CUSTOMER

SAP – Simio Product Integration Guide

October 2020

Simio
Forward Thinking

THE BEST RUN SAP®

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This document contains hyperlinks to supporting material. Some links are public while others require SAP Community credentials, typically provided through SAP S-user or P-user accounts. More information on the SAP Community can be found at https://community.sap.com/.

OVERVIEW

Many Digital Supply Chain use cases exist for a robust discrete-event simulation and scheduling tool, including modeling of global and regional supply networks, production plants (discrete and process), warehouses and distribution centers.

While models can be configured to simulate all of these use cases, this document focuses on production planning and scheduling… creating finite capacity plans or detailed operational schedules for work centers, machines, operators and materials, while taking into account all resource and material constraints. Schedule versions are created for analysis (what-if) or for operational execution.

Simio LLC's Risk-based Planning and Scheduling (RPS) product extends the value of SAP's Digital Supply Chain portfolio in multiple ways. Simio RPS provides a detailed digital twin of the production facility, together with a third-generation discrete event simulation engine allowing it to replicate the behavior of the factory and generate the detailed production schedules quickly and with high confidence of attainability. More information on Simio RPS can be found in its product documentation set and at https://www.simio.com/software/production-scheduling-software.php

This document introduces concepts for integrating SAP products with Simio RPS. Three functional scenarios for integrating SAP and Simio products are described. Each scenario builds upon the previous, with increasing technical complexity and business value. The three scenarios are:

- **Site Design Analysis**: in this *design scenario*, master data is passed to Simio RPS to construct simulation models for site design and other analyses.
- **Production Simulation and Capacity Planning**: in this *planning scenario*, planned orders are passed to Simio RPS to generate capacity-constrained production plans.
- **Detailed Production Scheduling and Dispatching**: in this *operational scenario*, production or process orders (and revisions) and shop floor information are passed to Simio RPS to generate detailed production schedules. Schedules may be generated periodically or on demand as shop floor events occur or orders change.

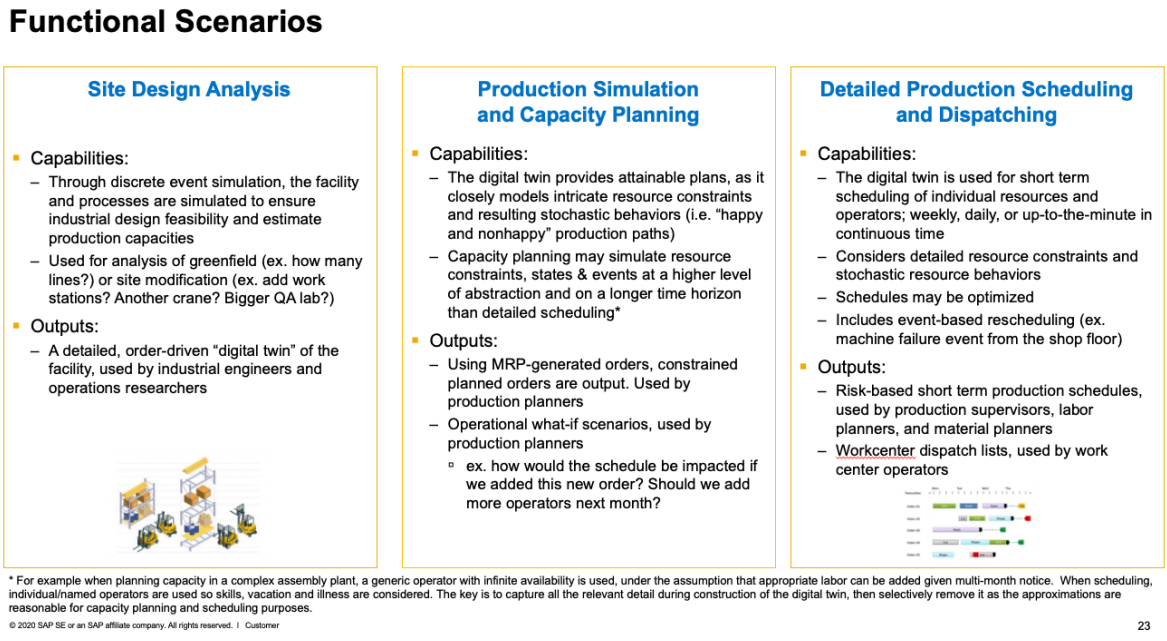

Figure 1: Usage scenarios in greater detail

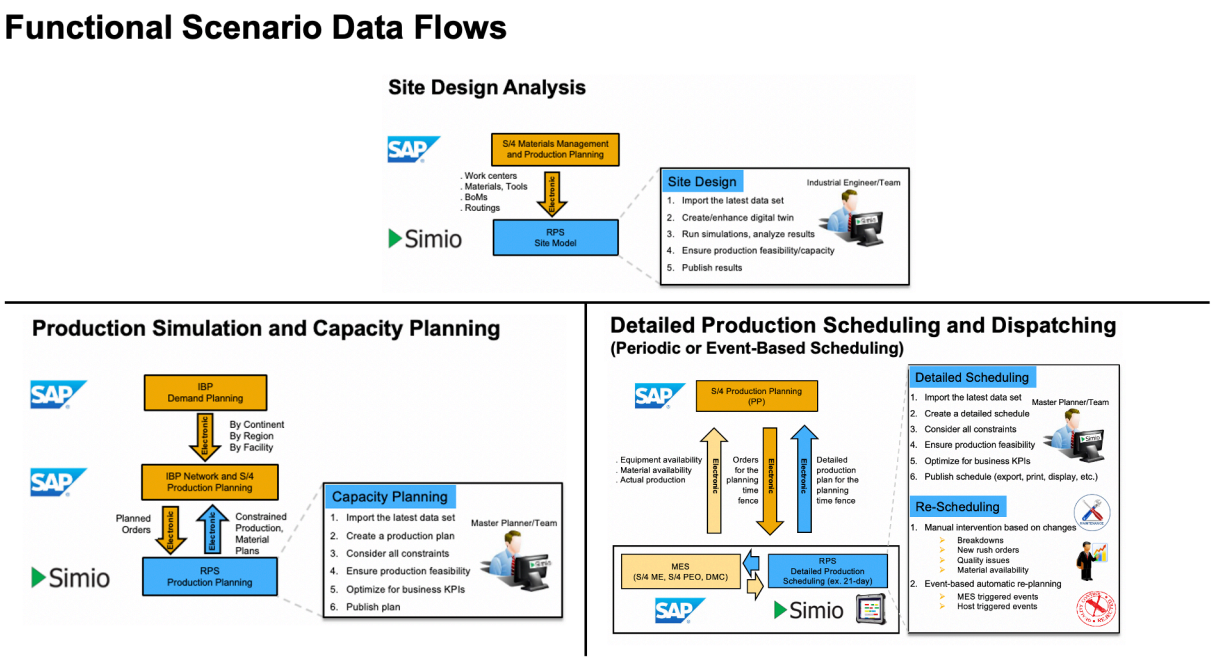

Figure 2: Conceptual data flow supporting each usage scenario

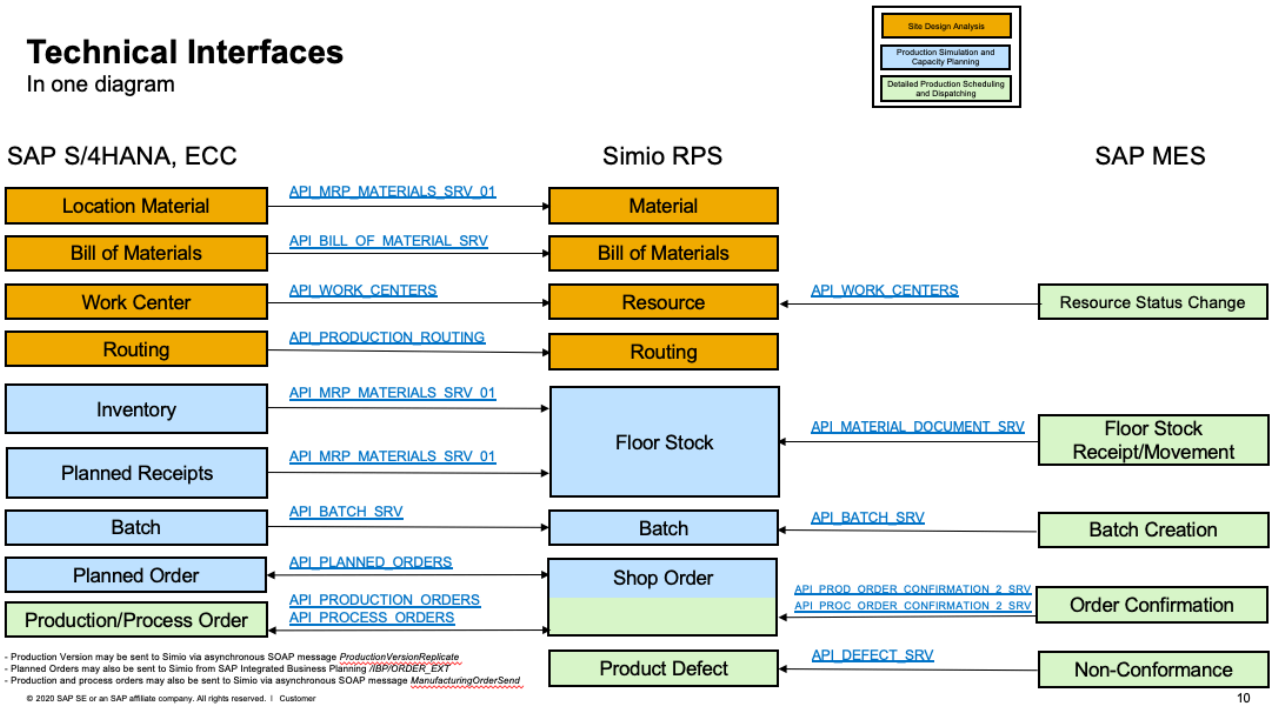

Figure 3: Typical sequence of web service calls to support the functional scenarios

