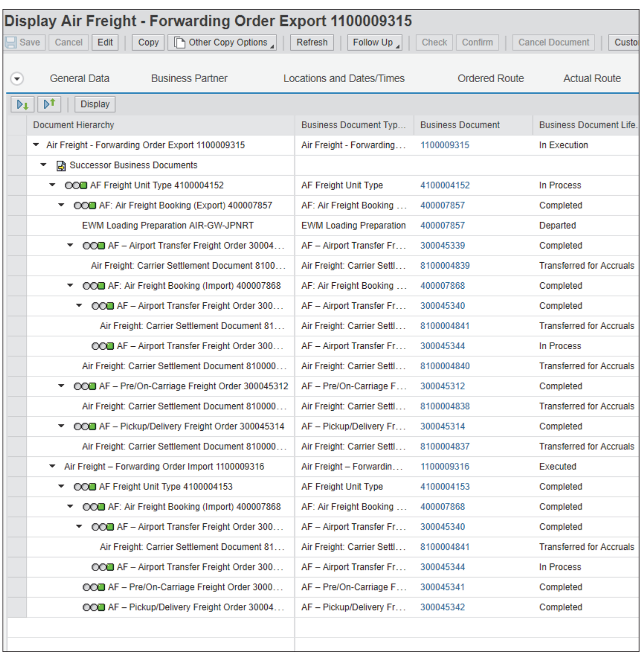


Figure 12.29 Document Flow of the Completed Air Freight Process

12.2.4 Warehouse Billing

Upon the creation of TM, there was a decision that a dedicated transportation management system would need a flexible and powerful charge management framework that allowed for the maintenance of rate structure across all modes of transport while considering the necessities of a very diverse methodology for the calculation of charges across the globe. Since its creation, transportation charge management has evolved, and it still adds new capabilities with every release. Contrary to this, EWM didn't have similar requirements upon its creation, so no framework for charge calculation is embedded in the software.

With the trend of outsourcing warehouse-based activities and processes, cost calculation became a necessity to determine the value of services performed in a warehouse. As an example, a LSP using EWM regularly performs value-added services such as packaging and relabeling of goods for its customers. Both parties agreed that these services will be charged at the end of each month. The LSP uses its EWM system to keep track of how often the respective actions were performed, to calculate the amount to be charged, and to trigger the billing process.

There are two process variants for warehouse billing depending on who performs the service in the warehouse and ultimately who runs the SAP system in the process:

- The LSP performs services for a customer. It measures how often the ordered actions have been performed and subsequently bills the customer for an amount that was calculated based on this data.
- The customer tracks services performed by an external party. These measurements are used to calculate the costs of the services performed. The amount is settled via self-billing.

  Billing and self-billing in both scenarios happen periodically.

In this section, we'll give an overview of both variants. The overall transportation charge management process on which the warehouse cost calculation depends is described in Chapter 9, Chapter 10, and Chapter 11, so we'll focus mainly on the integration aspects here. As usual, we'll look at the process from an SAP S/4HANA perspective; however, it will run the same way in a side-by-side installation scenario.

Measurement of Services and Billing to Customer

This scenario fits the air freight situation we introduced in Section 12.2.3. The LSP will measure the services performed and bill the customer(s) periodically. The LSP is also accountable for providing proof on which basis the billing was performed if necessary.

At the start of the process depicted in Figure 12.30, a forwarding agreement is created in TM. The line items of the linked calculation sheet represent the services that are to be measured. The calculation base for each item is `quantity_val`. A remark can be added to each charge line to clarify which measurement is expected as the basis for the calculation of costs.

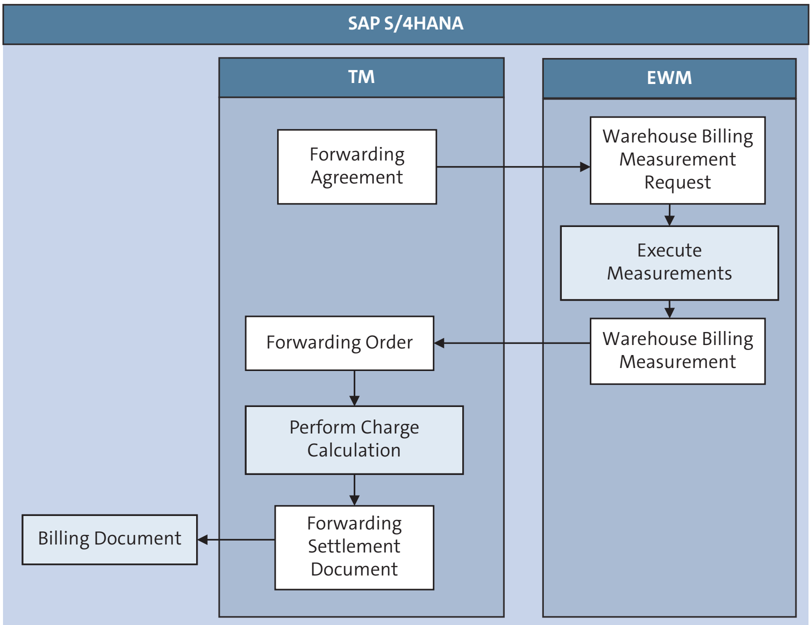


Figure 12.30 Warehouse Billing Process

After the release of the agreement this is the starting point for the EWM operations and is used to define which measurements are to be used to determine the cost of services performed. For changing the TM forwarding agreement after this step, it must be set back into the **In Process** status. After its subsequent release, the changes will be reflected in EWM. The periods in which the amounts will be settled, and the warehouse measurements will be performed is maintained in the business partner master data as a factory calendar.

In EWM, the received *warehouse management billing request* (WMBR) is reviewed by an expert who decides which EWM measurement service is to be used to determine the correct amounts (20 pre-delivered services are available).

The service amounts are periodically calculated based on *snapshot tables* in EWM. These snapshots are used to document the situation in the warehouse at distinct measurement points by providing a picture of the database at that time, as well as providing proof of the services performed when required.

The calculated amounts are finally sent to TM in SAP S/4HANA, where they create a forwarding order. The warehouse charges can then be calculated based on this object. The subsequent steps are the creation of the forwarding settlement document and the billing in the SAP S/4HANA digital core, as described in Chapter 11.

Note that after the agreement has been created in TM, and the measurement services have been assigned in EWM, the subsequent process steps occur periodically and can be automated so that no further user interaction is required to perform the billing.

Measurement of Services and Self-Billing

The process steps in the self-billing scenario don't change, but the objects used in the TM system are different. In this process, the customer outsources work to an LSP. The customer runs the EWM and TM systems required to measure the services performed and, in the end, performs a self-billing with the LSP to settle the cost. The changed objects in TM are listed as follows:

- At the beginning of the process, instead of a forwarding agreement, a freight agreement is created. For more details on freight agreements, refer to Chapter 9.
- The document created to calculate the cost of the measured services is a service order in TM.
- Consequently, the document that initiates the self-billing on the TM side is the freight settlement document. For further details on the charge settlement process, refer to Chapter 10.
- In the last step, the purchase order and service entry sheet are created in the SAP S/4HANA digital core where accruals-posting and self-billing are performed.

This concludes our brief description of the process variants for warehouse billing. We've discussed how costs for warehouse activities are calculated to perform either a self-billing to an LSP or to bill a customer periodically. For further information about this process, refer to *http://s-prs.co/v557511*.

12.3 Advanced Shipping and Receiving

SAP TM and SAP EWM were initially created as side-by-side solutions. Since SAP S/4HANA release 1709, as we've discussed, both solutions were integrated into the suite as embedded functionalities. By operating on the same platform as the core ERP, several design simplifications have become possible.

Apart from streamlining master data, configuration, and logistics execution integration processes, further architectural changes help to integrate EWM and TM by sharing the same object for logistics execution. The transportation unit as a baseline for integration is being replaced by the freight order, which can now be accessed in a warehouse context as well. All updates that are done to the freight order can hence be made available in both solutions immediately, removing the need for additional synchronization between transportation unit and freight order.

The *advanced shipping and receiving (ASR)* functionality is a new method to connect warehousing and transportation in an SAP context. It's no enhancement of the current transportation unit integration, but rather something completely new, which is intended to be the standard way of integrating warehousing and transportation in an SAP context. Transportation unit-based and ASR warehouse integration can run in parallel, allowing for a smooth transition from one scenario to the other. This protects investments into already-existing integration scenarios, while at the same time enabling to utilize the newly created processes.

In the following sections, we'll first show how ASR has simplified supply chain execution. We'll then walk through the warehouse-driven ASR process, taking a closer look at both outbound and inbound processing. We'll conclude with a look at integration with customs and TM.

12.3.1 Simplifications

In Figure 12.31, the transportation unit-based integration between TM and EWM is shown in comparison to the new ASR functionality. As depicted, when being part of the same SAP S/4HANA instance, both ways of integration work and can even be used in parallel (if the shipping points are different).

ASR with Standalone SAP TM and/or SAP EWM

At the time of writing, the ASR functionality isn't available for architectures where either SAP TM, SAP EWM, or both are used standalone. According to the official roadmap, this is to be addressed in 2023, when this book is already published. Refer to SAP Note 3232331 to determine the currently active restrictions for the ASR functionality.

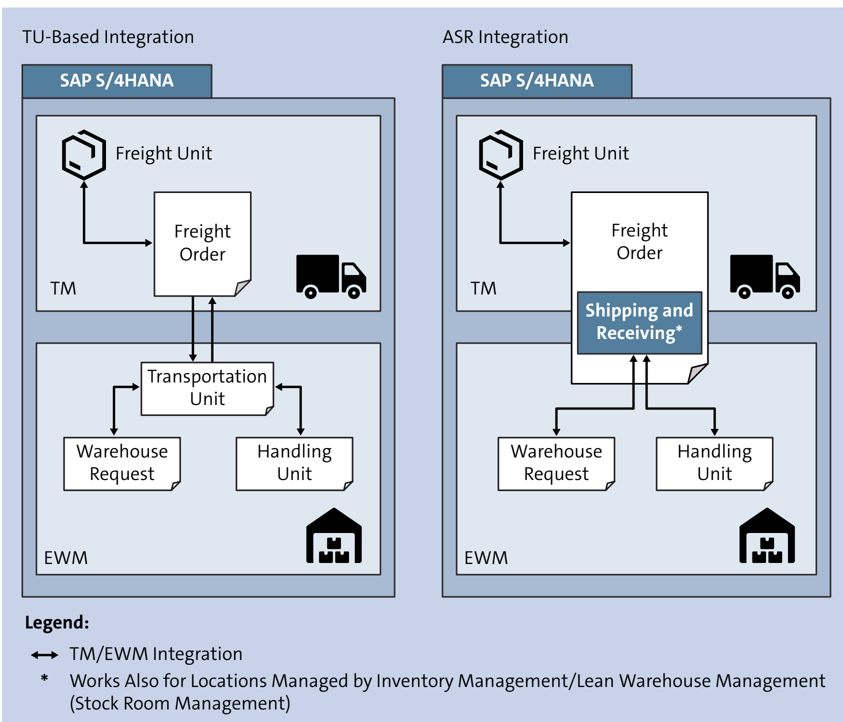


Figure 12.31 ASR Single Object Integration

The architectural change came with a set of simplifications that strengthen the overall supply chain execution capabilities, reduce causes of error, and make handling easier:

- **Alignment of the message structure**
  One such change is the alignment of the message structure for dispatch advices and advanced shipping notifications (ASNs). Contrary to the previous IDoc structure, both are aligned with the Electronic Data Interchange for Administration, Commerce, and Transport (EDIFACT) standard to allow for easier field mappings. They use TM freight orders or consignments as base objects. In systems where TM is used on the sending and receiving side, mapping isn't necessary at all.

  For an example of mapping to the Vendor Document Automation (VDA) communication standards, refer to SAP Note 3236759.
- **Consignments**
  Together with the introduction of ASR, a new object for planning was introduced, which allows for freight units to be further consolidated into consignments. Grouped freight units that share the same source, destination location, and multiple consignments can be assigned to one freight order. This is used as a way of communicating on a grouping of freight between suppliers and customers and is a de facto standard, for example, in the automotive industry, so it was introduced to TM. See Chapter 6, Section 6.3, for more information. Consignments are fully supported for TM-EWM integration with ASR (but not mandatory).
- **Loading and unloading points**
  New planning-relevant master data elements have been introduced, namely loading and unloading points, which resemble one or a grouping of warehouse doors. Physically, these points are located in front of the respective warehouse doors. Several such points are allowed per warehouse. One loading and unloading point can be linked to multiple warehouse doors, and doors can be shared between inventory management, EWM, and stock room management. Therefore, loading and unloading activities can be reported independent of the underlying SAP warehouse technology (inventory management stock or lean warehouse management, stock room management, EWM), allowing a mix of the respective deliveries on one freight order and/or consignment. Unloading/loading points are created using Transaction /N/SCMTMS/LOC3, choosing location type 1200. For assigning stock room management or lean warehouse management doors to loading points, a new SAP Fiori app was created called Assign STRM Doors to EWM Doors or Loading Points. Note that in EWM, loading point to door assignment is done using Transaction /SCWM/DOOR_SCU.
- **UI improvements**
  Several UI changes support the new integration; the most prominent are as follows:
  - New fields in the delivery show the ASR relevance:
    - In the **Picking** tab of the outbound delivery
    - In the **Stock Placement** tab of the inbound delivery

- New fields are enabled for ASR in TM and EWM:
  - Status updates (handling execution status, warehouse door status, warehouse processing status, goods movement status)
  - The new **Advanced SR** tab in the freight order
  - Unloading/loading points in the freight order overview
- UI enhancements in the transportation cockpit
- Worklists for handling consignments in the transportation cockpit
- Object page for consignments
- The new Load or Unload Freight Orders app
- A new button, **Set Ready for Warehouse Processing**, in the freight unit/freight order

- **Advanced error handling**
  Advanced error handling for inbound messages has been introduced in ASR. Within the freight order, a new tab called **Document Errors** is available, where existing errors can be displayed and resolved, and past error resolutions can be displayed. Whenever issues such as master data errors are resolved manually, an entry can be stored in a database, so that in the future, the system can make suggestions on how to resolve the same issue (most frequent solution, most efficient solution, or last solution).

  Note that for automatic error resolution and suggestions, additional Customizing is required by going to **Transportation Management • Basic Functions • Error History**.

  Resolved errors can also be enhanced with further information on the error reason (e.g., **Reason code 1: Data in supplier system is outdated**) and the preferred procedure (e.g., **Procedure Category 1: Contact supplier**) to correct the issue. To allow error corrections for externally produced freight orders, a new freight order Customizing setting is available.

All these architectural changes are aimed at a set of processes and simplifications that are made available with the ASR integration. In the next section, we'll introduce one of the processes that was used as a baseline for the ASR functionality.

12.3.2 Warehouse-Driven Execution

The general scenario depicts a situation where a producer of finished goods orders materials via a schedule line call-off from a supplier, each using their own SAP S/4HANA system with TM and EWM embedded and configured. After confirmation, the order is picked, packed, and consolidated into consignments at the supplier side, transportation is planned, and the respective advanced shipping notifications (ASNs) for the consignments are sent to the customer.

At the customer side, the consignments are received and linked with existing freight units and recorded freight orders. Inbound processing is completed in the warehouse. Figure 12.32 shows the involved objects in relation to each other and the system messages for the described process example.

Note that, in our example, we specifically describe a freight order scenario with a single leg (multiple loading and unloading points are possible, but not multiple start and end stops for the stage planning). As of the time of writing, this is the only scenario that is covered by the end-to-end ASR process. In addition, note that there could be variants of the process described where planning is done in TM instead of in an external system, and certain steps are performed manually instead of sending/receiving EDI messages. We decided, however, to describe the core process that was leading the design phase of the ASR process for a better understanding of the vision behind it.

Batches and Serial Numbers

The ASR process is able to consider serial numbers, batches, and just in time (JIT)/just in sequence (JIS) calls within the ASN messages.

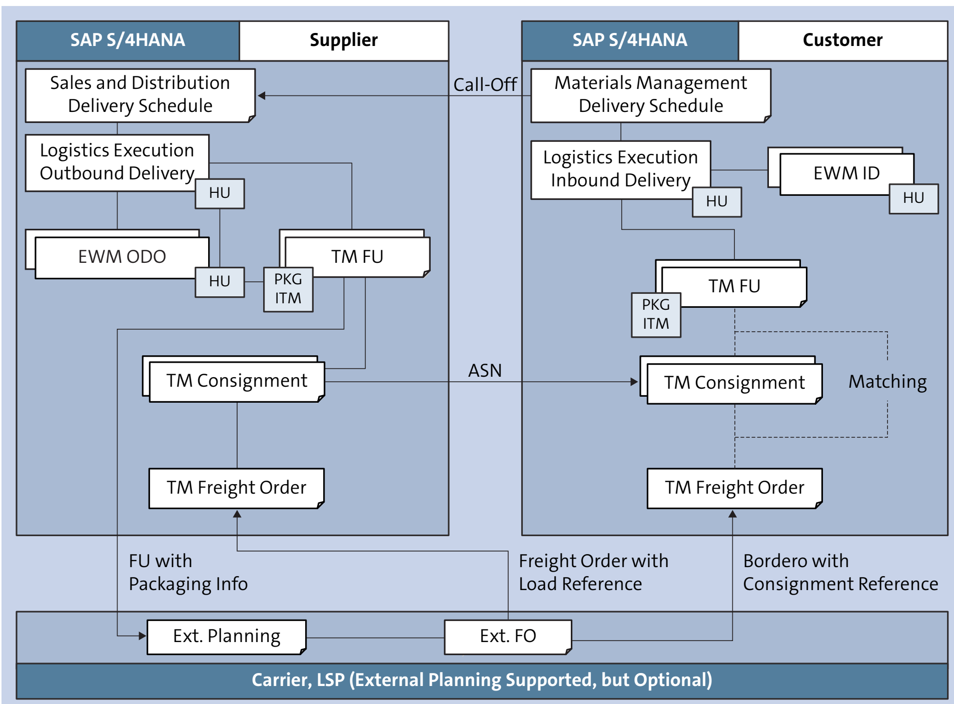


Figure 12.32 ASR Process Example

Within the depicted example, consignments are being used as a way for the customer and supplier to communicate on the packed goods that are being sent. EWM is being used as the warehousing solution. External planning by an LSP is being utilized, and the results of an external transportation planning are received back into the system in the form of a freight order (alternatively the planning can, of course, also be done within TM). We'll provide an overview of the end-to-end process in the following sections.

The example we use is warehouse driven; that is, goods are being picked and packed before transportation planning starts. In Section 12.3.3, we'll also briefly touch on the transportation-driven process (i.e., TM planning before warehouse handling) and where it deviates.

> **ASR Process Setup**
>
> The prerequisite system for ASR is minimum release SAP S/4HANA 2020 FPS01 with EWM and TM running embedded on the same client.
>
> For detailed instructions on how to set up SAP S/4HANA for ASR, refer to SAP Note 3225241. The guide shows the complete setup for an outbound and an inbound example, including configuration and master data.

Outbound (Supplier) Processing

The outbound process for the supplier starts with a sales order or a call-off from an existing scheduling agreement with schedule lines. The creation of the subsequent deliveries causes the creation of freight units.

The next steps align the warehouse activities with the transportation planning activities via statuses. In a warehouse-driven environment, the warehouse status of the freight unit changes immediately to **Ready for Warehouse Processing** to be seen in the **Planning and Execution** area of the **Status** tab in the freight unit (see Figure 12.33). At this stage, the freight unit can be used for freight planning, but item changes aren't allowed.

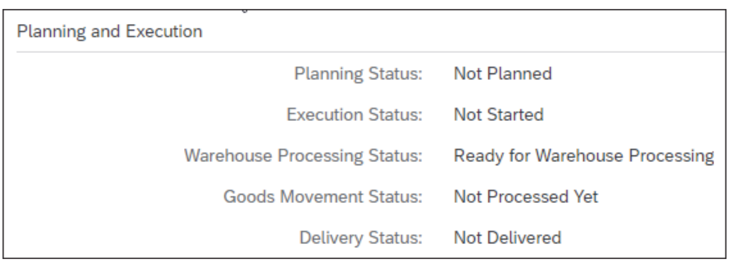


Figure 12.33 Warehouse Status: Ready for Warehouse Processing

On the EWM side, an ODO is created with the **Planning Type F** (**E** for transportation-driven scenarios). Warehouse processing can begin immediately. Once the picking and packing to HUs starts, the warehouse status on the freight order changes to **In Process**.

Once all warehouse tasks for picking and packing the products into SHUs have been completed, the status of the ODO is changed to **Ready for Shipping**. The freight units in TM are updated with the packing information and the warehouse status of the freight unit changes to **Completed**. Note that the same functionality would also work for stock room or lean warehouse management warehouses, updating the status when picking and packing are finished.

When the warehouse processing is completed, the work continues with a freight order. The respective freight order can either be supplied by an external carrier/LSP as depicted earlier in Figure 12.32 (sending out freight units and receiving the freight orders and their respective freight unit assignments) or created within TM. We won't describe the freight order creation process in detail here, as the focus of this chapter rather lies in the processing of the warehouse-relevant steps. A comprehensive guide on planning and freight order creation is given in Chapter 5 and Chapter 6.

As an additional object for planning and communication, consignment orders can be created (only for single, linear stage freight units). Each consignment has a specific ID and links to one or multiple freight units. Within our example, we'll use the created consignments to report which products will be delivered to the customer on a specific date. Each created consignment is linked with exactly one freight order (which itself can contain more than one consignment order). Consignments can either be built manually via the Create Consignment Order app or, as in our example, they can be built automatically using a consignment order building profile in the freight order UI (clicking on **Follow Up • Build Local Consignment Orders**). See Chapter 6, Section 6.3, for details on consignments.

In Figure 12.34, the item section of the freight order is shown, also giving the details about the EWM ODO ID (which also appears in the freight unit document flow), item (packaging) hierarchy, and loading points. The **Advanced SR** tab gives additional warehouse details for planned and actual warehouse numbers, doors, and loading/unloading points. Note that two consignment orders have also been created for each of the freight units and assigned to the vehicle resource.

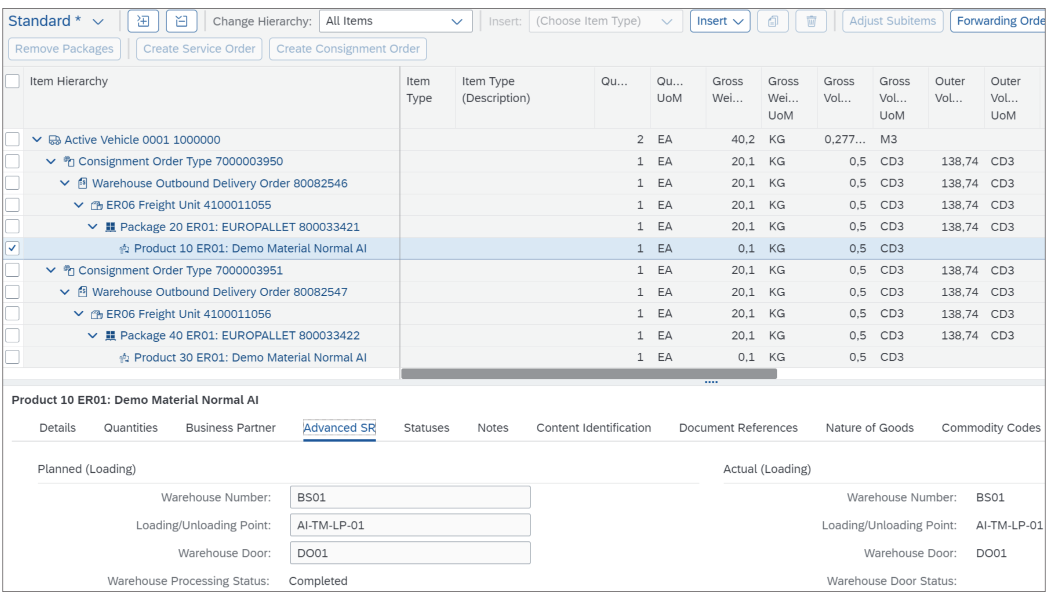


Figure 12.34 ASR Completed Item Details

After the freight order, including consignments, is planned and the subcontracting is done, we set the **Execution Status** of the freight order to **Ready for Transportation Execution**. With this, the next step in our process can be initiated: the arrival of the truck and the subsequent loading.

First, we perform the truck check-in when the truck has physically arrived at the door. This can be done directly from the freight order overview page by selecting the active vehicle resource or the loading stop and selecting **Execution Status • Set to Checked In**. Alternatively, this status could also be set electronically, for example, by checking in the truck in SAP Yard Logistics. The respective status also triggers an event, which is visible on the **Execution** tab of the freight order.

Subsequently, the **Arrived** status is set in the same manner to indicate that the truck has reached the door. This locks the door for the respective freight order until the status changes to **Departed from Door**, and no other freight orders can be booked on this door during this time (this system behavior can be suppressed, but for our example, in the master data of the used loading point, the **Allow Multiple Door Assignments** checkbox was set).

As a next step, the packages are loaded onto a truck. While it's possible to do this directly in the freight order overview UI, we rely on a warehouse worker to do it and use a new SAP Fiori app specifically created for this purpose: Load or Unload Freight Order. Within this app, a freight order can be selected, and only the specific activities to be performed for this object at the point where the warehouse worker is logged in are displayed. In Figure 12.35, the activities for a freight order in the outbound stop are shown with their respective status.

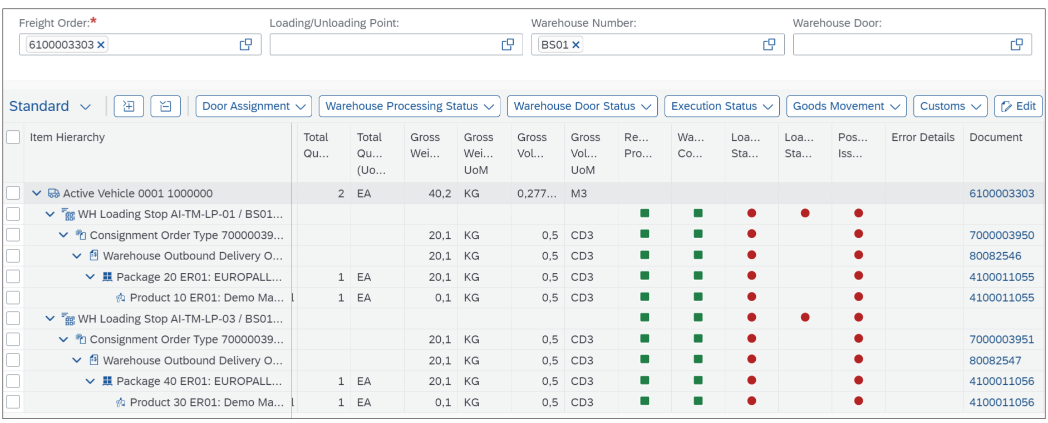


Figure 12.35 Load or Unload Freight Orders App

Within the freight order, on the **Overview** tab, a similar set of data is shown for all stops, displaying the warehouse status and a handling and execution status for each stop that displays if an activity is complete. As both the warehouse worker and the transportation planner work directly on the same freight order, the status update is immediately visible for both parties. Updates on the loading status could also be made in the freight order **Overview** tab (which apart from the freight order UI also works in the transportation cockpit), if necessary, by setting the execution status of a stop to **Loaded**.

Delivery Splits Based on Freight Order Loading

After the warehouse processing is completed, it's possible that not all processed items of an ODO can be loaded onto a freight order. The remaining items are split up, and a new ODO and logistics execution delivery is created for the remaining freight units.

This either happens during the planning/load planning of the freight order upon save, or, when the freight order is already in the **Ready for Transportation Execution** status and the truck is being loaded incompletely in the warehouse.

In a real-world scenario, RF devices would most likely be used to complete the individual warehouse tasks for picking, packing, and loading. As the statuses of the ODO, which receives the respective RF messages replicated to the freight order, this process is also supported.

Loading and Unloading at Multiple Points in the Warehouse

With the introduction of ASR, it's now also possible to model the warehouse internal structure more concisely than before. Loading and unloading points are derived from predecessor documents, such as orders or scheduling agreements, or added manually in the active capacity document **Overview** tab, which can also be displayed in the details page in the transportation cockpit.

Loading and unloading points for one stop can be combined on one freight order, so that loading/unloading at multiple warehouse doors becomes possible within the same object (previously loading and unloading at the same location required a separate freight order).

Furthermore, loading points may represent a stop at a lean warehouse management (inventory management) warehouse, stock room–managed warehouse, or EWM warehouse, allowing loading/unloading of freight orders independent of the SAP warehousing technology used.

Finally, the goods issue is triggered, which apart from doing it directly in the warehouse or logistics execution–specific UIs, can either be done from the Load or Unload Freight Orders app, directly within the freight order **Overview** tab or in the order details section for a specific freight order within the transportation cockpit. In the Load or Unload Freight Order app, for example, you can go to **Goods Movement • Post**. The accompanying handling execution statuses, which can be set from the same UI, are **Departed from Door** (warehouse door left and hence free for the next vehicle) and **Checked-Out** (check-out process complete, the truck is on its way).

Handling Execution Status

Note that the handling execution status, if properly set, allows you to determine a detailed status of an active vehicle resource being within the company premises, giving full transparency of the respective loading and unloading process.

After the goods issue, the process on the supplier side concludes. The truck is on the way, and the customer can prepare for the incoming goods. To support the customer in his process, the ASN is being sent before the goods arrive. The notification can either be triggered in the output management of the freight order or the consignment order, resulting in a B2B/EDI message to the destination system. The used web service is `TransportationOrderGenericRequest_Out`, triggered on check-out of the freight order by the PPF action `TOP_TPNOR_ASN`.

Inbound (Customer) Processing

Generally, the inbound side of the execution process will start with a message from the supplier about which goods have been packed and are due to arrive at a specific point in time at a certain location. purchase orders/scheduling agreements and freight units are already present in the system of the customer at this stage. Within our example, we receive this ASN based on the built consignments. Once received through the `TRANSPORTATION_ORDER_GENERIC_REQUEST_IN` interface, the message is processed.

The received consignments are created in the customer's TM system with an external reference ID. Existing freight units are determined automatically and assigned to the respective consignment. This determination process considers base documents such as existing purchase orders or scheduling agreements, product ID, and unloading point. During this step, the logistics execution inbound deliveries can be automatically created (if the ASR process is configured accordingly). If a consignment with the same external reference already exists, it can be updated by the respective message.

If no freight units are found, the consignment is stored, and the missing freight units are shown as an error in the **Document Errors** tab of the consignment. Note that as long as there is a valid source and destination location in the consignment, it will be created and stored for later error resolution.

In a separate inbound message, the freight order can be received, which automatically will assign the previously created consignments/freight units. In addition, in this case, the freight order will be stored with errors, if the information in the inbound message is insufficient. As with the consignment, planning, and execution of the freight order will be blocked until the issues are resolved.

There is a further variant of this process, where all necessary information, including consignments and item hierarchy, is received with the same inbound message. In this case, the complete document structure, freight order, consignments, and respective freight units are built and linked after the message is successfully processed. The idea behind receiving separate messages is that generally the consignment would be sent by the supplier to announce the incoming goods, while the freight order would be sent by a carrier or LSP separately to announce the truck that is due to arrive at the customer's location.

Advanced Error Handling

With the **Advanced Error Handling** tab on the freight order, consignment, and freight unit UI, error handling and resolution can finally happen in the respective UIs of the affected business documents. Erroneous documents can be filtered in the respective personal object worklists (POWLs).

Especially for errors that are caused by incomplete or faulty inbound messages, this creates a way for the end user to carry on with the process after manually or automatically (report /SCMTMS/TOR_RETRY_ERRORS) correcting the issues. Furthermore, errors and related error resolutions are stored, so that suggestions can be made on the most effective resolution.

The error handling functionality is new and will be further enhanced in the future. For the most current description, refer to the latest SAP S/4HANA TM help at *https://help.sap.com* (**Transportation Management •Freight Order Management • Creation or Update of Consignment or Freight Order on Inbound Messages • Correction of Errors in Business Documents**).

The result of the processed inbound messages is an freight order with assigned consignments, freight units, and the corresponding inbound deliveries that have been created in logistics execution as displayed in Figure 12.36. At this point, the inbound delivery in EWM is still in **Blocked** status, and for the inbound scenario, it's with the transportation planning type **E** (**Obligatory Planning in TM for Adv. SR (Release in TM)**).

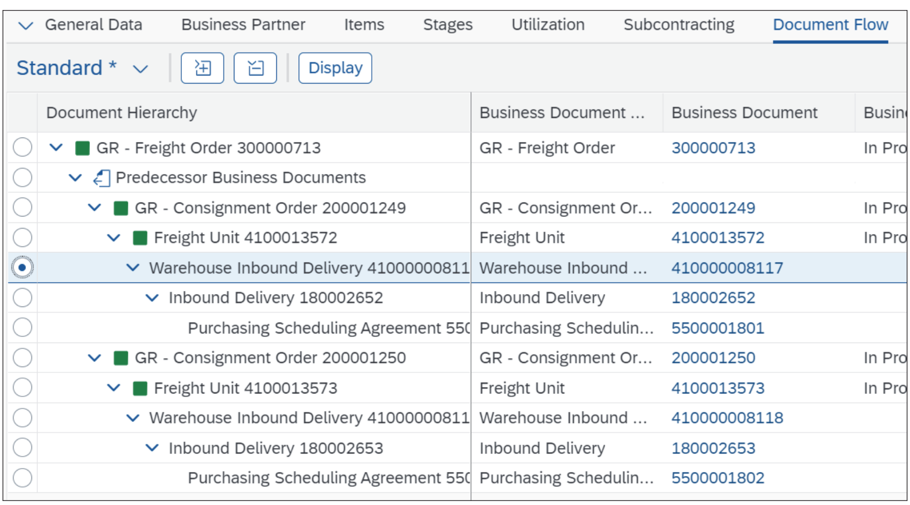


Figure 12.36 Inbound Freight Order Document Flow

Truck arrival will be recorded through the handling execution status, which is respectively set to **Arrived** as described for the outbound process. During the check-in, planned freight units need to be adjusted if the truck has a different load than initially planned. At this stage, the freight units that have been automatically assigned to a freight order are fixed, and their load plan status is set to **Finalized** to avoid accidental changes. By manually resetting this status (e.g., in the freight order **Overview** tab), freight unit quantities can be adapted to account for overdelivery or underdelivery. On adjustment, linked referenced documents can be updated accordingly if customized in the respective freight order type.

Freight Unit Merge

If a repacking was done during execution, and two freight units are part of the same package, the item structure of the freight order can be adapted manually or through additional inbound messages to reflect this change on the inbound side. If possible, the system will then perform a "merge" of the freight units by adding the items of one freight unit to the other and cancelling the empty freight unit.

Note in this context that cross-delivery packages where two freight units reference different deliveries aren't supported as of the time of writing.

Once all potential errors are fixed and the check-in is complete, an unloading point can be added/changed if necessary before we set the execution status to **Checked In** and the warehouse door status to **Arrived at Door** to indicate that the truck has reached the door, locking it for other freight orders.

The subsequent steps are basically a reversal of what we described on the outbound side, so we'll only described them briefly here. At this stage, the responsibility for the unloading of the truck is handed over to warehousing by setting the warehouse processing status to **Ready for Warehouse Processing** from the freight order UI, in the order details section of the transportation cockpit, or in the Load or Unload Freight Order app. Unloading can be recorded again within the new app or via RF devices.

As in the outbound process, the status of the unloading process is replicated to the freight order once the status of the HUs changes to **Unloaded**. freight units, consignments, and packaging items are updated to reflect the actual unloaded quantities. Once the unloading is finished, the goods receipt is being posted and the **Departed from Door** and **Checked-Out** statuses can be set (e.g., using the Load or Unload Freight Order app).

Stay Current!

We recommend regularly checking the SAP S/4HANA TM help on *https://help.sap.com* to stay current on the released functionality as well as checking the previously mentioned SAP Note 3225241 for known restrictions.

12.3.3 Transportation-Driven Execution

So far, we've described warehouse-driven execution, which means execution in the warehouse can start without specific acknowledgement in TM. Within this process, warehouse execution generally happens before the transportation planning is performed in TM. This also means that transportation-driven constraints (e.g., dimensions of the incoming truck, compliance, specific transportation times) can't be regarded in the warehouse. In this section, we'll briefly explain the functionality for the transportation-driven ASR process, which is available since SAP S/4HANA release 2022.

You can determine if a shipment is relevant for a transportation-driven process using Transaction SPRO and navigating to **Transportation Management • Advanced Shipping and Receiving • Determine Relevance for Transport-Driven Process**. The setting regards the combination of warehouse number, shipping point, and delivery type.

The respective setting causes the logistics execution delivery to be blocked until the freight units are released for warehouse processing. Within EWM, the delivery is shown with the transportation planning type **F** (**Obligatory Planning in TM for Adv. SR (Release in TM)**). Therefore, the picking and packing in the warehouse can only be started once the **Ready for Warehouse Processing** status is set in TM.

Figure 12.37 shows the respective button in the **Overview** tab of a planned freight order. The user clicks on **Warehouse Processing Status • Set to Ready for Warehouse Processing**. Once this status is set, the logistics execution delivery is updated with the transportation planning status, carrier, loading point, picking date, loading date, and planned goods issue and delivery date. If warehouse processing hasn't started, the **Ready for Warehousing** status can still be reversed. The planned goods issue and delivery dates in logistics execution are then not updated from TM until the warehouse processing status is set to complete.

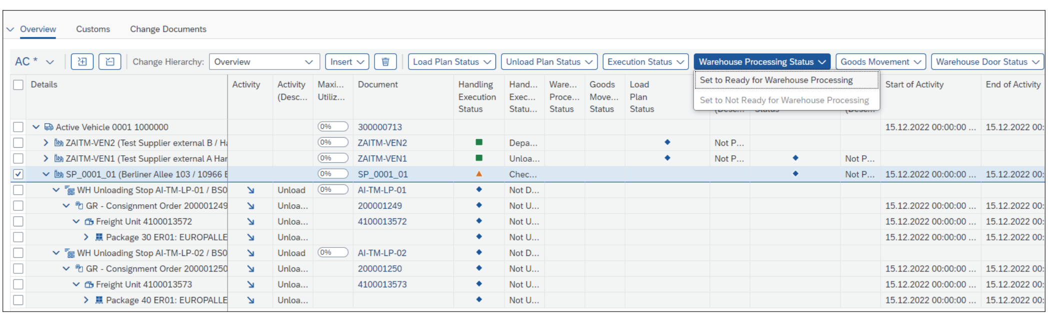


Figure 12.37 Set to Ready for Warehouse Processing

The subsequent warehouse processes start based on a completed transportation plan, where carrier, loading point, and dates are being pulled to EWM for warehouse planning and execution.

