ISEP INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO

P.PORTO

User Manual

Integrative Project LAPR3

MABEC

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Chapter 1

Glossary

Terms, Expressions and Acronyms (TEA) are organized alphabetically.

TEA (EN)	TEA (PT)	Description (EN)
2D-Tree	Árvore 2D	A k-dimensional tree (k=2) for spatial indexing, used for efficient geographic range and nearest-neighbor queries.
acceleration	aceleração	A key characteristic of a locomotive referring to its rate of increase in speed.
action	ação	Description of an operation performed by a user and recorded in the system log.
action_date	data da ação	Timestamp indicating when a logged action occurred.
Administrator	Administrador	A system user role with elevated privileges for configuration and management.
Aisle	Corredor	A passageway in a warehouse between rows of storage bays.
aisleNumber	número do corredor	Identifier or number of an aisle within a warehouse.
AllocatedInfo	Informação de Alocação	Information about the allocation of items to orders, including quantity allocated.
allocationId	id de alocação	Unique identifier for an allocation record.
Assign	Atribuir	To designate a resource (e.g., train, route) for a specific purpose or operation.
Assemble	Montar	To put together various components (e.g., locomotives and wagons) to form a train.
Backbone Network	Rede de Espinha Dorsal	A minimal subset of a network that connects all nodes with minimal total length or cost.
Bay	Zona de Armazenamento	A specific storage location within a warehouse aisle.
bayNumber	número da bay	Identifier or number of a storage bay within an aisle.

TEA (EN)	TEA (PT)	Description (EN)
Bellman-Ford Algorithm	Algoritmo de Bellman-Ford	A graph algorithm that computes shortest paths from a single source, capable of handling negative weights and detecting negative cycles.
Best Fit Decreasing (BFD)	Melhor Ajuste Decrescente	A bin packing heuristic that sorts items by decreasing size and places each item into the bin where it fits with the smallest remaining capacity.
Betweenness	Intermediação	A graph centrality measure quantifying the number of times a node lies on the shortest path between other nodes.
Board	Quadro	A software component that displays information (e.g., synoptic board) in a console.
BogieType	Tipo de Bogie	The type of bogie (wheel arrangement) used in locomotives or wagons.
Bottlenecks	Gargalos	Points in a network where capacity constraints limit throughput or flow.
Box	Caixa	A unit containing a quantity of a specific SKU, stored in a warehouse bay.
Boxcar	Vagão Coberto	A type of enclosed freight wagon used for transporting general goods.
Building	Edifício	A structure within facilities, such as Warehouse or Refrigerated Area.
BuildingType	Tipo de Edifício	A classification for buildings within facilities.
Caesar Cipher	Cifra de César	A simple substitution cipher where each letter in the plaintext is shifted a fixed number of places down the alphabet.
Capacity	Capacidade	The maximum flow or volume of trains that a connection or system can handle per unit time.
capacity	capacidade	Maximum number of boxes that a bay can store.
capacityBoxes	capacidade em caixas	The maximum number of boxes a storage bay can hold.
Cargo	Carga	Goods or products being transported.
CargoType	Tipo de Carga	Classification of cargo types (GENERAL_GOODS, CONTAINERS, LIQUIDS, etc.).
category	categoria	A classification for items or products.
Centrality Measures	Medidas de Centralidade	Quantitative metrics that identify the most important nodes within a graph.
Chemical Tank Car	Vagão-Tanque Químico	A specialized tank car optimized for transporting chemicals.
Chokepoints	Pontos de Estrangulamento	Critical nodes or links where congestion impacts system performance.
Circular Buffer	Buffer Circular	A fixed-size buffer that operates in FIFO mode.
Circulation lines	Linhas de Circulação	Railway tracks within a terminal where wagons move.
Closeness Centrality	Centralidade de Proximidade	A graph centrality measure based on average shortest path distance.