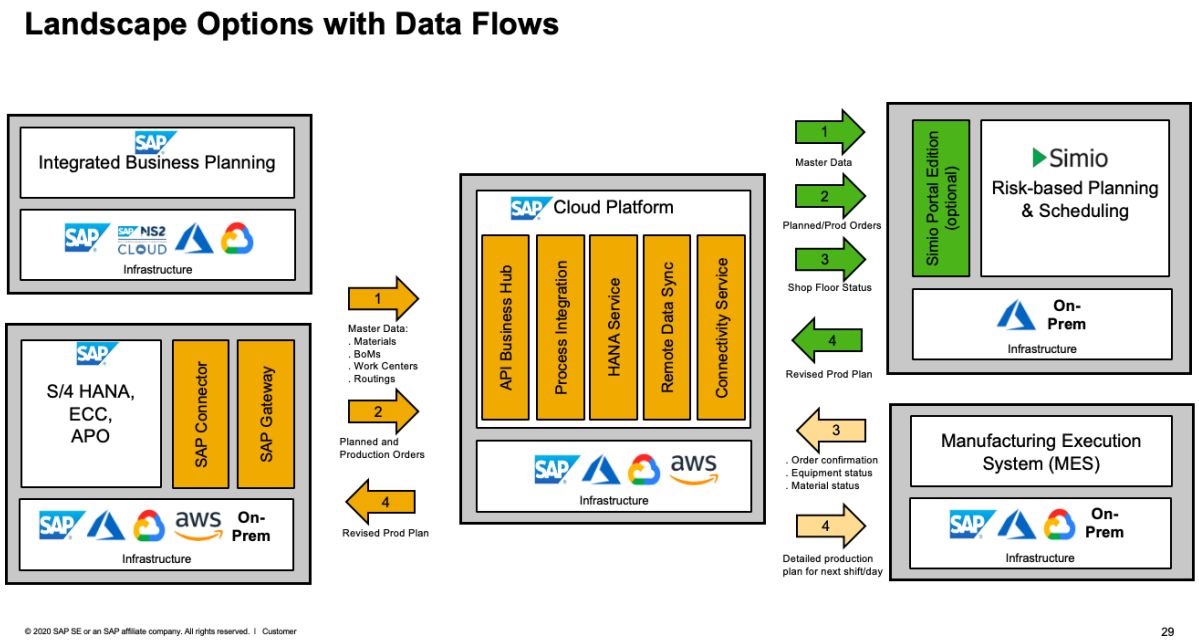

Figure 4: Landscape options and data flows for deploying SAP and Simio systems

INTEGRATION STRATEGY

The integration strategy described in this document merges existing capabilities from SAP and Simio. While it does not provide a comprehensive approach for all customers, the document aligns with the strategic product direction of both companies, as stated in 2020.

SAP's enterprise integration strategy defines the fundamental tenet for this document and can be found at https://www.sap.com/documents/2020/02/520ea921-847d-0010-87a3-c30de2ffd8ff.html. The "Design to Operate" business scenario for planning and managing supply chains and manufacturing sites is relevant to the SAP-Simio integration flows described herein.

INTEGRATION SCENARIOS

Site Design Analysis (Design Scenario)

The Site Design Analysis scenario is the starting point for integrating SAP and Simio systems. It may serve as the full project scope by using SAP master data in Simio RPS for analyzing site design alternatives. More often, it is phase-one of integration definition for more complicated projects.

In this scenario, master data is passed to Simio RPS from an SAP "system of record"; typically ECC, S/4HANA or IBP. Important objects include Materials, Bills of Material, Resources and Routings.

Simio models are **data generated and data driven,** as the model objects are created from an external resource list and the model behavior is driven by external process data. The model adapts to the environment as resources are added/removed and process data changes. This is a true predictive digital twin, as it replicates future factory behavior and automatically adapts to changes in the environment through externally provided data.

Using a prebuilt **model template**, RPS creates a shop floor model corresponding to the received master data. The RPS UI is used to validate model quality through simulation before the model is used in a production setting.

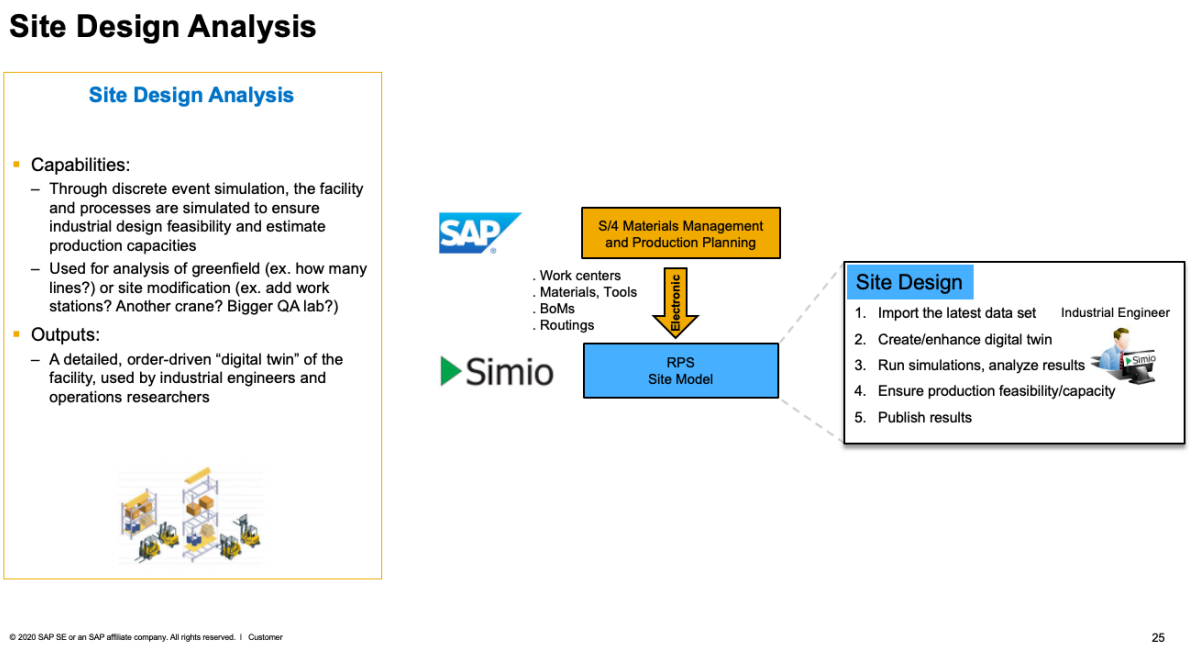

Figure 5: Conceptual Design for Site Design Analysis

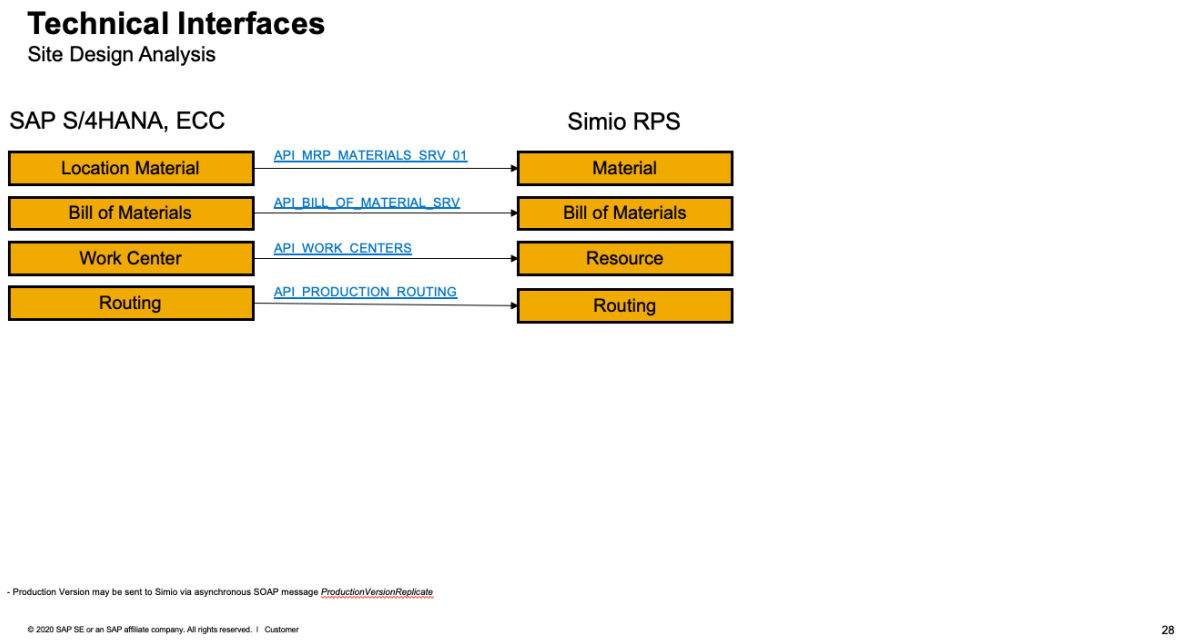

Figure 6: Technical Interfaces for Site Design Analysis

The following chart maps Simio tables to SAP web services. Links are provided to the SAP API Business Hub, where readers can explore and test each web service call on an S/4HANA sandbox system.