12.3.4 Customs Integration

Since the SAP S/4HANA 2021 release, the ASR process was enhanced to also support compliance processes in conjunction with SAP GTS. As a result, ASR is now also usable in contexts where cross-border transportation, where import and export regulations must be observed, is performed. In the following sections, we won't go into the details of the compliance checks for sanctioned party list screening, embargo checks, legal control indicators, and customs permissions and declarations as they have been discussed in Chapter 8 already, but rather we'll focus on how the process is embedded overall.

Outbound Customs Integration

Once again, we start with the outbound side. Legal checks are performed on the sales and distribution document level. If there is a legal split indicator present on the sales order, the freight units in TM will be built accordingly using the same split indicator. The respective settings are made in the logistics integration profile (navigate to the Customizing for **Transportation Management • Integration • Logistics Integration**).

All freight units within TM will be checked for compliance by SAP GTS (triggering a trade compliance check request at save). Until a positive check result is returned, the freight units can't be further processed and are blocked for planning, execution, and settlement (note that this block can't be overruled manually). In a warehouse-driven scenario, the **Ready for Warehouse Processing** status is set automatically, once the compliance checks have successfully concluded.

During planning, when freight units have been assigned to consignments and freight orders for each assignment, the compliance check is performed again, blocking the documents until the respective checks are complete. Blocks of individual freight units are propagated to the freight order. Each business partner change on the freight order will trigger an additional compliance check (sanctioned party list check).

Once the **Checked-In** handling and execution status is set on a stop of the freight order, stop-specific consignment groups are being built (legal split criteria are regarded during this step). Subsequently, the export declaration is requested automatically once loading is completed, and the **Ready for Export Declaration** processing status is set. This also triggers the creation of the customs invoice, which is being produced based on the underlying sales and distribution document.

Upon the receipt of the customs reference number (CRN) from SAP GTS, the freight order is released for further processing, goods issue can be posted, and the check-out be performed. The received CRN can be sent as an update to the executing carrier.

Inbound Customs Integration

On the inbound side, we follow the previously explained process, enhanced with compliance checks. The freight units that are created in TM based on the purchasing document will be determined as relevant for compliance, and the checks are performed accordingly by SAP GTS. When the linked consignments and freight orders are being built based on the incoming ASNs, the documents will be linked but remain in error and blocked until the compliance issues are solved.

The CRN is added on the consignment level in the freight order **Items** tab in the **Previous Document Number** field. Ideally, this will already have been part of the inbound ASN; otherwise, it must be done manually and is the prerequisite for the next steps.

Once the status of the freight order changes to **Checked-In**, customs groups are built automatically. A **Customs Transit Discharge Declaration Request** will be sent to SAP GTS, keeping the freight order in **Blocked for Execution** status until a positive returns message from SAP GTS is received.

The warehouse processing status can only be changed to **Ready for Warehouse Execution** once unloading has been approved by customs. Upon finishing the unloading for a specific customs group and booking goods receipt, the import declaration can be triggered in SAP GTS.

12.3.5 Returns Handling

An additional process to be briefly discussed is the returns of goods within the described ASR process. For this, the supplier creates a returns order in sales and distribution, which can then be further processed as part of ASR handling. This process assumes that an inbound ASN for the returns order will be received from the customer. The broad steps are as follows:

1. The ASN will create a new consignment order in TM. The freight units that have been created based on the returns order will again be automatically linked (ideally using the return order reference ID, but also considering business partner ID or material number).

> **Working with Returns in POWLs**
>
> In the freight unit POWL (navigate to **Transportation Planning • Freight Unit Worklist**), the freight units linked to a returns order can be filtered via the **Original Order** field by entering the number of the returns order and filtering for unplanned freight units. Once the freight units have been successfully assigned to a consignment, they will no longer show up in the list, allowing for an overview of the outstanding returns freight units.

2. Deliveries for customer returns can be created automatically upon receipt of the ASN and are initially blocked for warehouse execution.
3. Upon setting the status of the consignments to **Ready for Warehouse Processing**, subsequent steps can be performed as described in our inbound process description in Section 12.3.3.

12.4 SAP Transportation Resource Planning

SAP Transportation Resource Planning is a standalone solution that allows you to manage equipment for transportation, generally addresses resources in terms of various characteristics:

- Passive inventory used for transportation, such as containers, railcars, or trailers, can be managed in depot locations. Availability requests for equipment types and instances can be answered as well.
- Shortages and surplus of inventory instances can be detected and flagged. Resource imbalances in the network can be discovered.
- Ingoing and outgoing inventory streams from transportation to and from depots can be registered and included in the inventory availability calculation.
- Repositioning in the network can be simulated, proposed, and made transparent in terms of related cost.

Based on these features, SAP Transportation Resource Planning provides for efficient management of equipment for transportation moving around in a LSP network. These moves can easily cause imbalances, which can lead to unavailability of transportation equipment and thus to the inability to accept and execute transportation orders.

In the following sections, we'll unpack SAP Transportation Resource Planning. We'll begin with the integration basics, before providing a tour of the available features and views, as well as your deployment options.

12.4.1 Integration Overview

SAP Transportation Resource Planning is software that has been built as a genuine SAP HANA 2.0 solution. It runs standalone and can be integrated with TM, in which case, a deployment on the same SAP HANA database is possible. The direct integration of SAP Transportation Resource Planning into the shipment processes allows the following:

- Providing information on availability of equipment for order items or options to substitute at low costs with comparable equipment
- Registration of outgoing equipment and its requests as well as incoming equipment based on container units or freight orders and bookings

The main question in SAP Transportation Resource Planning is how to optimize the resource availability and usage for transportation processes. Detailed answers need to be given to the following questions:

- Is a resource of a specific type available (e.g., 40-foot dry container)?
- How can the supply of empty transportation resources be monitored?
- How can a company reliably forecast the supply and demand of resources?

- How can you avoid the repositioning of empty equipment, and how can the utilization of a company's own resources be increased?
- How can a company reduce cost per resource?
- Is it more economical to buy or lease new resources?
- How can a company handle service recovery in exceptional cases?

SAP Transportation Resource Planning will provide a proposal to realize equipment provisioning and balancing to provide the right equipment at the right time at the right location with the minimum cost. Of course, there are some local and global challenges in equipment management and balancing:

- Impact of global decisions on the local balancing situation
- Impact of local evacuation decisions as a reaction to imbalance in terminals
- Uncertainty of supply and demand forecasts
- Decisions on empty versus laden moves as empty moves cost money, and laden moves make money but potentially increase the imbalance
- Reconciliation of high-level planning with terminal operation constraints

To achieve these goals, multiple functionalities in SAP S/4HANA are integrated with SAP Transportation Resource Planning. In Figure 12.38, you can see an overview of the interaction of the related components with SAP Transportation Resource Planning:

- Materials management for purchasing or leasing equipment
- Asset management for resource master as well as maintenance and repair activities
- SAP S/4HANA Finance covering financial processes
- TM supporting operational processes
- SAP Event Management for event management
- SAP Transportation Resource Planning for equipment management

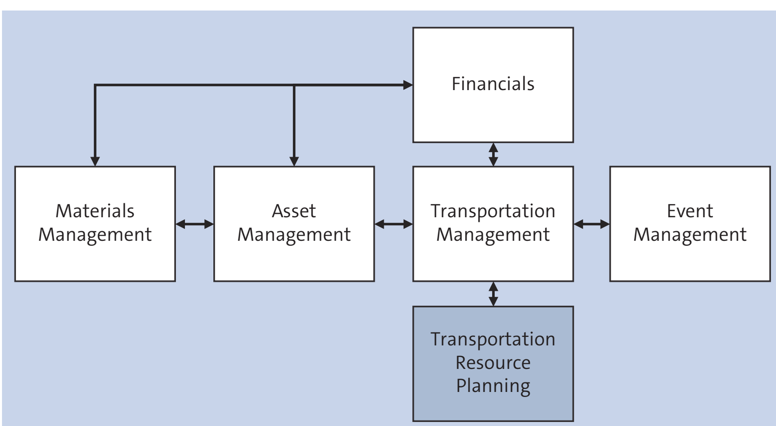


Figure 12.38 Component Interaction with SAP Transportation Resource Planning

TM is the component that is directly interacting with SAP Transportation Resource Planning. There are multiple interfaces to exchange data and to integrate the process flow, which you can see in Figure 12.39. For detailed functional descriptions of the subcomponents, refer to Chapter 1, Section 1.3.1. Figure 12.39 shows the same subcomponents and their integration into the SAP Transportation Resource Planning building blocks. The blocks with the light frame have optimization features in the resource planning process. Let's walk through these blocks:

- The components to secure capacity in TM, which also hold relevant master data, are synchronized with resource and network master data on SAP Transportation Resource Planning.
- The customer order management triggers requests to determine resource and equipment availability for transports related to the orders.
- If resources are associated to orders, the corresponding equipment is requested and reserved in SAP Transportation Resource Planning.
- Resources used and arriving or leaving a location in TM freight handling or assigned to tours in cargo management are synchronized with SAP Transportation Resource Planning equipment management.
- SAP Transportation Resource Planning equipment balancing creates moves and reservations in TM to reposition resources in the network.

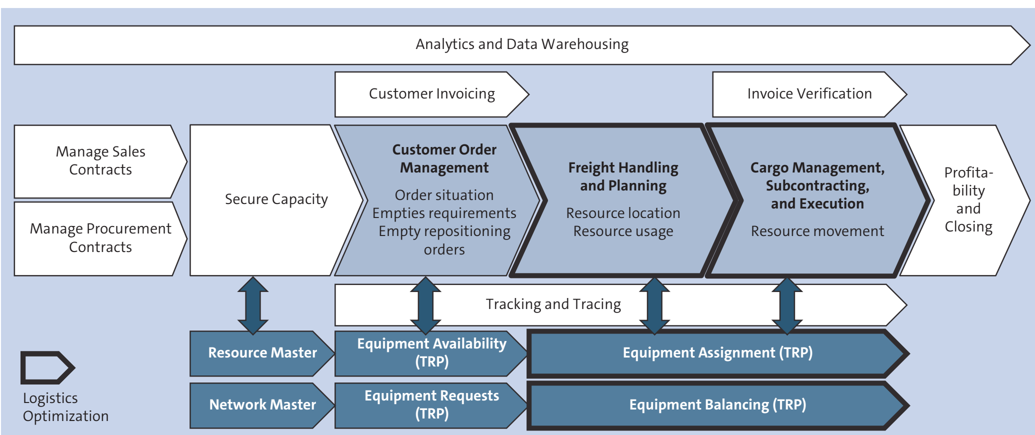


Figure 12.39 Integration of SAP Transportation Resource Planning Functionalities into the TM Process

The supply and demand optimization process in SAP Transportation Resource Planning can be run in different model definitions, which allows you to improve the equipment situation either on a global view for all resources or as a limited solution with a local scope or selected resource types. The optimization has a variety of input data, which you can see in Figure 12.40. This includes the inventory of equipment in the selected locations and on the transports to these destinations (depots, container yards, consignee locations), as well as bookings that require usage and assignment of certain equipment types or individual equipment.

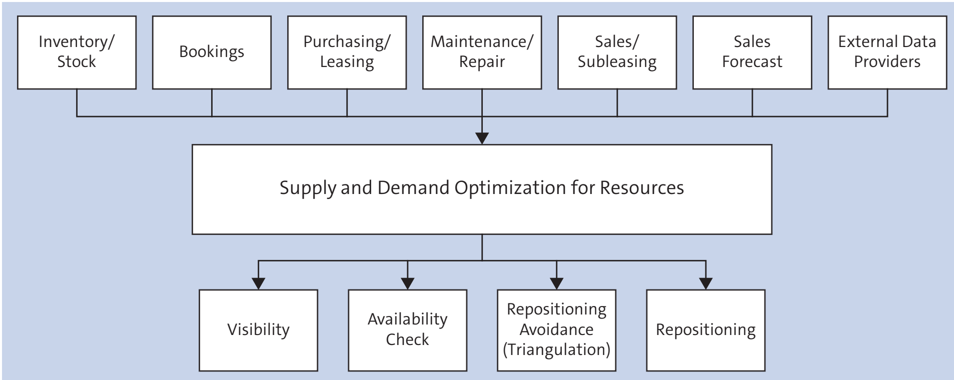


Figure 12.40 Supply and Demand Optimization and Input/Output Data

The equipment inventory for supply and demand optimization is influenced not only by the requested, planned, and ongoing transportation activities of types laden and empty but also by the entry of new resources into the network through procurement, leasing, or by temporary or long-term activities due to maintenance, repair, sales, scrapping, or subleasing. Concerning future calculations, further input information comes from sales forecasts of products to be shipped or logistics orders to be fulfilled. Last, but not least, external providers and their resources may influence the available resource pool.

12.4.2 Features

The supply and demand optimizations are made via an optimizer, which addresses the tasks as a multicommodity network flow problem. This requires solving a network flow problem with multiple commodities (flow demands) between different source and sink nodes inside the given network and with the resources to be considered. Technically, a linear programming algorithm (SOPLEX) for capacity-restricted networks and a special graph algorithm for planning without capacity limitation are utilized. The target strategies of the optimization are avoidance of empty equipment repositioning, a maximum level of order fulfillment, and minimization of cost.

In terms of cost, the optimization model and algorithm handle multiple components:

- Handling cost for loading and unloading
- Transshipment cost for storage and related fixed cost for infrastructure
- Transportation cost for empty equipment delivery, pickup, triangulation, or repositioning, considering a company's own fleet, a third-party fleet, and intermodal cost

After running an optimization, the model output can be used to support the availability check of requested equipment, the development of a solution with lowest possible cost and least repositioning activities, a solution for empty pickup or return moves, and a cost-efficient repositioning strategy for the equipment that needs to be moved to other terminal locations.

Triangulation is a strategy used by carriers to reduce cost of positioning, repositioning, and storage, especially when they are short of equipment. You can see the principle in Figure 12.41.

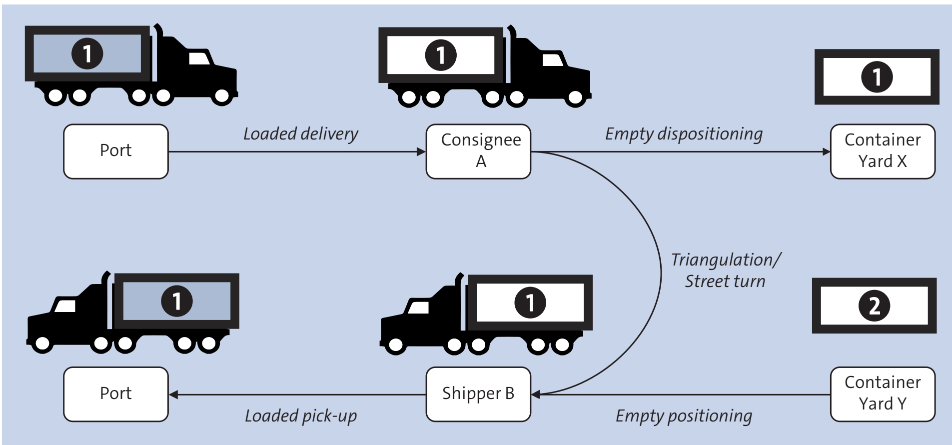


Figure 12.41 Triangulation of Containers

If container 1 of specific type (e.g., 40-foot-high cube) arrives at a port, it's moved, for example, to a truck that does the loaded delivery to consignee A. After emptying the container, usually it would be dispositioned to a feasible container yard X based on lowest cost or highest demand. Another container of comparable type requested by shipper B would, for example, be empty positioned by another truck from container yard Y to load it and move it loaded to the port. The idea behind triangulation, also called "street turn," is to avoid the three activities (dispositioning, storage, and positioning) for the two units, and instead search for two business cases (arrival and departure), which can be consolidated, so that an empty container to be dispositioned can be immediately turned around and positioned empty at a consignee. In this case, unit 1 never arrives in container yard X, and unit 2 isn't moved out of yard Y.

12.4.3 User Interface

Users of SAP Transportation Resource Planning are usually in charge of managing the used and available equipment of a carrier or logistics company or managing the space and activities in a container depot or yard with the perspective of managing the available space best and satisfying incoming equipment demand. For this purpose, SAP Transportation Resource Planning provides a variety of views, transactions, and optimization processes to allow users to manage their task best related to their corresponding authorization and scope responsibility.

You can define a home dashboard, which is your landing page in SAP Transportation Resource Planning. The home dashboard offers four tile categories (**Stock View**, **Supply and Demand**, **Alerts**, and **KPIs**), based on which you can personalize, add, or remove tiles from the home dashboard:

- The **Alerts** tile allows you to monitor alerts related to some scheduled supply and demand or to KPIs.
- The **Supply and Demand** tile visualizes a forecast of a certain equipment situation related to a selected plan. You may get an overview of the balance or incoming, stored, and outgoing resources for a selected scope (equipment types and locations).
- The **Stock** tile shows you the equipment situation for selected resource types and locations.
- In the **KPIs** tile, you can see a trend for typical equipment related KPIs (e.g., idle rate or import/export balance).

In addition to the overview of the home dashboard, SAP Transportation Resource Planning offers you several work centers for aspects of resource planning to work on resource visibility, supply and demand, KPIs, and pickup or return. The detailed transactions in the work centers allow you to look at the SAP Transportation Resource Planning data in three different ways:

- **Table views**
  Provide a detailed listing of the facts with various characteristics listed for all selected elements.
- **Chart views**
  Give a visual overview of the facts in the form of KPIs, for example, a bar chart. In some cases, the presented figure is enhanced with additional information, such as the safety stock indicator when looking at the current inventory levels.
- **Map views**
  Provide a geographic perspective on the data. On a zoomable and scrollable world map, the selected locations and resource types and the related data aspects are presented. Different indicators such as stock levels, empty or full status, and other aspects can be presented by geolocated, circular charts of different colors. Figure 12.42 shows an example of this form of data representation in SAP Transportation Resource Planning.

In Figure 12.42, you can see a map-based supply and demand visualization with a worldwide view related to **Plan SD_DEMO_REPO** and a point in time. Locations that have a surplus of equipment are depicted in violet, and those with a deficit are red. The size of the circles indicates the quantity, dark colors show supply, and light colors tag demands. This kind of representation allows you to get a very fast overview of resource distribution and supply-demand matching.

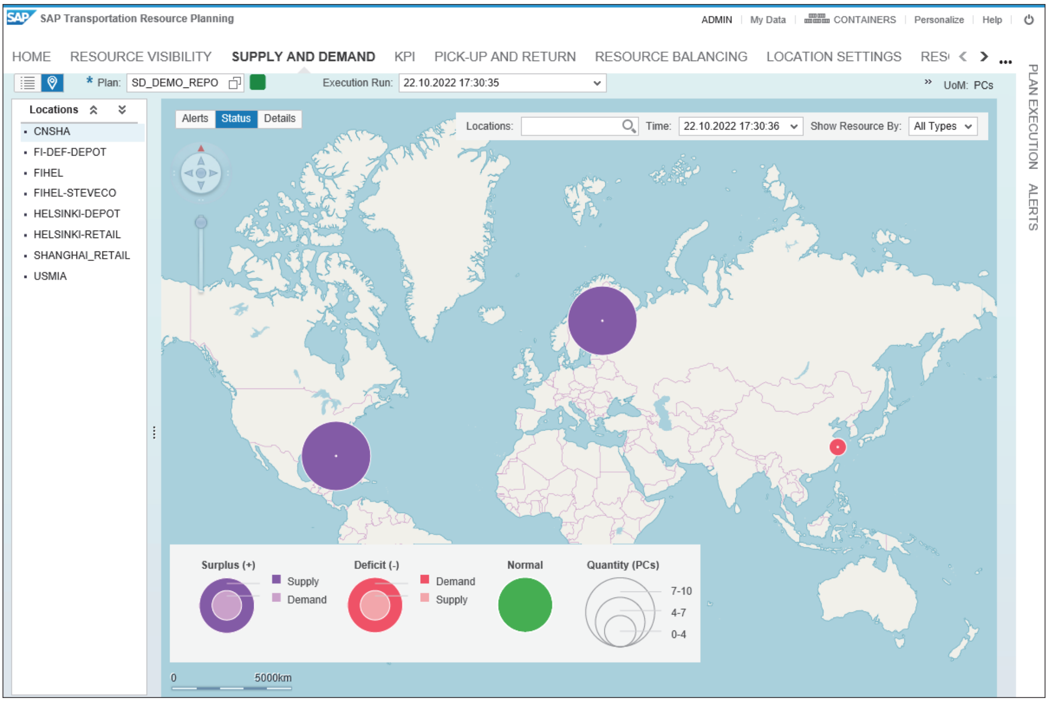


Figure 12.42 Graphical Supply and Demand Overview

For the **SUPPLY AND DEMAND** work center, an automatic scheduling of the plan providing a target equipment distribution is possible, which is indicated in the **Execution Run** time stamp field.

The **RESOURCE BALANCING** work center helps you detect critical situations of available and requested equipment and run simulations to optimize the resource balance in the corresponding part of your network. For a plan, multiple simulations are possible, out of which you may finally choose the one that provides the most sensible or cost-efficient result. In the **RESOURCE BALANCING** work center, different views are available:

- **Supply and Demand**
  This gives you a tabular representation of equipment items and their types in a list of locations with an indication of supply and demand per combination. Cells that lead to a deficit are displayed with an alert. In the example, the location **SHANGHAI_RETAIL** still has a deficit of containers, but other requests have been satisfied by running the **Balancing Simulation**, which shows status **OK**. You can see such a simulation in Figure 12.43.
- **Alerts**
  This view exposes the alerts in a resource balancing view.
- **Network/Routes**
  These views provide map displays that allow you to judge the resource balancing

with an emphasis on its distribution within your services network or along typical repositioning routes.

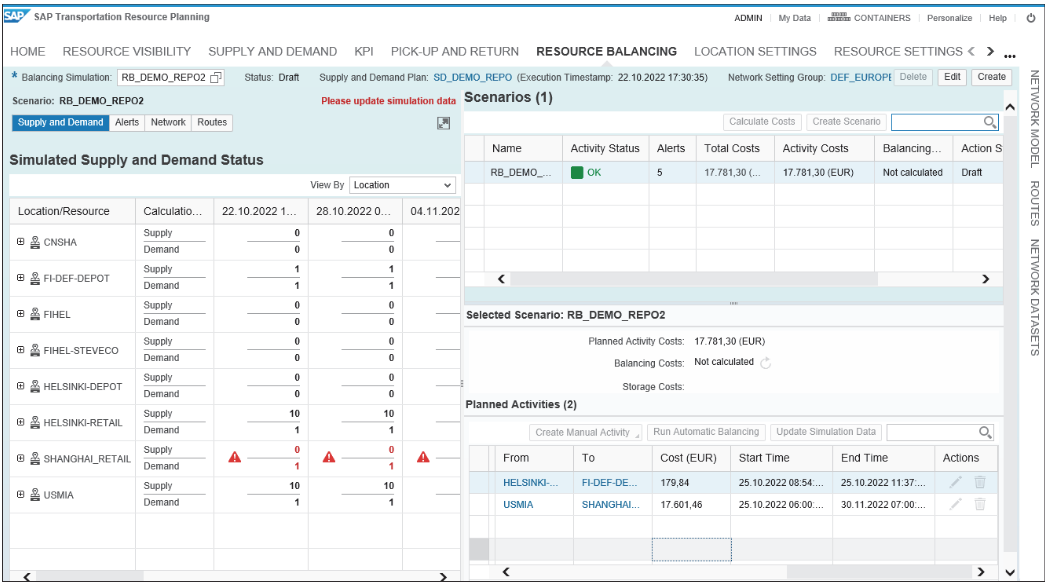


Figure 12.43 Simulated Supply and Demand Situation with Cost

The resource history of SAP Transportation Resource Planning provides you access to all events related to the resources managed by the system and gives you answers on resource state, usage, and current or previous locations.

12.5 SAP Yard Logistics

When you're looking at the end-to-end supply chain, transportation management covers the transportation pieces of the movement process, whereas warehouse management systems are powerful tools to organize and manage shipper's or contract LSP warehouses. In between these two systems or subprocesses of the supply chain, the transfers of cargo, shipments, and packages are handled in transshipment points, commonly referred to as hubs or yards. SAP decided to add more specialized software called SAP Yard Logistics to their logistics portfolio with which you can specifically manage the operations in these transshipment points of the supply chain. Transshipment points include the following, for example:

- Container terminals or container depots that allow storage of loaded or empty containers, handling of vehicles on the land side (truck, railway) and water side (ocean vessels, barges), and the related load transfer processes

- Railroad terminals that handle single railcars or groups of railcars (empty or loaded) and the related multimodal load transfer processes of containers, trucks, and vessels/barges
- Air freight ground-handling stations that facilitate loading and unloading processes for air cargo, including provisioning of air cargo containers and pallets
- Automotive hubs that allow intermediate storage for vehicles unloaded from or to be loaded to RORO car transporter vessels
- Bulk yards that allow intermediate storage and load transfer for bulky materials
- Ports or terminals with a focus on maritime operations, including vessel and barge imports or exports, with all discharge and load-related stevedoring activities

Typical use cases are in the following industry areas where cargo items, trucks, trailers, railcars, vessels, cranes, reach stackers, and other handling equipment need to be coordinated:

- **Automotive**
  Yards for finished vehicles or specialized machinery.
- **Building materials and heavy industries**
  Construction material yards and machinery project yards for various factory projects.
- **Chemical, oil, and gas industry**
  Management of liquid or gaseous bulk cargo hubs.
- **Consumer products, wholesale, and retail distribution and food industry**
  Prepackaged distribution of goods in ambient, chilled, or frozen condition.
- **Logistics industry, including container terminals, ports, and freight villages**
  All mode-crossing yard facilities, such as truck-rail, truck/rail-ocean, or truck-air terminals, which allow you to move or store cargo.
- **Steel and forestry**
  Yards facilitating break bulk cargo and the transfer of break bulk between different modes of transport.

SAP EWM was the technical basis for SAP Yard Logistics, so the portfolio of functionality seems similar at first glance: management of inbound and outbound movements, management of storage, and loading and unloading processes. But when going into the details of the solution, it becomes apparent that SAP Yard Logistics introduces more sophisticated support for the requirements of hub and terminal operations, including, for example, a higher flexibility in cargo storage (open space storages) or the reflection of complex, multistep inspection routines.

Let's take a closer look into SAP Yard Logistics, including its business processes, main features, UI, mobile options, and integration capabilities.

12.5.1 Integration Overview

The business processes supported by SAP Yard Logistics covers the planning, execution, monitoring and billing of yard operations. As a high-level example, this includes the check-in of transportation units and the associated cargo while identifying the driver of the vehicle, execution of foreseen and ad hoc activities, services and inspections (reflected as yard tasks), and the check-out of transportation units. These processes allow companies to improve their yard management in the following ways:

- Reduce the overall handling time of transportation units by automation and parallelization of subprocesses such as check-in procedures.
- Increase speed of operations and therefore increase the yard's throughput.
- Improve the visibility of movements in the yard.
- Use suitable tools for the required tasks instead of bending standard warehouse tools to somehow fit to a yard.
- Reduce total cost of ownership for the system landscape.
- Identify, assess, and remove bottlenecks in the yard processes.

You can subdivide the functionality of SAP Yard Logistics into four areas:

- **Yard planning**
  Yard planning activities around processes and resources in the yard, including the following features:
  - Arrival planning for everything arriving in the yard
  - Capacity and activity planning for resources and tasks in the yard
- **Yard execution**
  Execution of planned activities and tasks within the yard, including the following features:
  - Integration to TM, dock appointment scheduling (DAS), and SAP Business Network for Logistics
  - Gate operations
  - Task execution via mobile devices
  - Automated exception handling
- **Yard monitoring**
  Overseeing and controlling current and historical tasks and activities in the yard, including the following features:
  - Integration to hardware, Industrial Internet of Things (IIoT), and SAP EWM
  - 3D visualization of the yard and yard cockpit
  - Alerting for ongoing processes
  - SMS communication to yard operating persons and external providers (e.g., truck drivers)

- **Yard billing**
  Preparing costing information for activities in the yard, including the following features:
  - Extraction of yard measurements related to billing of sold services on the yard
  - Self-billing of services purchased on the yard

12.5.2 Features

As previously mentioned, SAP EWM was the technical foundation of SAP Yard Logistics. Many basic configuration and modeling approaches were reused for SAP Yard Logistics and can be combined with integrated EWM. However, to cope with the high complexity of specific handling processes in a yard, SAP introduced new, flexible, yard specific features in the solution. Some examples are as follows:

- Inventory and stacking management for containers in a container yard
- Multimodal concept of transportation unit types covering specific characteristics of containers, vessels, and railcars in the master data records
- Specialized management of the mode-specific loading areas in yards, such as berths for ocean vessels or rail ramps in rail yards
- Integration of yard-specific technologies in the IIoT and device-specific areas

The most important physical yard entities are reflected as master data:

- The yard number reflects the physical site or hub in the organizational structure.
- The yard transportation unit is the main object representing the physical means of transportation visiting the site; it's comparable to the SAP EWM transportation unit.

SAP Yard Logistics is fully integrated with TM, which sends the basic information about the expected workload to SAP Yard Logistics, resulting in the yard request. In Figure 12.44, you can see an overview of the main SAP Yard Logistics objects and their inheritance from the underlying EWM.

The central object, which usually starts a process in SAP Yard Logistics, is the yard request. This planning document provides you with information about structure and characteristics of a transportation unit that moves into, out of, or within a yard. A yard request may include a list of foreseen activities that are required to subsequently execute the transportation unit visit to the yard. Yard requests can be manually generated, be a result of a transportation planning process, or be triggered externally via interfaces. When integrated with TM, a yard request is created based on the data of a freight order or freight booking.

The purpose of a yard request is to identify the required workload of handling the transportation unit and the properties that may influence the execution. Based on the yard requests in a system, a long-term workload plan can be defined. Yard requests hold information about the planned process variation, the transportation unit, the arrival or departure locations and time windows, and the product characteristics that may require specific handling procedures. Once the planning is finished, the yard request is converted into a yard order.

Yard orders are short-term planning and execution documents within SAP Yard Logistics. They hold comparable information as yard requests but focus on executing the related tasks and logging of the execution details (e.g., time stamps). The yard order carries the execution status, which allows you to get an overview of the overall status of the transportation unit visit.

Yard tasks represent physical activities performed in the yard during an individual transportation unit handling and are created manually or by foreseen process types in Customizing. Typical yard tasks are, for example, cleaning a unit or storing a unit in a storage section.

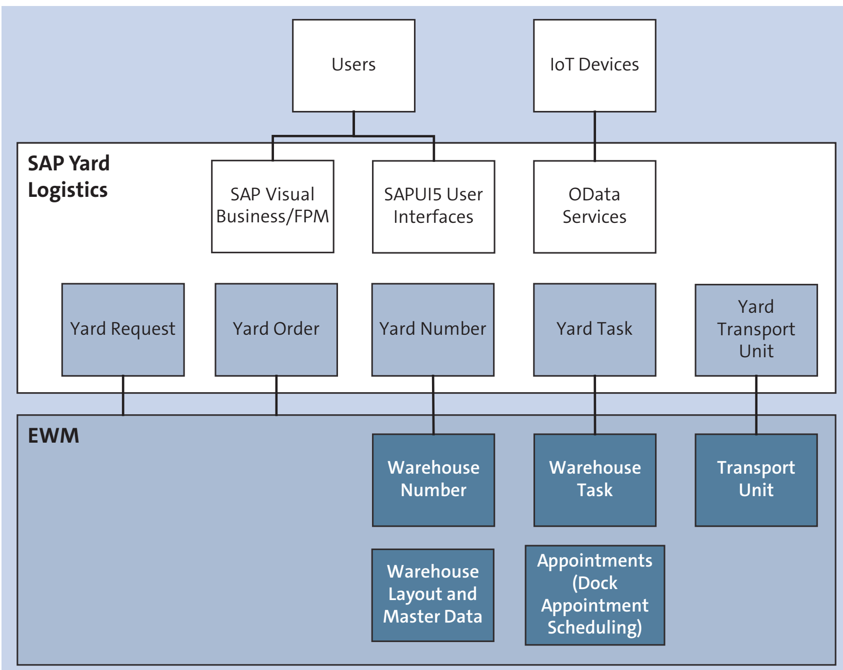


Figure 12.44 Overview of SAP Yard Logistics and the Comparable Objects of EWM

The sequence of yard tasks within the yard request/order represents the foreseen and/or the actual flow of activities for an individual transportation unit handling, for example:

1. Movement from check-in to inspection area
2. Inspection of the transportation unit
3. Movement to loading area
4. Loading to a waiting truck
5. Check out of the truck

Yard tasks are the main granularity of steps in which you're working and reporting back within SAP Yard Logistics.

12.5.3 User Interface

SAP Yard Logistics offers you a combination of overview, management, and operations UIs for on-site and mobile interaction. You can access SAP Yard Logistics via new applications, which are provided in SAPUI5 technology and the corresponding Floorplan Manager (FPM) configurations to allow integration into the SAP Fiori launchpad. Many applications are also optimized for use in typical mobile devices operation in the yard environment. Furthermore, many additional interfaces according to OData protocol services have been provided to allow the appropriate integration of yard-specific devices and IIoT technology to control the yard processes with the degree of automation that is currently pushed into the logistics market by various vendors.

Most of the yards managed in SAP Yard Logistics are large, widespread areas with a variety of subareas and subsections inside. Therefore, the solution offers a sophisticated real-time visualization of the yard itself and its ongoing processes, which provide a digital twin of the yard's operations.

The following are some examples of typical functional steps you can take in SAP Yard Logistics:

- Lay out and visualize your own site and facilities via layout editor.
- View the status of the yard in combination with ongoing movements.
- See the different statuses of cargo entities (e.g., **Blocked**, **Empty**, **Full**) with color coding.
- Manage exceptional situations.
- Create ad hoc tasks for containers, trucks, railcars, and other handling equipment.
- Manage space in the yard, for example, in a container storage area.
- Trigger movements of transportation units, for example, the restowing of containers.
- Block locations, such as gates, doors, or parking spaces for ingoing or outgoing movements.
- Request detailed information about individual entities (transportation units) in the yard.
- Request details about the current utilization of yard storage locations.

To manage the yard and the multitude of requests and orders, SAP Yard Logistics offers you the yard cockpit as a central application for monitoring and controlling the ongoing yard operations. The cockpit uses list-based as well as graphical tools to provide a best-fitting view to the yard and its units, orders, and activities. It also allows you to appropriately react to alerts coming up in the yard. In Figure 12.45, you can see an overview of the yard cockpit.

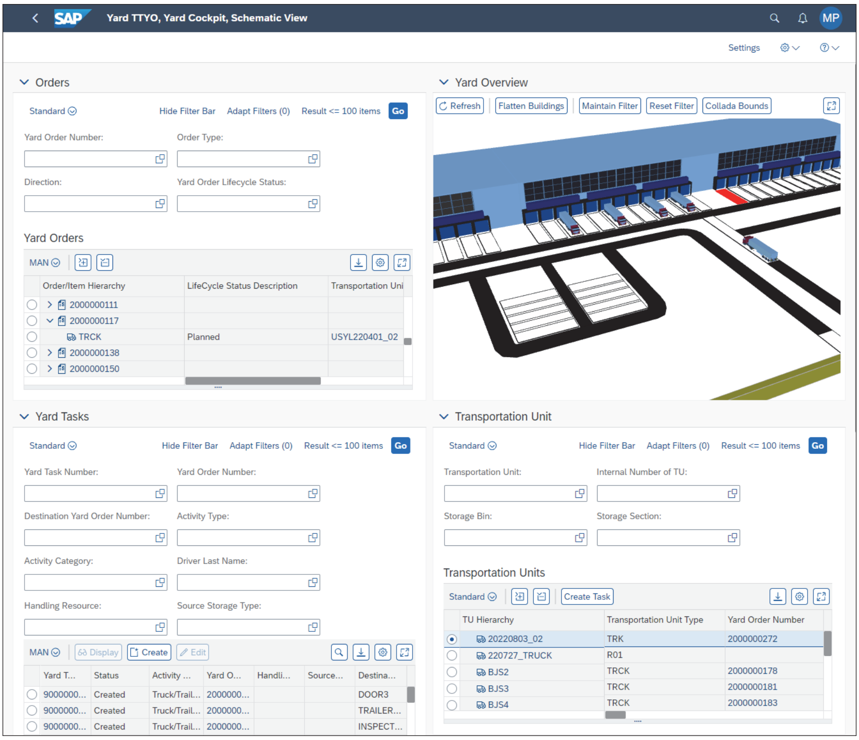


Figure 12.45 SAP Yard Logistics Yard Cockpit

In Figure 12.46, you can see several views of the SAP Yard Logistics cockpit with request details ❶, activities ❷, and trigger actions ❸.

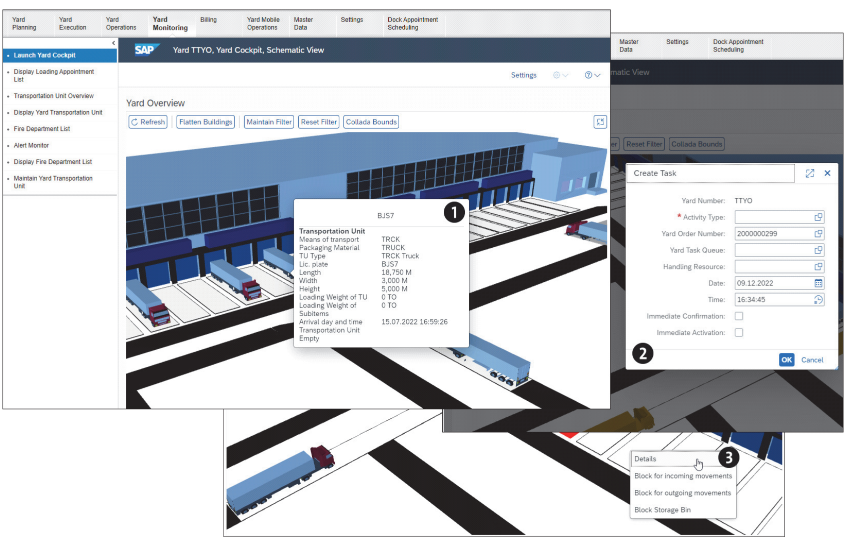


Figure 12.46 SAP Yard Logistics Cockpit with Examples of Request Details and Trigger of Actions and Activities

SAP Yard Logistics offers multiple roles for users to execute the required functions to manage a yard. Figure 12.47 gives you an overview of the typical tasks of a supervisor, hub manager, gate agent, driver, and operator, as well as some examples of what users of a particular role would be contributing as part of managing the yard.