TEA (EN)	TEA (PT)	Description (EN)
Containers	Contentores	Standardized reusable steel boxes used for freight transport.
Cost	Custo	A metric combining distance, capacity, congestion, and penalties.
Customer Remorse	Arrependimento do Cliente	A return reason where the customer returns an item that is still in good condition.
Cycle	Ciclo	In graph theory, a path that starts and ends at the same vertex.
Cycle Count	Contagem de Ciclo	A return reason related to inventory counting discrepancies.
Cycle Detection	Deteção de Ciclos	The process of identifying cycles in a graph.
Damage	Danificado	A return reason where the product is physically broken.
Degree	Grau	In graph theory, the number of edges connected to a node.
Depot	Depósito	A facility for storage or maintenance of rolling stock.
Deterministic sweep	Varredura Determinística	A fixed-order path sequencing strategy.
Dijkstra's Algorithm	Algoritmo de Dijkstra	A graph algorithm that finds shortest paths with non-negative weights.
Dimensions	Dimensões	The measurable extents of an object, such as length, width, or height.
Directed Graph	Grafo Dirigido	A graph where edges have a direction.
Directed edge	Aresta Direcionada	A graph edge with a defined direction.
Discard	Descartar	The action of disposing of returned goods deemed unsuitable for sale.
Dispatched State	Estado de Despachado	The status of a train indicating it has been authorized to begin its journey.
Dispatching	Despacho	The operational function of authorizing train movement.
Disposition	Disposição	The outcome of a quarantine inspection.
Dispatch	Despachar	To send a train to its destination.
Distance	Distância	The length of a connection between two nodes.
DOT file	Ficheiro DOT	A text file using the DOT language for Graphviz.
Double-track	Via Dupla	A railway segment with two parallel tracks.
dueDate	data de entrega	The date by which an order must be fulfilled.
Edge	Aresta	A connection between two nodes in a graph.
Edmonds–Karp Algorithm	Algoritmo de Edmonds–Karp	Algorithm for computing maximum flow using BFS.
Electrified line	Linha Eletrificada	A railway line supplying power to electric locomotives.
Eligible	Elegível	An order line status where full quantity can be allocated.
EndpointEvent	Evento de Ponto Final	An event recorded when a train arrives, departs, or passes.
entryDate	data de entrada	The date when returned goods enter quarantine.
EventType	Tipo de Evento	Classification of endpoint events.

TEA (EN)	TEA (PT)	Description (EN)
Expired	Expirado	A return reason where the product passed its expiry date.
expiryDate	data de validade	The date after which a product should not be used.
Facility	Instalação	A place designed for a specific operational purpose.
FacilityType	Tipo de Instalação	Classification for railway facilities.
FEFO (First-Expired-First-Out)	FEFO	Inventory method prioritizing earliest expiry.
FIFO (First-In-First-Out)	FIFO	Inventory method prioritizing oldest stock.
First Fit (FF)	Primeiro Ajuste	A bin packing heuristic.
First Fit Decreasing (FFD)	Primeiro Ajuste Decrescente	FF after sorting by decreasing size.
Flatcar	Vagão Plataforma	A freight wagon with a flat deck.
Flow Network	Rede de Fluxo	A directed graph with capacities.
Freight	Carga	Planned cargo to be transported.
Freight Manager	Gestor de Carga	Role managing freights and routes.
Freight Train	Comboio de Mercadorias	A train dedicated to cargo transport.
Freight Wagon	Vagão de Carga	A wagon carrying specific freight.
Freight Yards	Pátios de Carga	Facilities for sorting and assembling trains.
frequency	frequência	Electrical power frequency.
Fuel Type	Tipo de Combustível	Energy source used by locomotives.
gauge	bitola	Distance between rails.
General_Schedule	Agenda Geral	Timetable containing multiple trains.
Graph	Grafo	Mathematical structure of vertices and edges.
Graph Theory	Teoria dos Grafos	Study of graphs.
Graph with cycles	Grafo com Ciclos	Directed graph containing cycles.
Graph without cycles	Grafo sem Ciclos	Directed acyclic graph.
GRAPHVIZ	GRAPHVIZ	Open-source graph visualization software.
Harmonic closeness	Proximidade Harmónica	Centrality measure using harmonic mean.
Haversine Distance	Distância de Haversine	Formula to calculate great-circle distances.
Height	Altura	Vertical dimension of an object.
heuristicUsed	heurística utilizada	Packing heuristic used in picking.
Hopper car	Vagão Gôndola	Wagon for bulk materials.
Hubscore	Pontuação de Hub	Composite score for station ranking.
id	identificador	Unique identifier.
Industrial hub	Hub Industrial	Major industrial area connected to rail.
Infrastructure planner	Planeador de Infraestruturas	Role planning infrastructure upgrades.
inspectionDate	data de inspeção	Inspection date of quarantined goods.
inspector	inspetor	Person inspecting quarantined goods.
interm_stid1	stid_interm1	First intermediate station identifier.
interm_stidn	stid_intermn	N-th intermediate station identifier.
Intermodal Terminal	Terminal Intermodal	Facility for intermodal cargo transfer.
isElectrified	é eletrificado	Indicates if a rail line is electrified.
Item	Item	A distinct product for sale.
KD-tree (k-dimensional tree)	Árvore KD	Space-partitioning data structure.
Kruskal's Algorithm	Algoritmo de Kruskal	Algorithm for Minimum Spanning Tree.
Length	Comprimento	Horizontal dimension.
LightSigns	Sinais Luminosos	Hardware controlling railway signals.