Simio Table(s)	SAP Web Service	Source System	SAP API Business Hub URL
Materials	API_MRP_MATERIALS_SRV_01	ECC, S/4HANA	https://api.sap.com/api/API_MRP_MATERIALS_SRV_01/overview
BillOfMaterials, BillOfMaterialItems	API_BILL_OF_MATERIAL_SRV	ECC, S/4HANA	https://api.sap.com/api/API_BILL_OF_MATERIAL_SRV/overview
Resources, RoutingDestinations	API_WORK_CENTERS	ECC, S/4HANA	https://api.sap.com/api/API_WORK_CENTERS/overview
Routings, RoutingOperations	API_PRODUCTION_ROUTING	ECC, S/4HANA	https://api.sap.com/api/API_PRODUCTION_ROUTING/overview

Notes:

1. The ERP workcenter is designed to support ERP processes such as capacity planning and costing. It is not designed to support discrete event simulations. Therefore, resources must be enriched in Simio
2. Production Version may be sent to Simio RPS from ECC or S/4HANA via asynchronous SOAP message **ProductionVersionReplicate**
3. Resource Setup Groups and Matrices may be sent to Simio RPS from S/4HANA or APO **BAPI_SETMSRVAPS_GETLIST**

Production Simulation and Capacity Planning (Planning Scenario)

Production simulation and capacity planning represents a deeper level of integration for SAP and Simio RPS systems. Once SAP master data is passed to Simio RPS and the simulation model is validated, planned orders may be sent from SAP to RPS for planning. RPS is now ready to generate a production plan for analysis or test a plan generated by an SAP optimizer for feasibility. Orders may be sent to Simio RPS from SAP ECC, APO, S/4HANA or IBP. Beyond master data, important objects to support this scenario include:

- Planned orders, including all required component and resource demands along the order routings
- Work-In-Process inventory lots/batches
- Component inventory levels
- Primary and secondary resource status
- Resource setup groups and shift sequences

A production plan scenario is generated either automatically or more typically through the Simio RPS user interface, where the user can review and adjust the plan, simulating and comparing various scenarios.

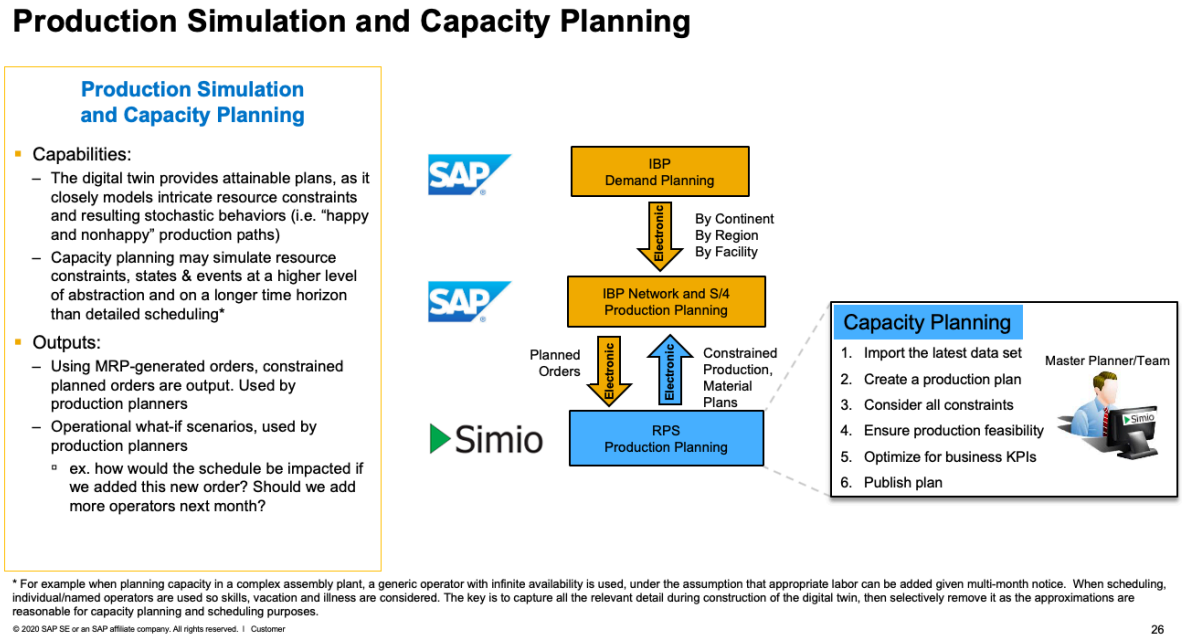

Figure 7: Conceptual Design for Production Simulation and Capacity Planning

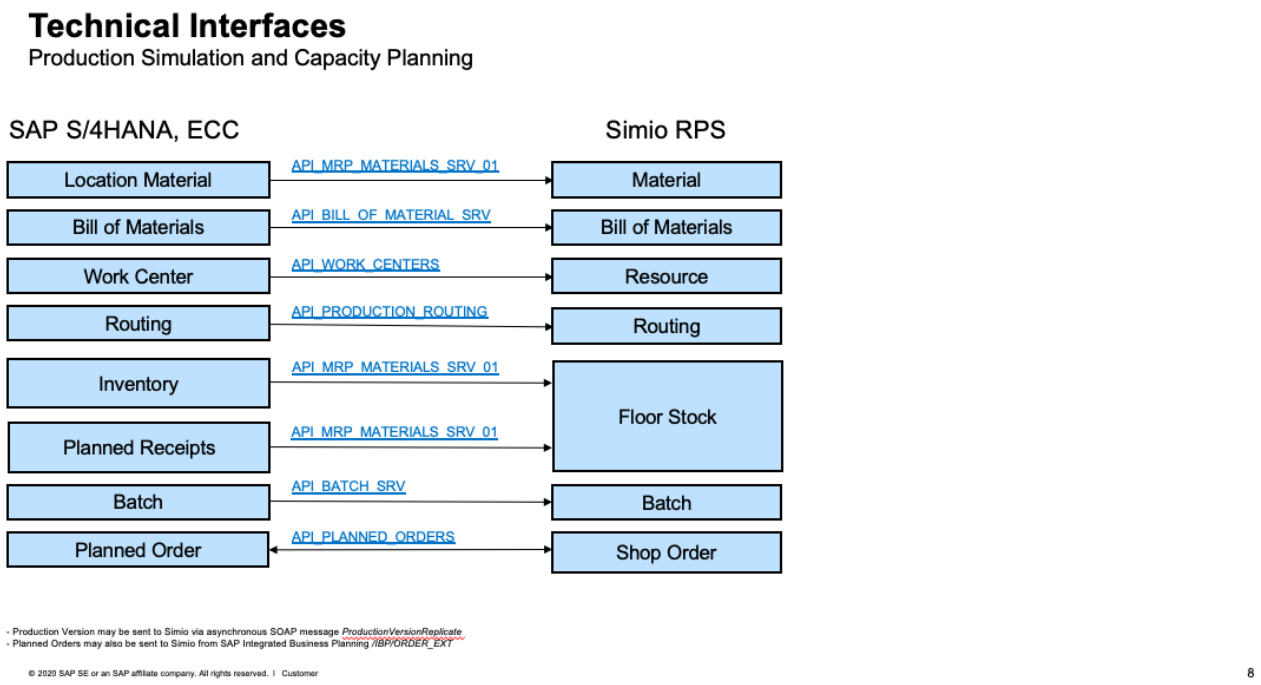

Figure 8: Technical Interfaces for Production Simulation and Capacity Planning

The following chart maps Simio tables to SAP web services. Links are provided to the SAP API Business Hub, where readers can explore and test each web service call on an S/4HANA sandbox system.