In SAP Yard Logistics, you can reflect your physical site, including all subareas and subsections, as master data. The location setup has a similar structure to the one you find in EWM but is more focused on the yard specifics. The yard number represents the organizational unit of the yard on the highest level. Storage types, storage sections, and storage bins allow you to hierarchically define the structure of the yard on a deeper level. In cooperation with EWM, it's always important to find a proper balance between using storage areas in the warehouse and yard. It's not a given that a storage section location outside of a warehouse is automatically managed by SAP Yard Logistics. Often, if mixed operation is required, it makes more sense to manage storage of materials completely in EWM, and manage yard movements and storage or empties in SAP Yard Logistics. As mentioned before, the structure of the yard can be visualized with the graphical layout design tool.

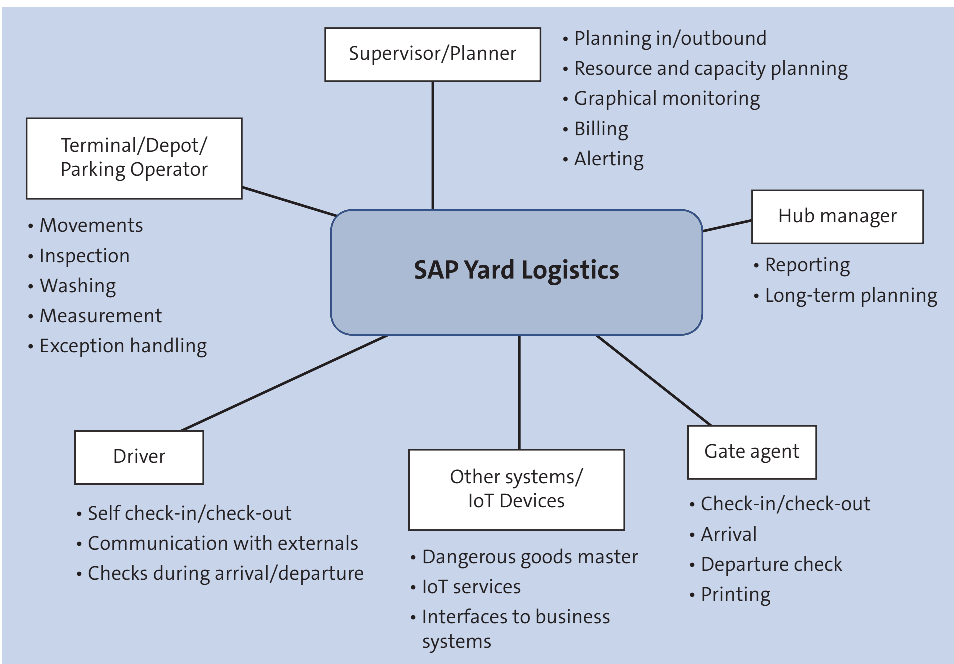


Figure 12.47 Roles within SAP Yard Logistics

12.5.4 Mobile Scenarios

One nature of yards is the continuous labor division between central planning offices and operators outside in the yard. With the implementation of SAP Yard Logistics, the manual job distribution can be converted into a digital workflow (a digital job distribution). Workers outside will receive their duties in various SAP Fiori mobile transactions, including yard task creation, yard task execution, and yard inspection apps. The SAP Fiori apps run on a variety of devices, including mobile phones, tablets, or typical onboard units of reach stackers, cargo trailers for yards (MAFIs), forklifts, or other handling devices. Figure 12.48 shows you a selection of such mobile devices.

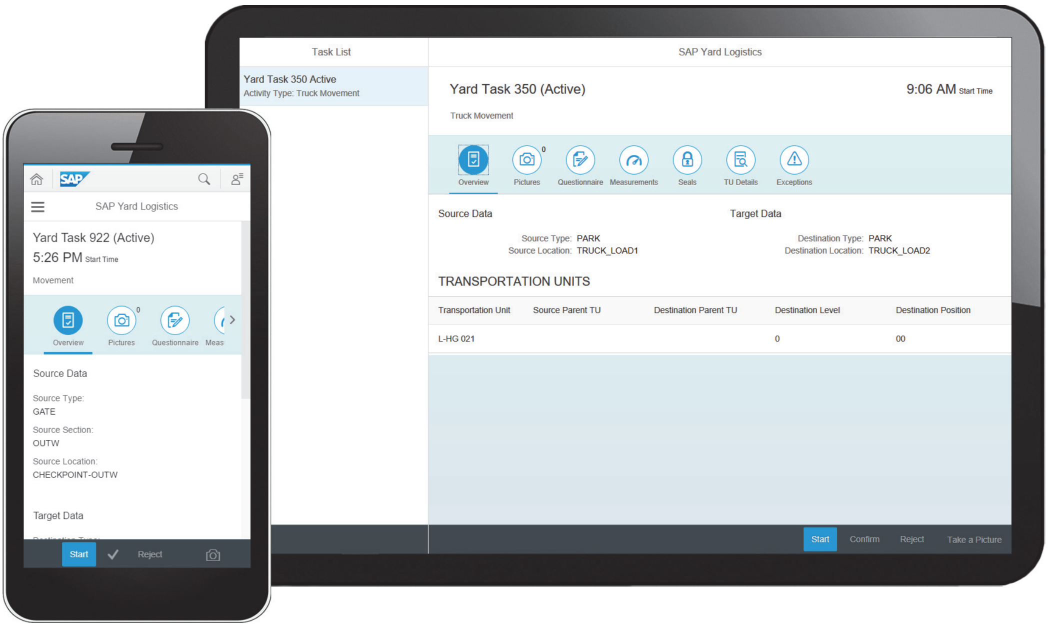


Figure 12.48 Mobile Devices and SAP Fiori Apps in SAP Yard Logistics

As yards usually require the involvement of external truck drivers in the process, a truck driver self- check-in is available within SAP Yard Logistics. Truck drivers are guided through the check-in procedure by choosing the preferred communication language, identifying themselves with a reference number, logging contact details, and answering questions as prerequisite of entering the premises. The self-check-in guided procedure is also an SAP Fiori app, running preferably on PC terminals or kiosk terminals.

12.5.5 Integration with Other Systems and Devices

For external forwarders or carriers, SAP Yard Logistics offers an integration to DAS or SAP Business Network for Logistics, which can be used by external parties to arrange time slots and locations for a loading or unloading activity.

Similar to the EWM warehouse billing described in Section 12.2.4, SAP Yard Logistics includes a billing capability that allows you to either sell yard services to a shipper or get billed by a service provider that supports you in handling certain yard activities. Contracts for yard billing are maintained in TM, which subsequently also is used as the settlement tool.

Furthermore, SAP Yard Logistics can be integrated using any middleware or integration layer (e.g., SAP BTP to various third-party software, hardware, or infrastructure providers). Typical examples are as follows:

- Integration to smart sensors allows you to monitor and control all assets in the yard using standard sensor integration.
- Optical character recognition (OCR) sensors and license plate detectors can be used to automate gate processes or damage inspections.
- RFID technology can be applied and integrated to a variety of units.
- Smart filling allows weighbridges, silos, and transportation assets to be connected to automatically control loading processes.
- Drone control can be used for the inspection of remote areas of the yard.
- Geofencing technology can be used to automate movement activities by using the geolocation data of transportation units and handling equipment.

12.6 SAP Business Network for Logistics

Within SAP's overall strategy, the business network takes on one of the key roles. It's meant as a layer for integrating the internal operations of a business with the contributing external business partners.

SAP Business Network provides four functional areas.

- **Discover**
  SAP Business Network for Logistics allows you to identify and connect new business partners, find and use new business services, and investigate in new business opportunities.
- **Connect**
  The network can be easily used from a company perspective as it's managed centrally, and onboarding a well as connectivity are provided by the operating party or the participants. There is an out-of-the-box integration with SAP systems and partner solutions. Managed integration services allow connectivity to various common standards (e.g., B2B/EDI, devices, sensors).
- **Collaborate**
  SAP Business Network for Logistics provides a global, multimodal network, allowing collaboration between all parties related to and authorized in viewing and managing data, content, and document sharing of a joint process. Comprehensive process and service coverage is intended to be provided in later releases.

- **Gain insight**
  Accessing the large amounts of operational data through the network, embedded analytics and real-time shipment visibility can be provided beyond the traditional tools operated from a single party perspective. The goal is to provide end-to-end visibility of intercompany processes.

SAP Business Network as such spans multiple processes and applications in procurement, asset management, and supply chain. Within this book, we focus on the part of the network that is related to TM, that is, SAP Business Network for Logistics. It was released in 2019 and, being a strategic product of SAP, new functionality has continuously been added since then.

Contrary to the Collaboration Portal, which was part of the classic SAP TM, SAP Business Network for Logistics doesn't rely on a customer-managed IT infrastructure but is a pure cloud application that is hosted on SAP BTP. The application itself consists of multiple building blocks, which can all be utilized individually by users. A rough outline of the network and its connections is given in Figure 12.49.

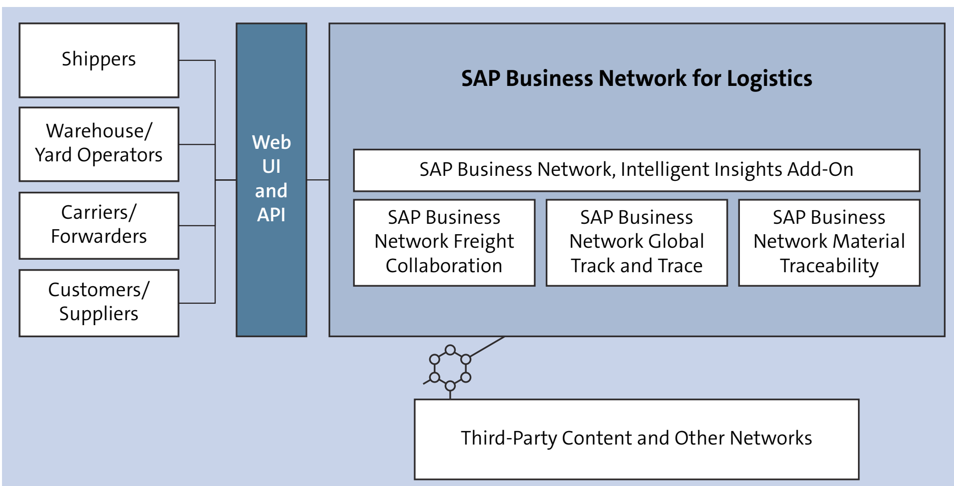


Figure 12.49 SAP Business Network for Logistics Overview

SAP Business Network for Logistics is meant to connect multiple business partners. The solution offers a browser-based SAP Fiori UI and allows you to connect to the system via application programming interfaces (APIs). As with all SAP cloud applications, a list of these APIs is available at *https://api.sap.com* (search for "Business Network"). Specifically, upon connecting to SAP S/4HANA, many of the interfaces already work out of the box and are fully integrated in the underlying business process, as you'll see later in this chapter. While most of the processes we'll describe also work in an SAP ERP setup, we'll focus our explanations in this book on the integration capabilities in SAP S/4HANA and the parts of SAP Business Network for Logistics that are relevant for freight execution and collaboration.

Compatibility

All functionality described in this book relates to the latest versions of SAP Business Network for Logistics connected to TM. However, some of the SAP Business Network for Logistics processes also support older TM versions. For a comprehensive list of compatible software versions and scenarios, see SAP Note 2620332.

An important factor of SAP Business Network for Logistics in terms of openness and reach is the network of networks concept, which allows acceleration of innovation and flexibility by leveraging the established services and new services of a variety of partners. SAP Business Network for Logistics becomes a multinetwork by not only integrating its own services but also linking into subnetworks, which are already up and running in logistics communities and in many cases concentrate on a subview of activities, such as tracking and tracing for truck fleets. The collaboration of partners can be consolidated to the end-to-end management of logistics and shipment processes, which is projected as a goal of SAP Business Network for Logistics. Table 12.3 shows the integrated networks and solutions as of the time of writing.

Digital-Enabled Truck Carrier Networks	■ Instafreight ■ Uber Freight
Road Visibility and Collaboration	■ Project 44 ■ Shippeo ■ FourKites ■ ForEye ■ Transporeon
Freight Booking and Container Visibility	■ Project 44 ■ ClearMetal
Ocean Freight Booking and Confirmation	Shipping lines through APIs
Risk Data	Everstream Analytics
Experience Data	Qualtrics

Table 12.3 SAP Business Network for Logistics: Integrated Networks

In the following sections, we'll give a comprehensive overview of the individual building blocks that form the core functionality of SAP Business Network for Logistics.

12.6.1 SAP Business Network Freight Collaboration

SAP Business Network Freight Collaboration is tightly connected to the TM solution and offers services long sought after by TM customers. The goal is that every interaction that occurs outside the core TM system is supported through the business network. This leads to increased transparency on order, execution, and settlement processes, as there is a digital thread that ties the whole process together. Furthermore, interactions via paper, email, or phone can ideally be eliminated, allowing for streamlined processes.

Freight Collaboration System Setup

As the range of processes increases rapidly within SAP Business Network for Logistics and new processes sometimes also result in new configuration options, we advise consulting the official help page for details on how to technically connect to the SAP Business Network for Logistics system at *http://s-prs.co/v557512*. Within this page, you can find administration guides for connecting as a carrier as well as for connecting as a shipper.

Figure 12.50 shows the individual connections of SAP Business Network Freight Collaboration and TM. In a holistic approach, all steps of a TM process are linked to the individual building blocks of SAP Business Network Freight Collaboration.

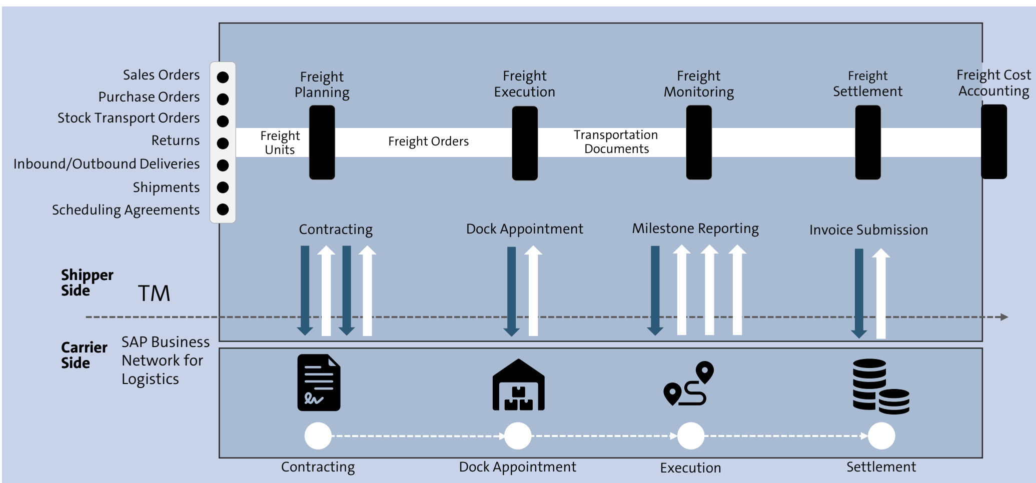


Figure 12.50 Freight Collaboration

We'll take a closer look at the individual steps in the following sections.

Contracting

The start of an integration scenario of SAP Business Network Freight Collaboration is the TM carrier selection process. As a reminder, this can be done manually or automatically in TM to either select an available carrier directly after freight planning or to start a tendering process to determine a suitable carrier on the spot market.

For carriers that are part of SAP Business Network for Logistics and have been onboarded there, the RFQ/transportation request can be directly published via the business network. The respective entry is maintained in the business partner profile of the carrier in the EDI communications profile. The carrier receives the request for quotation/direct order with request for confirmation in the SAP Business Network for Logistics online portal. In addition, the scenarios for email notifications can be configured to prompt the users on the carrier's side if their attention is required.

As the portal itself is accessible via browser from an external source, this provides an easy way to digitally interact with carriers without granting access to the internal network of a company. As an additional option, the carrier can connect directly to SAP Business Network for Logistics via the available APIs to receive the request electronically.

Figure 12.51 shows the tendering of a freight order and how it's displayed in SAP Business Network for Logistics. From top to bottom, we see first the view from within the **Subcontracting** tab of a freight order, where a tendering is underway ❶. The middle screen ❷ shows the SAP Business Network for Logistics UI, where the tiles with the information on open requests, quotations, and confirmations are shown. By selecting the **Freight Requests for Quotation** tile, the third screen opens ❸, displaying the tender, which was shown in the first screen in SAP Business Network for Logistics for further processing outside the TM system by the carrier.

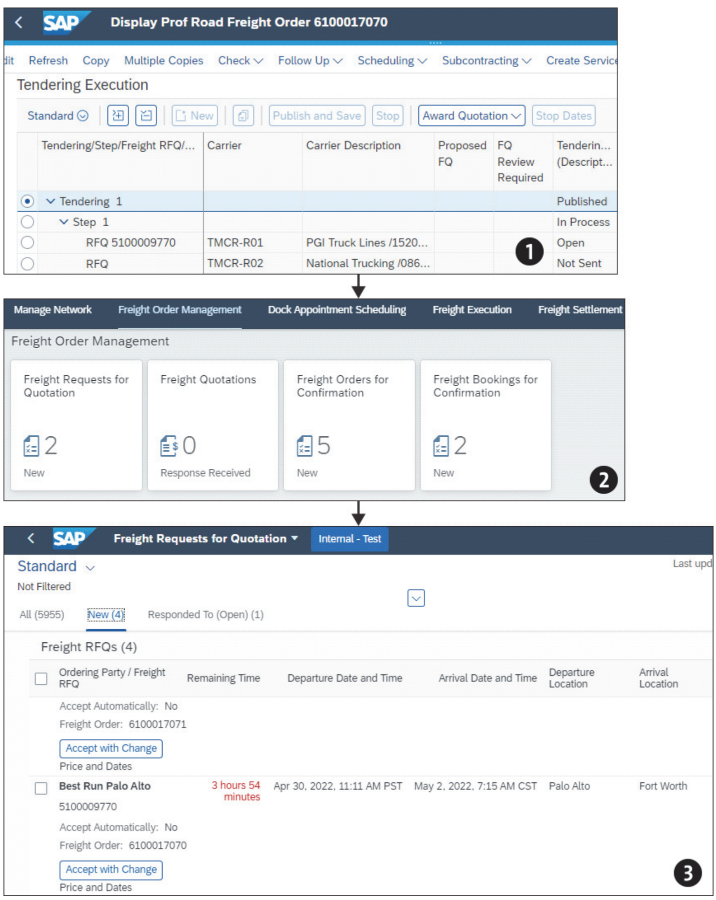


Figure 12.51 SAP Business Network for Logistics: Freight Quotation

The request contains budget, locations, dates, cargo details, tour details, notes, attachments, and contact information for each of the locations. This data is derived from the underlying freight order. For ocean freight bookings information on capacity (container) bill of lading (B/L), vessel, voyage, and IMO number is also available.

This initial request can be altered, rejected, or accepted by the carrier, with each step being reflected in the TM **Subcontracting** and **Status** tabs of the freight order/freight booking. As we discussed in Chapter 6, Section 6.6, the tendering process is stopped, and the respective carrier is updated in the TM freight order when a suitable offer has been received.

The process always follows these steps:

1. A tender is created in TM either manually or automatically based on the carrier selection settings and tendering profile. The individual tendering steps can be reviewed in the **Subcontracting** section of the tendered freight order, same as with any SAP Business Network for Logistics integration.
2. Based on the business partner settings, the tender is forwarded to SAP Business Network for Logistics and is visible in the web interface of the selected carriers (including email alerts, as indicated before).
3. The carrier can review the request by calling up the Freight Requests for Quotation app in a web browser. General information on locations, nature, and dimensions of cargo; contact details; tour details; notes; and attachments (directly replicated to and from TM) is displayed. Times for the requested stops can be changed, a price can be added, and the request can be submitted as accepted (with or without change) or rejected. Figure 12.52 shows an example request, as opened by a carrier, with general information.
4. Once received, the response is either automatically or manually evaluated within the TM system and, upon positive review, awarded to the carrier. The **Subcontracting** tab in TM shows which carrier was awarded and adds the carrier to the respective freight order or freight booking.
5. The carrier receives an order (road-freight) or booking (sea-freight) for final confirmation. The request can be reviewed in the respective online interface of SAP Business Network for Logistics again and confirmed or canceled. Once the response is received in TM, the confirmation status of the respective freight order or freight booking is updated.
6. If there is no tender, but a direct order with a specific carrier, the process only changes slightly. The freight order/freight booking is sent without tender, and the last step of the previously described process is directly active.

External Planning

In 2023, an alternate process for external planning was introduced, where SAP Business Network for Logistics can be utilized to forward freight units, and freight orders can be received via publicly available APIs and created in TM. (Check *https://api.sap.com* for the latest implementation advice of the following APIs: Consumer API to Request for Planning in External System, and Provider API to Create Planned Freight Documents from External System.) The decision regarding whether a freight unit should be sent out is linked to the purchase organization that is added in the freight unit.

This is a pure B2B scenario as of the time of writing; that is, no specific UI representation (e.g., an SAP Business Network for Logistics planning screen for carriers) is available as part of SAP Business Network for Logistics.

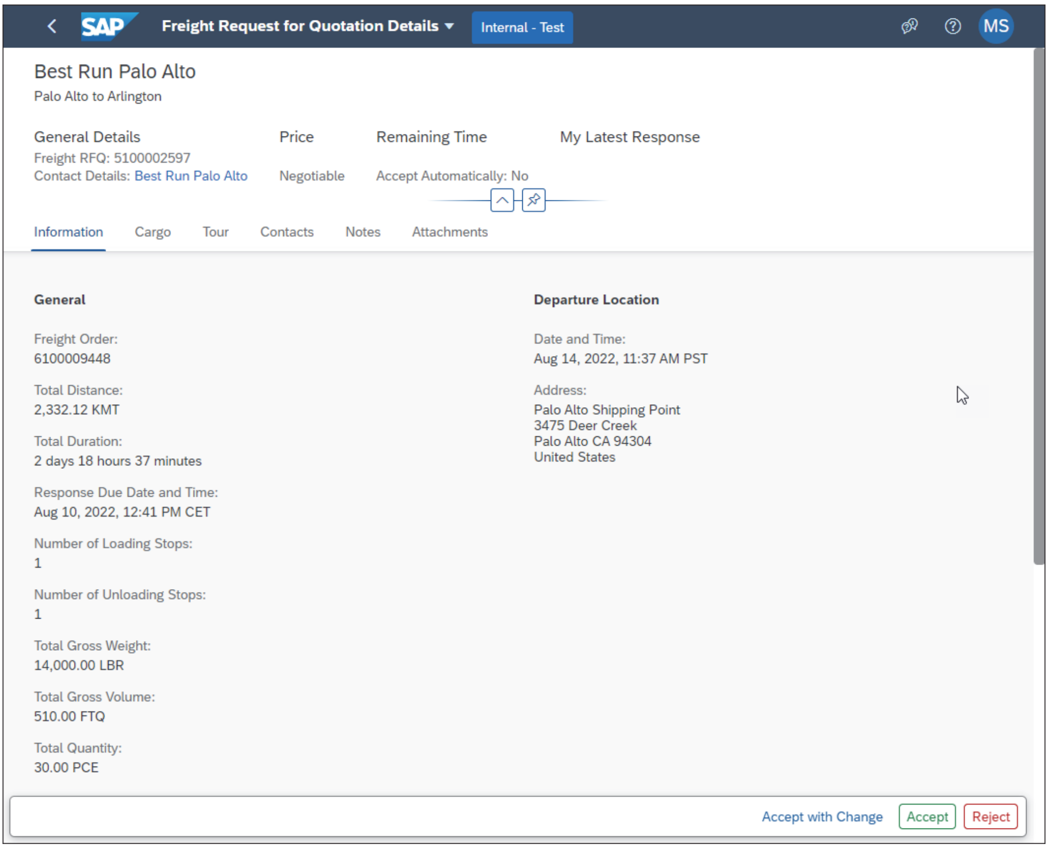


Figure 12.52 SAP Business Network for Logistics: Freight Collaboration Carrier RFQ Response

Dock Appointment

An existing and confirmed freight order allows the carrier to optionally perform a self-service dock appointment. In a business context, this allows for easier truck check-in/check-out processing at the respective site, as the truck arriving already follows a pre-booked schedule with the respective loading and unloading points already assigned and the truck and driver details already digitally available. Apart from efficiency in processing trucks at the company gate, these prebookings also avoid congestion at the gates, in that trucks are ideally arriving close to their booked time slot.

As a prerequisite to create dock appointments, the master data for each location must be maintained by the shipper operating SAP Business Network for Logistics via the Manage Entities app in SAP Business Network for Logistics. For maintenance, the locations are distinguished with location types as **Loading Point**, **Docking Location**, **Gate**, and **Yard**. Several loading points (situated in the same general geographical location) can be grouped into one docking location. Gates and docking locations can be assigned to yards. The individual entities can also be imported from/exported to Microsoft Excel for easier maintenance.

Location-specific settings such as working hours, time slots, cutoff times, capacities, and so on are enabled to further specify the attributes and availability of the individual locations.

Note

For a detailed explanation of the dock appointment entity settings, go to *http://s-prs.co/v557513*. For the purposes of this discussion, we'll explore some key dock appointment features in the following sections.

Booking an Appointment

The basis for a dock appointment is always a freight order in TM. It's possible, however, to already book dock appointments for freight orders that aren't finally confirmed by the carrier. One-time carriers can be manually specified that allow an email notification of a manually created appointment to a carrier that isn't yet onboarded to SAP Business Network for Logistics. Determination of potential loading points for booking a time slot by a specific carrier is done via the location IDs of the connected docking locations, which have to match the locations used in the TM system for the respective source and destination locations (master data replication of the locations is done via the Data Replication Framework [DRF] and described in the previously mentioned setup guide in the beginning of Section 12.6.1).

Using the Self-Book Dock Appointments app, the available loading points and their respective capacities for each individual freight order are shown to the carrier. Based on the desired schedule, the desired available slot can then be selected and booked as depicted in Figure 12.53. Access for individual users can be restricted by loading point.

Once a slot is booked to capacity, the respective time will be shown as **Unavailable** in the app, and other carriers will be forced to select different times/loading points for their appointment. This leads to real-time visibility for all affected business partners on the respective shipper's location, one of the main building blocks to avoid congestions at the gate and to avoid exceeding warehouse processing capacities.

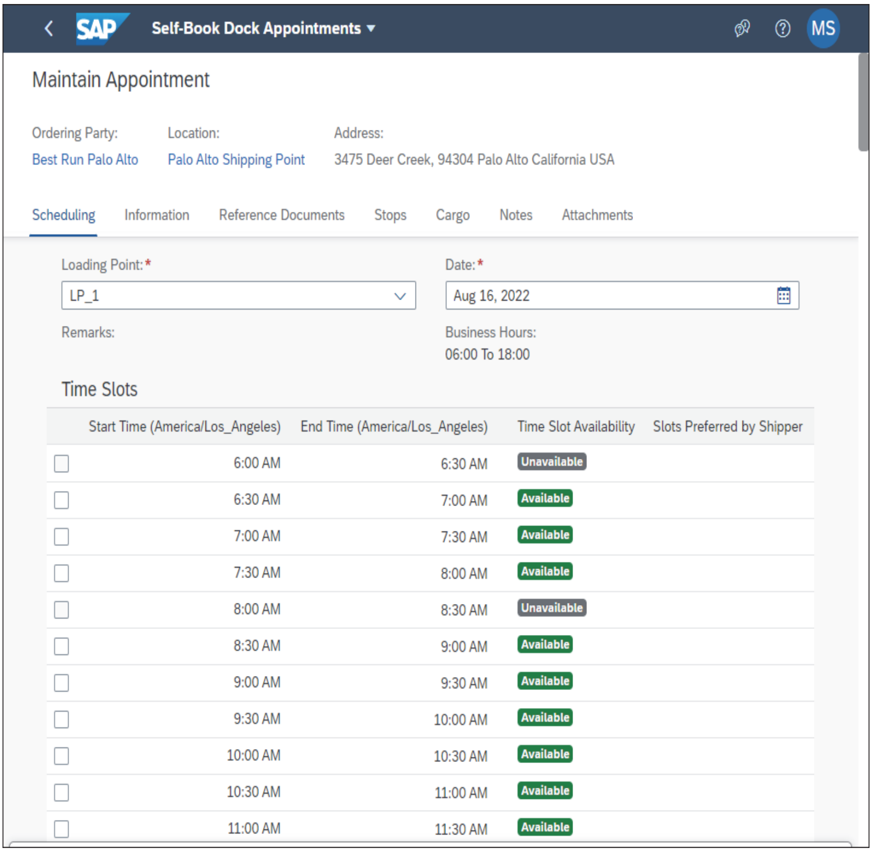


Figure 12.53 Carrier Dock Appointment Selection

For shippers, a separate app, Manage Dock Appointments (see Figure 12.54), allows visibility of the current situation across the managed docking locations per user via analytical apps.

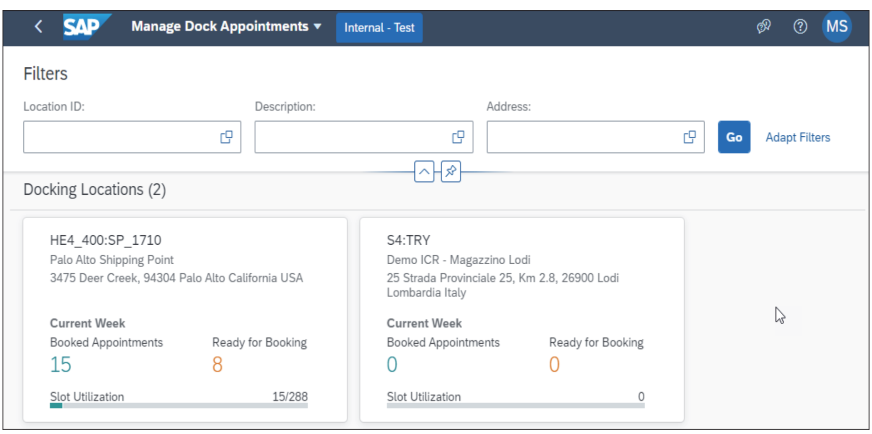


Figure 12.54 SAP Business Network for Logistics: Shipper Loading Appointment Overview

Upon selecting the respective docking location, a Gantt chart opens, where appointments can be altered or manually maintained for existing freight orders and where time can be blocked to make the loading points unavailable for bookings (e.g., to account for maintenance times or unexpected events during loading/unloading).

For each maintained appointment, the shipper can report the events for loading start, loading end, and delays (with reason code) out of the respective SAP Business Network for Logistics apps. In addition, it will be visible for the user if a truck has already been checked-in (see next paragraph).

As previously mentioned, the appointments created are linked to a TM freight order. In case of a change of dates or locations these changes are reflected in the open appointments via update or cancellation. Canceled freight orders will also lead to the cancellation of all connected appointments.

Gate Processing

Apart from making sure that a docking location for a truck is determined, it's also necessary to determine if a truck should gain entry to the company's yard and keep track of its leaving as well. This check-in and check-out processing is supported in SAP Business Network for Logistics as well. SAP Business Network for Logistics uses existing loading appointments to provide an overview to the shipper on which trucks should be allowed to enter. The respective process for shippers (intended to also be used by yard operators) is supported by the Manage Gate Operations app. The app shows the existing appointments and allows you to start the connected check-in and check-out processes, as depicted in Figure 12.55.

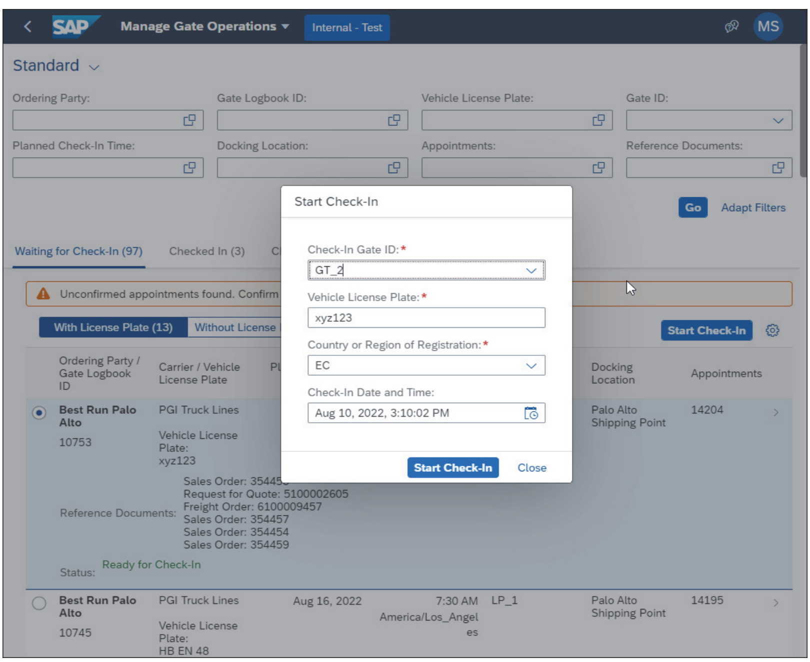


Figure 12.55 Perform Check-In for Loading Appointment

This logbook of gate operations also combines several freight orders and appointments for one vehicle to provide a single point of entry for incoming and outgoing trucks.

During the check-in/check-out, missing details (apart from the ones already shown in Figure 12.55) for a freight order can be finalized, such as these:

- Driver details
- Confirmed weights (check-in and check-out)
- Seals
- Attached equipment
- Confirmation of verification: vehicle safety
- Confirmation of verification: driver safety (only check-out)
- Confirmation of verification: required documentation
- Notes
- Attachments

Upon completion of the check-in and check-out processes, the loading/unloading at the shipper's location is complete, and the actual execution starts. Utilizing the dock appointment functionality of SAP Business Network for Logistics bridges a gap in the TM software, where cloud-based online gate operations and loading point management weren't available in the past. As a final addition to make the solution also usable for carriers that aren't onboarded to the business network, a one-time invitation can be sent to a guest carrier for single-use slot booking by the shipper.

Advanced Integration of DAS

For advanced integration scenarios of SAP Business Network for Logistics DAS with TM and other applications, we recommend the following cookbook: *http://s-prs.co/v557514*.

Execution and Event Reporting

After the initial planning and loading/unloading steps are performed, the carrier has the option to report on fixed predefined milestones (i.e., events). For TM, this is generally facilitated by SAP Event Management or SAP Business Network Global Track and Trace (described in Chapter 7, Section 7.2 and Section 7.3, respectively). However, with SAP Business Network Freight Collaboration, there is now an additional option to integrate events that occur outside the company's premises. A fixed set of events can be reported directly via SAP Business Network for Logistics for a subcontracted freight order, directly updating the **Execution** tab.

With the wide reach of a business network connecting shippers, carriers, and visibility networks, this tackles one of the biggest challenges of transportation execution tracking: "Where does the data come from, and how do I integrate it?" We'll walk through the key features next.

Carrier Reporting

Each carrier can access a list of freight orders that the carrier has confirmed via the SAP Business Network for Logistics web UI (alternatively active tracking requests can also be consumed via the API). In the Freight Orders for Reporting app, a specific order can be selected and, subsequently, the execution event can be reported as depicted in Figure 12.56. For real-time maintenance of events, carriers can allow their drivers direct access to the SAP Business Network for Logistics web UI. As the UI is programmed with the responsive design principle, it allows for seamless operation on mobile devices.

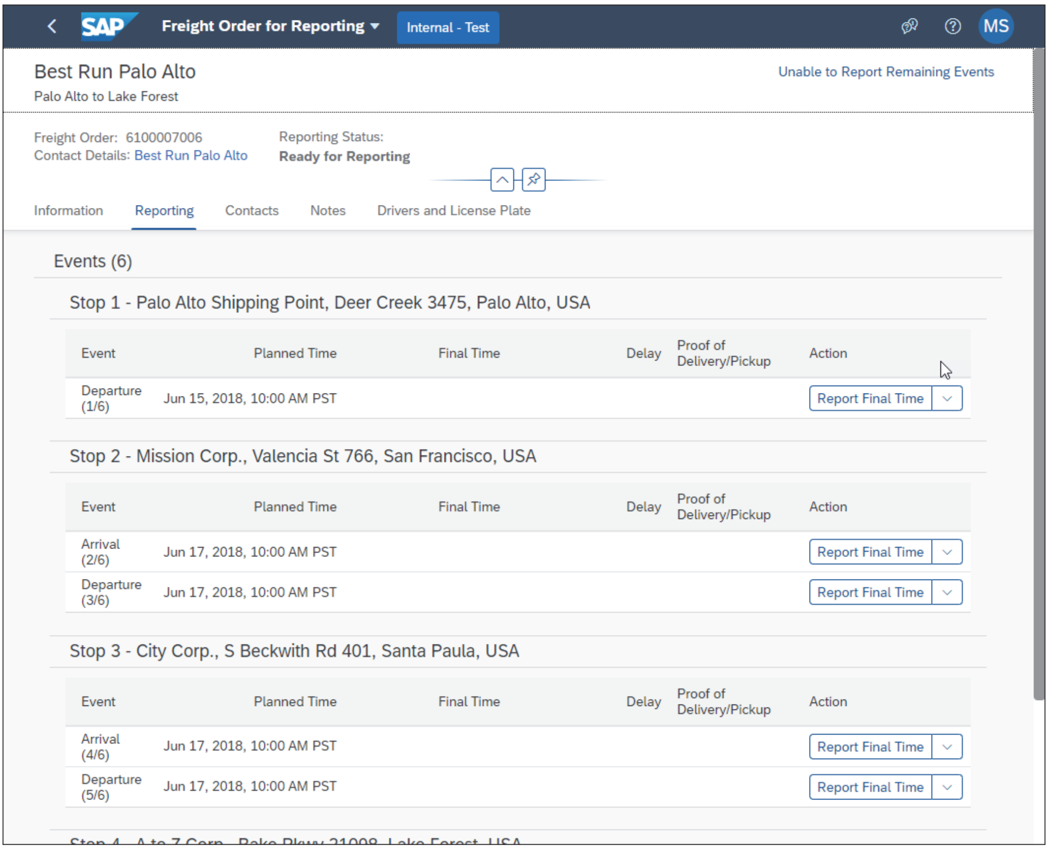


Figure 12.56 SAP Business Network for Logistics: Execution Event Reporting

Within the app, the carrier sees all the already-reported and still-open events. Via a dropdown menu, the carrier can select the following options to report/update events:

- **Report Delay**
  Reports the new expected date, time, and duration of the delay event together with a selectable delay reason (from a dropdown list) and an optional comment.
- **Unable to Report**
  Selects that the event not be reported.