TEA (EN)	TEA (PT)	Description (EN)
Line	Linha	Railway route.
Line Segment	Segmento de Linha	Contiguous railway section.
lineNumber	número da linha	Order line index.
Loading	Carregamento	Cargo loading operation.
Locomotive	Locomotiva	Powered railway vehicle.
LocomotiveModel	Modelo de Locomotiva	Locomotive specifications.
Log	Registo	Records user actions.
Maintenance Planner	Planeador de Manutenção	Role planning maintenance activities.
make	marca	Manufacturer.
Manager	Gestor	Core management component.
maxFlowValue	valorFluxoMáximo	Maximum flow value.
Maximum Flow	Fluxo Máximo	Greatest possible flow.
maximumWeight	peso máximo	Maximum supported weight.
Minimum Spanning Tree (MST)	Árvore de Cobertura Mínima	Minimum-weight tree connecting all vertices.
Mineral oil car	Vagão-Tanque de Óleo Mineral	Tank car for mineral oils.
ModelName	Nome do Modelo	Model designation.
Moving Median Filter	Filtro de Mediana Móvel	Signal processing noise reduction technique.
MVP (Minimum Viable Product)	Produto Mínimo Viável	Minimal product version.
name	nome	Descriptive identifier.
Nearest-neighbour	Vizinho Mais Próximo	Greedy proximity strategy.
Nearest-Neighbor Query	Consulta do Vizinho Mais Próximo	Spatial nearest query.
Neato	Neato	Graphviz layout engine.
Negative Cycle	Ciclo Negativo	Cycle with negative weight.
Node	Nó	Graph vertex.
Non-perishable goods	Bens Não Perecíveis	Goods without expiry date.
numberOfBogies	número de bogies	Number of bogies.
Operations Analyst	Analista de Operações	Role analyzing network performance.
Oracle DBMS	SGBD Oracle	Oracle database system.
order	ordem	Sequence position.
Order	Encomenda	Customer request.
orderId	id da encomenda	Order identifier.
OrderLine	Linha de Encomenda	Item within an order.
OrderLineStatus	Estado da Linha de Encomenda	Allocation status.
Parking lines	Linhas de Estacionamento	Sidings for waiting wagons.
Partial	Parcial	Partial allocation status.
Path	Percurso	Ordered list of stations.
payload	carga útil	Revenue-generating load.
Perishable goods	Bens Perecíveis	Goods with expiry date.
Picker	Recolhedor	Warehouse worker.
Picking	Recolha	Item collection process.
PickingPlan	Plano de Picking	Detailed picking plan.
plannedBoxCount	contagem planeada de caixas	Planned number of boxes.
plannedCargoWeight	peso planeado da carga	Planned cargo weight.
PointType	Tipo de Ponto	STOP or PASS classification.
Port	Porto	Maritime facility.
Position	Posição	Abstract physical location.
possibleBox	caixa possível	Candidate boxes.
power	potência	Energy per unit time.