Simio Table(s)	SAP Web Service	Source System	SAP API Business Hub URL
Materials	API_MRP_MATERIALS_SRV_01	ECC, S/4HANA	https://api.sap.com/api/API_MRP_MATERIALS_SRV_01/overview
BillOfMaterials, BillOfMaterialItems	API_BILL_OF_MATERIAL_SRV	ECC, S/4HANA	https://api.sap.com/api/API_BILL_OF_MATERIAL_SRV/overview
Resources, RoutingDestinations	API_WORK_CENTERS	ECC, S/4HANA	https://api.sap.com/api/API_WORK_CENTERS/overview
Routings, RoutingOperations	API_PRODUCTION_ROUTING	ECC, S/4HANA	https://api.sap.com/api/API_PRODUCTION_ROUTING/overview
MaterialLots, MaterialSubLots	API_MRP_MATERIALS_SRV_01	ECC, S/4HANA	https://api.sap.com/api/API_MRP_MATERIALS_SRV_01/overview
PurchaseOrders	API_MRP_MATERIALS_SRV_01	ECC, S/4HANA	https://api.sap.com/api/API_MRP_MATERIALS_SRV_01/overview
MaufacturingOrders, RoutingOperations, RoutingPhases, BillIlOfMaterialItems	API_BATCH_SRV	ECC, S/4HANA	https://api.sap.com/api/API_BATCH_SRV/overview
MaufacturingOrders, RoutingOperations, BillOfMaterialItems	API_PLANNED_ORDERS	ECC, S/4HANA, Simio	https://api.sap.com/api/API_PLANNED_ORDERS/overview

Notes:

1. The ERP workcenter is designed to support ERP processes such as capacity planning and costing. It is not designed to support discrete event simulations. Therefore, resources must be enriched in Simio
2. Production Version may be sent to Simio RPS from ECC or S/4HANA via asynchronous SOAP message **ProductionVersionReplicate**
3. Resource Setup Groups and Matrices may be sent to Simio RPS from S/4HANA or APO **BAPI_SETMSRVAPS_GETLIST**
4. Shift sequences may be sent to Simio RPS from S/4HANA or APO **BAPI_RSSRVSCMB_GETLIST2**
5. Planned Orders may also be sent to Simio RPS from SAP IBP (Integrated Business Planning) **/IBP/ORDER_EXT**
6. Although this scenario is intended primarily for mid to long term capacity planning beyond the time fence, simulation of the opening period may require production and process orders to also be loaded into Simio so they can be treated as fixed material supply / fixed capacity load (see next scenario for more information)

Detailed Production Scheduling and Dispatching (Operational Scenario)

Detailed production scheduling and dispatching represents an even deeper level of integration for SAP and Simio RPS systems. This operational scenario extends the simulation model built in the prior scenario by adding production or process orders within the planning “time fence”, sent from ECC PP or S/4HANA PP.

An operational schedule is generated either automatically (event based) or through the Simio RPS user interface, where the user can review and adjust the schedule, simulating and comparing various scenarios. Once a desirable schedule is generated, the updated production or process orders containing appropriate scheduling information are written back to where they originated and/or to the MES system for execution. As time passes, updated order and shop floor information is passed to Simio RPS and an updated schedule is generated and returned.

Often times, shop floor master data contained in the MES is at a finer level of granularity than what is contained in the ERP system (ex. resources). In addition, shop floor events important for scheduling purposes may not be available in the ERP system. For these reasons, it is often important to integrate Simio RPS with the MES system in addition to the ERP system.

Shop floor events sent from the MES system include:

- resource status changes
- material movements
- lot/batch creation
- order confirmations
- production defects

Data from SAP MES systems may be pulled from ECC ME, MII, S/4HANA ME, S/4HANA PEO and DMC.

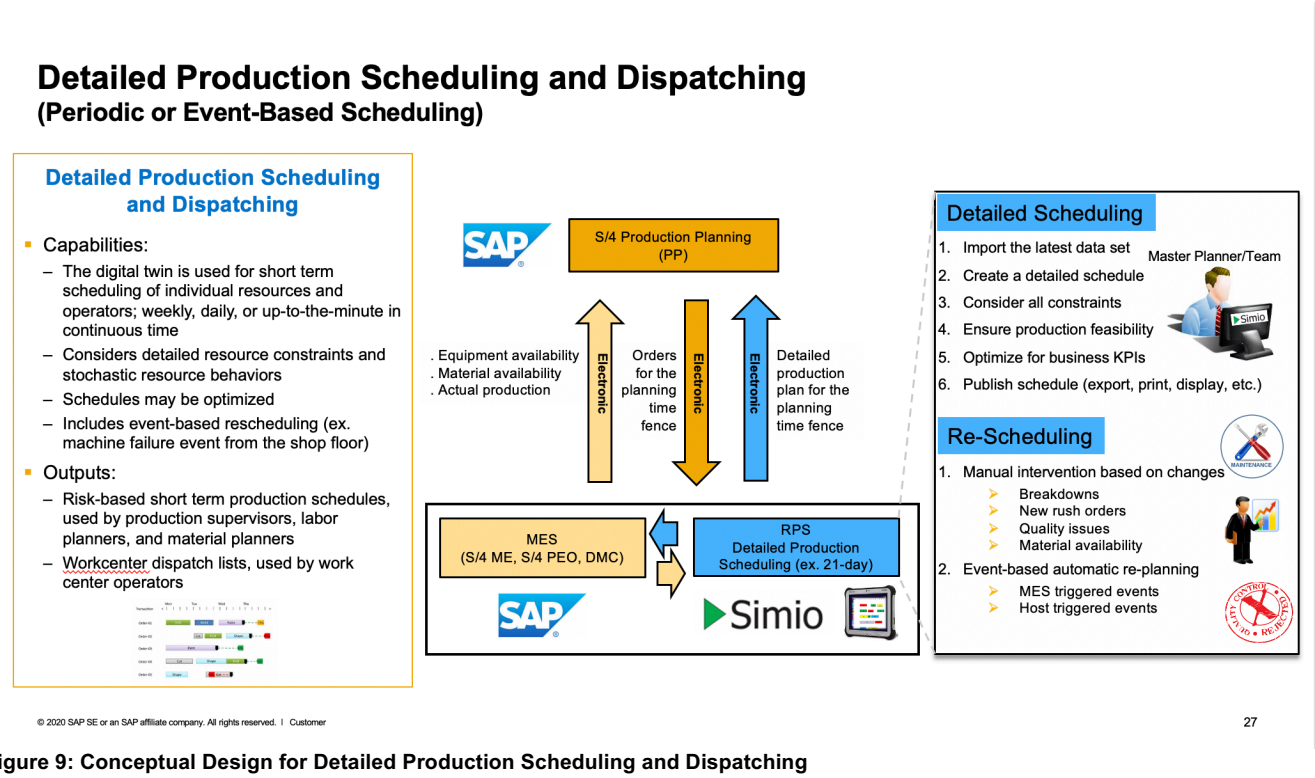

Figure 9: Conceptual Design for Detailed Production Scheduling and Dispatching

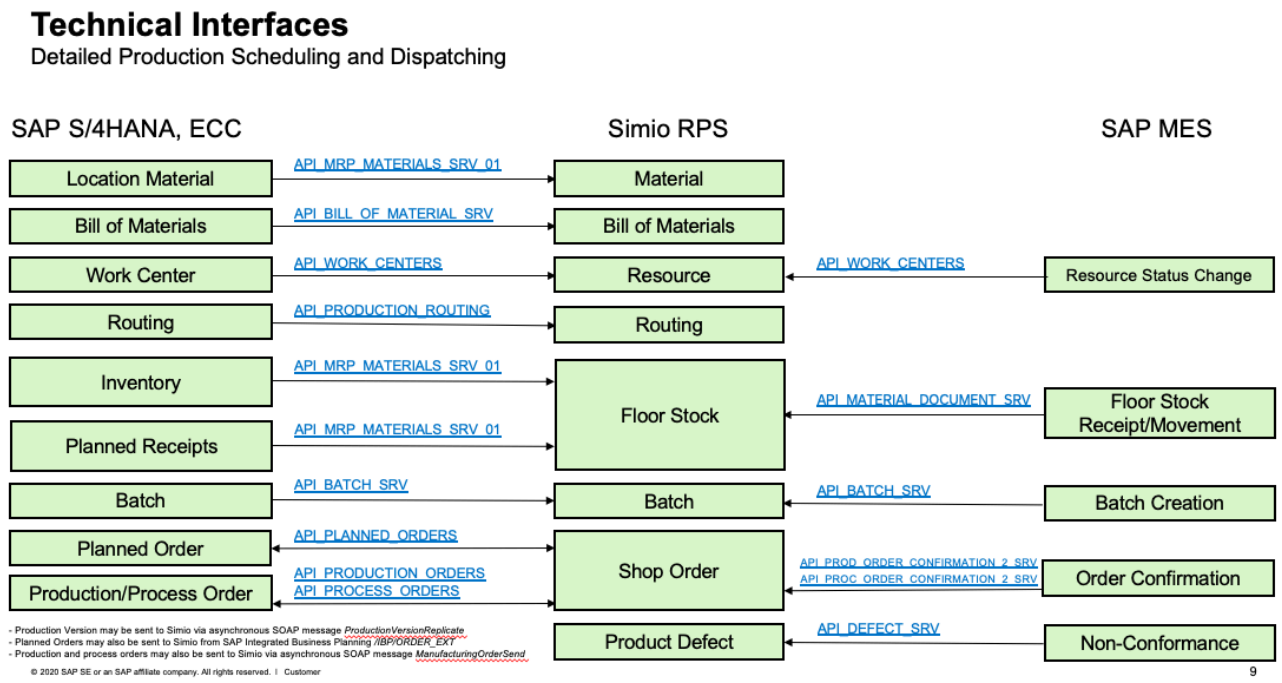

Figure 10: Technical Interfaces for Detailed Production Scheduling and Dispatching

The following chart maps Simio tables to SAP web services. Links are provided to the SAP API Business Hub, where readers can explore and test each web service call on an S/4HANA sandbox system.