- **Report Proof of Pickup/Proof of Delivery**
  Allows the respective events to be reported, including the upload of attachments.
- **Report Exception**
  Allows for the reporting of an exceptional event during transportation, including time of exception, reason, comment, and file upload.

All reported events are visible in the TM freight order **Execution** tab, including the respective file uploads, which are stored as attachments.

Although the listed events are a basic subset of the things that can occur during transportation, they still allow the shipper to gain visibility of what is happening after a truck left the premises. In addition, the nature of the reportable events allows you to create follow-up scenarios such as creation of freight settlement documents after proof of delivery reporting or update of freight orders after exceptions have been reported.

Network Visibility

SAP Business Network for Logistics allows for the connection to visibility service providers to attain tracking data. In this case, the carriers aren't required to report events via SAP Business Network for Logistics directly but can rely on a visibility provider to supply the respective data. To achieve this, a tracking request is initiated by a TM freight order or freight booking. It contains details such as carrier ID (Standard Carrier Alpha Code [SCAC]), shipment ID (B/L, freight order ID, etc.), locations, license plates, and so on. This request is routed via SAP Business Network for Logistics to a visibility platform such as Project 44 or FourKites.

Based on the request, shipment updates with time stamps, status codes (in transit, etc.), geocoordinates, and arrival codes (late, early, etc.) can be received by SAP Business Network for Logistics and subsequently forwarded to TM as event notifications.

The following ready-to-run scenarios are currently supported by SAP Business Network for Logistics:

- **Full truckload (FTL)**
  Reporting on vehicle position, status, and predictive ETA.
- **Less than truckload (LTL)**
  Milestone reporting.
- **Less than container load, full container load**
  Vessel and container status, geolocation, and predictive ETA.

Currently supported events in freight collaboration are shown in Table 12.4.

Event Code	Description
DEPARTURE	Departure
ARRIVAL	Arrival

Table 12.4 Supported Event Types for Visibility Provider Integration

Event Code	Description
LOAD_BEGIN	Loading start
LOAD_END	Loading end
COUPLING	Coupling
DECOUPLING	Decoupling
POPU	Proof of pickup
POD	Proof of delivery
DELAYED	Delay
GEOLOC	Geolocation update
RECEIVE	Receive
STUFF	Stuff
UNSTUFF	Unstuff
GATEIN_START	Gate-in start
GATEIN_END	Gate-in end
GATEOUT_START	Gate-out start
GATEOUT_END	Gate-out end
DELIVERED	Delivered
RETURN	Return
OTHER	Other
OUT_FOR_DELIVERY	Out for delivery
EXCEPTION	Exception
EVENT_EST_UPD	Event estimated update
EMISSION	Emission event

Table 12.4 Supported Event Types for Visibility Provider Integration (Cont.)

Note that OTHER and EXCEPTION are generic events for handling visibility provider–specific event types and can be mapped for specific messages such as “container cleaning in progress” and reported back to TM as such. An event reported back by a visibility provider is automatically handled via the OTHER event category, unless it’s specifically mapped to another event type.

Shipper's Visibility

While event messages are being sent to TM, SAP Business Network for Logistics also provides the shipper with an additional visibility solution that can reflect the reported time stamps, geolocations, and events. In the Track Freight Movements app, all subcontracted shipments are displayed with their current status (**In Transit**, **Arrived**, **Overdue**, etc.), allowing for a concise overview of the current transportation situation.

Upon selecting an individual shipment, all milestones and tracking information, including geolocation and ETA, are displayed (see Figure 12.57).

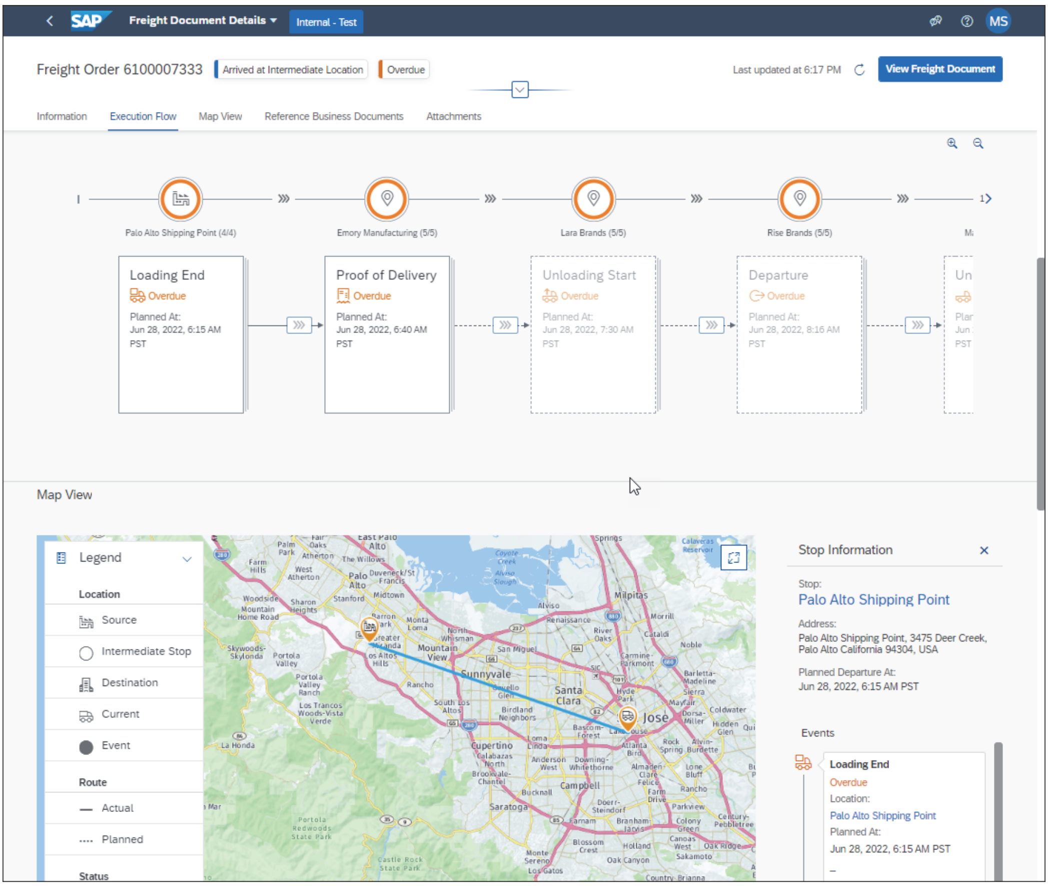


Figure 12.57 SAP Business Network for Logistics: Shipper Detailed Tracking

Freight Settlement

As a final step, after completion of the transport, the carrier can upload an invoice and trigger the payment process. Via the Invoice Freight Document app, all invoicing-relevant freight documents are selectable for review and start of an invoicing process. This includes the addition of an invoice reference and invoice date, and the upload of an invoice document. Furthermore, additional attachments and notes can be added. If a deviation of planned and actual cost has occurred, the carrier also has the option to alter existing or to add additional charge lines to the invoice, as depicted in Figure 12.58.

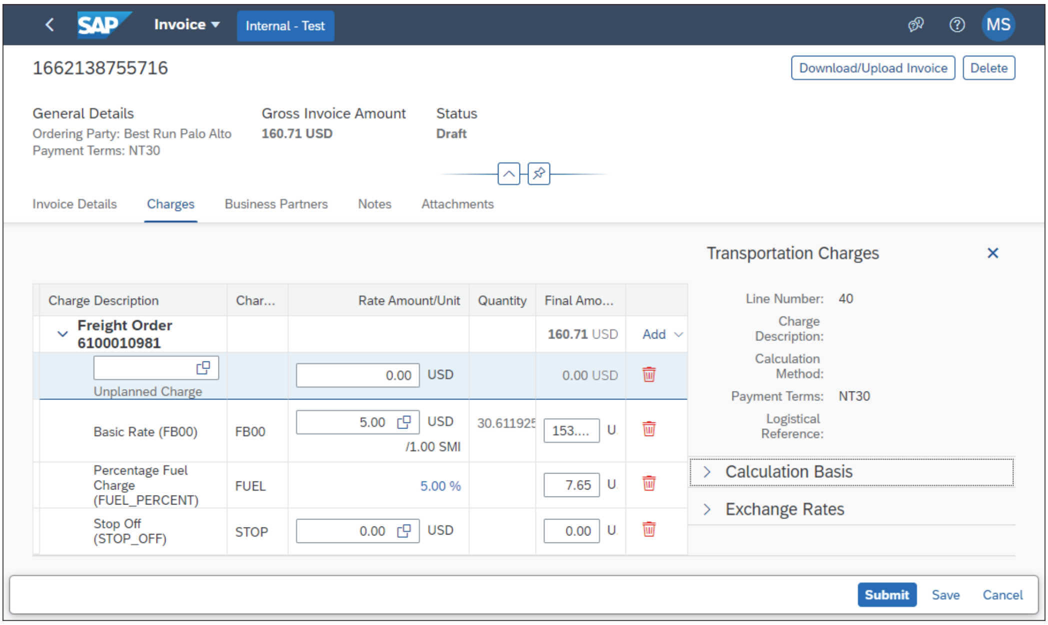


Figure 12.58 Adding Unplanned Charges in SAP Business Network for Logistics

During this step, each discrepancy that occurs to the previously agreed price will lead to a dispute, which can be resolved in the online platform of SAP Business Network for Logistics. As an example, a carrier might face unexpected wait times at the customer site, which incurs additional cost as the vehicle is blocked during that time.

Each dispute can be reviewed through the shipper's and carrier's browser-based SAP Business Network for Logistics UI through the Manage Disputes app. Deviations from the originally agreed shipping cost are shown with a reason code and can be accepted or rejected with additional notes. Figure 12.59 shows an ongoing dispute for stop off charges as an example. Within this process, workflows can be utilized to approve rate changes for disputes that exceed a certain cutoff value.

This functionality allows for a transparent standardized online resolution of rate disputes and hence solves the issue of a disjunct process, where emails and phone calls are required to allow settlement.

Once the invoicing process is started by the carrier and the freight settlement document has been posted in TM, the logistics invoice verification can be triggered and the invoice posted. This also works for the collective invoicing scenario through the selection of several freight documents. As of the time of writing, only road- and ocean-based freight orders and freight bookings were supported for settlement through SAP Business

Network for Logistics. The invoice itself is received digitally into the SAP S/4HANA back-end via the upload through SAP Business Network for Logistics.

Self-billing is also part of the usable scope. Carriers can review the freight orders and freight bookings that are relevant in the Review Freight Documents – Self Billing app. From there, the order details can be displayed and disputes initiated by altering or adding charge lines.

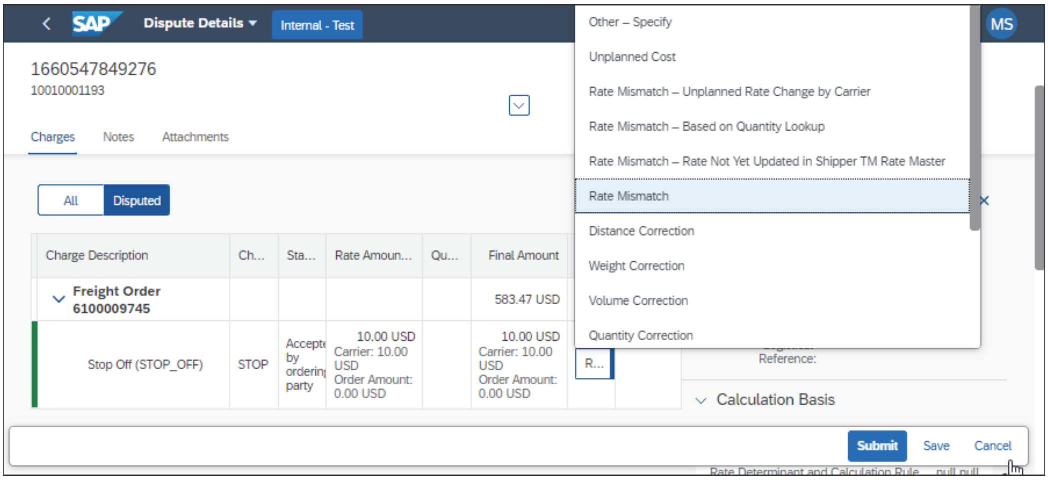


Figure 12.59 Dispute for Unplanned Charges with Selection of Reason Codes

12.6.2 Further Solution Capabilities

The previously discussed capabilities for SAP Business Network Freight Collaboration and SAP Business Network Global Track and Trace are directly linked to TM, and data is exchanged between the respective solutions and the TM core. Further parts of the SAP Business Network for Logistics solution capabilities are mentioned in the following paragraphs to provide a holistic overview of the solution without going into further detail, as there is no direct relation to TM processes (insights from the individual solutions might be used to support TM processes, however).

Material Traceability

SAP Business Network Material Traceability provides the means to gain transparency on materials through an n-tiered supply chain, where multiple raw materials and semi-finished products are combined into a finished good, which is then shipped to an end customer. The tool is designed to allow tracking product genealogy and status for both serialized- and batch-manufactured products.

For example, a manufacturer of a chocolate bar can follow each of the ingredients back to the source, from the supplier of the milk to the company that uses it to make butter up until the company that supplies the wafers for the chocolate bar. Figure 12.60 shows one example for such a supply chain, where products marked in red have been recalled, and their relation to the end product is discernable immediately.

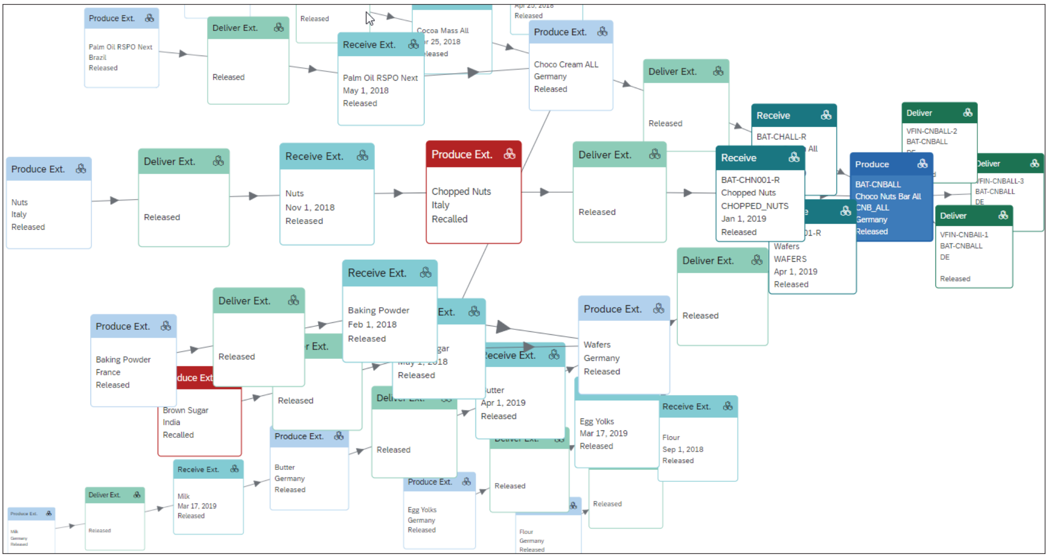


Figure 12.60 SAP Business Network for Logistics: Batch Traceability, Graphical View

The desired visibility in this case is for the procurement side to satisfy, for example, the demands of supply chain transparency acts such as the EU Supply Chain Law, as well as to allow quick and efficient management of product recalls in case of faulty product batches or serial numbers.

The network owner can invite business partners (i.e., suppliers) to join and can define how much visibility those partners have on the shared data.

Product-related data (goods issue, goods receipt, and product manufacturing) can be extracted from SAP ERP and SAP S/4HANA as source system and genealogy data can be captured via APIs. Product properties (carbon footprint, country of birth, temperature range, etc.) and categories (certificates, allergens, properties, etc.) are freely definable for each product. To allow data immutability, SAP Business Network Material Traceability can be used to integrate blockchain capabilities.

Graphical and tabular views as well as alerts help to keep track of product issues and allow quick resolution by showing which products are affected by a certain problem in the supply chain and defining follow-up actions directly in the UI.

Product locations for material traceability are determined via goods receipt and goods issue of the companies taking part in the network; no connection to transportation service providers is required. This is in direct contrast to SAP Business Network Global Track and Trace, where detailed tracking of transportation activities and goods locations is possible and is explained by the different focus of the two SAP Business Network for Logistics functionalities.

Intelligent Insights

SAP Business Network, intelligent insights add-on, provides a consolidated map-based view of the current transportation situation of a network owner. It's based (and dependent) on data from SAP Business Network Global Track and Trace to create a live supply chain situation room of all monitored shipments and locations of a supply chain.

The solutions we've discussed so far focused on individual shipments/orders for tracking. For informed decision-making, a collated view is required to, for example, not reroute incoming shipments to a location that has already reached its capacity for handling trucks. Furthermore, by integrating Everstream as a data provider, current events that affect the supply chain, such as weather, disease, and so on, can be integrated into the situation room with a risk score as well.

The logistics insights solution provides the following functionalities:

- Configurable views per user role (e.g., global versus location specific)
- A global, map-based logistics situation room, as shown in Figure 12.61, with the following features:
  - Live view of shipments
  - Live view of locations with the number of incoming and outgoing goods movements and dwell times
  - Filters for mode, status, and location
  - Search functionality
  - Detailed insights by clicking on the respective object on the map and links to the SAP Business Network Global Track and Trace solution
  - Color-coded animated warnings in case of unexpected events and risk scores
- Ready-to-use self-service dashboards with insights on the following:
  - On-time status overview of inbound and outbound shipments
  - Carrier execution performance
  - Supply chain activity overview
  - Risks for shipments in transit and locations

When using the situation room, a top-down approach can be followed, where the live view across the supply chain can be used to gain initial insights on current and upcoming issues, further details can be explored for individual shipments in the SAP Business Network Global Track and Trace solution, and finally actions can be triggered in the connected core ERP systems to prevent or minimize supply-chain disruptions and increase service levels.

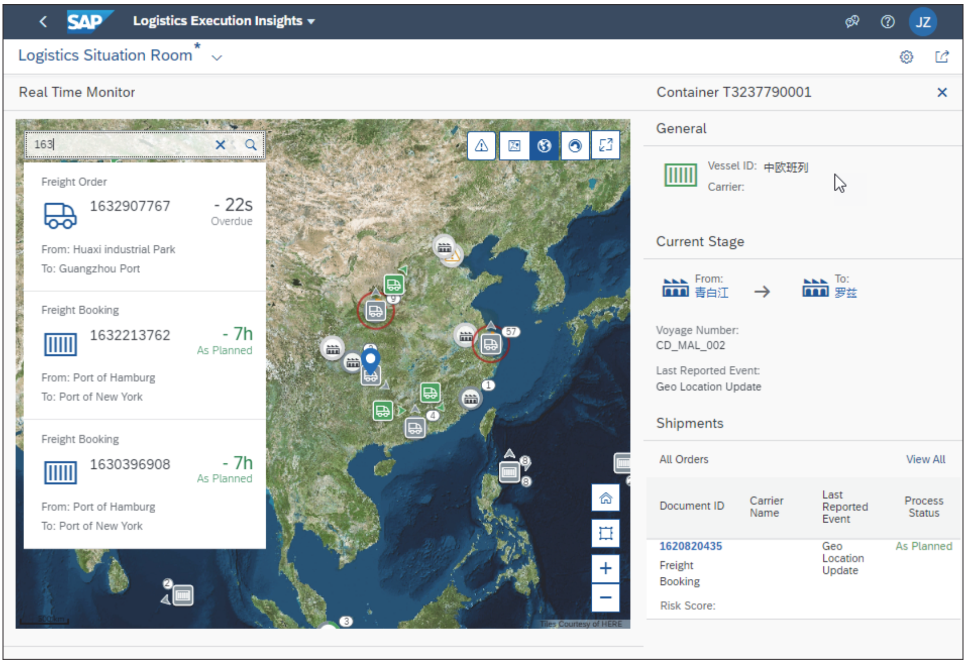


Figure 12.61 SAP Business Network for Logistics: Intelligent Insights Situation Room

Onboarding Business Partners

For enabling the collaboration with business partners within SAP Business Network for Logistics, the participants have to be invited or uploaded by the network owner. There are three ways to add business partners to the network, and all of them are executed via the Invite Business Partners app:

- **Manual entry**
  In the Invite Business Partners app in the **To be Submitted** tab, choose **Add Invitee • Business Partner**, and enter the requested details (name, address, language, etc.) in the following screen. As a result, the partner will be visible in the worklist, and an invite can be sent by selecting it and clicking the **Submit** button.
- **Microsoft Excel upload**
  Instead of entering business partners one by one, as described in the previous point, they can be mass uploaded via a Microsoft Excel template. The template can be downloaded in the Invite Business Partners app via the **Download Excel Template** button. After adding the business partners in the template, they can be uploaded to the system via **Download Excel Template**, which will import the data, perform a duplicate and completeness check, and make the respective partners available for submitting an invitation.
- **TM integration**
  Similar to the preceding point, business partners can be imported from TM. To achieve this, the Microsoft Excel file with existing carriers can be downloaded from

TM via a report (to be executed in Transaction SE38): /SCMTMS/R_LBN_CARR_LIST_DWNLD. The number of carriers downloaded can by restricted by TM organizational unit (all carriers mentioned in active freight agreements will be downloaded) or by specifying carrier names in the offered selection criteria.

The resulting Microsoft Excel list can then be uploaded to SAP Business Network for Logistics as described in the previous point.

Once the carriers have been uploaded and are in status **Accepted** on SAP Business Network for Logistics, the carrier master data (specifically their SAP Business Network for Logistics IDs) must be updated in TM. To support this process and reduce manual labor, an additional Microsoft Excel export and import functionality was introduced. Within the Invite Business Partners app, navigate to the **Accepted** tab, and choose **Download Business Partners**. The resulting CSV file can be uploaded in TM via executing the report /SCMTMS/R_LBN_ID_BP_UPD in Transaction SE38.

Once the invitations have been submitted, carriers will receive an email with instructions on how to connect to SAP Business Network for Logistics. Carriers that are already onboarded can review and accept additional incoming invitations via their Mange Invitations app.

Carrier Setup and Onboarding

A specific setup and onboarding guide is available for carriers to detail the first steps in SAP Business Network for Logistics, and it enable them to do business with the respective inviters: go to *http://help.sap.com* (**SAP Business Network for Logistics • SAP Business Network Freight Collaboration • Administration Guide for Carriers**).

While for shippers, a lot of emphasis lies on integrating existing business partners into SAP Business Network for Logistics to form a digital thread in supply chain execution, another big use case for business networks is the capability to discover additional business partners. Especially when dealing with disruptions in the supply chain, where new sourcing and delivery options must be quickly determined to prevent stock-outs or delays, the capability to easily find and digitally connect with an LSP helps to overcome or mitigate challenges.

This is enabled in SAP Business Network for Logistics via the Discover Business Partners app. It shows all carriers that are already active within SAP Business Network for Logistics and allows you to send invitations to these business partners. Several filters for industry coverage, geographical reach, connection status, and role are available to narrow down search results and effectively discover new business partners.

12.7 SAP Direct Distribution

In consumer product and retail industries, there are certain scenarios that come up in customer discussions where, even though a transportation problem is part of an overall process, TM as a standalone solution might not be the best fit. The scenario entails a loaded truck or van that drops off a sometimes-unspecified amount of goods at points of sales or consumption on a predetermined route. The process entails elements of merchandising and marketing, information gathering, and additional services. For beverage companies or food wholesalers, for example, the respective process allows you to bypass retailers and directly sell to customers. Other advantages for companies that use this direct store delivery process include speed for keeping items in stock and better customer experience through increased service and a "face in the store."

In the past, SAP offered SAP Direct Store Delivery for this, which wasn't directly connected to TM. In SAP S/4HANA, SAP Direct Distribution delivers a wholly remade solution, which was built and co-innovated with customers. It's optimized for SAP S/4HANA and integration, which includes a connection to TM for optimized logistics execution.

The full solution includes elements of SAP Sales Cloud, the central SAP Direct Distribution component on SAP S/4HANA, and a mobile application, as well as a tie in with the SAP BTP functionality. For a full description of the SAP Direct Distribution process, we refer to the feature scope description on *http://s-prs.co/v557515*, as we'll focus on the TM-related parts in this description.

In Figure 12.62, the complete process for SAP Direct Distribution is depicted on a high level. The TM-related part of the process integrates estimates, planned services, or concrete orders of what should be loaded on the truck; load planning; calculating the most efficient route; communicating it back to SAP Direct Distribution; and printing documents. The actual execution part of SAP Direct Distribution, where the TM integration comes into play, tours are planned, and sales and presales visits are executed is called *last-mile distribution (LMD)*.

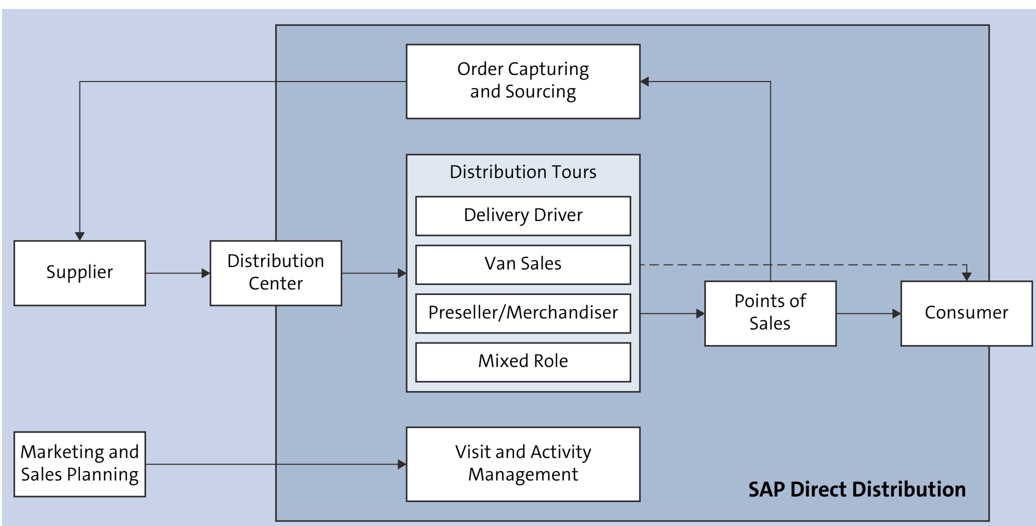


Figure 12.62 SAP Direct Distribution Overview

For LMD, the following basic scenarios are relevant:

- **Van sales**
  In a van sales scenario, the driver of a vehicle acts as a salesperson, drives to potential customers on a predetermined route, and performs ad hoc sales and services (e.g., restocking of shelves) of products loaded. The van in this case serves as a "shop on wheels." Prior to the start of the tour, the exact items needed for each stop aren't known so the van is loaded based on estimates, which is called a *speculative load*.

  During execution, the van seller can access the route, remaining stock, and prices and then record the performed activities using a mobile device. The steps are as follows:

  - Basis for the scenario is a *visit list*, which is created outside of TM in an SAP CRM system. The visit list contains stops for the included business partners, the times calculated for the stops at each site, a date, when the tour should start, and a driver assignment.
  - Based on the visit lists, the LMD starts a planning process for which product proposals (speculative loads) and services tasks (both without reference to a sales order) for the individual stops are created. Planners can also create *load requests* manually (resulting in a sales order) and add them as planned loads.
  - The speculative loads, load requests, and service tasks are sent to TM and lead to freight units that are created with a reference to the visit list.
  - LMD triggers the creation of a freight order, including the driver details.
  - Freight units are assigned to the freight order automatically (via an LMD planning strategy) or manually in TM.
  - The scheduled freight order with all assigned freight units is sent to LMD upon a predetermined status change (generally customized as **In Execution**). At this stage, the goods issues are also posted.
  - Document printouts for execution and freight settlement can optionally be performed in TM.
  - Once the route is reported as fully executed in LMD, the freight order status changes to **Executed**. freight orders are updated with sales order references, should any sales have occurred during the route and were captured by the van-seller.

- **Preordered delivery**
  For a distribution scenario with preordered deliveries, sales and distribution documents are created to resemble the expected loads on a truck. The driver is going along a fixed route to deliver goods and collect returns. TM is the leading system for planning.

  The steps described for van sales are slightly altered:

- The visit list is only relevant for the service-related stops. In this scenario, these stops are to pick up return deliveries of goods, deposits and returnable packaging.
- Service freight units are created out of LMD, while freight units for goods deliveries are created based on deliveries.
- Package building is performed.
- TM leads the process in that it plans the service freight units and freight units on freight orders. It performs the scheduling and routing and then produces a load plan. Drivers are assigned, and the route is handed over to LMD.

- **Preseller/merchandiser**
  The main aim of the preseller tour is to do marketing and trade promotions to capture future demands from the customer for later delivery tours. Also, the preseller might perform service tasks such as filling up shelves and collecting payments.

  As such, the freight orders in TM are generally created for service freight units only, with the main task of TM being the scheduling of the preplanned tour.

A high-level overview of the system interaction for the described processes is shown in Figure 12.63. The integration between SAP Direct Distribution and TM is centered on the freight order. Demands for transportation are handed over by the LMD portion of SAP Direct Distribution to be optimized into freight orders by TM. The demands are represented by freight units. We distinguish freight units for service tasks, product proposals, driver loads, and customer deliveries and returns.

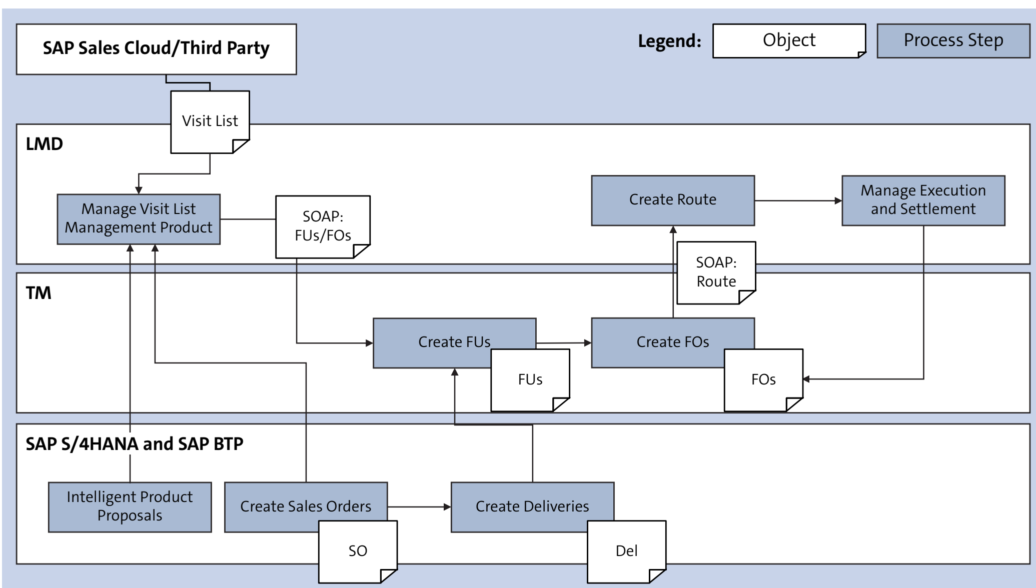


Figure 12.63 LMD System Interaction

Created freight orders are then sent back to LMD and create a route. The connection between LMD and TM is based on SOAP messages:

- **`TransportationOrderGenericRequest_Out`**
  Used to send the freight order to LMD and create the route object, triggered by the SAP Direct Distribution `PPF_Profile`.
- **`TransportationOrderGenericRequest_In`**
  Used to receive freight unit and freight order details derived from the LMD visit list.

The main TM-related configuration in SAP S/4HANA is centered around the TOR objects involved:

1. Set up SOAP communication (for more information, refer to *http://s-prs.co/v557516*).
2. Perform LMD configuration to identify relevant TOR types in logistics execution by following menu path **Last Mile Distribution • Integration • Integration with Transportation Management • Specify Relevant Freight Order Types**.
3. Create freight order types for the SAP Direct Distribution processes, ideally one for each of the described processes in use (delivery driver with and without route stock, van sales, presales/marketing). This helps to identify the respective scenario in daily operations. The freight order as such can be configured based on the needs of the respective planning scenarios, but you have to ensure that the LMD output PPF settings (`LMD_Output`) are maintained to release the freight order to LMD after planning.
4. Create freight unit types. Here, it's again advisable to create individual types for the respective integration scenarios for ease of use (i.e., driver loads, deliveries and returns, product proposals [predictive loads], service tasks). Within the freight unit types, the output profile again needs to be maintained as `LMD_Output`.

12.8 Summary

In this chapter, we discussed the interplay of functionality of TM and several additional solutions within the SAP landscape. Each solution discussed enhances the core capabilities of TM and enables end-to-end logistics execution and monitoring. Let's revisit the solutions we covered:

- **Analytics**
  Analytics supports companies using TM with meaningful statistics, dashboards, and KPI calculations.
- **EWM integration**
  Warehouse and transportation processes are linked, and the interplay between TM and EWM enable seamless logistics execution in inbound and outbound processes.
- **ASR**
  The new ASR process for TM and EWM connects warehousing and transportation.

- **SAP Transportation Resource Planning**
  SAP Transportation Resource Planning is used to provision and track transportation resources.
- **SAP Yard Logistics**
  This is an additional solution to manage and execute check-in and check-out processes as well as keep track of the resources stored and moving on the company premises.
- **SAP Business Network for Logistics**
  This public cloud solution seamlessly integrates TM with business partners for logistics subcontracting and logistics visibility.
- **SAP Direct Distribution**
  This solution is used to support direct store deliveries via TM as a tool for transportation planning.

In the next chapter, we'll move on to a discussion of the migration path to TM in SAP S/4HANA.

Chapter 13

Migrating to and Running TM in SAP S/4HANA

As a software tool, transportation management (TM) has reached a high maturity level. However, due to the changing SAP deployment and component strategy, there is a lot of variability when managing implementations or system migrations from one deployment or component form to another. Additionally, you should be aware of topics that become relevant when operating TM in large or performance-critical environments, such as monitoring and awareness/control of data volume.

The path from an existing SAP-based transportation solution to a well-integrated TM solution within your company landscape can be quite a journey. Different from traditional software, TM can be provided in many releases, forms of deployment, and integration variants. You got an idea of the diversity in Chapter 1 when we talked about deployment and integration with other components and cloud services. Transition or migration scenarios generally refer to the methods of implementing a new solution by replacing a previously running application and taking over existing processes, data, or integrations into a new environment. In each migration, you should factor in various viewpoints:

- Where does your transportation management system (TMS) or installation come from? It may be a legacy system, an older SAP ERP with integrated LE-TRA, an older version of an SAP NetWeaver–based SAP TM, or already a standalone version of an SAP S/4HANA–based TM.
- Which of the processes and data available on the existing installation must be taken over, and which ones may be replaced, remodeled, or added from scratch?
- Does the move from the old to the new TM system go in one step or is it a multiphase journey over some intermediate releases, solutions, or components, with regional or organizational differences?
- Where do you finally need to go in TM? Is it targeted to an embedded TM in an SAP S/4HANA system or a decentralized instance?

The details of how to move TM functionality from one release and deployment form to another one will be the focus of the first section of this chapter. However, there are two situations where you also have to think about limiting and operational factors of your TM system:

- When deciding on a deployment and installation form that may affect the performance and capabilities of your TM system such as if you want to use functionalities, which still requires certain deployment forms for full utilization (e.g., advanced shipping and receiving [ASR] works best in an embedded environment)
- When you're targeting to run your TM system smooth with large data volumes or high performance requirements

In the following sections, we'll give you an overview of options to migrate TM from an existing older release or by changing the method of deployment (Section 13.1). We'll also provide tips on how to deal with high performance requirements (Section 13.2), monitor your TM system (Section 13.3), and manage large volumes (Section 13.4).

13.1 Moving SAP TM from SAP Business Suite to SAP S/4HANA

Using TM in SAP S/4HANA or standalone brings a variety of benefits starting from the more than 400 simplifications available to the technical advantages, data integration, and embedded analytics benefits. If you want to implement TM in SAP S/4HANA release 1809 or higher, there are generally three different scenarios:

- **New implementation**
  A new implementation (or greenfield approach) is where you start as if on a greenfield site and you first define requirements and processes before you implement them technically. Agile methodologies ensure that the business and technical parts are no longer so clearly separated during implementation, but, generally, the definition of business requirements precedes the technical implementation.

  In the SAP context, this involves the reengineering and process simplification-based implementation of innovative business processes using SAP Best Practices content on a new SAP S/4HANA platform with initial data load and retirement of an old landscape (legacy or third party). Looking at TM, it's a new setup of a TMS.
- **System conversion**
  A system conversion (or brownfield approach) involves the transfer of existing processes and developments to a new technical platform. Here, the technical migration takes place first, followed optionally by optimization or reengineering as a business component.

  In the SAP context, this means a complete technical in-place conversion of an existing SAP Business Suite system to SAP S/4HANA to adopt innovations. The main scenario for a TM move is an existing SAP Business Suite installation that should be moved to an SAP S/4HANA platform, which will be addressed by this chapter in detail.

- **Selective data transition**
  A third variant between the two extremes is the selective data transition. It has been established by combining the strengths of both greenfield and brownfield approaches, by only migrating a selected part of the old processes and data. The other part is redefined in a greenfield-like manner.

  In the SAP context, this involves value-driven data migration to the new platform by consolidation of current multiple SAP Business Suite landscapes into one global SAP S/4HANA system or selective data migration based on legal entities. This scenario can be left out in our case, as it's primarily focused on a distributed SAP ERP landscape with multiple instances and provides a guideline to consolidate these. It's therefore not the typical goal for a TM installation.

Looking into the details of a TM system conversion, there are two migration paths available, as shown in Figure 13.1. Either you migrate from an SAP TM system (SAP NetWeaver-based) to a standalone SAP S/4HANA TM system with an SAP S/4HANA or SAP ERP system connected ❶ or to embedded TM in SAP S/4HANA ❷. In both cases, the SAP TM system needs to be on release 9.5 or 9.6 when you want to use the standard capabilities for the migration. If your current SAP TM system is on a lower release, an upgrade needs to be done first. Similar restrictions apply to the SAP S/4HANA system. The system needs to be on the 1809 release or higher.