TEA (EN)	TEA (PT)	Description (EN)
Pressure gas car	Vagão-Tanque de Gás Pressurizado	Tank car for gases.
Prim's Algorithm	Algoritmo de Prim	MST greedy algorithm.
priority	prioridade	Processing importance.
Product Owner	Dono do Produto	Scrum role.
Quality Operator	Operador de Qualidade	Inspects returned goods.
quantity	quantidade	Amount of items.
quantityAllocated	quantidade alocada	Allocated amount.
Quarantine	Quarentena	Isolation state.
qtyDiscarded	qtdDescartada	Discarded quantity.
qtyRestocked	qtdReposta	Restocked quantity.
RailLine	Linha Ferroviária	Railway route.
RailLineOwner	Proprietário da Linha	Line owner.
RailLineSegment	Segmento de Linha	Railway segment.
Range Query	Consulta por Intervalo	Spatial range query.
reason	razão	Cause of an event.
receivedAt	recebido em	Receipt timestamp.
Refrigerated areas	Áreas Refrigeradas	Temperature-controlled areas.
Refrigerated car	Vagão Frigorífico	Refrigerated wagon.
Restock	Repor em Stock	Return to inventory.
returnId	idDevolução	Return identifier.
ReturnReason	Motivo da Devolução	Reason for return.
Retrospective	Retrospetiva	Scrum reflection meeting.
Return	Devolução	Customer return process.
RISC-V	RISC-V	Open-source ISA.
Risk-Aware Path	Caminho Consciente do Risco	Path considering penalties.
Rolling stock	Material Circulante	Railway vehicles.
Route	Rota	Transport plan.
Route Planner	Planeador de Rotas	Determines optimal routes.
RoutePlan	Plano de Rota	Scheduled route plan.
RoutePlanPoint	Ponto do Plano de Rota	Specific route point.
RouteType	Tipo de Rota	SIMPLE or COMPLEX route.
Schedule_Event	Evento de Agenda	Train schedule event.
Schedule_Event_Type	Tipo de Evento de Agenda	Schedule event classification.
Scheduler	Programador	Dispatch planner.
Scheduling	Calendarização	Planning train movements.
Segment	Segmento	See Line Segment.
Sensors	Sensores	Hardware monitoring components.
Shortest Path	Caminho Mais Curto	Minimum weight path.
Siding	Desvio / Aparcamento	Parallel track section.
signaling system	sistema de sinalização	Train safety systems.
Single-track	Via Única	Single railway track.
sku	SKU	Product code.
Sorting	Triagem	Cargo classification.
source	fonte	Flow network source.
source_stid	stid_fonte	Source station identifier.
speedLimit	limite de velocidade	Maximum allowed speed.
Stations	Estações	Railway facilities.
Station master	Chefe de Estação	Oversees station operations.
Station operator	Operador de Estação	Coordinates train traffic.
Station Operator	Operador de Estação	Coordinates train traffic.
stid	idEstação	Station identifier.
stname	nomeEstação	Station name.