Simio Table(s)	SAP Web Service	Source System	SAP API Business Hub URL
Materials	API_MRP_MATERIALS_SRV_01	ECC, S/4HANA	https://api.sap.com/api/API_MRP_MATERIALS_SRV_01/overview
BillOfMaterials, BillOfMaterialItems	API_BILL_OF_MATERIAL_SRV	ECC, S/4HANA	https://api.sap.com/api/API_BILL_OF_MATERIAL_SRV/overview
Resources, RoutingDestinations	API_WORK_CENTERS	ECC, S/4HANA, MES	https://api.sap.com/api/API_WORK_CENTERS/overview
Routings, RoutingOperations	API_PRODUCTION_ROUTING	ECC, S/4HANA	https://api.sap.com/api/API_PRODUCTION_ROUTING/overview
MaterialLots, MaterialSubLots	API_MRP_MATERIALS_SRV_01	ECC, S/4HANA	https://api.sap.com/api/API_MRP_MATERIALS_SRV_01/overview
MaterialLots, MaterialSubLots	API_MATERIAL_DOCUMENT_SRV	MES	https://api.sap.com/api/API_MATERIAL_DOCUMENT_SRV/overview
PurchaseOrders	API_MRP_MATERIALS_SRV_01	ECC, S/4HANA	https://api.sap.com/api/API_MRP_MATERIALS_SRV_01/overview

Simio Table(s)	SAP Web Service	Source System	SAP API Business Hub URL
ManufacturingOrders, RoutingOperations, RoutingPhases, BillIOfMaterialItems	API_BATCH_SRV	ECC, S/4HANA, MES	https://api.sap.com/api/API_BATCH_SRV/overview
ManufacturingOrders, RoutingOperations, BillOfMaterialItems	API_PLANNED_ORDERS	ECC, S/4HANA, Simio	https://api.sap.com/api/API_PLANNED_ORDERS/overview
ManufacturingOrders, RoutingOperations, BillIOfMaterialItems	API_PRODUCTION_ORDERS	ECC, S/4HANA, Simio	https://api.sap.com/api/API_PRODUCTION_ORDERS/overview
ManufacturingOrders, RoutingOperations, BillIOfMaterialItems	API_PROD_ORDER_CONFIRMATION_2_SRV	MES	https://api.sap.com/api/API_PROD_ORDER_CONFIRMATION_2_SRV/overview
ManufacturingOrders, RoutingOperations, RoutingPhases, BillIOfMaterialItems	API_PROCESS_ORDERS	ECC, S/4HANA, Simio	https://api.sap.com/api/API_PROCESS_ORDERS/overview
ManufacturingOrders, RoutingOperations, RoutingPhases, BillIOfMaterialItems	API_PROC_ORDER_CONFIRMATION_2_SRV	MES	https://api.sap.com/api/API_PROC_ORDER_CONFIRMATION_2_SRV/overview
MaterialLots, MaterialSubLots	API_DEFECT_SRV	MES	https://api.sap.com/api/API_DEFECT_SRV/overview

Notes:

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4. Shift sequences may be sent to Simio RPS from S/4HANA or APO **BAPI_RSSRVSCMB_GETLIST2**
5. Planned Orders may also be sent to Simio RPS from SAP IBP (Integrated Business Planning) **/IBP/ORDER_EXT**
6. Production and process orders may also be sent to Simio RPS from ECC or S/4HANA via asynchronous SOAP message **ManufacturingOrderSend**

Manufacturing Complexities Affecting Integration

There are a number of functional and non-functional considerations (requirements) that affect how SAP and Simio product integration is designed. Important functional considerations include:

- Manufacturing process: discrete, process batch or hybrid?
- Make to Stock, Make to Order, Assemble to Order, Configure to Order, Engineer to Order
- Large BoMs, multiple BoM levels, multiple BoM versions, many component types
- Inventory pegging
- Labor skills and certifications
- Planned versus in-process maintenance
- Industry specific considerations, such as:
    - Variant configurations
    - Product shelf life
    - Quality or dimension-based routing (ex. Fab CPU binning, Pharma)
    - Characteristic-based planning
    - Co-products and by-products

Non-functional considerations include:

- Production data volumes
- Number and type of plant software applications
- Existing enterprise architecture constraints
- Degree of shop floor automation

TECHNICAL COMPONENTS FOR INTEGRATION

This section presents the technical foundation required to support the integration flows mentioned above. SAP and Simio integration assets required to support the landscape options are described in separate subsections.

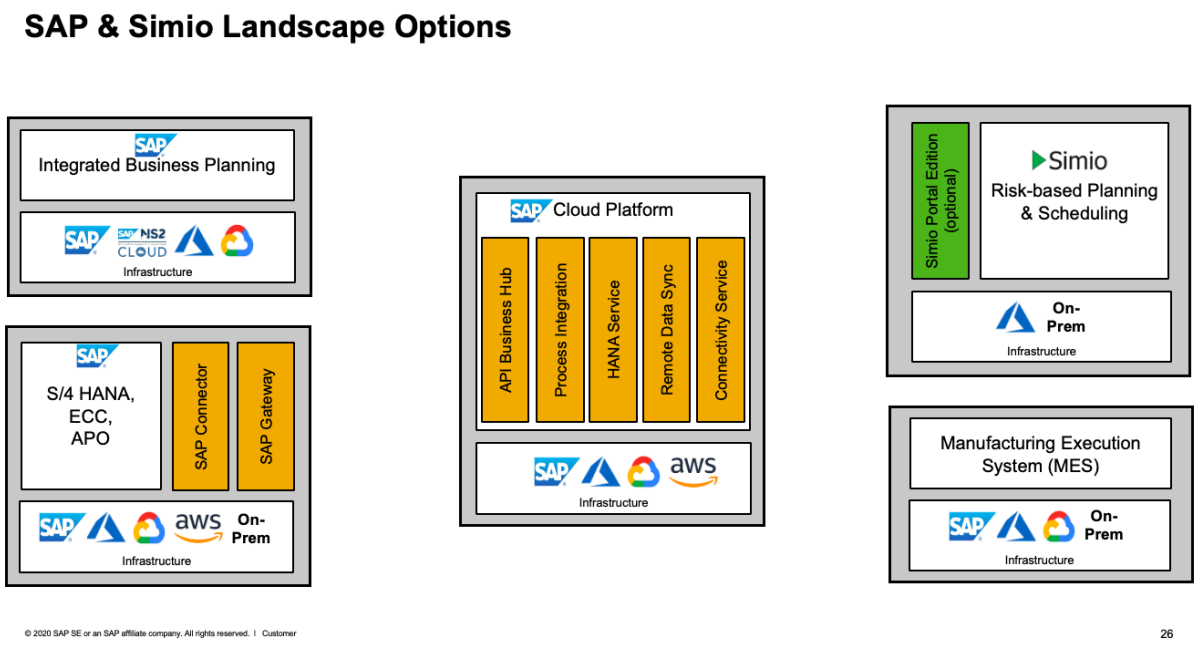

Figure 11: Conceptual view of landscape options for deploying SAP and Simio products

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SAP Cloud Platform Integration Suite

SAP's Platform as a Service (PaaS) is called the SAP Cloud Platform (SCP). SCP provides an entire suite of integration services and serves as the backbone for extending and integrating SAP products from the cloud. SCP information can be found at the following links.