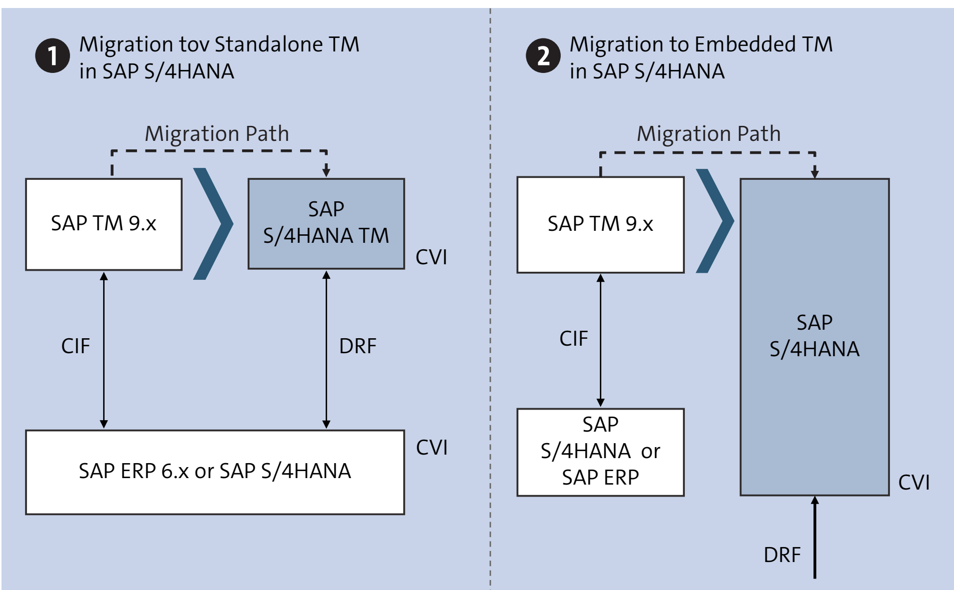


Figure 13.1 Migration Paths from SAP TM to SAP S/4HANA TM

The system conversion of SAP TM is supported by the SAP TM migration tool (TM-only tool!). The tool provides an overview of all supported data and objects, transfers data to the SAP S/4HANA system, and logs important messages. The migration is based on a remote function call (RFC) connection between both systems. Figure 13.2 shows the supported scope of the migration tool (white boxes):

- TM-specific Customizing (e.g., freight order types)
- TM-local master data (e.g., freight agreements, resources)
- Consistency checks for number ranges
- Organizational units (e.g., forwarding houses)
- Current settings/system settings

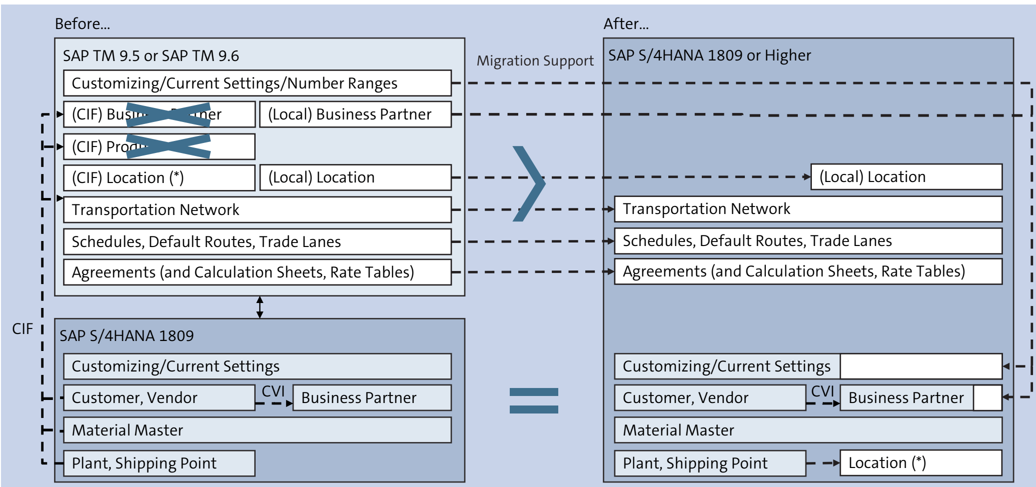


Figure 13.2 Supported Scope of SAP TM Migration

As the tool doesn't support all necessary activities for the migration, it's also important to check what isn't included:

- **Setup and transfer of global master data**
  Migration of global master data such as business partners and shipping points to SAP S/4HANA or standalone SAP S/4HANA TM needs to be done via the Data Replication Framework (DRF) and customer-vendor integration (CVI).
- **Transfer of custom enhancements**
  Extensions of Data Dictionary (DDIC) elements or custom codes need to be transferred via the workbench, which isn't supported by the tool.
- **Setup of number range objects and intervals**
  For this activity, the migration tool provides a kind of consistency check, which can be executed to check the existence of number range objects in SAP TM and to verify that number range intervals are intersection-free between SAP TM and TM in SAP S/4HANA. The creation of the number ranges needs to be done manually.
- **Non-TM-specific Customizing**
  Settings that aren't TM-specific, for example, from SAP NetWeaver, can be exported in SAP TM or SAP ERP into a transport of copies, which can be imported into the new

SAP S/4HANA system. For TM embedded in SAP S/4HANA, this should have happened during the upgrade of SAP ERP to SAP S/4HANA already.

- **Personal object worklist (POWL) queries and settings**
  TM in SAP S/4HANA is no longer using SAP Business Client or the POWL. It's using the SAP Fiori frontend server and SAP Fiori apps, such as all the apps of SAP S/4HANA. However, the TM overview apps, which are replacing the former POWL overview queries, aren't based on core data services (CDS) views, but still based on the POWL settings. That means the backend of the SAP Fiori TM overview lists still uses the Business Object Processing Framework (BOPF) queries and the backend PFCG role-based authorization profile assignments. The frontend uses SAP Fiori and the frontend server, which are using app assignments of the related frontend PFCG roles. The migration of the roles and settings isn't supported by the tool in the SAP standard.
- **Transactional data**
  Business documents such as freight orders, freight bookings , and so on aren't transferred by the migration tool. Instead, open business processes should be completed in SAP TM, and new documents should be started in TM. After a while, all open business documents should run in SAP S/4HANA. From then on, SAP TM can be put on standby—only accessed for research or audit purposes—until it can be completely dismantled.
- **Setup of user management and authorizations in SAP S/4HANA**
  In SAP S/4HANA, the authorization roles concept was completely changed. There, you now have two roles instead of formerly just one role: one role is needed for the backend containing the authorization data, and the other role contains the SAP Fiori launchpad definitions. Therefore, user management, including system users, needs to be set up and isn't supported by the tool.

Enhancement of Migration Tool Capabilities

You've now heard many things that aren't supported by the migration tool in the SAP standard, but, for some, there are other ways. SAP Note 2769186 includes many conversion tips and tricks and should be read in detail to improve the process. It also includes an enhancement guide.

Let's take a deeper look into the different steps of the migration (see Table 13.1), their sequence, and how to perform each. Step 1 of the migration is the transfer of custom development to the new SAP S/4HANA system via workbench requests. Afterward, admin users for Customizing and master data need to be created in the new system (step 2). Step 3 is the transfer of generic non-TM-specific Customizing. Examples are language keys, currency codes, countries, and organizational units. In step 4, the number ranges are created manually in the SAP S/4HANA system based on the settings in the old system. It's not recommended to do it automatically due to the risk of inconsistencies. Additionally, a buffer to the old last used number should be added in the new system to avoid double numbers. The migration tool provides consistency checks during the migration to check if the number ranges are setup correctly.

Step Number	Description	Supported by SAP TM Migration Tool?
1	Migrate custom development (ABAP, DDIC, etc.)	No
2	Create admin users for Customizing/master data	No
3	Transfer generic non-TM-specific Customizing	No
4	Create relevant number range objects and define sufficient number range intervals	Yes
5	Migrate and adapt TM Customizing	Yes
6	Migrate organizational units	Yes
7	Set up DRF and CVI for global master data (if needed)	No
8	Transfer key map information for global master data	Yes
9	Migrate TM local master data	Yes
10	Create relevant user master for business users	No
11	Migrate current settings and system settings	Yes
12	Migrate and set up authorization roles	No

Table 13.1 Sequence of Migration Steps

Afterward, the migration tool is used for the first time to migrate the TM-specific Customizing such as freight order types in step 5. The next activity (step 6) is the transfer of the organizational units via the migration tool. Then in step 7, the global master data such as locations, materials, or business partner needs to be replicated to the new SAP S/4HANA system (see Chapter 3, Section 3.1, for more information). This will be done via the DRF, or, in the embedded scenario, the data should be already in the system. Figure 13.3 shows the different data and the transfer between the different systems.

Based on the global master data, the migration tool can create the key mapping of the data that TM can use (step 8). After the creation of the global master data in the new system (step 9), TM-specific master data can be transferred from the SAP TM system to the SAP S/4HANA system. The migration tool supports the migration of Business Application Programming Interface (BAPI)-based data (e.g., resources and transport zones) and BOPF-based data (e.g., freight agreements). BAPI-based data is used by many SAP Supply Chain Management (SAP SCM) applications and isn't TM specific.

Afterward, the user master data for the business users needs to be created (step 10), so that in step 11, the user-specific and systems settings can be transferred via the migration tool to the new system. The last activity of the migration (step 12) is the setup of the authorization concept and roles for the users.

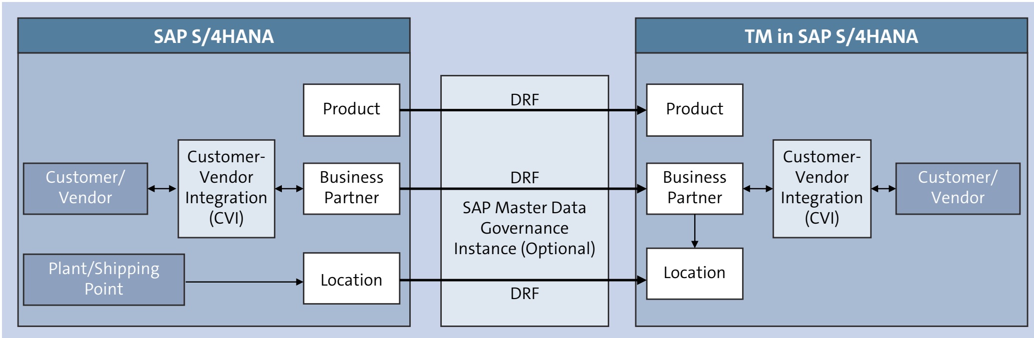


Figure 13.3 Global Master Data Transfer via the DRF

The migration tool is a TM-specific tool that can be accessed by Transaction /SCMTMS/2S4H. The tool, as shown in Figure 13.4, is divided into different areas. The toolbar ❶ includes buttons to check the documentation of every migration object, highlight the migration scope in the activity log area ("How many objects exists in the system? How many are selected for the data migration?"), simulate the transfer of the data, and perform the actual transfer of the data to the new system. The **Target System Information** area ❷ displays the technical information such as the logical system and the transport request number.

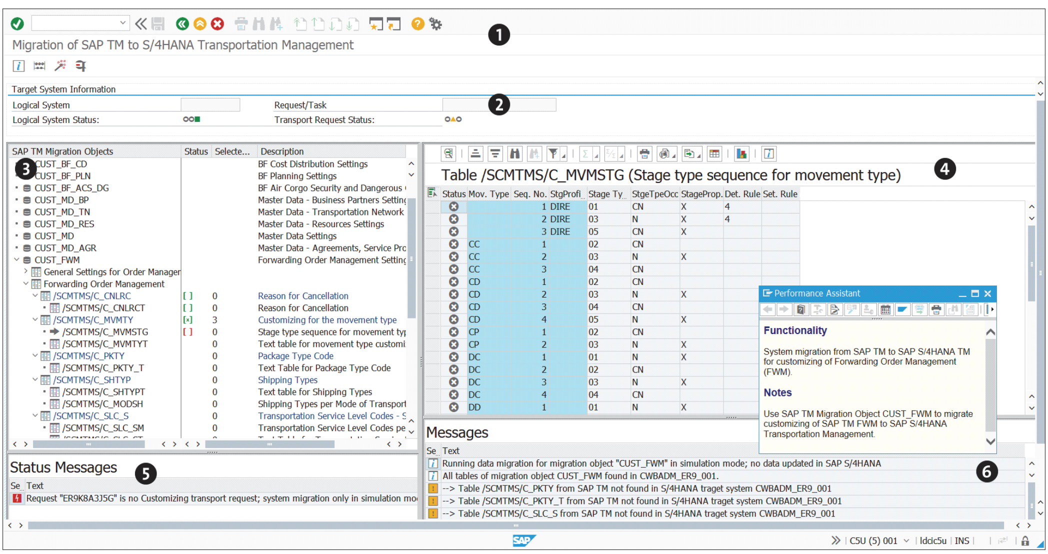


Figure 13.4 SAP TM Migration Tool

The migration object and content area ❸ shows all migration objects, including the following:

- Consistency check
- Customizing
- Organizational hierarchy
- Key mapping
- BAPI-based master data
- BOPF-based master data
- System and user settings

These objects are selected during the migration in the different steps and transferred to the new system. The data area ❹ shows a table with the details of the selected migration object. The **Status Messages** area ❺ always shows general status messages, which are informing about general issues or limitations during the actual execution of the tool, for example, due to limited user authorizations or specific filter settings from the selection screen of the tool. Finally, messages from any activities being performed in the tool are shown in the **Messages** activity log area ❻. Such messages aren't permanent and will change with every following activity in the tool.

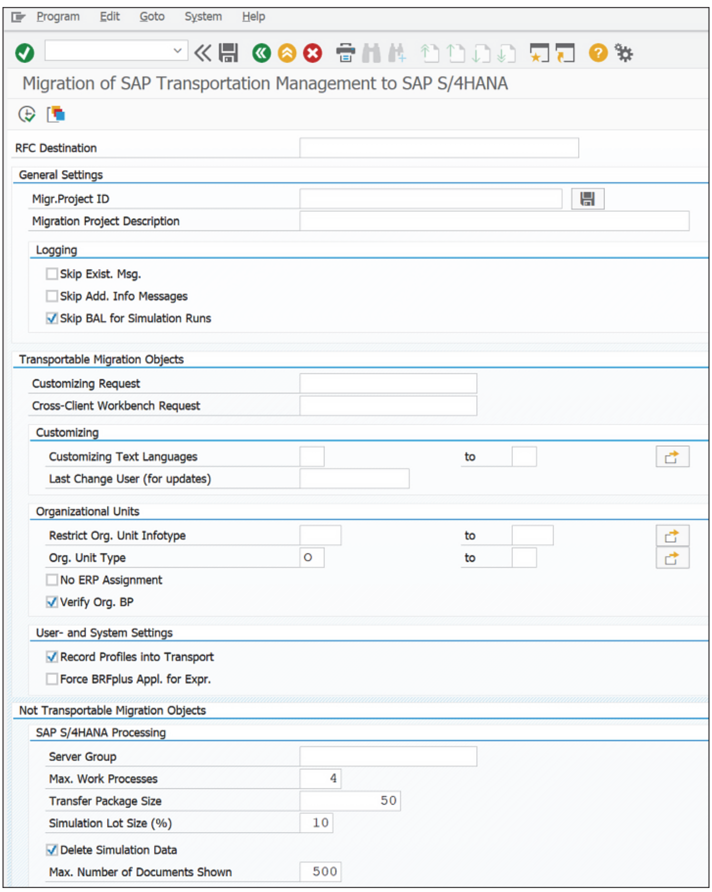


Figure 13.5 SAP TM Migration Tool: Selection Screen

To support continous work, the tool enables you to create migration projects to save a current setup. Additionally, parameters to restrict data are given in the selection screen (see Figure 13.5). To improve the transfer, the tool also offers capabilitites to adapt the number of work processes, package sizes, and the used RFC connection.

13.2 Large and Performance-Critical TM Installations

In this section, we'll discuss typical situations of large organizations running TM. We'll cover performance-related hints and examples of typical performance-critical activities and the possibility of handling them in TM.

13.2.1 Use Case for Large Installations

Typical situations in large or extra-large organizations dealing with TM, for example, logistics service providers (LSPs) or large shippers, occur either due to the extreme transportation demand and system load or due to an organizational distribution and its networking requirements. We find these challenges at companies heavily involved in parcel shipping or thousands of traditional shipments per day, as well as in worldwide freight-forwarding or carrier organizations.

First, let's look at the example of an LSP's company and network setup to better understand some of its challenges:

- An LSP might be divided into many global, regional, and local organizational units with different responsibilities, their own profitability goals, and thousands of employees interacting in different roles with each other and external parties. A fictitious profile of a large, worldwide LSP may be, for example:
  - Operating 1,000+ stations in 100+ countries
  - Employing 10,000+ persons, of whom, many may be direct users of a TM installation
  - Running multilevel organizational hierarchies, which need to have business interaction through the TM system
  - Serving 100,000+ customers with customer hierarchies (enterprise, companies, and then subsidiaries) assigned to one or multiple organizational units, some of which are one-time customers, and others may be key customers with very high shipping volumes
- Global, regional, or local customers and subcontractors might have individually created contracts with corresponding pricing and service-level agreements (SLAs). It's very important that all the employees in the logistics chain are—within their responsibility area—aware of the characteristics, commitments, and restrictions of the services sold.

- Support for many modes of transport might be creatively mixed. In regions and countries, the type of vehicles used can vary widely, from a motor bike in Africa to a 20,000-ton bulk train in Australia or a 20,000-container ocean vessel.
- LSPs need to identify, capture, and respond to many—often very individual—customer preferences.
- LSPs must adhere to legal, cargo, and country-related obligations and regulations to avoid penalties.
- It's important to be able to change the organizational or network structure setup when the business foundation changes and to introduce new services, products, or geographical regions into the business.

Figure 13.6 shows a simplified example of this type of LSP organization.

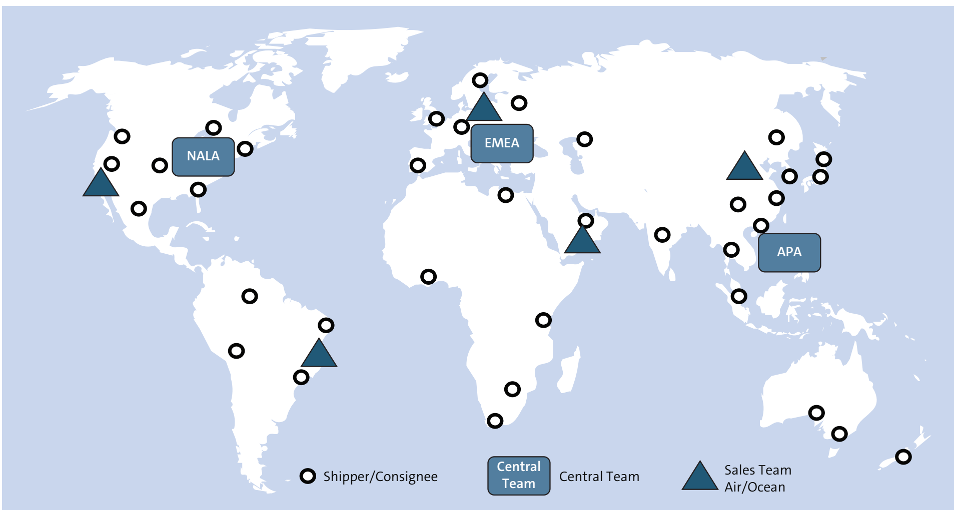


Figure 13.6 Example of a Worldwide LSP Organization and Network (Simplified)

In addition to the distribution of work tasks and workforce, individual teams must deal with many local legal settings in terms of handling cargo, local customs requirements, and local obligations to print or communicate. This needs to be reflected in the authorization and role settings of the users, menus, and worklist setup of the individual assigned roles.

Because LSPs are often still organized in a very regional way (i.e., different regions have profit center responsibility but must work together on customer orders), there is often the requirement to hide specific data from the eyes of the "competitive" internal organization. For example, the export organization only can view an invoice from an import group for an ocean shipment but should not be able to see the import group's price paid to the ocean carrier. This internal hiding requires very detailed authorization settings, which often may cause difficulties for IT departments in terms of data maintenance. Some LSPs already identified this as a disadvantage and cost driver, and they started increasing transparency and standardization. This often leads to restructuring of an organization as well as financial and business processes to be simplified for better internal collaboration.

13.2.2 General Performance Considerations

Above and beyond the organizational, interactional, and data-association requirements and configuration of a TM instance, it usually also must deal with high amounts of data in many stages of processing (orders, cargo/freight units, planning cycles and elements contained, consolidated shipments, or invoices). Therefore, there are some general topics you should consider when implementing TM for sophisticated scenarios and use cases.

First, many process steps within a TM system are predefined in terms of scope and functional runtime by utilization of the BOPF (see Chapter 2, Section 2.1). This also means that the way TM works and handles large amounts of data is to a large extent standardized. However, there are many areas which require special handling and options that leave you freedom to use or extend existing mechanisms, and adapt it to your special requirements. One such example is bulk data handling in interfaces, which we explain in a later example.

Next, in general, sizing as well as performance evaluation and management are some of the critical topics during a project implementation with respect to software and hardware. This needs to be kept in mind during various phases of a project:

- **Design**
  During this phase, you must consider potential performance bottlenecks and critical situations, as well as decide on a proper form of deployment and sizing. Cloud deployments offer more flexibility, as dynamic scaling of implementation size is easier to do, compared to on-premise installations. A cloud provider could easily add additional application nodes to your system, allowing many more users, or switch processes to more powerful platforms (which is difficult if you own the hardware).
- **Development and implementation**
  During this phase, you have to make proper considerations regarding how to handle the recognized performance-critical situations and parts of your system architecture. You also should already plan for suitable test cases for performance checks, which definitely also should be executed while still implementing. In such a case, data volumes, data handling speed, and complex processing chains should be thoroughly tested with realistic mass data.
- **Testing and go-live**
  During this phase, the complete list of identified test cases should be executed, ideally with available real customer data or data that is identified to be of similar quality and volume. Tests need to be properly logged and analyzed to remove any potential or remaining bottlenecks.

Concerning performance, you should be aware that standard software is performance tested only to a certain degree, which covers the typical best practices and standard cases that are recommended for TM. This has the following implications:

- Especially new releases don't always provide performance as required, as not all thinkable process combinations fully run through all performance tests.
- Not all process variants used to implement customers processes are tested concerning performance, as some may not be according to the best practices recommended by the software manufacturer.
- Not all required forms of performance tests are thoroughly run by the software maker, as there may be tools that aren't used for performance testing in any case.

If we talk about good performance in the context of a TM implementation and system, this usually means making reasonable use of critical resources of your system such as response time, network, memory, parallelization of processes, background processing, and so on. Figure 13.7 shows an overview on some performance-limiting, technical factors for the network and the three typical layers of a TM system.

For all user interaction processes, you should keep the response time at a minimum. When distributing applications or using long-distance system integration (e.g., via virtual desktops), you should take into consideration performance aspects of network communication. If you develop or enhance software for customization of TM, your software should be scalable and should avoid things such as nested loops or full table scans.

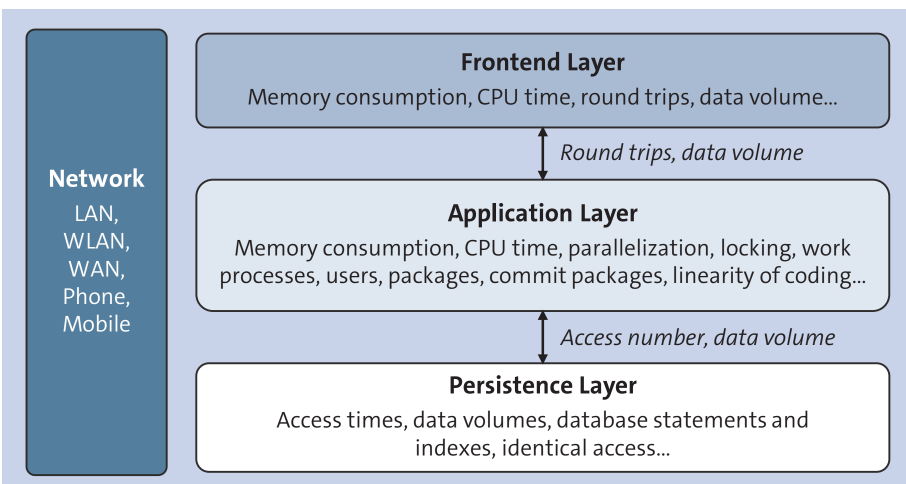


Figure 13.7 Performance-Limiting and Technical Factors in a TM System

Performance of an application system is typically measured by three metrics:

- **Response time**
  Speed of task completion.

- **System throughput**
  Amount of work done within a given amount of time.
- **Linearity and scalability**
  Predictable resource consumption of a software application under different system loads (linearity with data volume/concurrency).

There are various ways to determine, measure, and analyze performance of TM systems. Performance tests and acceptable results should already be defined in the planning phase of your project. Key performance indicators (KPIs) of what is considered good performance should reflect the performance both from a user and a system point of view, and you should be able to document them accurately. An expectation for dependency of the result from factors such as number of objects or concurrent users should be indicated. Good performance also requires reproduceable measurements; that is, potential dependencies for differing results should be readily identified. To determine the unknown factors is the next step in the performance analysis and optimization process. Finally, good KPIs should give indications for possible optimizations.

In each TM implementation project, you need to consider the final purpose of your implemented software. During planning, clarify what type of software your team is expected to configure or build, and make sure the software components you plan to use fit this purpose. Generally, in your system, there are three different kinds of software tasks, and each kind has its own purpose:

- **Dialog processing**
  This is a standard task to quickly produce a response to a user's request, for example, get a schedule for a freight booking or create an invoice for a freight order.
- **Mass data processing**
  This task requires proper use of mass data–enabled functionality such as database statements, parallelization, and mass-enabled interfaces (application programming interfaces [APIs]). Examples in TM are background reports such as mass settlement creation or optimizer planning with many freight units in large networks.
- **Time-boxed tasks**
  These tasks usually need to complete within a fixed interval of time. These don't occur often in TM, but may be more related to real-time situations, where the system is linked to external hardware or entities, for example, when controlling an automation system in a warehouse, where a robot has to be controlled in a timely manner.

Finally, consider the following tips, which are especially targeted to situations where your team has to extend existing TM software. These tips should be considered as best practices for technical implementation teams:

- A good software architecture doesn't implement everything that is possible, but only what is really required. This has to be done in a clearly understandable and structured way.

- You should implement a process with a linear runtime, at worst, *n log(n)*. You should definitely avoid higher runtime behavior (e.g., n^2 or nested loops). Figure 13.8 shows the comparison of these three runtime behaviors. As you can see, with a higher number of objects, the runtime of a potentiating behavior rises very fast.
- Allow for scalability and prepare for mass data processing; that is, create programs that work well with both 10 and 1,000 or more objects.
- Deallocate memory that is no longer used, and allocate only when used to not waste precious system resources.
- Limit parallel resource consumption, and don't spawn off as many separate processes as possible. Controlling too many parallel processes may become cumbersome in ABAP and can actually lead to a decrease in performance.
- Save network round trips and avoid sequentialization.
- Avoid wrong indexes and full table accesses in databases. Both will slow down your programs, especially on non-SAP HANA databases.

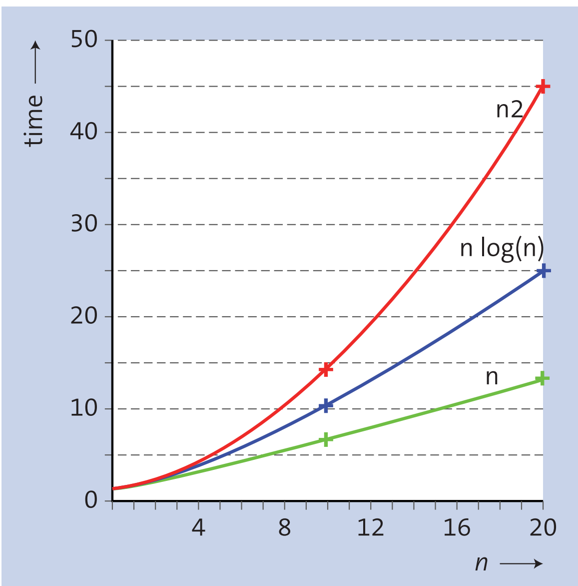
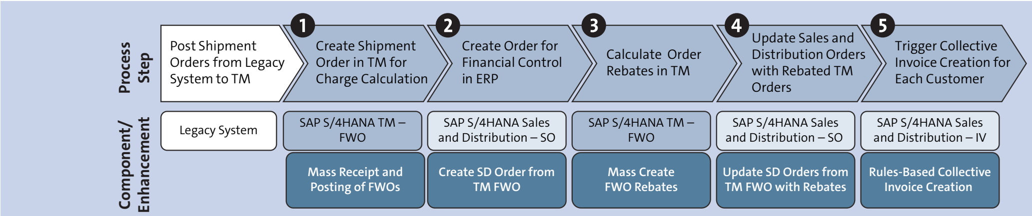


Figure 13.8 Linear (n), Logarithmic, and Potentiating Runtime Behavior

13.2.3 Example of System Enhancement

In this section, we'll explore an example of custom system enhancements that have special performance requirements. The example is based on the process of an LSP who handles large numbers of customer shipments per day that are mostly parcel-sized and moved in a worldwide network with various means of transport.

The focus of the implementation isn't a complete end-to-end coverage but is concentrated on proper calculation of charges and creation of the appropriate invoices. However, as this is only considered to be the first step of a process also to be foreseen to cover the logistics part, the system of choice is TM. In Figure 13.9, you can see an overview of the related process, the components used for implementation, the corresponding enhancements done, and the performance aspects of the specific implementation.



Performance Background	Receive between 100,000 and 800,000 orders to ship packages per day in a legacy system	Receive between 100,000 and 800,000 orders to ship packages per day and create FWOs	Create one sales and distribution order for each FWO to get financial overview	Calculate cross-FWO rebates according to a variety of different rules	Update each sales and distribution order with calculated rebate items	Create consolidated invoices for each customer according to contract, including rebates
Performance Requirement		Create >100,000 FWO/hr	Create >100,000 SO/hr	Calculate rebates for > 100,000 FWO/hr	Update > 100,000 SO/hr	Create > 900,000 invoice items/hr and consolidate invoices
Performance-Critical Factor		Mass creation of FWOs from legacy system	Mass creation of sales and distribution orders from FWOs	Mass cross-FWO and rule-based calculation of rebates	Mass update of sales and distribution orders from FWOs (including rebates)	Mass creation of consolidated customer invoices with up to 100,000 invoice lines
Architecture Approach		Bulk processing: 200 FWO per call Parallelization: >2 processes	Linear processing Parallelization: >4 processes	Linear processing, no parallelization	Linear processing Parallelization: >4 processes	Linear processing Parallelization: >4 processes
Runtime per Object		0.059 sec/FWO/process 61,000 FWO/process/hr	0.12 sec/order/process 30,000 orders/process/hr	0.006 sec/FWO/process 600,000 rebate calculations/process/hr	0.11 sec/order/process 33,000 orders/process/hr	0.013 sec/invoice item 277,000 invoice items/process/hr
Behavior		Linear behavior	Linear behavior	Linear behavior	Linear behavior	Close to linear behavior

Figure 13.9 Shipment Charge Calculation Process with Enhancements and Performance Aspects

The process includes the following steps after the initial orders are transmitted from a legacy order entry system:

❶ Each order coming from the legacy system is used to create a corresponding forwarding order in TM, which is subsequently running through the calculation of charges for the order. However, as the number of shipments is very high (some days more than 500,000 orders per day), creation in TM can't be done one-by-one, but instead needs a special mass-creation mechanism, which allows bundling many orders into a joint package of forwarding orders, which are created in one go on the TM database. For each order, one-time locations need to be created dynamically, as many ship-from or ship-to locations are unknown so far. Additionally, the custom API to create forwarding orders from the package can be called in parallel, so that multiple processes can be used at the same time to create forwarding orders.

In the implementation, it proved sensible to bundle between 50 and 200 orders into one package because fewer orders were much slower and more orders weren't favorable. Concerning parallelization on the available system, which has 50 dialog processes, the maximum usable number of parallel processes is around 15, and higher process numbers are leading to performance reduction and longer runtimes of the loading process. However, in the practical case, 3–4 parallel processes are sufficient.

❷ Instead of using the standard process to create consolidated forwarding settlement documents from forwarding orders for settlement, followed by subsequent transfer to SAP ERP Sales and Distribution (SD) invoices, the approach chosen was different. There were three reasons for this:

   – As the customer needed an early capability to analyze financial data in SAP ERP, it was helpful to have the orders and initial data for the financial transactions available, as this was done via SAP ERP, not TM.
   – Using forwarding settlement document on TM would limit consolidation options and lead to very large forwarding settlement documents with tens of thousands of line items, which may have led to functional issues.
   – Having a forwarding settlement document in place may have led to complex recalculation processes, as rebate calculation runs over the forwarding orders.

   These three reasons where enough to simplify the concept with a new approach and work around the standard process.

❸ The rebate calculation is done by an add-on, which was enabled to not only verify mass invoices but also to calculate rebates according to complex rules on a large number of forwarding orders. An example for such a rule is provide 15% rebate for all shipments of a customer with a particular product category, if the overall shipped weight within this month for this category exceeds 1,000 kg.

❹ The initially created sales and distribution orders with initial charges now have to be updated with the corrected amount resulting from rebate calculation.

❺ The final step is the rule-based creation of consolidated invoices in SAP S/4HANA sales and distribution. The challenge here was to provide invoices with up to 100,000 item lines.

In Figure 13.10, you can see how the described solution behaves in terms of overall runtime over one month. Each of the steps shown in the process in Figure 13.9 has a certain footprint in the daily workload and runtime on the system.

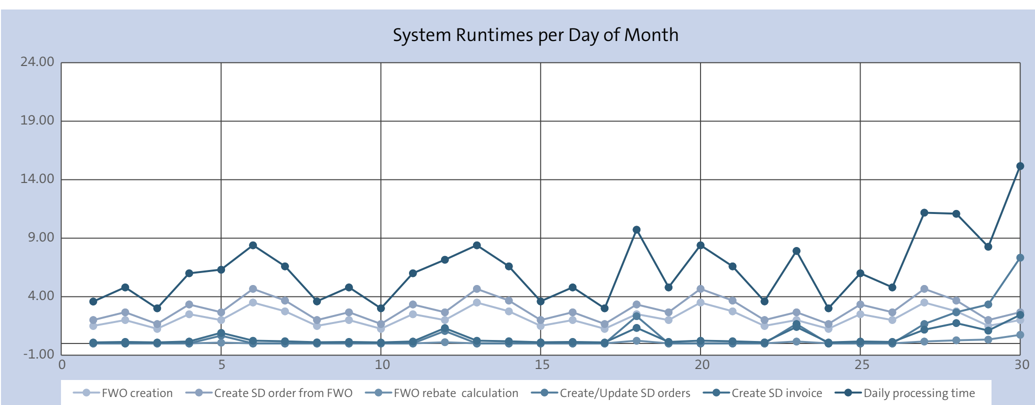


Figure 13.10 Performance and Runtime of the Example Solution over One Month

The overall runtime is still well below 24 hours each day, which allows for enough flexibility. Even the last day of the month, which usually is the time when end-month invoices are created, can be managed with the approach.

Another special handling process relates to planning in case of very high numbers of shipments. Again, this can be found in logistics areas where lots of small parcels are shipped, for example, with large suppliers or logistics companies. The following example is based on the system utilization of a North American company, which uses TM in conjunction with SAP Event Management to manage shipment of up to 1 million orders per day in their parcel network.

One of the main challenges in terms of performance is planning of logistics. Each shipment in our example equals a forwarding order item and a freight unit. The usual pattern of planning would demand to run an optimizer or heuristic approach to assign the freight units to freight orders. However, this would not work, as TM can hardly manage more than 100,000 freight units in one planning run, and a sensible breakdown into sub scenarios with the company's own planning profiles can be tricky.

However, reality also doesn't demand this way of planning, as the business process works different. In the network, a piece (shipment item) is just dynamically assigned to a truck leaving the current hub (i.e., it's scanned and thrown into the truck) in hopes to get it closer to its destination. In the next hub, the parcel is unloaded and again dynamically assigned to another truck driving in the direction of the destination. In Figure 13.11, you can see how planning is done based on a demand forecast in such a situation. The process replaces the traditional approach of TM to run the optimizer to find out how a load is to be distributed to available capacity.

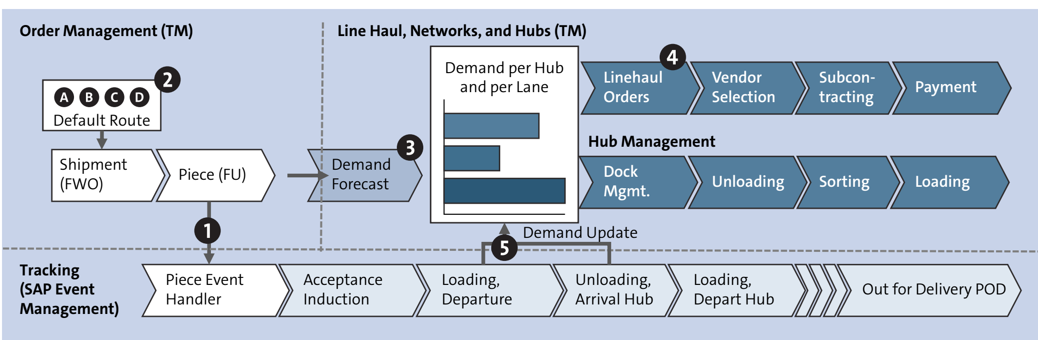


Figure 13.11 Planning Based on the Demand Forecast for a Large Number of Shipments (Parcels)

In the demand planning–based approach, you can see the following steps:

❶ The freight units generated based on the forwarding orders create piece event handlers, which allow tracking of each parcel through the network. Tracking status and locations are acquired by scanning the pieces. Each freight unit also holds information on the size and weight of the piece, which can be automatically verified by Cubiscanners.

❷ The foreseen path of the parcel can be generated by assignment of a default route, indicating movement over a defined chain of hubs. However, the real movement path may differ due to handling errors.

❸ Before the first movement happens, the demand forecast can calculate the overall volume and weight of all pieces to be moved to a certain hub, which enables an estimate to be made of the required number of trucks to deliver these pieces to the next hub.

❹ The calculated number of trucks can be provided by the company, and the pieces are scanned and loaded on the truck. As mentioned, in this step, errors may happen, and pieces are moved in the wrong direction. However, this isn't a big issue, as it can be identified in the next hub and then be corrected.