TEA (EN)	TEA (PT)	Description (EN)
Stock Keeping Unit (SKU)	Unidade de Manutenção de Stock	Inventory identifier.
StopType	Tipo de Paragem	Stop classification.
Storage manager	Gestor de Armazenamento	Oversees warehouse operations.
Strength/degree	Força/Grau	Centrality measure.
StartDateTime	DataHora de Início	Planned start datetime.
StartedDateTime	DataHora de Início	Actual start datetime.
Synoptic board	Quadro Sinótico	Real-time display board.
System administrator	Administrador de Sistema	Manages system configuration.
Tank car	Vagão-Tanque	Liquid transport wagon.
TankCarSubtype	Subtipo de Vagão-Tanque	Tank specialization.
target_stid	stid_alvo	Target station identifier.
Tare weight	Peso Tara	Empty vehicle weight.
TDD (Test-Driven Development)	Desenvolvimento Guiado por Testes	Test-first development practice.
Terminal operator	Operador de Terminal	Manages terminal operations.
Terminals	Terminais	Major railway facilities.
timeEvent	hora do evento	Event timestamp.
Time Zone	Fuso Horário	Uniform time region.
Time Zone Group	Grupo de Fuso Horário	Group of time zones.
Timestamp	Marca Temporal	Date and time record.
Token	Token	Data label.
Topological Sorting	Ordenação Topológica	DAG vertex ordering.
Track	Via	Physical railway track.
Track Location	Localização da Via	Track position.
TrackGauge	Bitola	Rail distance.
trackNumber	número da via	Track identifier.
TrackState	Estado da Via	Track operational state.
TrackType	Tipo de Via	Track classification.
Traffic Dispatcher	Despachante de Tráfego	Manages traffic patterns.
Traffic Manager / Planner	Gestor de Tráfego / Planeador	Optimizes timetables.
Train	Comboio	Railway vehicle set.
Train Schedule	Agenda de Comboio	Schedule of a train.
Train driver	Maquinista	Operates trains.
TrainOperator	Proprietário do Operador de Comboios	Train operating company.
TrainTrip	Viagem de Comboio	Route execution.
TrainTripStatus	Estado da Viagem de Comboio	Trip status.
Trolley	Carrinho	Warehouse cart.
TrolleyAllocation	Alocação de Carrinho	Trolley assignment.
TrolleyModel	Modelo de Carrinho	Trolley specifications.
Throughput	Vazão	Processing rate.
Undirected Graph	Grafo Não Dirigido	Graph without edge direction.
Undispatchable	Indespachável	Allocation impossible.
Unloading	Descarga	Cargo removal.
Unloading docks	Doca de Descarga	Cargo unloading points.
Unit	Unidade	Measurement unit.
unit	unidade	Packaging unit.
unitVolume	volume unitário	Unit volume.
unitWeight	peso unitário	Unit weight.
User	Utilizador	System user.
UserRole	Papel do Utilizador	User permissions.
User Story (US)	História de Utilizador	User requirement description.

TEA (EN)	TEA (PT)	Description (EN)
Value	Valor	Numerical measurement.
Vertex	Vértice	Graph node.
voltage	tensão	Electrical voltage.
volumeCapacity	capacidade volumétrica	Maximum volume.
Wagon	Vagão	Freight vehicle.
WagonModel	Modelo de Vagão	Wagon specifications.
WagonType	Tipo de Vagão	Wagon classification.
Warehouse	Armazém	Storage building.
Warehouse Planner	Planeador de Armazém	Plans warehouse operations.
WeightTare	Peso Tara	Empty weight.
WheelCount	Número de Rodas	Wheel count.
Width	Largura	Horizontal dimension.
WMS (Warehouse Management System)	Sistema de Gestão de Armazém	Warehouse management software.
yearOfEntryInService	ano de entrada em serviço	Year vehicle entered service.

Chapter 2

Introduction

2.1 Purpose and Scope of the Document

This document aims to present and describe the development of a computer-based solution to support logistics operations in railway networks. It serves as the main technical and functional reference for the Integrative Project of the 3rd semester, bringing together concepts, requirements, and solutions developed across multiple course units.

The scope of this document includes the analysis of the problem domain, the description of the system architecture, the definition of functional and non-functional requirements, and the explanation of the implemented features throughout the different project sprints. It also documents the roles of the system users, the supported logistics processes, and the technical decisions made during the development of the solution. The document is intended to provide a comprehensive overview of the system and to support both implementation and evaluation activities.

2.2 Type of Product Described

The product described in this document is a software system designed to support logistics and operational planning in railway freight networks. It is a decision-support and operational management system that integrates multiple modules related to railway infrastructure, rolling stock, freight management, route planning, and train scheduling.