- SCP Solution Overview: https://www.sap.com/products/cloud-platform.html
- SCP Online Help: https://help.sap.com/viewer/product/CP/Cloud/en-US?task=discover_task
- SCP Trial Sign Up: https://www.sap.com/cmp/td/sap-cloud-platform-trial.html

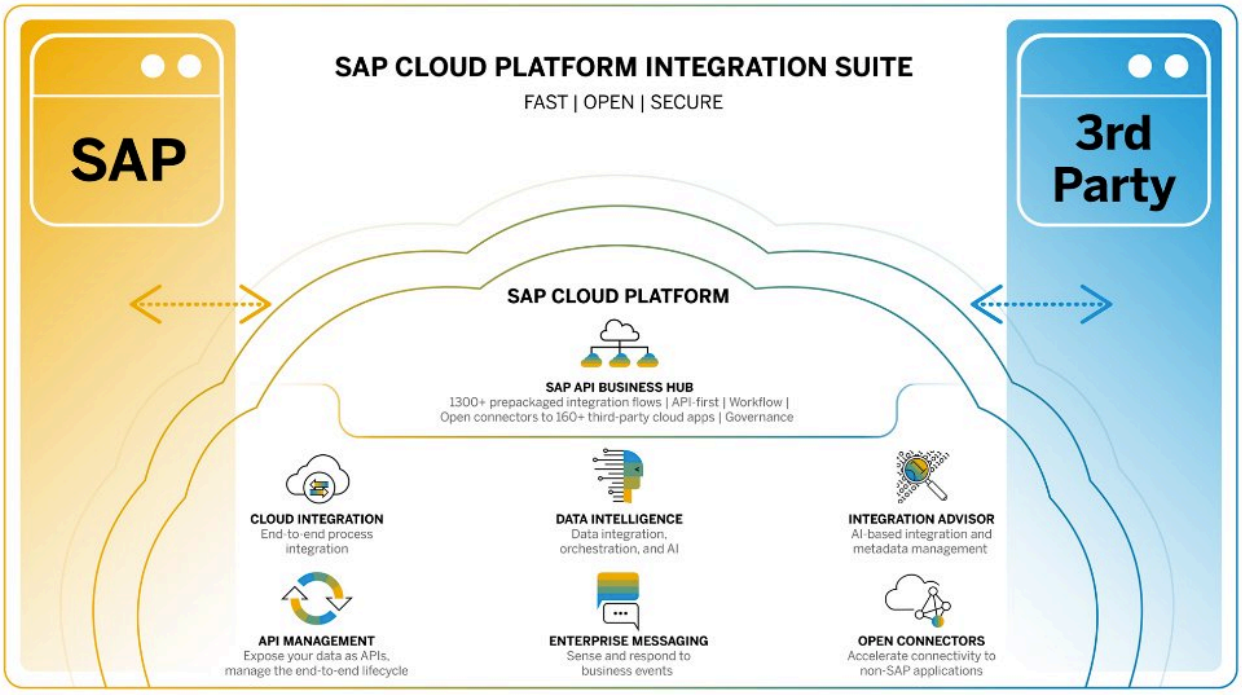

Figure 12: SAP Cloud Platform Integration Suite

More SCP Integration Suite information can be found at:

- SAP Integration Introduction: https://www.sap.com/products/application-development-integration/integration.html
- SCP Integration Suite Solution Overview: https://www.sap.com/products/cloud-platform/capabilities/integration.html
- SCP Integration Suite Online Help: https://help.sap.com/viewer/product/CLOUD_INTEGRATION/Cloud/en-US?task=discover_task

SCP Integration Suite Components relevant to SAP-Simio integration include:

- SAP API Business Hub
- SCP Process Integration Service
- SCP HANA Service
- SCP Remote Data Sync Service
- SCP Connectivity Service
- On-Premise Cloud Connector
- On-Premise SAP Gateway

SAP API Business Hub

SAP's current-generation integration interfaces and artifacts are available to browse and test at the SAP API Business Hub, located at http://api.sap.com. Most interfaces are defined as OData services, while others include SOAP and RFC messages. Interfaces specific to supporting SAP-Simio integration can be found in the following categories:

- SAP S/4HANA and ECC (ERP interfaces): https://api.sap.com/package/SAPS4HANACloud?section=Artifacts
- SAP Digital Manufacturing Cloud (MES interfaces): https://api.sap.com/package/SAPDigitalManufacturingCloud?section=Artifacts
- Templates for SAP S/4HANA Integration with SAP Digital Manufacturing Cloud: https://api.sap.com/package/DMEIntTemplates?section=Overview

Details of specific interface usage will be provided in following sections.

SCP Process Integration Service

While the API Business Hub is where interfaces are explored and tested, integration process flows that execute the interfaces are built, run and monitored in the SCP Process Integration Service. Interface developers may build and test integration templates (flows), while operators may deploy and monitor live integration connections between enterprise systems in the cloud and on premise, including those from SAP, other ISVs and the customer.

- SCP Process Integration Service - Development: https://help.sap.com/viewer/368c481cd6954bdfa5d0435479fd4eaf/Cloud/en-US/78d23d4d913e4f5e9bbe065df30075f7.html

SCP HANA Service

The SAP HANA service leverages the in-memory data processing capabilities of SAP HANA in the cloud. As a managed database service, backups are fully automated and service availability guaranteed. Using the SAP HANA service, SAP HANA databases can be set up, managed and bound to applications running on SAP Cloud Platform.

While not required for SAP-Simio integration, the SAP HANA Service may optionally be used, for instance, to synchronize data pulled from various plant systems (ex. MES) prior to sending to the Simio simulation system.

SCP Remote Data Sync Service

SCP Remote Data Sync Service performs a two-way data synchronization between SQL Anywhere remote databases and a central consolidated SAP HANA database on SAP Cloud Platform. It is not required for SAP-Simio integration but may prove useful in certain customer projects.

SCP Connectivity Service and On-Premise Cloud Connector

The SCP Connectivity Service enables SCP integration flows and applications to securely access remote services that run on the Internet or on-premise.

Running on-premise, the SAP Cloud Connector allows cloud applications and integration flows running on the SAP Cloud Platform to securely access on-premise systems running on isolated networks. SAP on-premise systems typically used for SAP-Simio integration include S/4HANA, ECC and APO.

- SCP Connectivity Service video presentation:
  https://www.sap.com/products/cloud-platform/capabilities/integration.cloud-integration.html?video=a4d95c73-617d-0010-87a3-c30de2ffd8ff
- SCP Connectivity Service and Cloud Connector Online Help:
  https://help.sap.com/viewer/product/CP_CONNECTIVITY/Cloud/en-US

On-premise SAP Gateway

The SAP Gateway runs on-premise and receives OData messages sent from SCP Process Integration flows. It is typically used by customers running legacy SAP Business Suite applications such as ECC and APO. More information can be found at:
https://help.sap.com/viewer/product/SAP_GATEWAY/2.0/en-US

Alternatively, the SCP OData Provisioning Service provides standardized OData access without needing to provision an SAP Gateway server on-premise. More information is available at:
https://help.sap.com/viewer/a7c6d8a0bd1f415887f6246d8cf8e68e/Cloud/en-US/6cfbe11c83ec4fa2a102f35a74844249.html

Simio RPS Integration Assets

Simio RPS Model Templates

Simio relies on domain-specific modeling and integration standards to define interfaces to its products. The table structures in Simio RPS **model templates** are based on the ISA95 standard. Once data are added to the tables, they are mapped to Simio objects used during execution of the discrete event simulation model.

These templates can be uses across industries with some modification based on the needs of the model. (See 2006 whitepaper titled “ISA 95 Implementation Best Practices Workflow Descriptions using B2MML”). The transformation of the data will be done within the SAP CPI Process Integrator (PI) integration flows. This ensures the data structures are aligned across industries and the same Simio model template can be used across industries.

While ISA95 / B2MML (Business to Manufacturing Markup Language) is predominantly used in the batch industries, the discreate industries typically use either the ISA95 / B2MML or the OAGIS (Open Applications Group Integration Specification). For simplicity reasons, the ISA95 / B2MML standards will be used for both batch and process industries. Since the Simio table schema is flexible, the schema and integration flow transformations could be changed to use OAGIS instead.

Below is a view of a clean template used to create the data driven (and data created) model. The only tables that are populated in the template are data that does not exist in any other system. In this template, only the Dispatching Rules table is populated since the rules are likely to not exist in another system and will only be configured within the Simio model.