❺ Each activity of loading or unloading a piece at a hub can correct the demand forecast and allow the next hub to get a more realistic calculation of the necessary truck capacity for their onward movements. This pattern can be continued until the pieces reach their destination.

Providing solutions and hints on how to improve performance in challenging processes or systems can help you manage the critical steps in your company's business. However, flexibility, thorough planning, and proper validation are important steps to successfully manage performance-critical solutions.

13.3 System Monitoring

During an implementation project or when a TM system is live, errors can and will occur. To recognize these issues, a proper system monitoring needs to be set up to analyze errors and correct them as soon as possible to avoid disruptions in the business.

As you learned in Chapter 2, TM uses several different frameworks. Some of these frameworks offer monitoring transactions that help you understand errors and clean them up. Some customers underestimate the monitoring and root cause analysis in TM, especially when they are already operating an SAP S/4HANA or SAP ERP system. But due to frameworks such as BOPF or background remote function call (bgRFC) trigger, the monitoring in TM is different than in a classic SAP ERP system. The monitoring concept should be discussed up front, before go-live, and the required training sessions for the IT support should be planned.

In this section, we'll take a look at the important frameworks and how to monitor them. Figure 13.12 shows a basic TM flow to freight order creation and highlights the monitoring spots.

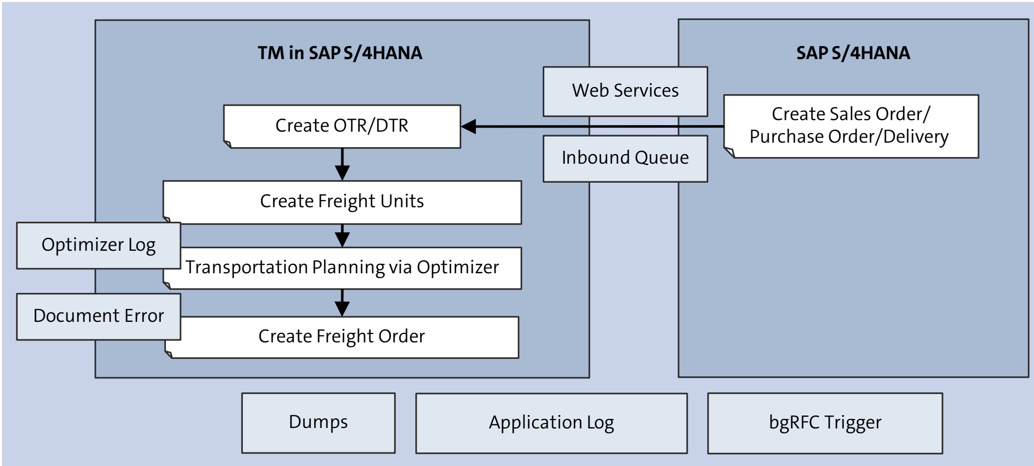


Figure 13.12 Monitoring Spots in TM

The first monitoring spot in a basic TM flow with a standalone SAP S/4HANA TM is the integration between the two systems. Here, web services (XML messages) come into the game, which are sent from one system to another one. The web services in TM are queued. Therefore, you can monitor them also in a second way via the queue monitor. Web services can be sent several times during a TM flow, for example, between TM and SAP EWM or to an external system. To ensure that all web services are successful, proper monitoring during tests and after go-live should be set up.

The next monitoring point could be the different optimizer engines if you're using one of them. Here, logs and explanation tools are available to support the analysis of issues. On the freight order business document, a new feature was released that enables the TM system to create freight orders via web services with errors such as wrong material master data. This error can be corrected by a business user afterward. Proper monitoring with POWL can be set up to find these issues in one spot. This feature is also available for consignment orders.

Issues with dumps, application logs, or bgRFC triggers can occur during the TM business flow. The three monitoring objects should be checked regularly for errors. Dumps can be observed, for example, when ABAP coding fails or hardware isn't sufficient for the system utilization. Application logs are mainly written for logic that is processed in the background without user activity. Therefore, issues can be hardly observed, and the log needs to be checked on a regular basis to see them. bgRFC triggers are also processed in the background, and errors aren't shown to anyone. Monitoring triggers is also important as every trigger in a TM system means that one action isn't processed successfully, and there is an inconsistency in the system.

Table 13.2 summarizes the monitoring objects, associated transactions, and what to check. In the following sections, we'll dive closer in on each monitoring object.

Monitoring Object	Transaction or Menu Path	Check
Web services	■ Integration via SAP Process Integration: Transaction SXMB_MONI ■ Direct integration: Transaction SRT_MONI ■ Forward error handling: Transaction /SAPPO/PPO2	Check for failed web service messages
Inbound queues	Transaction SMQ2	Check for failed queues
Optimizer log	Transaction RCC_LOG	Check for failed optimizer runs or details in explanation tool
Document error handling	Access via SAP Fiori launchpad (**Order Management • Freight Order Worklist**)	Check for issues during business logic
Dumps	Transaction ST22	Check for dumps during runtime
Application log	Transaction SLG1	Check for errors in business logic
bgRFC trigger	Transaction SBGRFCMON	Check for failed trigger processing

Table 13.2 Overview of Monitoring Objects

Additional Support: Root Cause

If you face issues during your implementation project, check SAP Note 3195231 for more tools for root-cause analysis.

13.3.1 Web Services

Communication with TM is usually established using web service interfaces with or without SAP Process Integration as middleware. In implementation projects, you might encounter situations when the communication setup is finished, but the incoming messages don't yet achieve the desired result. To troubleshoot, it's recommended to monitor the incoming and outgoing messages in TM to see which fields were filled incorrectly or what error messages occurred during processing of the message.

The monitoring of service messages isn't specific to TM but is common to many SAP applications. However, it's worth looking at it now because it rounds out the topic of communication between different systems.

With Transaction SXMB_MONI (using an SAP Process Integration), you can display all messages that have arrived in your TM application or left the TM system. After you enter the transaction, select **Monitor for Processed XML Messages**, and then define further selection criteria, such as the name of the interface or the time frame. If you're using a direct integration, use Transaction SRT_MONI. Both transactions look quite similar.

The first column of the result list of messages shows the **Overall Status** and whether it was processed correctly (see Figure 13.13). Consider a few common examples:

- **Checkered flag**
  The message was processed successfully.
- **Green flag**
  The message has been recorded, but the queue needs to be started manually.
- **White flash on red button**
  An error has occurred.
- **Grey flag**
  A dump has occurred.
- **Green arrow**
  The message wasn't processed successfully but can be restarted in Transaction /SAPPO/PPO2 in the forward error handling, which handles issues during data conversion or business logic processing.

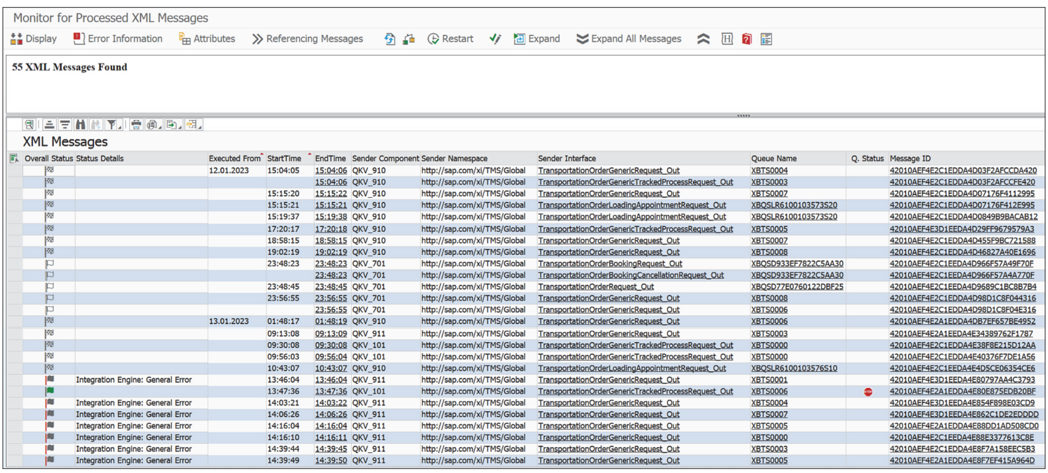


Figure 13.13 Monitor for Processed XML Messages

In the **Queue Name** and **Q. Status** columns, you can see the related queue, which can be checked either via Transaction SMQ2 for inbound or by double-clicking on the column. In general, it's good to have a regular look in Transaction SMQ2 to see if there are stopped queues. TM queues for inbound web service processing starts with XB*.

By double-clicking the **Status Details** field, you can view the XML message that was sent or received. If an error has occurred, you can see the error message on the right side. If you want to view the content of the message, navigate to **XML Message • Inbound Message • Payloads • MainDocument**, and the message content is displayed in the lower window on the right side of Figure 13.14 in **Window 2**.

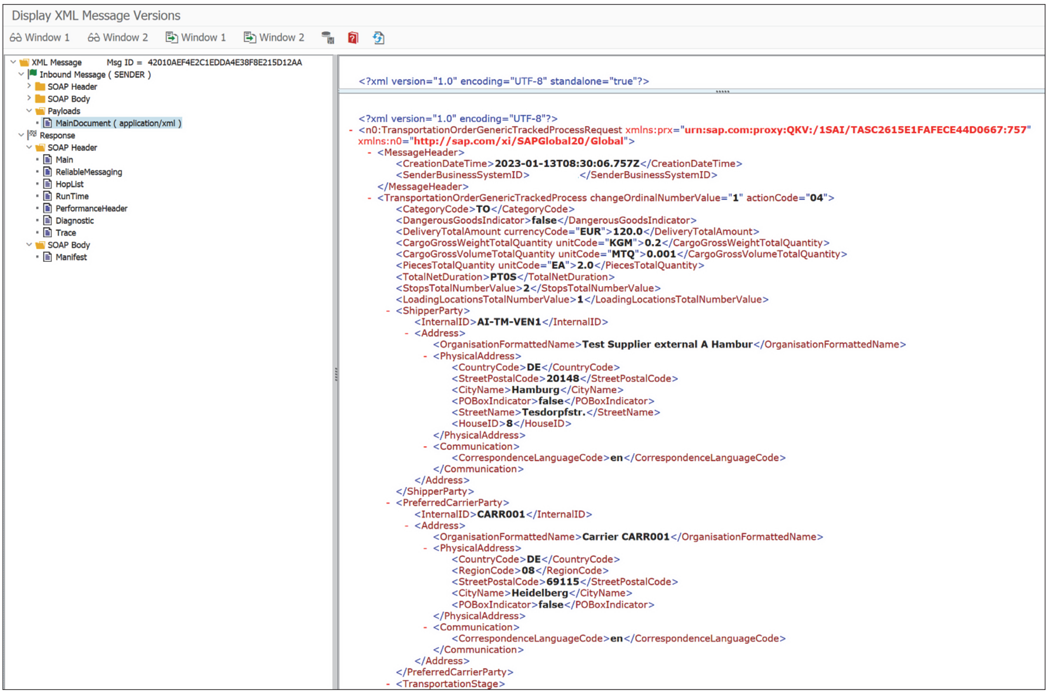


Figure 13.14 Display XML Message

Sometimes, the message isn't processed correctly because a field wasn't filled in or was filled in incorrectly. In this case, if you want to test whether this is the only issue with the message, you don't need to resend data from SAP S/4HANA; instead, you can simulate the message entry. When displaying the message content as explained, download this XML file to your computer by clicking the **Download Window 2** button at the top of the message display screen (see Figure 13.14).

After that, go to Transaction SPROXY, and enter the service interface you used. Notice the **Test** button in the menu bar as in Transaction SE80. If you enter test mode, you'll be able to upload your XML file again, manually alter data in the XML editor, and then process the service interface using your manipulated message. Keep in mind that you need to trigger `COMMIT WORK` manually to write data to the database. You can do this in the general menu of this transaction by following menu path **Extras • Trigger COMMIT WORK** (see Figure 13.15).

Another option to investigate on web services is to use the information provided in the communication history of a business document. Figure 13.16 shows one example of the **Communication History** of a freight order with several web services. In the document itself, you can see the time stamp, version number, business partner, message ID, and the XML message, but you can't see if this message was successful. This can only be checked in the monitoring transaction. The easiest way is to copy the **Message ID** by entering Transaction SXMB_MONI and searching for the ID. In the monitor, you can investigate if the message was successful or if an error occurred.

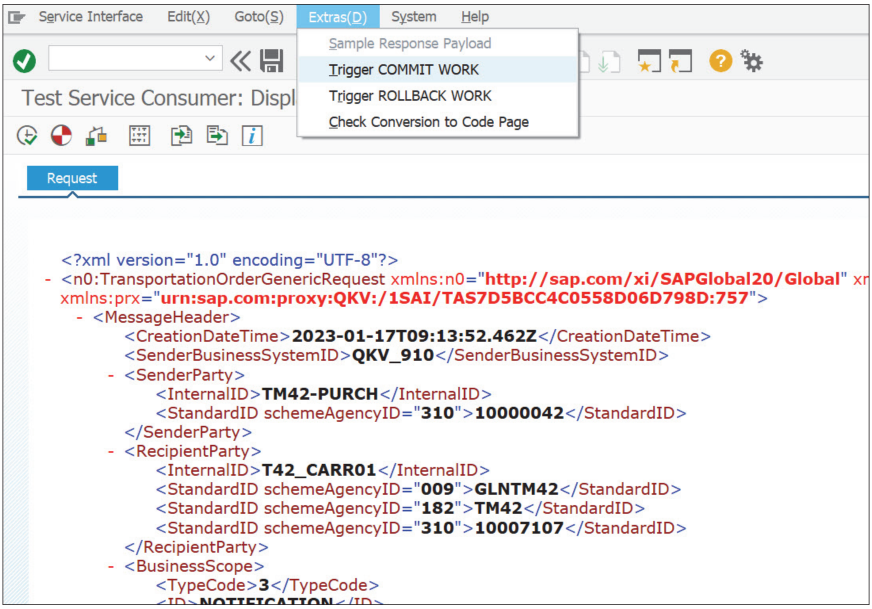


Figure 13.15 Simulating Data Entry for an XML Message

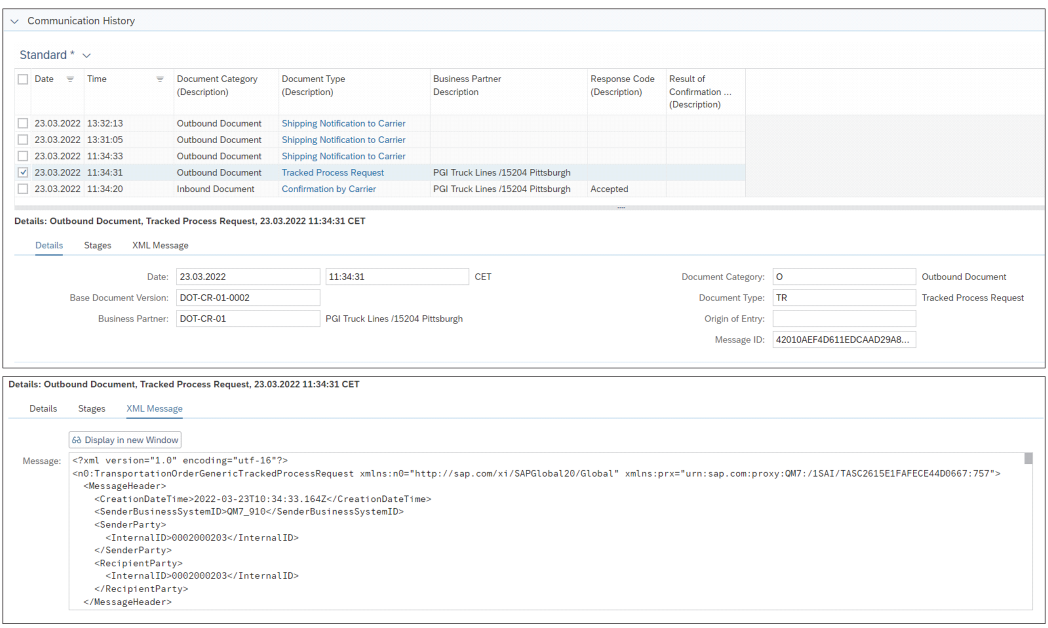


Figure 13.16 Communication History of a Freight Order

13.3.2 Document Error Handling

In Figure 13.17, you can see that TM can create freight orders (also consignment orders) with document errors. This feature is possible when an inbound web services message, such as advanced shipping notifications (ASNs) or a replication message from an external TMS, is creating the document. Before the SAP S/4HANA 2020 release, faulty messages had generally been rejected by the system, and no business documents had been created based on such messages. You can find the document errors in a freight order via menu path **Order Management • Edit Freight Order** on the **Document Errors** tab.

The errors can be master data (e.g., product ID is wrong) or reference errors (e.g., freight unit not found). A business user can solve this issue manually on the freight order itself. Before solving, the system sets automatic planning, execution, and invoicing blocks.

The feature prevents many failed XML messages, which normally would be displayed in the web service monitor with a **Failed** status, causing the business partner or IT to restart the message. Nevertheless, these freight documents contain errors that need to be monitored. The easiest way to find these freight orders or consignment orders is to create a POWL to display all documents with a master data or reference error. A business user can check the POWL daily, and dependent on his analysis, the related XML message can be corrected either directly on the user interface (UI) of the document, or an exceptional process needs to be conducted with the related business partner (e.g., resending the message).

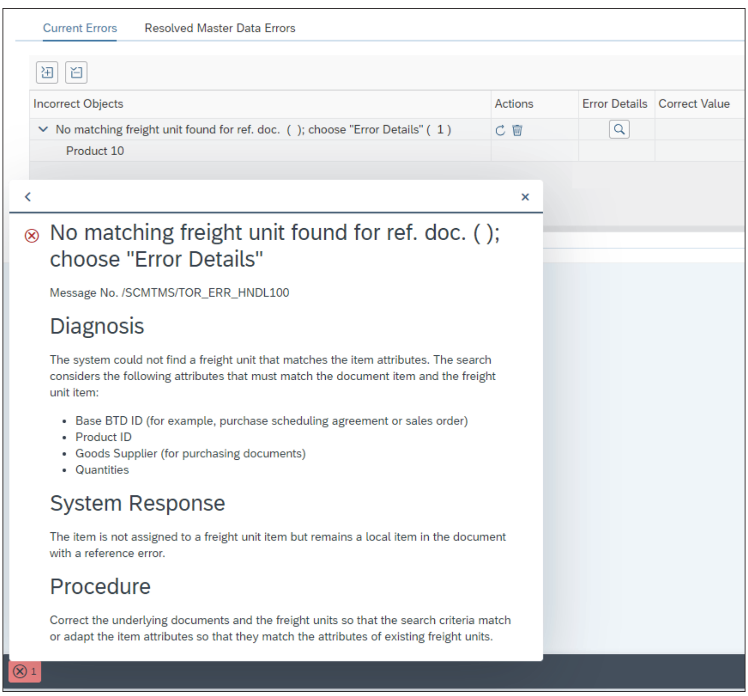
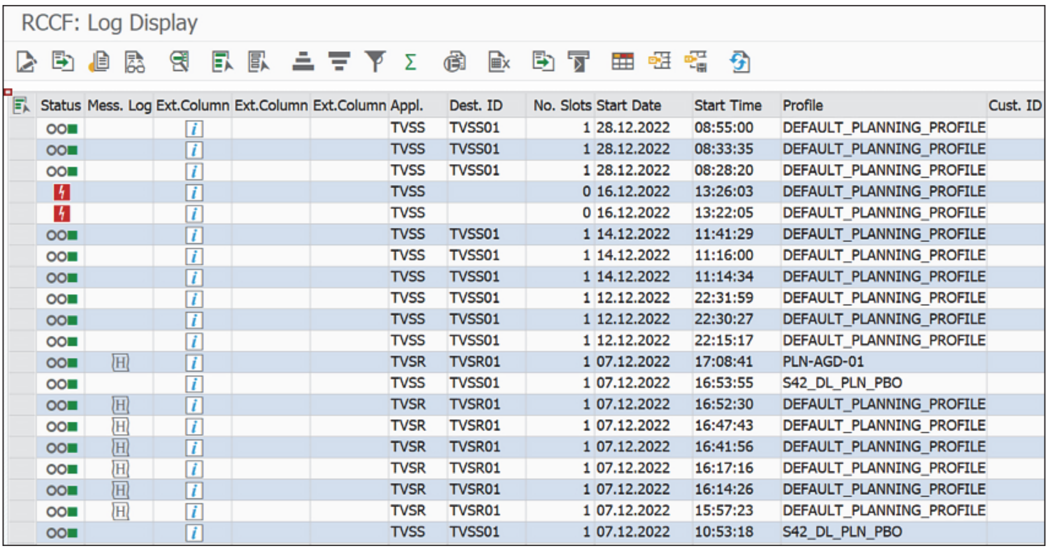


Figure 13.17 Document Error Handling on Freight Order

13.3.3 Optimizer Logs

If you're using one of the optimizer engines, Transaction RCC_LOG is helpful for analysis. The log shows if an optimizer run was successful or not (**Status** column in Figure 13.18) and provides information about the time, user, and which optimizer engine was started with the used planning profile. Additionally, you can find the link to the explanation tool in the **Ext. Column** column, which is explained in detail in Chapter 5, Section 5.8.6. Transaction RCC_LOG should be checked, especially during integration tests and the go-live phase. You would be amazed at how often, during a go live, a customer recognizes that the RFC connection to the optimizer wasn't set up correctly or the hardware and the performance settings weren't sufficient.


RCCF: Log Display

Status	Mess. Log	Ext.Column	Ext.Column	Ext.Column	Appl.	Dest. ID	No. Slots	Start Date	Start Time	Profile	Cust. ID
		i			TVSS	TVSS01	1	28.12.2022	08:55:00	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	28.12.2022	08:33:35	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	28.12.2022	08:28:20	DEFAULT_PLANNING_PROFILE	
		i			TVSS		0	16.12.2022	13:26:03	DEFAULT_PLANNING_PROFILE	
		i			TVSS		0	16.12.2022	13:22:05	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	14.12.2022	11:41:29	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	14.12.2022	11:16:00	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	14.12.2022	11:14:34	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	12.12.2022	22:31:59	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	12.12.2022	22:30:27	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	12.12.2022	22:15:17	DEFAULT_PLANNING_PROFILE	
	H	i			TVSR	TVSR01	1	07.12.2022	17:08:41	PLN-AGD-01	
		i			TVSS	TVSS01	1	07.12.2022	16:53:55	S42_DL_PLN_PBO	
	H	i			TVSR	TVSR01	1	07.12.2022	16:52:30	DEFAULT_PLANNING_PROFILE	
	H	i			TVSR	TVSR01	1	07.12.2022	16:47:43	DEFAULT_PLANNING_PROFILE	
	H	i			TVSR	TVSR01	1	07.12.2022	16:41:56	DEFAULT_PLANNING_PROFILE	
	H	i			TVSR	TVSR01	1	07.12.2022	16:17:16	DEFAULT_PLANNING_PROFILE	
	H	i			TVSR	TVSR01	1	07.12.2022	16:14:26	DEFAULT_PLANNING_PROFILE	
	H	i			TVSR	TVSR01	1	07.12.2022	15:57:23	DEFAULT_PLANNING_PROFILE	
		i			TVSS	TVSS01	1	07.12.2022	10:53:18	S42_DL_PLN_PBO	

Figure 13.18 Optimizer Logs

13.3.4 Dump Analysis

Runtime errors occur in every ABAP application and aren't specific to TM. Transaction ST22 shows detailed information about every dump. In the TM system, it's sometimes hard to find the "real" pain spot as error messages are processed by the BOPF framework. As guidance, always check the runtime analysis in detail. There are many hints to find a good spot for debugging, as shown in Figure 13.19. If you read the **What happened?** carefully, you can see that the action `PROCESS_EXEC_INFO` with implementation class `/SCMTMS/CL_TOR_A_PROC_EXEC` caused the dump. Remember the name convention from Chapter 2. The A in the class name indicates that it's an action, and the TOR means it's an action on the `/SCMTMS/TOR` object. After checking the class in Transaction SE80, you'll see that the description of the class says "Process Follow-Ups on Exec Info," which indicates it's an action on the execution information. Therefore, you can go to

BOPF, check the actions of the execution information node on the /SCMTMS/TOR object, and you'll find action PROCESS_EXEC_INFO with all the information about the design, including implementation class /SCMTMS/CL_TOR_A_PROC_EXEC.

The application information, if available, also provides helpful information. Report RSDUMPQM provides an aggregated view of the runtime errors that occurred in the system.

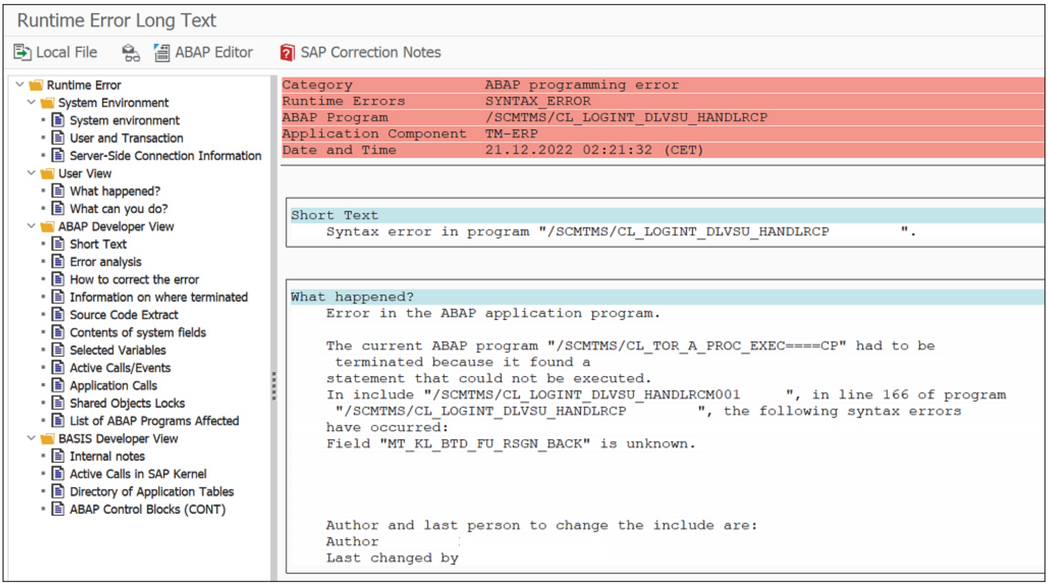


Figure 13.19 Runtime Error: Detailed Information

13.3.5 Application Log

Like the runtime errors, the application log is not TM-specific, and other components are also using this tool to write down messages from background reports or other processing. TM content can be found in Transaction SLG1 with the following applications as selection criteria:

- /SCMTMS/TMS (TM)
- Post Processing Framework (PPF)

In Figure 13.20, you can see one example application log. The first column provides the status of the log: error (red circle), only a warning (yellow triangle), or a successful action (green box). Additionally, you can see the **Subobject Text**. Logs are categorized; for example, all messages related to bgRFC triggers belong to the subobject TRIG or CHACO.

The application log should always be checked on a regular basis as it's sometimes the only way to see issues in background processing.

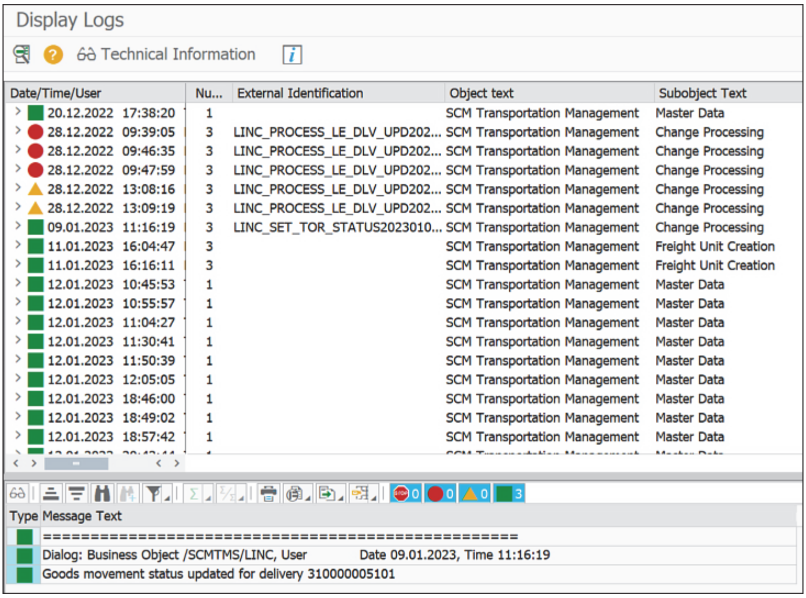


Figure 13.20 Application Log

13.3.6 bgRFC Trigger

The last monitoring object is the bgRFC trigger. Remember from Chapter 2, Section 2.3.7, that every trigger reflects a missing performed action due to locking issues. It's an inconsistency in the system for a short period. Therefore, it's important to monitor this framework closely.

Transaction SBGRFCMON is used for monitoring and debugging the state of bgRFC triggers. Most of the time, you only see failed units in the monitor as successful units are already deleted by the framework.

In the monitor shown in Figure 13.21, you can restart trigger units in a debugging mode by right-clicking and choosing **Unit Analysis • Debug Unit with Current User**. In addition, you can simply choose **Restart Unit**. There shouldn't be any stopped or pending triggers for a longer period in the monitor as this would indicate an inconsistency or missing update on a TM business document.

bgRFC trigger units are technical objects and not easy to analyze. Therefore, the TM development team developed report /SCMTMS/BGRFC_ANALYSE to support the investigation of failed (red) bgRFC units, as shown in Figure 13.22. The report can be used in different ways. One way is to use the **Unit ID in Background RFC** from the monitor (double-click on the trigger to show the details screen) and enter it in the report (see the top screen). The result in the bottom screen will show information about the related business object, related business documents, document IDs, and the name of the trigger. Additionally, you can enter a document ID in the report to check if there are any open triggers for a certain business document.

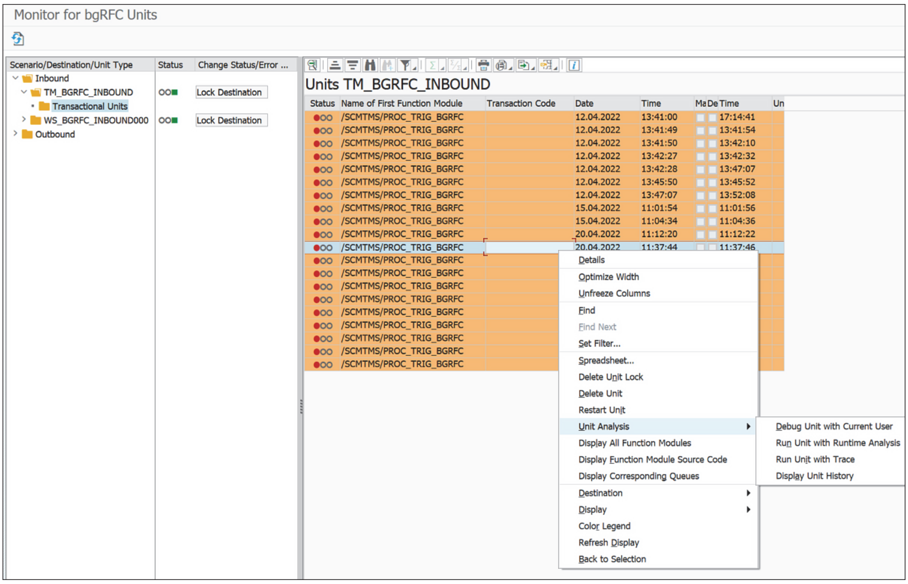


Figure 13.21 Monitor for bgRFC Units: Trigger

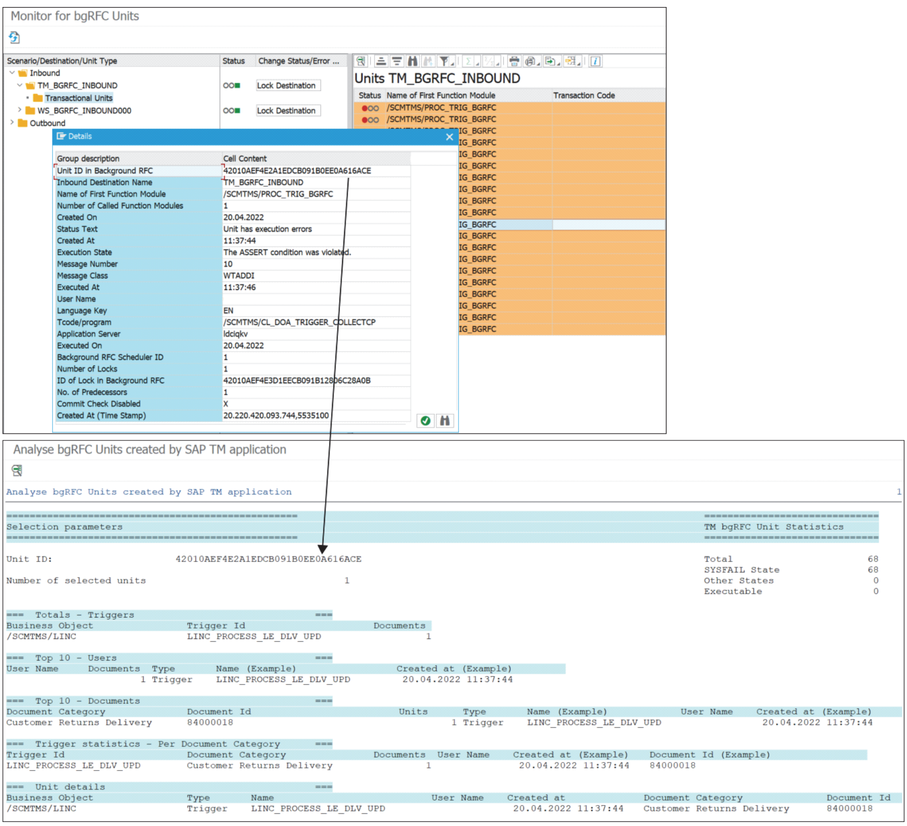


Figure 13.22 TM Analysis Tool for bgRFC Triggers

Note

SAP Note 2838210 provides additional information about the analysis of bgRFC triggers.

13.4 Manage Data Volume

Implementing is one task in the lifecycle of a TM system, but more important is to keep the system alive and in good shape for a long time. Therefore, thinking about data volume management (DVM) is also necessary. Data continues to grow over the years, and the challenge is to keep the system lean and clean while simultaneously being able to fulfill legal requirements (e.g., data protection and privacy regulations) and conduct an audit.

Overloaded database tables can lead to long request times during the processing of ABAP coding, leading to an overall decrease in system performance. Furthermore, messy data can cause additional work during upgrades and long downtimes. DVM is, unfortunately, an activity that is forgotten many times during a TM project and only done when there are already issues. We recommend thinking about DVM before it becomes urgent.

DVM differentiates between three different approaches to keep a system lean and clean (see Figure 13.23): avoidance, deletion, and archiving. For all three, the question is always, “Do I really need this kind of data?” Let’s take a deeper look into the methods of each approach.

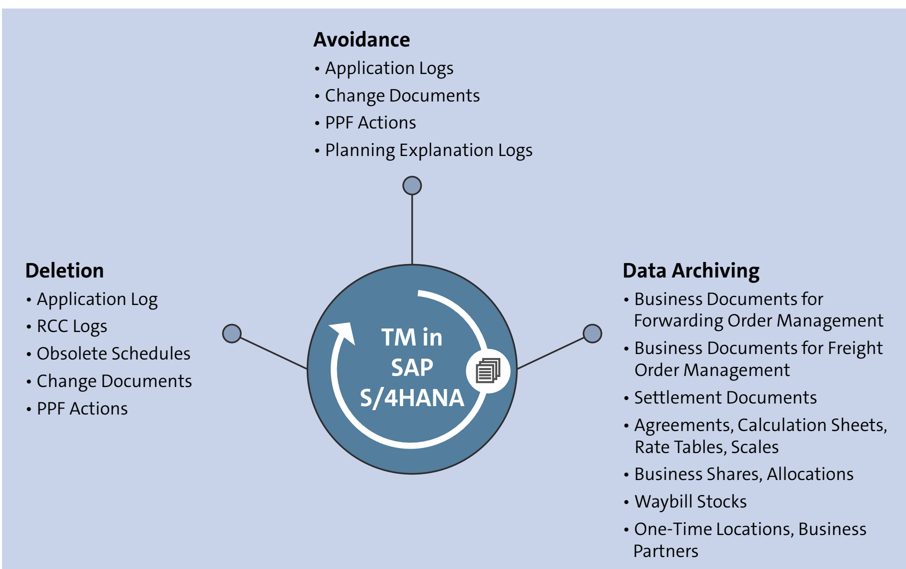


Figure 13.23 Data Volume Management: Avoidance, Deletion, and Archiving

13.4.1 Data Avoidance

One approach to limit the amount of data in a TM system is to avoid the initial creation of the data. This is especially possible for data that is normally only used for root-cause analysis during the implementation or hypercare phase after a go-live. Customers activate this data during the project (which is rational), but after a successful go-live, this kind of data isn't deactivated.

In Table 13.3, you can find a list of all data objects that could lead to a large amount of unused data. Additionally, the table contains the corresponding database tables, methods to avoid or delete the data, and some further comments such as SAP Notes.

Data Object	Largest Tables	Avoidance	Deletion	Comment
Basis application log	Table BALDAT	Deactivate application log	Program SBAL_DELETE or Transaction SLG2	See SAP Note 195157
Change documents	Table CDPOS Table CDPOS_STR Table CDPOS_UID	Deactivate change documents in type Customizing	Program RSCDOK99 (not recommended)	
PPF actions	Table /BOFU/DPPFCNTR Table PPFTTRIGG	Check PPF actions: Are they necessary? Are they set up correctly?	Programs RSPPFCLEAN and RSPPFPROCESS	See SAP Notes 896858, 2633354, and 2539882
Business Communication Services (BCS)	Table SOOD Table SOOS Table SOFFCONT1 Table BCST_SR Table BCST_CAM Table BCST_PDF	Check communication: Are they necessary? Are they setup correctly?	Program RSBCS_REORG	See SAP Note 2633354
Planning explanation logs	Table /SCMTMS/D_PLNX* Table /SCMTMS/D_LSOX* Table /SCMTMS/D_VSSX*	Deactivate planning explanation logs	Program /SCMTMS/PLN_EXP_DELETE	

Table 13.3 Data Avoidance and Deletion in TM

Data Object	Largest Tables	Avoidance	Deletion	Comment
RCC logs		N/A	Program RCC_CLEANUP	
Schedules		N/A	Program /SCMTMS/SCH_DELETION	Delete obsolete schedules
Alerts		N/A	Program /SCMB/ALEN_ALERT_DELETE	

Table 13.3 Data Avoidance and Deletion in TM (Cont.)