The system includes functionalities such as route and path planning, freight handling, train assembly and assignment, schedule generation, network optimization, and monitoring of railway operations. It combines different technological components, including databases, graph-based algorithms, scheduling mechanisms, and user interfaces, developed using multiple programming languages such as Java, PL/SQL, C, and Assembly. The solution is developed iteratively as a Minimum Viable Product (MVP), following an agile and incremental approach.

2.3 Intended Audience

This document is intended for a diverse audience involved in the development, evaluation, and use of the proposed system. Its primary audience includes students and instructors participating in the Integrative Project, who require a clear understanding of the problem domain, system requirements, and implemented solutions.

Additionally, the document is relevant for technical stakeholders such as software developers, database designers, and system architects, as it provides detailed information about the system structure, data models, and algorithms. It is also suitable for domain-related roles, such as traffic managers, freight managers, and infrastructure planners, as it describes how the system supports decision-making and operational activities in railway logistics. Finally, it may serve as a reference for evaluators and reviewers assessing the correctness, completeness, and quality of the developed solution.

Chapter 3

System Overview

3.1 Purpose and Use of the Product

The MABEC system is designed to support the planning, execution, and monitoring of logistics operations in railway-based freight transportation. Its main purpose is to model and manage the interaction between railway infrastructure, rolling stock, freight operations, warehouse activities, and scheduling processes in an integrated and consistent way.

The product is used to assist different operational roles in performing tasks such as route planning, train assembly, freight allocation, scheduling, dispatching, warehouse management, and network optimisation. By combining infrastructure data, operational constraints, and logistics rules, the system enables informed decision-making, improves operational efficiency, and ensures traceability across all logistics processes.

3.2 Structure of the Product

The product is structured as a modular system composed of several interconnected subsystems, each representing a specific domain of the railway logistics ecosystem. These subsystems include infrastructure management, rolling stock management, freight and route planning, warehouse operations, order processing, scheduling, and user management.

Each module is represented in the domain model through a set of entities and relationships that define its responsibilities and interactions. The system follows a layered and domain-driven structure, where core business concepts such as trains, routes, facilities, orders, and schedules are clearly separated but logically connected. This structure promotes scalability, maintainability, and clear responsibility boundaries between different functional areas.

3.3 Reference to the Main Features

The main features of the product are directly derived from the domain model and reflect the core logistics and operational requirements of the system. These features include railway infrastructure modelling (rail lines, segments, sidings, and tracks), rolling stock representation (locomotives, wagons, and train compositions), and the definition of facilities such as stations, terminals, and freight yards.

Additional key features include freight management and routing, order and allocation handling, warehouse storage and picking operations, train scheduling and dispatching, and the management of returns and quality control. The system also supports multiple user roles, each with specific permissions and responsibilities, ensuring that operations are executed according to defined business rules and operational constraints.

3.4 Highlight of the Main Modules

The system is organised into several main modules, each corresponding to a major functional area of the domain. The **Infrastructure Module** manages rail lines, segments, tracks, gauges, and facilities, defining how different locations are connected and constrained.

The **Rolling Stock Module** represents locomotives, wagons, models, and train operators, supporting the creation and assignment of trains. The **Freight and Route Module** handles freights, routes, paths, and route types, enabling both manual and automatic route planning.

The **Warehouse and Orders Module** manages buildings, aisles, bays, boxes, orders, order lines, picking plans, trolleys, and allocations, ensuring correct stock rotation using FIFO and FEFO rules. The **Scheduling Module** is responsible for generating and managing schedules and schedule events, representing train movements, waiting periods, loading, and unloading operations.

Finally, the **User and Logging Module** manages system users, roles, and logs, ensuring access control, traceability, and accountability for all actions performed within the system.

3.5 Product Structure Diagram

The product structure is represented through the domain model shown in Figure 3.1. This diagram provides a high-level view of the main entities of the system and the relationships between them, covering infrastructure elements, operational components, logistics processes, and supporting entities.

The domain model serves as the conceptual foundation of the system, illustrating how different modules interact and how data flows across the railway logistics lifecycle. It also acts as a reference for both implementation and validation, ensuring consistency between business requirements and the implemented solution.