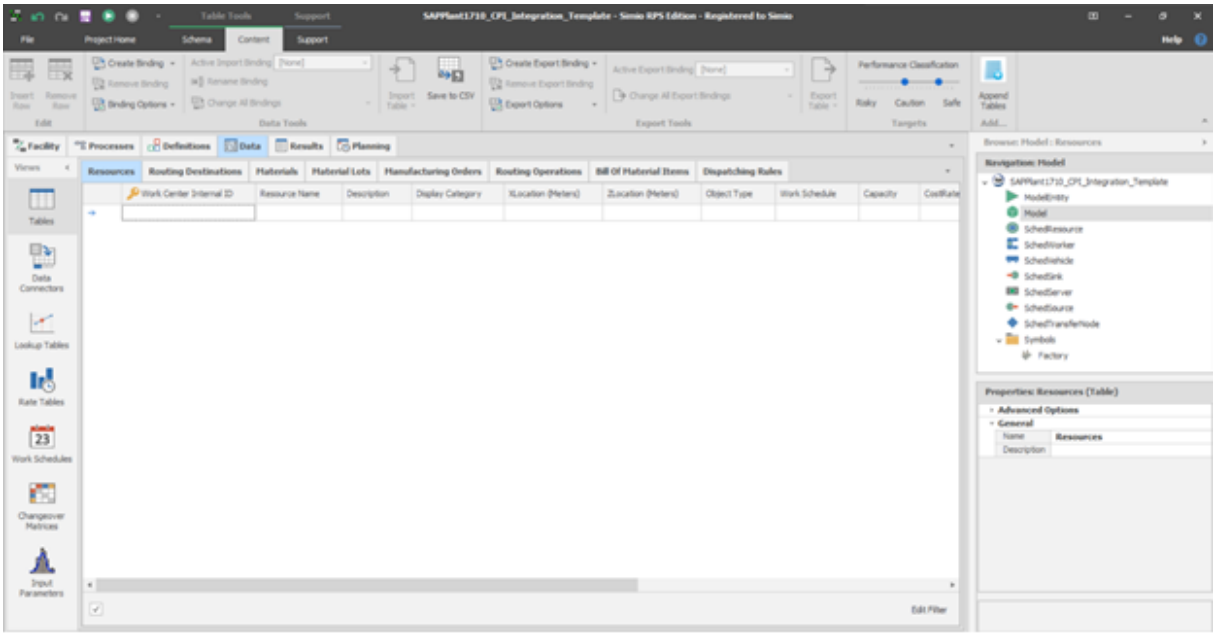

Figure 13: A clean Simio RPS Template

The specific Simio tables are listed in the *Technical Interfaces* section of the three scenarios above.

SAP Cloud Platform PI Flows for Simio RPS

Simio provides prebuilt **integration flows** for the SAP Cloud Platform *Process Integration* Service (SCP PI) to cover the following use cases:

- Master Data download from SAP S/4HANA (ECC) to Simio RPS
- Planned and Production Order flow between SAP S/4HANA (ECC) and Simio RPS
- Shop floor events from SAP MES (MII, ME, PEO, DMC) to Simio RPS

SCP PI provides the following benefits for Simio RPS customers:

- Simio RPS is brought into SAP's cloud-based integration space, where customers and partners can take advantage of SAP's enterprise grade capabilities for integration and extension
- Simio RPS is aligned with SAP's strategic integration approach, which helps future-proof the SAP-Simio integration architecture and assets
- Simio RPS accesses a Middleware Solution / Integration Broker to pre-configured integration flows that connect to SAP as well as other information systems (e.g. 3rd party MES systems, IoT Gateways, custom databases, etc.)

The integration flows are described in the *Technical Interfaces* section of the three scenarios described above.

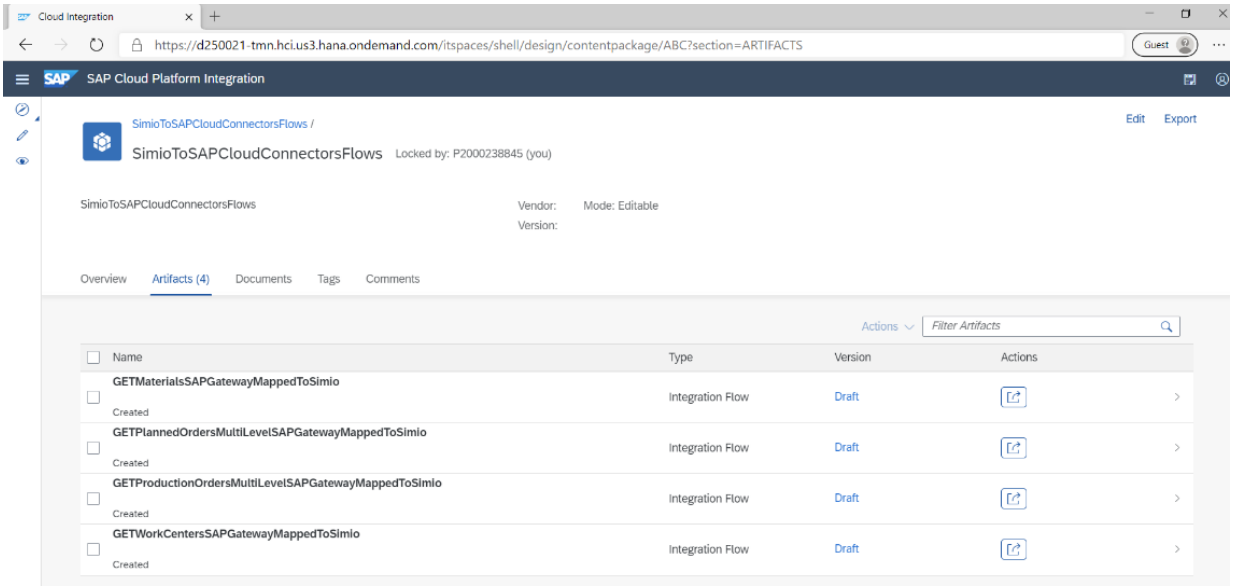

Figure 14: A sample list of SCP PI integration flows

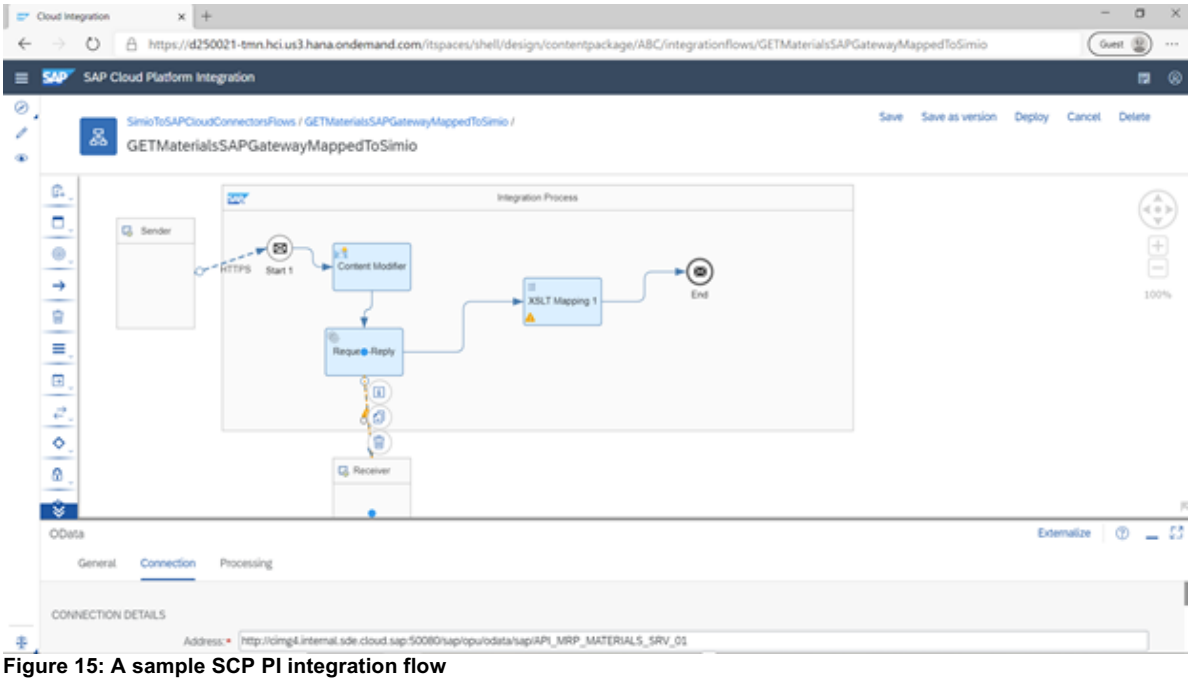

Figure 15: A sample SCP PI integration flow

The core components of the sample flow are:

- HTTP Connector to call the integration flow
- ODATA Connector to query data from SAP using the Cloud Connector
- XSLT Mapping to transform the data into the format of the Simio table(s). This is where the SAP ODATA in transformed into the B2MML table structures that will be imported into the Simio model. Multiple Simio tables may be populated from a single integration flow call.

Simio RPS Data Connectors

Simio uses **Data Connectors** to import and export from its table structures through various technical methods. Simio has CSV, Excel, Database and Web API import connectors and CSV, Database and Web API export connectors.

Multiple data connectors can be set to a table. The data connectors can be setup to run manually or automatically when the schedule is started/completed. Automatic imports happen before the schedule is run and automatic exports happen after the schedule is run.

For this integration, the Web API import and export data connectors are used. The data connectors import data into Simio tables directly from SCP PI using a HTTP GET. The data connectors export data directly from Simio tables to SCP PI using a HTTP POST.

Below is an example of importing SAP Work Centers into the Resources table. The import data connector calls an SCP PI integration flow. The flow then returns the work center in the format of the Resources table.