The biggest growing tables in an TM system are normally the ones from the application log (table BALDAT) and the change documents (table CDPOS, table CDPOS_STR, table CDPOS_UID). The reason for this is quite simple. The application log, dependent on Customizing, stores messages from all activities from all business users and system users. The change documents capture every change on a business document such as the freight order. That means the amount of data increases quite heavily based on the system utilization.

After a successful go-live, you should check if all this data is necessary. There are simple ways to avoid growing data, such as changing the logging level of the application log or switching off the change documents in the type Customizing of a freight order, freight unit, and so on. The same applies for the optimizer explanation log. As soon as the optimizer is running in a proper way, you can switch it off. If you recognize issues again, you can switch it on every time.

There is also one additional data object that causes unused data in many TM systems, the PPF actions. In this case, the root cause for more data isn't just higher system utilization. It's more about how customers set up many different output actions that are checked regularly by the TM system and create PPF triggers, but then they are never used in business. It's recommended to check the PPF settings after the go-live again and clean them up. It's not only better for the data volume but also for root-cause analysis.

13.4.2 Data Deletion

The second way to reducing the data amount in a TM system is to delete data that isn't used anymore. This is especially relevant if you can't switch off data such as the change documents, logs, or alerts because you still need them for root-cause analysis. But nevertheless, why keeping a log from last year? Nobody will check this kind of data because it's not business relevant. You can delete it. In Table 13.3, shown earlier, you can find the deletion reports for the data objects. The reports should be set up on a regular basis to get rid of the unused data.

Additionally, to the already-discussed data objects in the data avoidance section, one deletion object should be named: the schedule. When you're using schedules for ocean or air transport, or even for shuttles in road transport, they only have a certain validity period. Afterward, they aren't used anymore and can be deleted after a while.

13.4.3 Data Archiving

The last possibility to manage the data in TM is archiving. Business documents such as freight orders or freight units need to be stored somewhere to allow audits for a certain time. However, to avoid decreases in system performance of the production system, they should be stored somewhere else, in an archive directory.

TM offers archiving objects for all business documents and their related data. Table 13.4 lists all of them and highlight the tables that are affected by the archiving object. They can be checked in Transaction AOBJ. The archived data can still be displayed in the TM system via special worklists, so that an audit is always possible.

Business documents can be archived in TM when the lifecycle status of the whole document flow is either completed or canceled and the residence period is over. What does this mean? Let's think about one road transport. In this scenario, we have a freight unit, freight order, and a freight settlement document. It's possible to archive the freight order when the lifecycle status of all three documents reached the last status: **Completed** or **Canceled**. If the freight settlement document is still in progress due to a missing payment, the freight order can't be archived. The whole document flow needs to be completed.

The residence period is customer-specific and needs to be adapted based on their requirements. The following questions should be considered during the discussion:

- How long does a completed document need to be reopened for adjustments?
- What is the data growth rate?
- What are the legal requirements and restrictions?
- What is the time period for real-time analytics?
- Is the data warehouse used for long-term analytics and reporting?

Usually, a 6–12 month residence time is used for data archiving.

Data Object	Archiving Object	Biggest Tables
Application log	BC_SBAL	Table BALDAT
Change documents	CHANGEDOCU	Table CDPOS
PPF containers		Table /BOFU/DPPFCNTR Table PPFTTRIGG
Forward error handling	/SAPPO/PPO	Table /SAPPO/ORDER_HDR Table /SAPPO/ORDER_MSG Table FEH_MESS_PERS

Table 13.4 Archiving Objects in TM

Data Object	Archiving Object	Biggest Tables
Business partner	CA_BUPA	Table BUT* Table ADR*
One-time location	/SCMB/OTL	Table /SAPAPO/LOC Table ADR* Table /SCMB/TOENTITY
Transportation charges		Table /SCMTMS/D_TCHRGE
Business documents of forwarding order management	SCMTMSTRQ	Table /SCMTMS/D_TRQITM Table /SCMTMS/D_TRQSTG
Business documents of TOR object	SCMTMSTOR	Table /SCMTMS/D_TORITE Table /SCMTMS/D_TORSTP Table /SCMTMS/D_TORTRQ Table /SCMTMS/D_TORTRE
Forwarding settlement	SCMTMSCFIR	Table /SCMTMS/D_CF_IT
Freight settlement	SCMTMSSFIR	Table /SCMTMS/D_SF_ITM
Business shares	SCMTMSBS	Table /SCMTMS/D_BSROOT
Allocations	SCMTMSTAL	Table /SCMTMS/D_TALBUC Table /SCMTMS/D_REFOBJ Table /SCMTMS/D_ROBJQ
Scales	SCMTMSTCSC	Table /SCMTMS/D_SCAH1 Table /SCMTMS/D_SCAIT2
Scale items	/SCMTMS/SC	Table /SCMTMS/D_SCAIT2
Rate table	SCMTMSTCRR	Table /SCMTMS/D_TCRTVP Table /SCMTMS/D_TCRTCP Table /SCMTMS/D_TCRT*D
Rate table validity	/SCMTMS/RA	Table /SCMTMS/D_TCRTVP Table /SCMTMS/D_TCRTCP Table
Calculation sheet	SCMTMSTCCS	Table /SCMTMS/D_TCCSIT
Agreements, request for quotation (RFQ), and service products	SCMTMSFAG	Table /SCMTMS/D_FAGITM Table /SCMTMS/D_OPTSTG
Waybill stocks	SCMTMSWBIL	Table /SCMTMS/D_WBNCON

Table 13.4 Archiving Objects in TM (Cont.)

The archiving process, which is shown in Figure 13.24, follows a three-step approach: preprocessing, archiving, and postprocessing. During the preprocessing ❶, the system checks, for example, if the whole document chain is completed and if the objects can be archived. Afterward, the archive run ❷ takes place. The data is stored to a separate file system and deleted from the database of the TM system ❸. Optionally, the file system can again fetch the data to a separate external content server to optimize it a second time ❹. In the last process step, postprocessing actions are performed to clean up the archiving process ❺. The archiving process is performed in Transaction SARA.

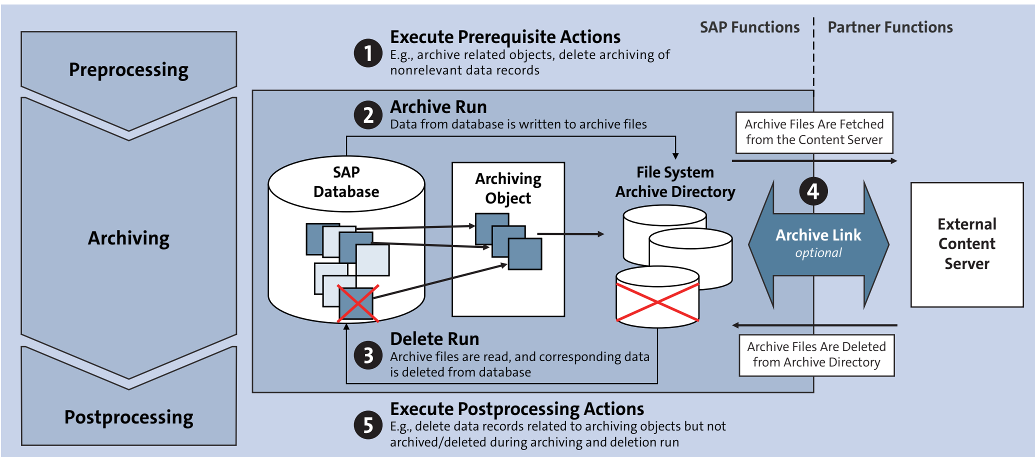


Figure 13.24 Archiving Process

Additional Information: DVM

SAP Note 3046065 contains additional information about archiving in TM. In addition, the operations guide for SAP S/4HANA, which can be found on the SAP Help Portal, contains an area for TM and gives insights about DVM.

13.5 Summary

In this chapter, we provided an overview on ways to migrate an SAP TM system (SAP NetWeaver-based) to the SAP S/4HANA environment. In addition to moving your TM to an up-to-date state, we also explained the importance of performance management of a TM in terms of performance hints, system monitoring capabilities, and solutions to manage the data volumes within your system.

In the next chapter, we'll provide an overview of implementation best practices. We'll give you hints on important elements and configurations in TM, how to configure it best, how to move your data between systems, and what kinds of risks and challenges you may face when implementing TM in a project.

Chapter 14

Implementation Best Practices

For an integrated software suite such as transportation management (TM) in SAP S/4HANA, it's always helpful to get hints on where to start, what to do next, and what to consider in the overall implementation. In this chapter, we describe some best practices to help you reach your goal of using TM more easily and safely.

With all the previously described functionalities, usage variants, and configurations, TM in SAP S/4HANA is a very comprehensive software suite for use in addressing your requirements. Its breadth and coverage are comparable with an enterprise system. It covers areas such as sales, procurement, planning, execution, costing and settlement processes, system configurations, and connected components. From this perspective, it's important to know where to start with implementation, which steps are critical, and where you can find dependencies or characteristics that need to be considered to successfully get transportation processes up and running.

In this chapter, we give you an overview of the challenges and things to know when you're involved with implementing TM. We offer TM configuration hints that fall into the following categories:

- Cross-functional influence of specific settings (i.e., settings that may influence various parts of the TM functionality) and general Customizing know-how of TM (Section 14.1 and Section 14.2)
- Scenario bundling and copying for specific needs (Section 14.3)
- Understanding the strengths and weaknesses of the TM system (Section 14.4)
- TM-specific and general views in risk and change management topics in TM projects (Section 14.5)
- Setup sequence approach for TM and topics to be considered when new customers are onboarded to a TM system used for logistics service providers (LSPs; Section 14.6)
- System improvement dos and don'ts (Section 14.7)

Organizational setup, process coverage, and the complexity of the process steps and details can make implementing a transportation management system (TMS) quite a challenging process. This isn't unusual and is valid for all TMS setups that are targeted at managing the core business processes of a company.

14.1 Use of Central Control Elements in TM Setup

Throughout this book, you've learned that TM has many settings and configuration capabilities. You can influence these when creating scenarios and processes for transportation management. Most of these settings are straightforward in their setup and have a local or direct influence on the behavior and design of the system (e.g., limited to order management or invoicing). However, some very central control elements need special attention. Note that the following list isn't exhaustive:

- Elements that can affect the behavior of multiple process steps in various areas. Changing a setting for a specific process purpose might unintentionally affect the behavior of quite different process steps, such as the following:
  - Means of transport
  - Equipment types and groups
  - Freight unit building rules and freight unit types
- Elements that are critical in terms of well-designed data structuring and long-term maintenance:
  - Charge calculation sheets and tariffs
  - Rate tables

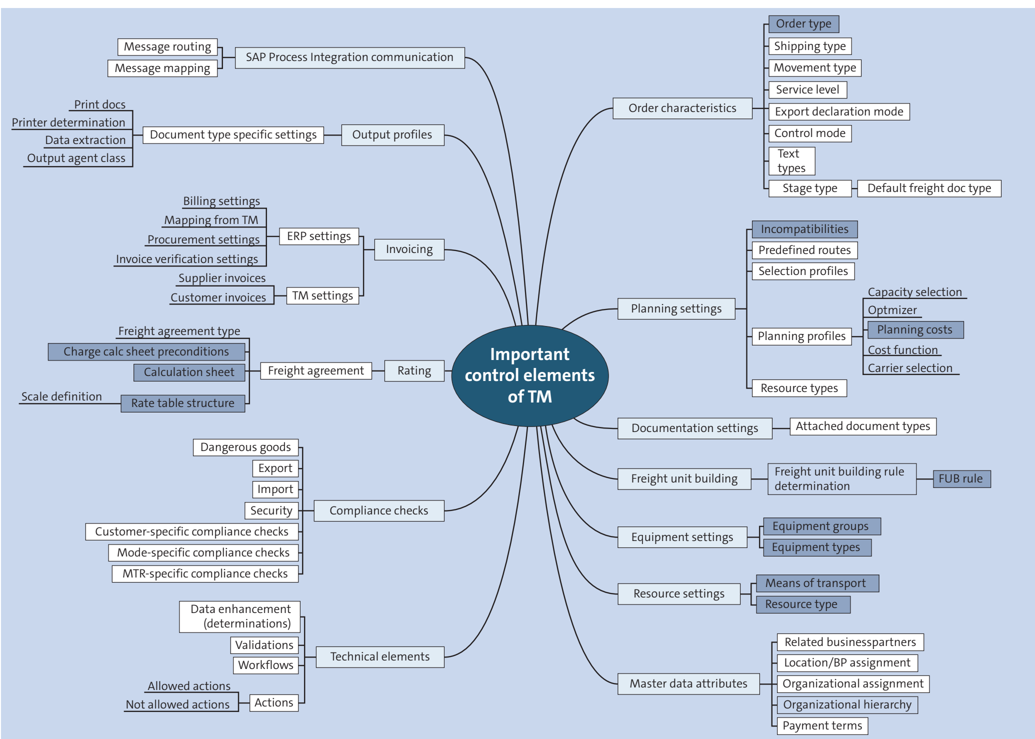


Figure 14.1 Some TM Control Elements

- Elements that must be set up in a balanced way:
  - Transportation planning cost
  - Forwarding and freight order types
  - Resource types

Figure 14.1 presents an overview of selected Customizing elements and configuration settings that control the transportation management process. Let's consider some of these central control elements further.

14.1.1 Define Means of Transport

As a very central control element, means of transport is used in many ways. Because it's crucial to transportation planning, cost calculation, and decision-making by conditions, it's important to think hard about the required granularity and complexity of means of transport for planning, costing, and conditioning and to select a model that fits best into all three aspects.

The means of transport indicates a categorization of groups of resources that can be anything from coarse to very fine and detailed, which makes it a bit tricky. On top, means of transports have a big impact if they need to be changed in a broader range in a running project or after a go-live, that is, if you notice that a setup has particular disadvantages. Depending on the regional, country, or organization-specific requirement, you can define the means of transport according to different strategies. Some examples are listed here:

- **Truck, tractor, trailer (to build semitrailer truck)**
  This is a very coarse definition just to decide between a self-moving vehicle and a passive vehicle. For example, it might be sufficient for planning in *some* overall contexts but not granular enough for local decisions or costing purposes.
- **Large truck, small truck, tractor, large trailer, small trailer, and chassis**
  This is a definition of different self-moving vehicles, as well as passive vehicles with different characteristics and loading capabilities, but it's still valid on a general basis. Planning and costing may be done in a more detailed and exact manner.
- **12-ton truck (Germany), 30-ton trailer (Germany), standard tractor (United States), 80,000-pound trailer (United States), and many more**
  This is the usual case for large LSPs and shippers with detailed demand in planning dependencies, especially if the assets are their own or there are concrete requirements. If the fleet becomes very diverse due to national, regional, local, or subcontractor-specific regulations and capabilities, the definition of means of transport can become manifold, and you may end up with hundreds or thousands of means of transport.

If the definition of the means of transport is simply for controlling the planning, then the variety doesn't have a major impact. Otherwise, in many implementations, means of transport definitions are also used as input parameters for calculation of freight costs and prices or for other condition evaluations, such as determination of loading durations. In this case, the complexity is linked directly to the number of definitions in planning. If you define many means of transport because it's practical for planning, you may create unnecessary complexity in cost calculation. On top, changing planning-relevant usage of means of transport may result in high efforts to adapt costing.

14.1.2 Structure Equipment Types and Groups

The situation described for means of transport is also valid for equipment types and groups: the more complex the definition of cargo aspects, the larger the impact on pricing definition and condition complexity.

Equipment type and group have an additional challenge. The equipment type is usually based directly on definitions of individual kinds of equipment, such as 20-foot standard container, 20-foot-high cube container, and 20-foot refrigerated container (reefer), which are assigned to the individual equipment master records for each unit (e.g., according to ISO 6346). The grouping can be used to determine which equipment types logically belong together. A grouping defined for cargo handling and movement purposes focused on use of space and compatibility of stowing doesn't need to be in line with a grouping focused on pricing. Table 14.1 shows some examples of cases in which the grouping criteria may lead to conflicts.

Grouping for Cargo Handling	Grouping for Pricing
Dry containers, high-cube containers, reefer containers, flatbed containers	20-footer dry (standard, ventilated, high-cube), 40-footer dry, and so on
By category (e.g., open railcars, closed railcars, bulk railcars)	By railcar size/length and maximum weight

Table 14.1 Equipment Grouping from the Cargo Handling and Pricing Perspective

For equipment grouping, you should therefore also create a well-defined set of equipment types and groups that meets your requirements up front.

14.1.3 Balance Freight Unit Complexity

Freight units are created using freight unit building rules. For the creation of a freight unit and the setup of the corresponding rule, you need to find a good balance between the flexibility of freight unit assignment and system performance, and then choose the correct freight unit granularity.

If, for example, you want to ship three orders with general cargo (in our example, let's say it's 20 forwarding order items with 577 loose packages), you can use a freight unit building rule to create various results. Table 14.2 gives an overview of three of these options. If space utilization of vehicles up to the limit isn't the first goal, you may want to create fewer freight units because this creates the lowest workload for the employees and the system. You also have the option to split the freight unit as required and optimize space utilization selectively.

Strategy of Freight Unit Building	Result of Freight Unit Building	Consequence
Freight units per item	20 large freight units	■ Low flexibility in distributing freight units over trucks and utilizing available smaller remaining capacity ■ Simple dispatching and cargo management ■ Reaching better utilization requires manually splitting freight units
Freight unit with maximum of 10 packages	58 medium-sized freight units	■ Compromise between increased flexibility to use small loading spaces and handling effort in cargo management ■ No direct control of which package goes into which freight unit
Freight unit per package	577 small-sized freight units	■ Best flexibility in using the remaining capacity of the truck, leading to the highest utilization results ■ High effort in cargo management; many objects on dispatching screens ■ Higher performance requirements due to many freight units

Table 14.2 Example Results and Consequences of Freight Unit Building

The freight unit granularity faces another challenge with bulk transportation. In this case, the split result of freight unit building is highly dependent on the transport means used for loading. If this is known up front (e.g., a container or railcar of a particular size), the transport means definition can be assigned to the freight unit building rule. If the knowledge isn't available, a sensible split quantity for freight units is challenging. As a cargo hold for bulk can be 50, 500, or 5,000 tons, it may be wise to leave the freight unit in the full size (e.g., an order with 7,200 tons bulk) and split the required quantities, once the used transport means is known (e.g., a cargo vessel with 4 holds of 3,000 tons each).

In case of multimodal transportation with small and large vehicles, the split is usually driven by the smallest resource. If the preceding example order with 7,200 tons needs an on-carriage by train wagons, the capacity of the wagons would dictate the freight unit building rule.

14.1.4 Structure Charging Rules and Rates

When you're working with tariffs, charge calculation sheets, and rate tables, it's advisable to create templates for most of the pricing entities. This allows you to give guidance to the users who must set up forwarding and freight charge calculations. These templates should align with the company's pricing strategy or the typical pricing approaches of your LSPs. A standardized, company-wide strategy simplifies the price definition, negotiation, quoting, and contracting process. It also allows you to do price maintenance (e.g., uplift or rate increase) in a more straightforward way without giving up the flexibility of individual pricing.

Standardization means defining a set of rate table structures with sensible scales, a list of reused charge elements, and a set of template charge calculation sheets based on service products (e.g., air freight transatlantic, ocean freight standard, or road freight by weight and zip codes). These are all reused to create customer-specific contracts that may then have individual prices but a structure that follows the template scheme.

14.1.5 Other Planning Configuration Settings

You may want to think twice about how simple or diverse you set up some other configuration elements. These settings should be well balanced among easy maintenance, process flexibility, and practical value, and you should answer some typical questions to help you to find the right solution:

- **Transportation planning costs in optimization**
  What factors drive decisions in transportation planning and optimization? Do you need to include virtual penalty costs for late deliveries or nondeliveries to get the best result, or is it sufficient to plan just by cost-driving factors, such as miles driven, space usage, or vehicles used? The answers to these questions drive the complexity of cost models in optimization.
- **Forwarding and freight order types**
  How many order types do you need for your processes? Is an express order a separate order type, or is it simply modeled by characteristics such as the shipping type or a service product? We generally recommend that you reduce the number of order types to those that have a clear-cut focus (e.g., air freight order or ocean freight order, and perhaps a distinction between less than container load [LCL] and full container load [FCL]).

- **Resource types**
  Do you need separate resource instances for each vehicle that is used to transport cargo? In many cases, it may be sufficient to model resources just as a resource pool (e.g., 20 instances of a generic 40-ton truck resource instead of a distinct resource per individual truck, which may be applicable if you own a fleet). Distinct resources are required if you also need to maintain the resources. Mixed models are often suitable; with these, you might have instance-based models in your own fleet, core regions, or core business, and you might have pool-based models for regions where you don't have direct control.

14.1.6 Structure and Name Your Data Well

Before starting configuration, think about naming schemes for your configuration data. After the employees are familiar with these schemes, they can more easily find their way around a complex implementation project. Naming schemes such as the following should be applied for all settings:

- **Naming of forwarding order or freight order types**
  You can name the forwarding order or freight order type in a way to indicate the mode of transport and service (e.g., ZAC1 for air freight standard consolidation and ZOL1 for ocean freight LCL).
- **Rate tables**
  You can include the scope, service, and customer significance in the naming. "BSF_APUS_C1234" could be a rate table applicable for basic sea freight (BSF) on a route from Asia Pacific to the United States (APUS) with specific prices for customer 1234.

If you run multiple scenarios in a single client, it's helpful to segregate the settings by selecting consistent identification names, such as starting all air freight settings and purely air freight–related master data with "AF" and starting those for ocean freight with "OF". This can be beneficial in setting up consolidation settings, such as planning profiles, where you need to select other entities by referencing. By consistently segregating the name spaces for unit-specific settings, you can reduce the maintenance effort considerably.

14.2 Optimize the Sequence of TM Configuration

You already understand the importance of having well-structured configuration data before going into a larger process implementation project. This is especially important if the configuration is done in a system where processes are already running and may be affected.

The following system setup sequence should give you a rough guideline (note, this isn't an exhaustive list):

- **Set up basic systems settings**
  If you start in a new system, several prerequisite settings are required:
  – Set up logical system connections (cross-application).
  – Create an active version and model for SAP Supply Chain Management (SAP SCM) master data; otherwise, no master data can be maintained (TM).
  – Set up geolocation services (cross-application).
  – Set up archiving, attachments, and Post Processing Framework (PPF) basics (cross-application).
- **Set up basic TM settings**
  Basic TM settings should be done in the beginning because they can be referenced in a later phase of configuration:
  – Set up code lists (e.g., aircraft type codes, referenced United Nations Code for Trade and Transport Locations [UN/LOCODEs], etc.).
  – Set up fundamental types and categories after deciding on the granularity of the model (e.g., means of transport types, forwarding agreement item types, and charge element types).
- **Set up business object configuration**
  Business object configuration includes setting up the behavior of different object types used. If you use the order integration with SAP ERP in an SAP Business Suite implementation, the general layout of the process should already be done before you start TM configuration (e.g., SAP ERP sales order types and their use in TM). The same is relevant if you use SAP S/4HANA and integrated sales orders and deliveries:
  – Define a basic SAP ERP object setting, for example, order and delivery types that impact TM
  – Define customer order types and order types used for SAP ERP integration (e.g., forwarding order types, forwarding quotation types, order-based transportation requirement [OTR], and delivery-based transportation requirement [DTR] types) or corresponding SAP S/4HANA object types.
  – Define planning and capacity object types (e.g., freight unit types and freight booking types).
  – Define subcontracting order types (e.g., freight order types).
  – Define relevant item types for previously mentioned order types and assign the types to the orders.
  – Define agreement types (e.g., freight agreement types and forwarding agreement types).
- **Set up processes and their configuration**
  Process configuration defines the behavior of the system when it works with data

and functions that span multiple business objects, create new information, or update existing information. Because some of the required setup may be heavily dependent on master data, you may need to make some refinements later or define some master data first:

- Set up the pricing-relevant services and the global service product catalog.
- Set up charge calculation rules (e.g., forwarding agreement determination, charge calculation sheet structures that reuse the charge element types, and rate tables).
- Set up planning rules (e.g., freight unit building rules, planning profiles, and incompatibilities).

■ **Define master data**
Master data can be set up in parallel with the process configuration:

- Business partner master data
- Organizational model
- Location and network master data (e.g., locations, schedules, and resources)
- Rate and tariff data

■ **Set up integration with other components or systems such as SAP S/4HANA billing, warehouse management, SAP Yard Logistics, SAP Event Management, and SAP Global Trade Services (SAP GTS)**

- Set up system integration (remote function call [RFC], Core Interface Framework [CIF], enterprise services, etc.).
- Transmit master data.

■ **Set up ancillary services**
Ancillary services can be set up relatively late in the implementation process:

- Set up output or printing rules and printing forms.
- Integrate with the analytics system.
- Configure archiving integration and document management within the process (archiving itself has already been set up).

■ **Set up user interface (UI) configuration**
UI setup is done in SAP S/4HANA or SAP Business Client (SAP Business Suite):

- Set up users, roles, and authorizations.
- Set up menu structures, roles, launchpad, and tiles (as applicable), and assign to roles and users.
- Set up worklist layouts based on the standard layout so that they meet their purpose and show valuable information.
- Set up transportation cockpit layouts.
- Adjust screen layouts with the Floorplan Manager (FPM).
- Give menu topics and fields recognizable names and adjust to country-, industry-, or customer-specific naming.

It's generally wise to run early, small tests during the configuration, so you can estimate the extent of design flaws in the whole setup. In some cases, you must go back to a previous step and complete or adjust the configuration (e.g., add a default output profile to an existing forwarding order type).

14.3 Scenario Builder

In the previous chapters, you read that a configuration of a scenario in TM may contain a variety of settings, such as master data, Customizing, configuration, and transactional data. With traditional SAP tools, only a part of this data can be packaged in a way that a complete scenario can be defined, transferred to another system, or redeployed in a new system or client to retest and run existing scenarios.

However, the *Scenario Builder* (available since SAP S/4HANA release 1709) allows you to create nearly complete scenarios with only a few elements missing (e.g., cost definitions, which can be transferred via Microsoft Excel). The Scenario Builder is an SAP Fiori app, which is provided for nonproductive use and allows you to create test data for TM with the goal of simplifying bundling and repeated creation of master data, transactional data, Customizing, and configuration for test and demo situations. However, it isn't supported and won't be used to transfer data between or into productive environments.

The Scenario Builder can be started in SAP S/4HANA via **Application Administration • Scenario Builder**. In Figure 14.2, you can see the Scenario Builder overview page.

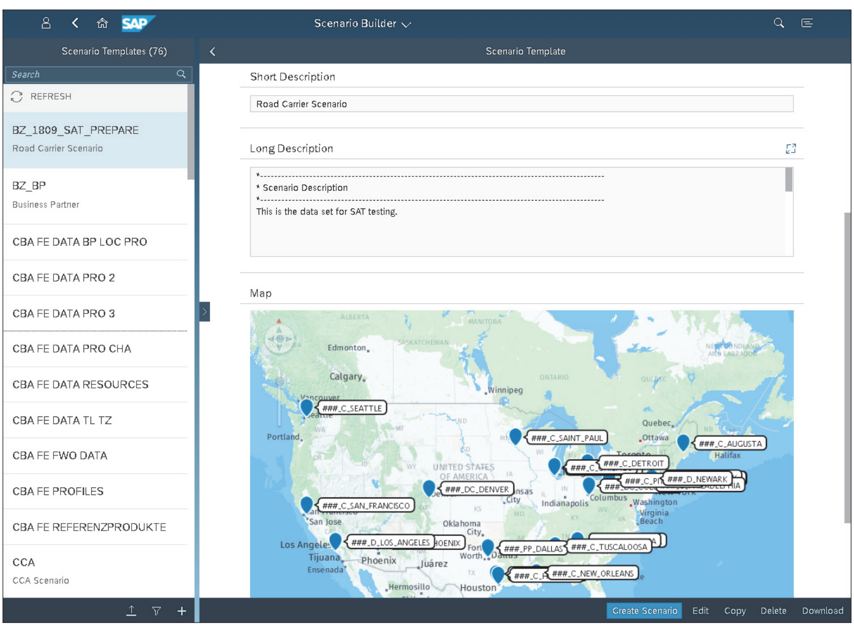


Figure 14.2 Scenario Builder Overview Page

After selecting a scenario or creating a new scenario, various aspects of the scenario can be edited; that is, the related master data, Customizing entries, configuration entities, or transactional objects can be added. In the current version, the following elements are available:

- Info:
  - Short and long descriptions for the scenario
  - Map display that visualizes the geographical elements of the scenario (see Figure 14.2)
- Master data, which is displayed in an example in Figure 14.3:
  - Transportation network: Locations, transportation zones, transshipment locations, schedules, and transportation lanes
  - Vehicle resources
  - General master data, such as business partners and their relations and materials

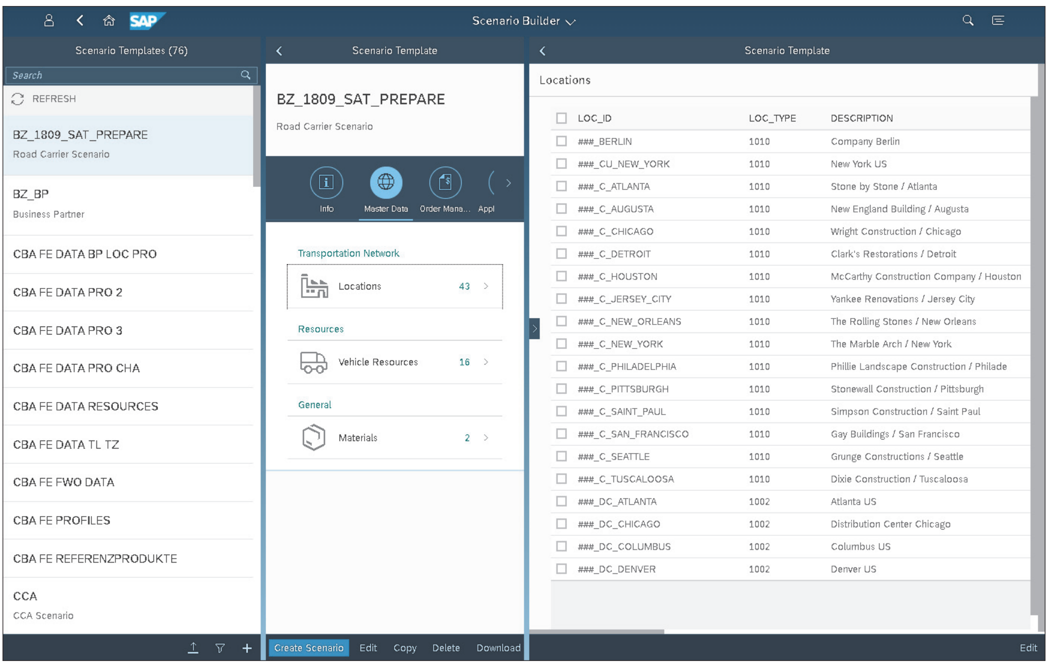


Figure 14.3 Master Data Maintenance of a Scenario

- Order management data for use as templates:
  - Forwarding orders
  - Transportation orders for road, rail, air, and ocean
- Administrative planning settings:
  - Freight unit building profiles
  - Planning profile elements and selection profiles

- Reporting variants
- Customizing data consolidated in business configuration sets

As of the time of writing, it isn't possible to include charge calculation data into the scenario definitions. However, charge data can be exported and imported via the charge calculation specific download and upload tools.

After a scenario is completely defined, it can be exported in a Microsoft Excel–based table format per entity and bundled in a ZIP archive, which allows system-independent copying of scenarios. Figure 14.4 shows such an export file.

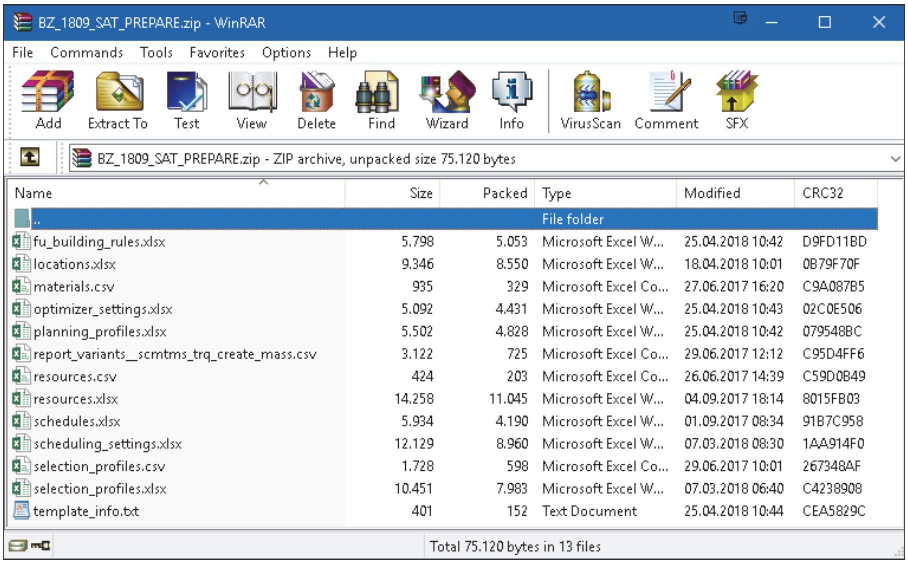


Figure 14.4 Example Export Zip File for a Scenario

The current version of Scenario Builder is mainly targeted to support reuse of order and planning scenarios. The charge management data is still missing; however, this may be added in a later version or alternatively export and import via charge and contract objects can be an option.

14.4 Consider TM's Strengths and Limitations

There are some additional hints that can clarify both the capabilities and current limitations of TM and its ecosystem:

- **Limit the network and plan to necessary elements and complexity**
  Because TM has many means of defining a transportation network and using it for planning and routing, you might be tempted to set it up in a very detailed way. You may perhaps tend to define customer locations down to the dock door as part of the transportation network.

Instead, we recommend that you keep the network as simple as possible so that the planning performance is good, and the definition of planning rules doesn't become overly complicated. Detailed location definitions for loading or unloading points may be added on the stage level without complicating planning processes.

- **Be cautious when using SAP Fiori or Web Dynpro screens on the web**
  You technically can use TM's Web Dynpro screens on the internet. Some screens are prepared for this (e.g., the still available Collaboration Portal in TM on SAP Business Suite, where a carrier can place bids on tenders), but many of the TM screens shouldn't be exposed to external access in this way. Of course, intracompany use on the web via a virtual private network is no problem, but don't try to expose a forwarding order entry screen as a customer portal screen for online ordering because the data security isn't targeted for external use. On the other side, additional user licenses are required. If an external user is able to use, for example, a forwarding order UI to place an order by pressing F4 while the cursor is in the **Business Partner** field, the user can see a large list of customers that the user isn't authorized to see. If TM screens are reused for external web usage, you need to create a new screen (also as a copy of an existing one) and adjust the layout, security, and authorization so that it meets the required standard.
- **Consider configuration versus personalization**
  Many tasks that are done during TM setup are classified as configuration; they control the system for all users with the appropriate authorization (other users simply can't use a configured feature). In UI setup, some tasks can be classified as *personalization*, which means that the setup is made only for the user making the alterations. This is applicable to all nonadministrative activities in the UI adjustment (e.g., hiding fields) or worklist setup, where you change the selection criteria, queries, or layout and sequence of columns. If you need to provide changes to a larger group of users, do it with the administrative tools. Don't overload your IT with tons of individual personalization that users may have done. It will confuse the IT team when problems with a UI arise.
- **Create new worklist applications**
  Worklist applications can't be reused directly and adjusted to a different context. If, for example, you want to create a menu structure with different branches for order management (e.g., industrial customer orders and end customer orders) and reuse the forwarding order worklists in both menu branches, then adjustment of the worklist in one branch automatically leads to the same changes in the other branch. If you need to reuse a worklist, you must do the following to create a new personal object worklist (POWL) application (do this in the SAP GUI, not SAP Business Client):
  - Call Transaction FPB_MAINTAIN_HIER. Create a new POWL application as a copy of the one you want to reuse (e.g., the order management POWL `SCMTMS_POWL_OM`).
  - Go to Transaction POWL_TYPER, and set the role assignment for the new POWL application.

– Use Transaction POWL_QUERYR to define the role assignment details.
– Finally, run report POWL_D01 using Transaction SE38 to reset the POWL caches.

14.5 Risks and Change Processes with TM Projects

Running TM projects is often not just a single, easy-to-oversee task, but includes a lot of variations, as multiple customer organizations or countries with a variety of processes are included in multiple phases of the project. In addition, each TM project may be just a part of a larger program running in a customer organization to transform the whole logistics including warehousing, yard, and in/outbound processes, or even as part of a complete SAP S/4HANA transformation. As such, a TM project can't be viewed separately, but is influenced by many risk factors, which may have a negative or positive impact on the project execution and the implementation success. In Table 14.3, you can see a list of positive or negative impact factors in a variety of risk areas related to a TM implementation.

Risk Area	Negative Impact Factors	Positive Impact Factors
Company management	Missing management support	CEO endorsement driving project top-down through the business and not IT
Implementation quality	Low quality implementation and programming guidelines for enhancements (e.g., spaghetti code)	Clearly defined and controlled quality guidelines and gates
	Very high interfacing complexity and data/process distribution	Appropriate use of templates and available interfaces to adjust to a common and standard-driven scope
	Too many remaining legacy systems	Business and IT working hand in hand
	Inappropriate system sizing	Appropriate sizing and process-driven mass tests
Knowledge	Missing knowledge of implementing party	Involve expert teams for critical system enhancements Central customer center-of-excellence with business owners/experts from customer site

Table 14.3 Positive and Negative Impacts on TM Implementations

Risk Area	Negative Impact Factors	Positive Impact Factors
Process handling	Too much process complexity handled in one go	Pilots and rapid iterations – scale afterwards
	Too little process coverage by standard	Make use of standard software appropriately according to its design
	No or unclear business blueprint	Proper business blueprint with signoff from all involved parties
	Missing master data cleanup	Master data cleanup as part of project where necessary
Project management	Unrealistic project effort and duration estimation	Transparency and clarity on scope, budget, and responsibility
	Weak change management	Process streamlining ahead of project with clear scope and defined change management process
	Project and program interdependencies (e.g., financial accounting and logistics)	Involve important stakeholders and business owners also from other areas

Table 14.3 Positive and Negative Impacts on TM Implementations (Cont.)