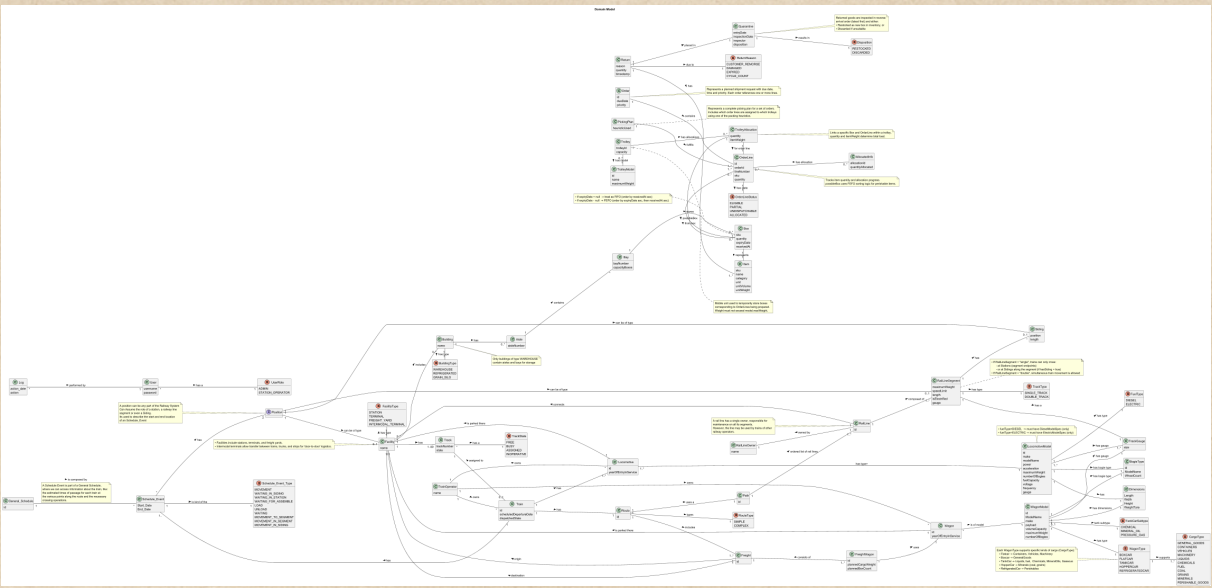

Figure 3.1: Domain Model

Chapter 4

System Requirements

4.1 Hardware Requirements

The MABEC system is a desktop-based application that relies on both a Java execution environment and a relational database management system. As a result, the host machine must be capable of running the application and the database server simultaneously.

The minimum recommended hardware requirements are:

- **Processor**: Dual-core CPU (2.0 GHz or higher)
- **Memory (RAM)**: 8 GB minimum
- **Storage**: At least 5 GB of free disk space (application files, database files, and logs)
- **Display**: Minimum resolution of 1366×768

For optimal performance, particularly when executing graph algorithms, scheduling simulations, and database-intensive operations, the following configuration is recommended:

- **Processor**: Quad-core CPU or higher
- **Memory (RAM)**: 16 GB or more
- **Display**: Full HD (1920×1080) resolution

The system can be executed on Windows, Linux, or macOS, provided that all required software dependencies, including the database system, are correctly installed.

4.2 Installation Procedure

The installation of the MABEC system requires setting up both the application environment and the database environment. The following steps describe the recommended installation procedure:

1. Install a compatible **Java Development Kit (JDK)**, version 17 or higher.
2. Install a **relational database management system** (e.g., Oracle Database or an equivalent system supported by the project).
3. Create a database instance and user with appropriate permissions.
4. Execute the provided SQL scripts to create the database schema, tables, constraints, and initial data.
5. Configure the database connection parameters (URL, username, password) in the application configuration files.
6. Compile and run the Java application using an IDE or command-line tools.

After successful installation, the system starts with the Login interface, allowing users to authenticate and access the application according to their assigned role.

For academic testing and demonstration purposes, the database can be restored to its default state using the **Reset Database** option available within the application.