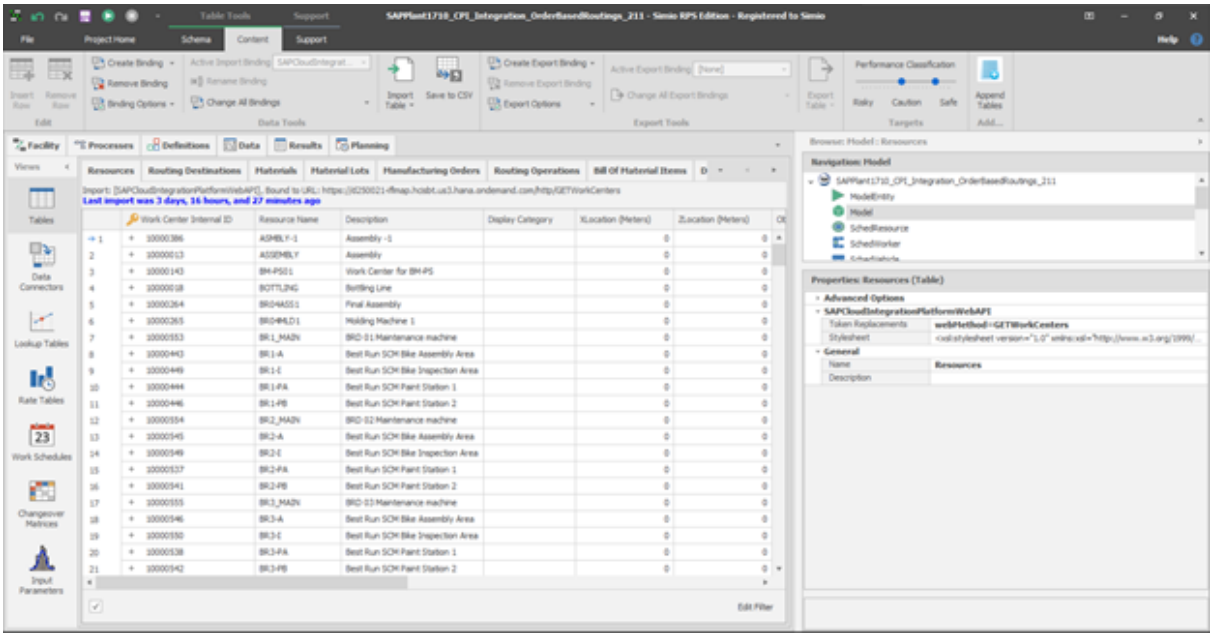

Figure 16: Importing SAP Work Centers into the Simio RPS Resources table

Resources are setup to automatically create the Simio simulation object in the model. Once added, the user can use the 3d view to move the object to the correct location within the 3d model. The Resources table data connector is setup to be an “Update and Append” import type. Any changes to the position of the object in the model will not be overwritten by future imports of the work center data.

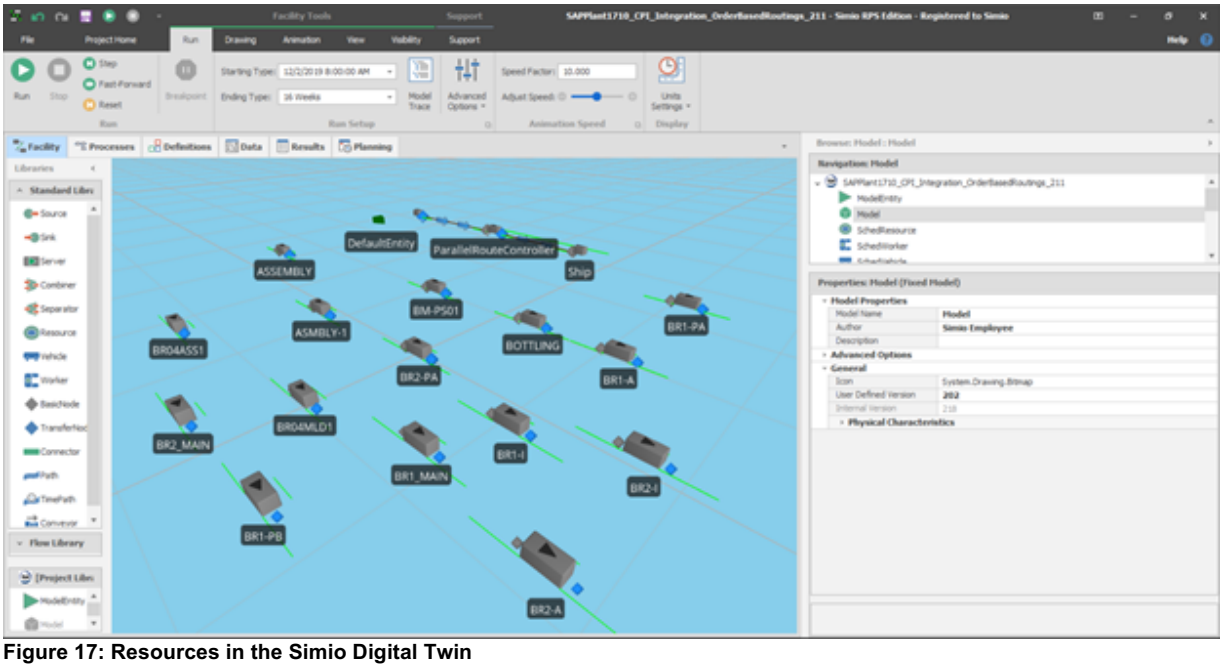

Figure 17: Resources in the Simio Digital Twin

Once all data connectors are configured, the model can either be run within Simio desktop application or uploaded to Simio Portal to be run centrally, either On-Premise or in the Cloud.

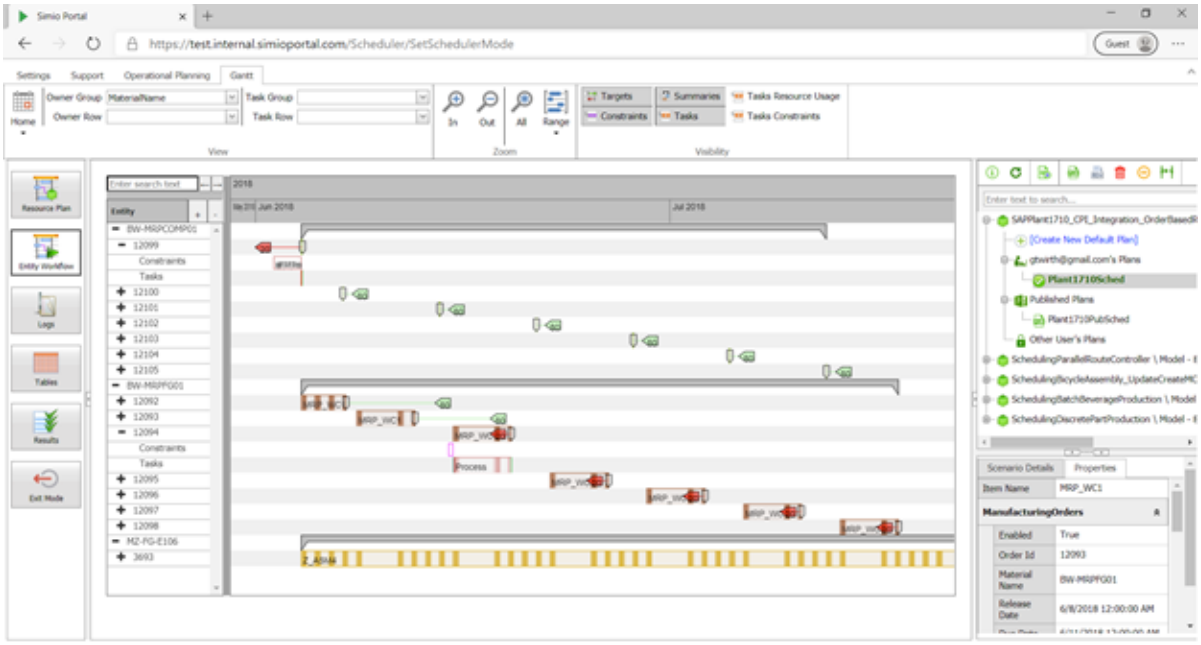

Figure 18: Sample results of a schedule run in Simo Portal

If the user has the appropriate permission, they can see the dashboards, table report, table data, scheduling logs, an entity (order-based) Gantt chart and a resource-based Gantt chart.

Figure 19: A Simio Portal Dashboard

Simio RPS Schedule Automation

The scheduling functions (whether out-of-the-box or customized using Simio process logic) are the same whether run on desktop or Simio portal.

Simio has two APIs for automating schedule generation. If the schedule is run on Simio Portal, the Simio Portal Web API is used. If the schedule is run on a desktop, the Simio .NET API is to be used.

A sample flow for automatically rescheduling based on a downtime event from the MES might include:

- Flow subscribes to a MQTT topic called “mes/downtimeEvent”
- Updates to the MQTT topic will initialize flow
- First, an authentication token is obtained
- Next, the running of the schedule is initialized. The data connectors are in the model are set to automatic, so both the imports and exports will happen automatically by just running the schedule. The imports will happen before the run and the exports will happen after the run
- The run is then monitored until it has been completed
- Once completed, the schedule is published so users within the organization can view the schedule