As we noted in Table 14.3, the risks, which come along with a TM implementation project you execute in your company, require an appropriate level and set of change management awareness and support. The effort that you need to put into these management tasks depends on how radical the changes in your company are. Figure 14.5 shows the three pillars that the business operation of a company is built on in transportation, as well as in many other areas.

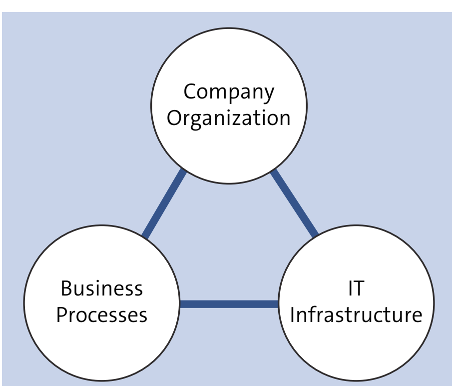


Figure 14.5 Pillars of Change within a Company (When Implementing TM)

Let's walk through these three pillars of change:

- **Company organization**
  Organizational structure and setup of the various parts of the company often change, especially in the way their responsibilities, obligations, and interactions are affected. Organizations can be changed when restructurings of a company occurs, which also sometimes goes in line with IT adjustments or business process reengineering.
- **Business processes**
  Business processes define how their behavioral patterns, input, and expected outputs are defined. It also includes interaction between organizational structures to define how their resources are involved in transforming input to output, for example, producing a particular product with machines from raw materials.
- **IT infrastructure**
  The IT infrastructure defines the sum of elements used to provide computer system support accompanying the business processes and organizations. It includes automated parts as well as user-operated parts in transactional, strategical, and organizational activities.

Looking at the impact that changes in one or more of these pillars may cause, a proper level of change management is of very high importance. Table 14.4 provides a comparison of if you change one, two, or three of the pillars at the same time.

Change Topic	Change Any One Pillar	Change Two Pillars	Change All Three Pillars
Example	Introduction of new IT system for transportation management	Introduction of new IT system for transportation and changes to the air freight and ocean freight processes	Restructuring of the company operation, implementation of a new IT system, and changes to sales and procurement processes
Impact examples	Users must learn a new TM system	Users must learn a new system and handle very different processes than before	Responsibilities, goals, and duties changed (unclear?), users get new tasks and must learn a new system
Change management	Normal attention and change management required	Extensive attention and change management required	Very efficient and constantly monitored and corrected change management required

Table 14.4 Change Management Requirements When Running a Project with Impact on One or Multiple Pillars of Change

Change Topic	Change Any One Pillar	Change Two Pillars	Change All Three Pillars
Pillar concentration	Concentrate on changed topics	High efforts to sync between involved pillars	Very high effort to sync all three pillars on all levels
Management involvement	Involve management of changed area	High management attention on upper-management level	Top management attention and priority
Expected runtime	Normal runtime according to project calculation	Extended runtime incorporating sync and change efforts	Very long runtime with added stabilization phases
Risk	Normal risk handling	High risk of failure	Very high risk of failure and of reaching company goals

Table 14.4 Change Management Requirements When Running a Project with Impact on One or Multiple Pillars of Change (Cont.)

If a company runs through massive changes of their organization, processes, and IT systems, the success of the company can't be guaranteed by using a right implementation of the underlying IT. Many additional factors influence the successful operation and profitability of the company.

Another aspect of risk for TM projects is missing collaboration and communication in projects, where several partners are contributing. As TM is often not implemented as an isolated process in a company, but as part of a larger supply chain or end-to-end system renewal or process reengineering, there may be multiple consulting companies, software providers, or system integrators involved in the overall project. Ideally, every party with a stake in the overall project scope needs to align with the others; head for a solution which fits the overall goal and results in the best coverage of customer requirements. However, in many projects, involved parties act as if they were doing projects alone and aren't affected by or impacting anything outside of their scope. In Figure 14.6, you can see examples of shortcomings in communication or collaboration between multiple involved parties in a larger project.

The issues you can see in communication or collaboration can be often mitigated if a customer or a central system integrator pays attention and actively addresses critical areas where synchronization is required. If this isn't happening, the involved parties may not push for a solution actively, as they are just playing a role linked to their scope, which in the end bears a high risk of project failure. Typical shortcomings include the following:

- Implementing companies don't talk to each other because they don't like each other or just work inside their own silos.
- A software provider isn't allowed to talk directly to the customer because the customer only wants to talk to a single partner, which may be system integrator A. In this case, important information may easily get lost.
- A software provider may not talk to other consulting companies handling other products, which may lead to error-prone integration processes.
- A consulting partner subcontracted by the system integrator may not talk to the customer directly but only to the system integrator. Again, lots of important information may be lost.

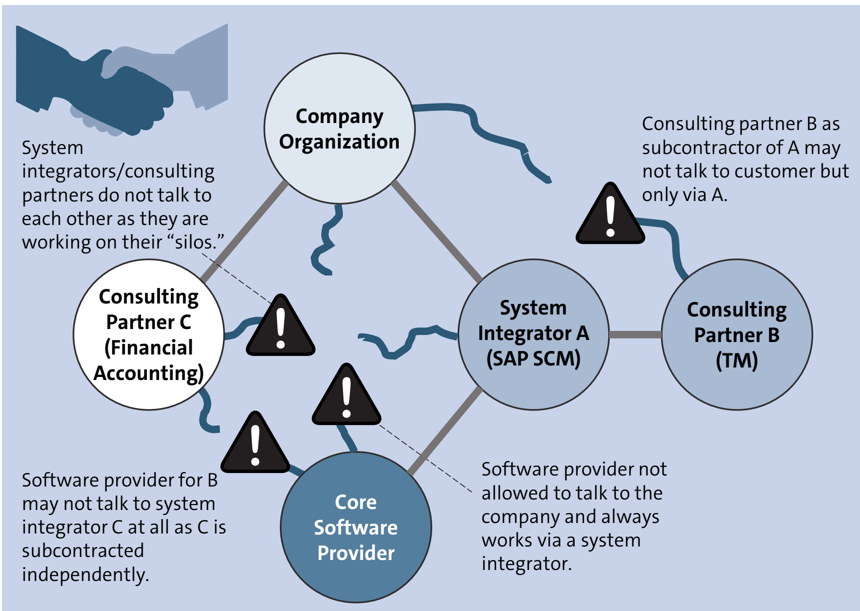


Figure 14.6 Typical Communication and Collaboration Shortcomings in Multipartner Projects Involving TM

An example for the situation shown in Figure 14.6 is a company that wants a new business system. Say they contract SAP SCM to system integrator A based on an SAP system, who has no experience in transportation. Therefore, they subcontract to consulting company B for the TM implementation. In parallel, as driven by another organizational unit of the customer, financial processes are upgraded from an existing financial system (non-SAP) by a different consulting company.

The shortcomings in this scenario may lead to several issues. First, financial accounting may not be properly integrated with SAP SCM and TM. Next, the TM implementation may be very basic because the system integrator has no understanding of an efficient TM, and check backs of consulting partner B aren't properly understood and handled by A. Finally, sensible functions provided by the software in the next release may not be properly factored in because the communication channel to the customer via system integrator A lacks clarity.

A situation like this one may quite easily be avoided if all parties are open to collaborate and communicate in an open and goal-oriented manner. As general guidelines, the following can be done:

- Never cut a line in a large project, but take care that all parties collaborate well, inform all parties on decisions, and involve all parties if crucial decisions are made. Every party has its important contribution that may impact the health of a project: never treat a collaborating party just as a simple “worker.”
- Let information flow. Financial and logistics should not be seen as two independent projects because for some issues, they are highly related, especially if we think about an integrated platform. There are important touchpoints of different projects that need to be identified, and information and decision collaboration need to be established and clearly communicated.
- Don’t build silos, but do have a general responsible person for communication and collaboration. If you have several parts of projects, don’t treat them as silos only because they are run by different system integrators. The overall architecture and business process guideline has to be known and respected by everyone. There needs to be a person responsible for the overall project and for alignment of the contributing parties.

14.6 Customer Onboarding in TM Installations for LSPs

Customer onboarding is the process of setting up the requirements of a new customer in an LSP’s existing system installation (e.g., TM). In simple cases, onboarding just means a bit of master data maintenance. In more complex situations—for example, a new worldwide customer with custom-tailored logistics service requirements that must be supported—configuration settings for the processes defined for a new customer must be fitted into the existing system. Setup must be done in a way that other, already-running processes for existing customers aren’t affected, and the LSP can manage the new customer with all its requirements. The following list gives you an overview of the various steps you should consider:

1. In the contracting phase, it’s important to properly specify the customer’s requirements, including the service-level agreements (SLAs). Take the following steps to document and close the contract:
   - Document the customer-specific requirements.
   - Issue the contract.
   - Obtain internal approval of the contract.
   - Close the contract.
   - Initiate setup of the contract through the related IT and logistics departments.

2. During setup, you need to translate requirements into straightforward system settings. There are various aspects to be considered. Because setup sometimes increases complexity, keep an eye on the impacts of new settings on existing processes (e.g., if you're implementing a completely new air freight service that requires a new means of transport).

   Take the following steps to set up contract-specific settings:

   - Translate the contract to system-specific settings in Customizing, master data, and enhancements.
   - Identify potential impact on other existing processes and settings.
   - Implement settings.
   - Implement coding and enhancements.
   - Document settings, for example, in SAP Solution Manager.
3. During the test phase, existing processes should be thoroughly tested but also checked regarding impact and side effects with other, existing processes:
   - Test settings with real customer data.
   - Test influence of customer settings on other customers and on regional or global settings (regression test).
   - Release settings.
4. In the run phase, run customer orders with the following steps:
   - Receive and process orders.
   - Analyze SLAs.
   - Execute contract reviews.
5. After the customer process is up and running, maintenance must be done because customer business changes, contract renewals, and requirements adjustments might affect system settings.
6. To update settings when required, follow these steps:
   - Update, extend, or close new contracts.
   - Identify existing settings.
   - Identify potential impact on other existing processes and settings.
   - Retire unnecessary settings.
   - Update or create new and changed settings.
   - Retest new and existing scenarios.

14.7 Enhancements for TM

Even though TM is a very powerful tool, it's not always complete in terms of covering everything customers envision or require. Therefore, several organizations are adding enhancements to TM as either part of an SAP-driven development or a partner-initiated functional enhancement.

SAP Innovative Business Solutions is an SAP-internal organization that provides solutions and software enhancements for single customers or small groups of customers requiring deeper functionality in specific areas. Several *custom development projects* (CDPs) have been created for TM, including the following:

- **Validation framework**
  Business Rules Framework plus (BRFplus) can be used to easily set up validation rules in order processing that gives users hints on how to check or complete an order.
- **Container shipping line (CSL) solutions**
  CSL is a complete suite of add-on applications that includes three separate packages Lead-to-Agreement for CSL, Order-to-Cash for CSL, and Network and Operations for CSL, which allow an end-to-end operation for large container ocean carriers on top of TM.
- **Resource planning Gantt chart**
  This Gantt chart is a scheduling board for vehicle and driver resources in the trucking business. It comes with a very practical "yard in–out view," allowing you to clearly see when certain resources are expected to come into a yard and which shipments still need assignment of resources to go out on time.

Several other CDPs have been developed as well. SAP may decide to retrofit some of the CDPs in a future TM release.

From the perspective of SAP's partner network, there are quite a few innovations that add functional enhancements to TM based on requirements of single customers or groups of customers. These enhancements may often be developed in a more straightforward way compared to SAP Innovative Business Solutions, as they don't have to guarantee for long-term development alignment and therefore can be created in a more cost-efficient way.

An example for such an enhancement is a mobile driver app to support the daily work and standard workflow tasks of the truck drivers, which is installed on their mobile devices. Other examples can be invoice verification tools, scanning tools, or integrations with logistics companies or express providers. Enhancements of the scope of TM directly benefit from the flexibility of the architecture, data model, and interfaces.

14.8 Summary

In the previous chapters, you've learned about the various functional areas and components of TM, examined the technical foundation and other integrated SAP applications, and explored various scenarios. With these best practice tips, we conclude the journey through this book.

We hope to have achieved an overview of TM in SAP S/4HANA release 2022. In this chapter, you learned useful best practices, hints for implementing TM, and innovative methods for making use of SAP's extensibility. You got insight into topics such as customer onboarding, specific things to take care of when implementing TM, and tools to transport business scenario content for TM between different system instances.

We'll end with a final chapter reflecting on what we've learned and the outlook on TM's future.

Chapter 15
Summary and Outlook

Digitalization, cloud enablement, company consolidations, new process approaches, competition from new players in the logistics market, and severe disruptions are among the variety of major challenges for today's logistics companies, but they also provide a chance for companies to increase the efficiency and resilience of their own processes. The transportation management (TM) solution in SAP S/4HANA is an important building block to handle today's complexities.

In today's transportation and logistics world, you're facing a variety of challenges, which may to a large extent, influence your company's efficiency and long-term strategy. Additional threatening circumstances driven by pandemic or war situations tend to complicate the overall situation in logistics, and thus the maneuverability of an enterprise. Despite these current additional complication factors, which are very challenging, a well-integrated transportation management system (TMS) such as TM is of big help in getting better structure and consistency into your supply chain.

Based on universal availability, logistics has functionality mapped into the standard business software context in the recent years. However, consuming the benefits of integrated processes, the market requires an even greater demand for transportation functionality, adaptability to digital data sources and capabilities, and capability to implement transportation management in complex supply chain systems with the know-how of a strong software provider and knowledgeable partners. Logistics has grown from a fifth wheel to an essential, if not way-pointing, element of strategic corporate leadership.

Customer orientation, digitalization, and new players with innovative ways of shipping—either as competitors or potential partners—are demanding trends characterizing required efforts to protect existing markets and grow into new channels, regions, or services. Many companies need to reorganize their value-creating processes, paying special attention to the interfaces between the sales and procurement markets, which are increasing in importance. With the new digital platforms, the integration of corporate functions has become more important than ever before.

The operational significance of logistics for many companies lies in its rationalization potential. In addition, due to the manyfold crisis situations, logistics got a very strong safeguarding aspect, as supply chains need to be protected and secured, inbound as well as outbound. A well-defined TMS such as TM can be a rock-solid building block within a frequently changing supply chain environment.

In general, a reduction of logistics costs should improve or at least assure corporate success by achieving a competitive advantage. Besides surveys of businesses, which have shown that companies are still counting on a considerable cost reduction potential, digitalization strategies and new networking opportunities open plenty of opportunities but also apply pressure to adapt and stay flexible.

Looking at the digitalization in recent years, an important factor is provision of transportation functionality to companies. The provision is more and more moving away from traditional on-premise systems and toward cloud deployment and enablement. Independent of being a business- or IT-focused person, you need to factor in that large software providers such as SAP will more and more move away from the traditional on-premise software model to pure cloud provisioning. Today, due to existing functional or technical gaps, this still leaves the option between private or public cloud systems, as we also see for TM. However, if technically and functionally possible, private cloud deployments may also be phased out in several years from now. Models based on software as a service (SaaS) tend to offer the highest adaptability and flexibility, which can be seen in the way the functions and modules of SAP Business Technology Platform (SAP BTP) are provided (see Chapter 1, Section 1.3.1).

The scope of logistics in recent years has continually expanded. We now can include production planning or quality control systems into the end-to-end scope of logistics. In addition, significant investments are made in IT in areas such as supply chain management planning. In the future, this will lead to a decrease in administrative logistics costs (e.g., through shipment tracking, transport organization, or internet-based ordering). It not only affects efficiency but also the fulfillment of demands of customers, who expect better integration with all their supply chain partners and higher visibility and insight based on available digital data, big data evaluation, and intelligent technologies. This is still a journey, which has not reached its final state in software development, and much of it is provided on public cloud or collaborative apps.

In highly competitive supply chain environments, outsourcing of traditional core logistics processes, for example, is still a stable trend. It's also viewed as a decisive means of cost cutting and competitive differentiation, especially among manufacturers and retailers. In this context, companies expect further savings by subcontracting logistics services and outsourcing these services to logistics service providers (LSPs). Even in LSP domains, outsourcing of pure logistics operations and higher focus on serving their customers' needs and increasing their loyalty with the LSPs offering are high priorities. Again, SAP plays an important role through putting public cloud-based portal SAP Business Network for Logistics side by side with TM.

Operative logistics tasks, such as transport, storage, commissioning, and packaging, have already been outsourced to a high degree to external LSPs or carriers. Modern logistic solutions support all aspects of corporate and outsourced logistics, including warehousing and transportation, as well as a seamless integration with an organization or its customers' backend systems. In today's fast-moving, modern society, it's vital for suppliers to have a fully integrated solution and to prevent information silos with limited insight. From the perspectives of both shipper as well as LSP, many logistics processes either include interfaces with customers or affect the customer. Therefore, logistics processes need to be oriented toward customer requirements and performed in a service-friendly manner. The new technologies offered by the cloud, secure and immutable communication, and collaboration open the door to the kind of network that is demanded today.

From a shipper's company perspective, it may happen that the quality of competitors' products continues to become more comparable. In this case, companies are competing on the level of service performance, especially because there may hardly be room to lower prices anymore. Within these services, transportation as a direct or indirect service ranks high. Delivery perfection and flexibility, rapid returns processing, and high quality of customer service are characteristics with which a company can set itself apart from its competitors.

The commercial world is shrinking as modern communication channels give everyone the ability to share information. Many companies are beginning to think in terms of their global logistics operations rather than individual local goals. They want technology providers to deliver an integrated logistics and supply chain system that is capable of seamlessly delivering goods from one end of the globe to the other by integration of all relevant partners. In this context, transportation and logistics is the focus area and a priority field for investment today. Logistics costs represent around 10% of a country's gross domestic product and have a major impact on a company's profitability, customer service level, and sustainability balance sheet. Supply chain, transportation, and warehouse managers are now under pressure to automate, transform, and optimize their business processes. The integration of new technologies, such as sensors, Internet of Things (IoT) devices, machine learning and artificial intelligence processes, robotic process automation, and big data analytics can be seen as a benefit, as traditional legacy systems often prove to be dead ends in this new, fast-changing technology world.

TMSs have to also take into account that new modes of operation and business models may come up, which again requires flexibility and adaptability in your software foundation. One example for such a model is the European Technology Platform Alliance for Logistics through Collaboration in Europe (ETP ALICE), which has been set up to develop a comprehensive strategy for research, innovation, and market deployment of logistics and supply chain management innovation in Europe (*www.etp-alice.eu*). ALICE is moving toward an overarching view on logistics and supply chain planning and control. Shippers and LSPs are foreseen to more closely collaborate to reach efficient logistics and supply chain operations compared to today's system.

An important element of this vision is the *physical internet* (PI), which provides a platform from global to urban, that will be founded on a global open system of systems enabling assets and resources in logistics networks to be interconnected. The PI will enable using available capacity and productivity to its maximum while increasing agility and resilience of the end-to-end supply chains. The PI also should support an affordable transition of assets toward zero-emissions logistics.

The PI is planned to work comparable to the data- and communication-based (normal) internet, just that you would feed cargo into the network. As an ordering party, you would post an order to move cargo through the PI, the actual execution of the move is out of your hands, and it should arrive at its destination at a low cost, appropriate time and quality, and ideally zero emissions. The elements of the network are controlled by the implementation and partners of the ALICE platform, which would also target highly standardized services and operations. The program has a bit of the characteristics of a 4PL, 5PL, or a freight exchange, but it's more network- and community-oriented and mode-spanning. In Table 15.1, you can see the planned roadmap of the PI of ETP ALICE.

Phase	Buildup			Physical Internet	
Time Frame	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040
Governance	Scattered and unbalanced terms, rules and standards	Rules and governance for asset-sharing platforms	Foundation of PI governance body	Industrial adoption of PI rules and models	Stable PI rules and model
Access and adoption	Pooling and alliances	Sectorial, regional, seamless vertical PI demonstration	Large-scale PI demonstrations	PI expansion	Everyone can access the PI
System of logistics networks	Silos within silos (separated subnetworks)	Network-to-network connectivity	Extended internetwork connectivity	Scalable logistics networks	Fully autonomous PI network services and operations
Logistics networks	Rise of booking platforms	Operational synchromodality/physical intranets	Multiple shipment join/split	Sense-and-respond optimization of network flows	Fully autonomous PI network services and operations
Logistics nodes	Non-standardized transshipment nodes	Open and seamless nodes service offering	Automated node service request and response	Nodes interconnect across networks	Autonomous PI nodes

Table 15.1 Roadmap of the Planned Physical Internet

However, working with such a platform is to some extent new for a system such as TM. On the other hand, TM would be flexible enough to integrate such a platform into the end-to-end processes. This would even work when mixing transports to, for example, span across ALICE-based pre-carriage moves into traditional main carriage transportation (e.g., European truck move via ALICE to a port and direct shipping line subcontracting to US).

Without sophisticated transportation systems, logistics can't benefit from system advantages. Besides a good transport system, logistics activities could provide better logistics efficiency, reduce operation costs, promote service quality, and increase connectivity and insight. The improvement of transportation systems needs efforts from both customers and software vendors. SAP S/4HANA and SAP BTP form an ideal foundation to provide all of these features to a company and its peers.

By matching logistics demands and capacities to short-term planning; optimizing processes and resources of the entire distribution network; providing responsiveness and flexibility through complete real-time visibility; and giving insight into plans, operations, and inventory—all based on a transportation management that is seamlessly connected to the business network—SAP's vision is to help companies achieve their supply chain execution excellence, increase transportation and logistics efficiency and productivity, reduce supply chain execution costs, and improve sustainability and compliance.

TM is one of the most sophisticated and well-integrated transport management solutions. The content of our book has given you a guideline to relate the business and technical context of TM as we described in the previous chapters to your logistics activities and the strategy of your company in relation to the mid and long-term goals.

- **Chapter 1: Transportation Management Foundation**
  The chapter introduced you to the basics of an SAP S/4HANA system, as well as to TM and its connected components. We put some emphasis also on highlighting connectivity, SaaS services, and cloud deployment options.
- **Chapter 2: Solution Architecture and Technological Concepts**
  This chapter introduced you to the technical foundation of the architecture and solution to provide you with the knowledge on how to fit TM into an integrated landscape.
- **Chapter 3: Master Data**
  This chapter introduced you to the foundational data requirements of the transportation solution and allows you to understand which master data needs to be exchanged with the environment of TM.
- **Chapter 4: Transportation Requirements and Order Management**
  This chapter describes how the process flow of TM usually starts, when the transportation requirements and demand is made available to TM. In an integrated or cloud-oriented world, you'll define the link to the transportation demand coming from the source of logistics movements.

- **Chapter 5: Transportation Planning**
  Transportation planning deals with everything required and sensible to cut down transportation demand into manageable pieces and optimizes the combination of pieces in terms of scheduling, capacity, and compatibility. Planning is the link between the transportation demand and the execution of transportation by a company's own fleet or an external fleet. Planning processes can also support transportation demand provided by external sources.
- **Chapter 6: Freight Order Management and Subcontracting**
  Freight orders and bookings are used to execute plans with a company's own or third-party transportation capacity. They also define the link to LSPs in tendering and subcontracting. In a cloud scenario, freight orders and booking would be the recipients of plans worked out by third parties, which, for example, is the case when using SAP's public cloud transportation solution.
- **Chapter 7: Transportation Execution and Monitoring**
  Every move that is executed needs to be prepared before the actual transport in terms of compliance, documentation, and handling. From the loading to proof of delivery, there is also the need of documenting elementary steps of the move and provide updates for monitoring.
- **Chapter 8: Transportation Compliance**
  Compliance heavily influences transportation, especially when going cross-border or with nonstandardized or dangerous cargo. In this chapter, we highlighted how SAP components can be used to support compliance. The other way around, compliance integration is also where external services can be linked to TM to provide such functionality.
- **Chapter 9 to 11: Transportation Charge Management, Charge Settlement, and Charge Calculation and Settlement for Logistics Service Providers**
  In the description of charge management and settlement, we described how you can calculate customer, vendor, and internal charges for transportation and other services. Calculated charges can then be settled with the involved parties. In conjunction with third parties, the invoice information from the settlement can be exchanged and validated for payment or receipt.
- **Chapter 12: Integration with Other Components**
  Components that are heavily integrated with TM are described in this chapter on warehouse management, yard logistics, and resource planning.
- **Chapter 13: Migrating to and Running TM in SAP S/4HANA**
  As many companies are facing a move to a new system world, the migration to SAP S/4HANA is a move that enables well integrated and simple coexistence of SAP S/4HANA, TM, and other components.
- **Chapter 14: Implementation Best Practices**
  Practical hints on how to manage data volume and monitoring as well as best practice tips for configuration and day-to-day utilization of TM round off this book.

Following SAP's strategic mission to deliver the world's best logistics solution portfolio, SAP TM began a new era in the market for transportation management software. It became a best-in-class solution that supports integrated and connected supply chain execution processes with a vertical offering for shippers, freight forwarders, and carriers. In addition, with the integration into SAP S/4HANA, TM has a bright future, which is open to the level of digitalization that today's companies need.

In addition, there is a bucket of new topics on SAP's development road map, parts of which have already been started and are trickling down into the different release and deployment variations. Many of these have an integrational character such as advanced shipping and receiving (ASR) or unified package building. Parts of these functionalities have become productive with SAP S/4HANA release 2021 and 2022, and more will follow with further releases and feature pack stacks. Other topics may have a longer development cycle, combined with an even larger impact, such as order-based transportation planning (OTP) with fully integrated available-to-promise (ATP) functionality—a feature that already was started based on SAP ERP and SAP Advanced Planning and Optimization (SAP APO), but is still missing in the SAP S/4HANA and TM world.

Looking ahead, transportation logistics will greatly magnify the inefficiencies of spending too much time on tactical or low-value tasks. Granted, international transportation can be far more complex than domestic shipping. It's not uncommon for global shipments to touch many intermediaries, each of which has a distinct set of regulations, cultural beliefs, and IT capabilities. Nor is technology alone the answer; too many shippers have deployed transportation management software, only to have it fail and drive users back to their old, laborious duties. The most successful global companies use strategies that allow for "acceptable tolerances" in their transportation networks. They rely on event management features of technology to alert operators when attention is needed for unusual situations. In addition, effective transportation management solutions and services should allow users to generate a real-time, global "control tower" view of their networks and drill down into the specifics of each shipment, such as purchase orders, freight bills, stock-keeping units, and others.

This book is intended to provide you with a comprehensive reference work and workbook for transportation management with TM. Our experience as TM architects, developers, and product managers offers you comprehensive insight into application-oriented process handling, operation, and the technical background of transportation management with SAP.

SAP will extend and improve its transportation management solution as part of SAP S/4HANA with additional versions in the years ahead. This book describes functions of TM in SAP S/4HANA release 2022, which enable a major step forward in terms of practical relevance, functionality, user friendliness, and an even tighter integration across SAP's supply chain execution platform.

Finally, we also want to recommend that you have a look for online information and books from Rheinwerk Publishing. We hope you've achieved what you desired with this book and have found valuable answers to your questions and good guidance when navigating transportation management challenges. Most importantly, we hope we've sparked or encouraged your passion for transportation and logistics with TM in SAP S/4HANA.

Thank you very much for your interest in our works,

Dr. Bernd Lauterbach, **Dr. Jens Gottlieb**, **Meike Helwig**, **Dr. Christopher Sürie**, and **Ulrich Benz**

Appendix A
Abbreviations

Table A.1 contains some common abbreviations in the area of transportation management (TM) that you're likely to come across within this book, across your SAP system, or throughout your broader SAP studies.

Abbreviation	Meaning
24/7	7 days, 24 hours; i.e., around the clock
2PL	Second-party logistic provider (carrier with own assets)
3PL	Third-party logistics provider (forwarder potentially without assets)
4PL	Fourth-party logistics provider (end-to-end service provider)
A2A	Application to application
ABAP	Advanced Business Application Programming
ABD	Agency business document
ACI	Advanced Commercial Information (Canada)
ACS	Air cargo security
ADR	European agreement concerning the international carriage of dangerous goods by road
AMS	Automated manifest system (US)
ANLQ	Additional normalized load consumption quantity
API	Application programming interface
APO	SAP Advanced Planning and Optimization
ASEAN	Association of Southeast Asian Nations
ASN	Advanced shipping notification
ASR	Advanced shipping and receiving
ATP	Available-to-promise
AWB	Air waybill

Table A.1 Common Abbreviations

Abbreviation	Meaning
B/L	Bill of lading
B2B	Business to business
B2C	Business to customer
BAdI	Business add-in
BC	SAP Business Client
BI	SAP BusinessObjects Business Intelligence
bgRFC	Background remote function call
BN4L	SAP Business Network for Logistics
BO	Business object
BoB	Best-of-breed
BOBJ	SAP BusinessObjects
BOPF	Business Objects Processing Framework
BP	Business partner
BPM	Business process management
BRFplus	Business Rules Framework plus
BRIM	SAP Billing and Revenue Innovation Management
BS	Business share
BTD	Business transaction document
BTP	SAP Business Technology Platform
BW	SAP Business Warehouse
CASS	Cargo Account Settlement System
CC	SAP Convergent Charging
CCAD	Charge correction advice document
CDP	Custom development project
CDS	Core data services
CEP	Courier, express, and parcel
CFR	Code of Federal Regulations

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
CFS	Container freight station
CI	Convergent invoicing
CIF	Core Interface Framework
CO	Consignment order
CO-PA	Profitability analysis
CRM	Customer relationship management
CRN	Customs reference number
CRUD	Create, read, update, delete
CSL	Container shipping line
CSR	Cargo sales report
CSR	Customer service representative
CSV	Comma-separated value (file type)
CU	Container unit
CVI	Customer-vendor integration
DAD	Data access definition
DB	Database
DCM	Debit/credit memo
DD, D2D	Door to door
DDIC	Data Dictionary
DG	Dangerous goods
DGR	IATA Dangerous Goods Regulations
DRF	Data Replication Framework
DSD	Direct store delivery
DSO	Direct shipment option
DSO	DataStore object
DTR	Delivery-based transportation requirement
E2E	End-to-end

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
ECC	SAP ERP Core Component
ECS	SAP Enterprise Cloud Services
EDI	Electronic Data Interchange
EFTA	European Free Trade Association
EH	Event handler
EHP	Enhancement pack
EHS	SAP Environment, Health, and Safety Management
EM	SAP Event Management
EMS	Event management system
EP	SAP Enterprise Portal
ERP	Enterprise resource planning
ERS	Evaluated receipts settlement/self-billing
ESOA	Enterprise service-oriented architecture
ESR	Enterprise services repository
EUR	Euro
EWM	Extended warehouse management
FA	Freight agreement
FB	Freight booking
FBI	Floorplan Manager BOPF integration
FCC	SAP Financial Customer Care
FCL	Full container load
FEU	Forty-feet equivalent unit (container)
FI-AP	Financials – accounts payables
FI-AR	Financials – accounts receivables
FI-CA	Financials – contract accounting
FI-CO	Finance and controlling
FO	Freight order

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
FPM	Floorplan Manager
FPS	Feature pack stack
FSCM	Financial supply chain management
FSD	Freight settlement document
FTL	Full truck load
FU	Freight unit
FUB	Freight unit building
FUBR	Freight unit building rule
FWA	Forwarding agreement
FWAQ	Forwarding agreement quotation
FWO	Forwarding order
FWQ	Forwarding quotation
FWSD	Forwarding settlement document
GCR	General cargo rates
GFX	Global freight exchange (air freight)
GHF	Ground handling facility
GI	Goods issue
GIS	Geographical information system
GPS	Global positioning system
GR	Goods receipt
GRC	SAP governance, risk, and compliance solutions
GSP	Geographical service provider
GTS	SAP Global Trade Services
GTT	SAP Business Network Global Track and Trace
GUI	Graphical user interface
GUIBB	Generic user interface building block
HANA	High Performance Analytic Appliance

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
HAWB	House airway bill
HBL	House bill of lading
HEC	SAP HANA Enterprise Cloud
HS code	Harmonized system code
HSS	SAP HANA spatial services
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ID	Identifier
IGS	Internet Graphics Server
IM	Inventory management
IMDG	International Maritime Dangerous Goods Code
IMG	Implementation Guide
IMO	International Maritime Organization
ISF	Importer Security Filing
IT	Information technology
JIT/JIS	Just-in-time/just-in-sequence
KPI	Key performance indicator (analytics)
LCL	Less than container load
LDAP	Lightweight Directory Access Protocol
LE	Logistics execution
LMD	Last-mile distribution
LSP	Logistics service provider
LTL	Less than truckload
LO	Logistics general
LVD	Long-term vendor declaration
MAWB	Master air waybill
MBL	Master bill of lading

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
MDG	SAP Master Data Governance
MDM	SAP Master Data Management
MM	Materials management
MRN	Movement reference number
NAFTA	North American Free Trade Agreement
NLQ	Normalized load consumption quantity
NCTS	New Computerized Transit System
NOG	Nature of goods
NSC	Not secure
NW	SAP NetWeaver
NWBC	SAP Business Client
ODO	Outbound delivery order (EWM)
ODP	Operational data extractor (analytics)
OTR	Order-based transportation requirement
P2P	Peer-to-peer tendering
PDF	Portable document format
PI	SAP Process Integration
PM	Plant maintenance
PO	Purchase order
POWL	Personal object worklist
PP, P2P	Port to port
PPF	Post Processing Framework
PS&S	Product safety and stewardship
PSA	Persistent staging area (SAP BW analytics)
PU	Package unit
qRFC	Queued remote function call
RCCF	Remote control and communication framework

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
RCS	Repeatable custom solution (SAP custom development)
REACH	Registration, Evaluation, and Authorization of Chemicals
REST	Representational State Transfer
RFC	Remote function call
RFID	Radio-frequency identification
RFQ	Request for quotation
RU	Railcar unit
SCAC	Standard Carrier Alpha Code
SCM	SAP Supply Chain Management
SCO	Secure for cargo aircraft
SCP	Supply chain platform
SCR	Specialized commodity rates
SD	Sales and distribution
SDD	SAP Direct Distribution
SES	Service entry sheet
SFM	Strategic freight management
SFP	Strategic freight procurement
SFS	Strategic freight selling
SICF	Service Interface Component Framework
SLA	Service-level agreement
SLD	System landscape directory
SO	Sales order
SOA	Service-oriented architecture
SOP	Standard operating procedure
SPX	Secure for passenger aircraft
STO	Stock transfer order
TACT	The Air Cargo Tariff and Rules

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
TAL	Transportation allocations
TCCS	Transportation charge calculation sheet
TCM	Transportation charge management
TD	Transportation and distribution (oil & gas)
TEU	20-foot equivalent unit
TM	SAP Transportation Management in SAP S/4HANA
TMS	Transportation management system
TO	Transportation order
TOR	Transportation order (business object)
TOR Generic	TransportationOrderGenericRequest_In/Out (web service)
TP/VS	SAP APO transportation planning and vehicle scheduling
TRP	SAP Transportation Resource Planning
TRQ	Transportation requirement (business object)
TU	Transportation unit
UI	User interface
UIBB	User interface building block
ULD	Unit load device (container or pallet)
UN/LOCODE	United Nations Code for Trade and Transport Locations
UPB	Unified package building
URL	Uniform resource locator
USD	US dollar
VB	SAP Visual Business
VDA	German Association of the Automotive Industry (Verband der Automobilindustrie)
VDM	Virtual data model
VSR	Vehicle scheduling and routing
WD	Web Dynpro

Table A.1 Common Abbreviations (Cont.)

Abbreviation	Meaning
WM	Warehouse management
WMBR	Warehouse management billing request
WMS	Warehouse management system
WSRM	Web Services Reliable Messaging
XML	Extensible markup language
YL	SAP Yard Logistics

Table A.1 Common Abbreviations (Cont.)

Appendix B
The Authors

Dr. Bernd Lauterbach is chief solution architect for transportation management at Westernacher Consulting in Heidelberg. Until 2019, Bernd worked for SAP SE for 25 years. He gained 13 years of experience, both as a development manager for SAP TM and as a development architect for SAP Event Management, the Auto-ID infrastructure, and SAP ERP Logistics Execution (LE-TRA). Subsequently, Bernd was responsible worldwide as chief solution architect for the logistics industry at SAP IBU Travel & Transportation – Cargo & Logistics. An additional focus of Bernd's work is supporting many projects for Westernacher customers (logistics service providers [LSPs] and shippers), where he brings together LSP or shipper needs and SAP solution competence in terms of customer requirements, business processes, target architectures, and software capabilities.

Bernd studied and received a PhD in electrical engineering from University of Bremen, Germany. Before working with SAP, he spent several years in the areas of satellite electronics, parallel programming for image processing, assembler programming, geographic information systems (GIS), and auto-routing systems.

Dr. Jens Gottlieb has worked in supply chain software development at SAP SE in Walldorf, Germany, since 2000. He is chief product expert in the TM standard development unit. As the product owner responsible for transportation planning and the transportation network, Jens leads a development team. He has worked as a developer, development architect, and development manager, and led internal development projects as well as a standard-related custom development project for a TM customer in the beverage industry.

Jens received a PhD in computer science, has written six books and more than 25 scientific publications in the areas of transportation management and heuristic optimization algorithms, and edited six books.

Meike Helwig leads the Center of Expertise for transportation management (TM) at SAP SE in St. Leon-Rot. She is responsible for managing and delivering services for the premium customers of SAP SE in the EMEA region. Together with her team, she proactively supports customers during the whole lifecycle of a TM system with technical and advisory services. Furthermore, her team is responsible for solving critical situations and escalations in customer projects in the area of TM.

More than 10 years ago, Meike Helwig started her dual studies of business information systems at SAP and gained experience in consulting projects, managing critical engagements, and as a trainer for TM for functional and technical training courses. In the last few years, her focus has been on the enablement of new TM colleagues and building an expert team.

Dr. Christopher Sürie has worked for more than 18 years as a chief consultant in supply chain optimization and transportation management at SAP Deutschland SE & Co KG in Walldorf, Germany. In this position, he has been involved in numerous international customer projects, implementing both SAP APO and SAP TM and focusing on their planning capabilities and optimization engines in production and transportation. He worked as a solution architect in several SAP TM projects and taught numerous SAP TM customer trainings.

Before joining SAP, he worked in the department of production and supply chain management at Darmstadt University of Technology and completed his prize-winning PhD thesis in the area of production planning for process industries.

Ulrich Benz is an SAP supply chain management specialist with a focus on transportation management. As a consultant, he has managed and supported multinational IT transformation projects covering different industries over the past 11 years.

In his current role, Ulrich advises customers on a holistic IT architecture and roadmap for SAP S/4HANA logistics projects to achieve their vision of an intelligent enterprise.

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