4.3 Additional Technical Notes

The MABEC system follows a modular architecture that clearly separates the user interface, business logic, and data persistence layers. All persistent information — including users, stations, trains, routes, schedules, warehouse data, and logs — is stored and managed in the relational database.

The application relies on SQL scripts for database initialization and enforces data integrity through primary keys, foreign keys, and constraints defined at the database level. This approach ensures consistency between application logic and stored data.

Several computational components are embedded in the system, including graph-based algorithms for route planning and network optimisation, spatial indexing structures such as the 2D-Tree, and heuristic-based allocation strategies for warehouse and picking operations.

All significant user actions and system events are recorded in the database-backed logging system, providing traceability, auditability, and support for debugging and evaluation purposes.

The system is intended for academic use and simulation scenarios and does not require integration with external production railway or logistics systems.

Chapter 5

Features

5.1 Home Page

The Home Page is the initial page of the MABEC system and allows users to quickly access the main features via the side menu. This page also provides a summary of the User Manual and makes the complete file available in PDF format.

Figure 5.1 shows the home page interface of the system.

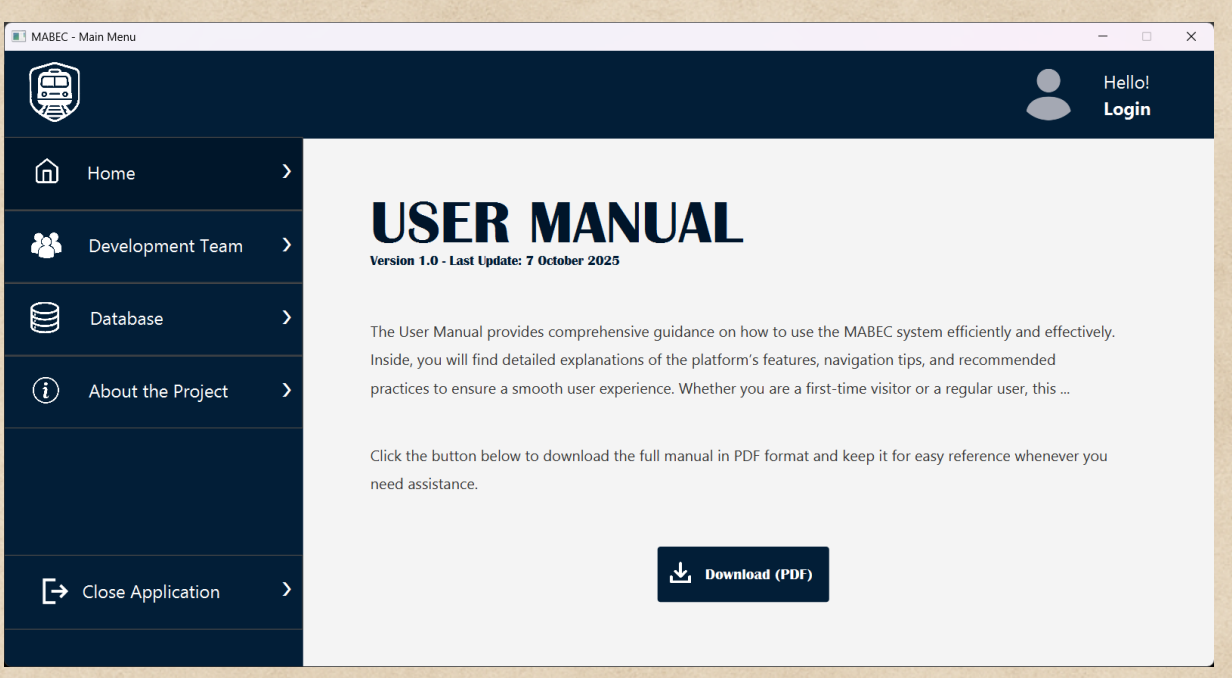

Figure 5.1: Home Page

5.1.1 Side Menu

The side menu, visible on the left in Figure 5.1, contains the main navigation buttons for the application.

5.1.2 Development Team

The Development Team page presents the team responsible for developing the MABEC system. Figure 5.2 shows the interface of this section.

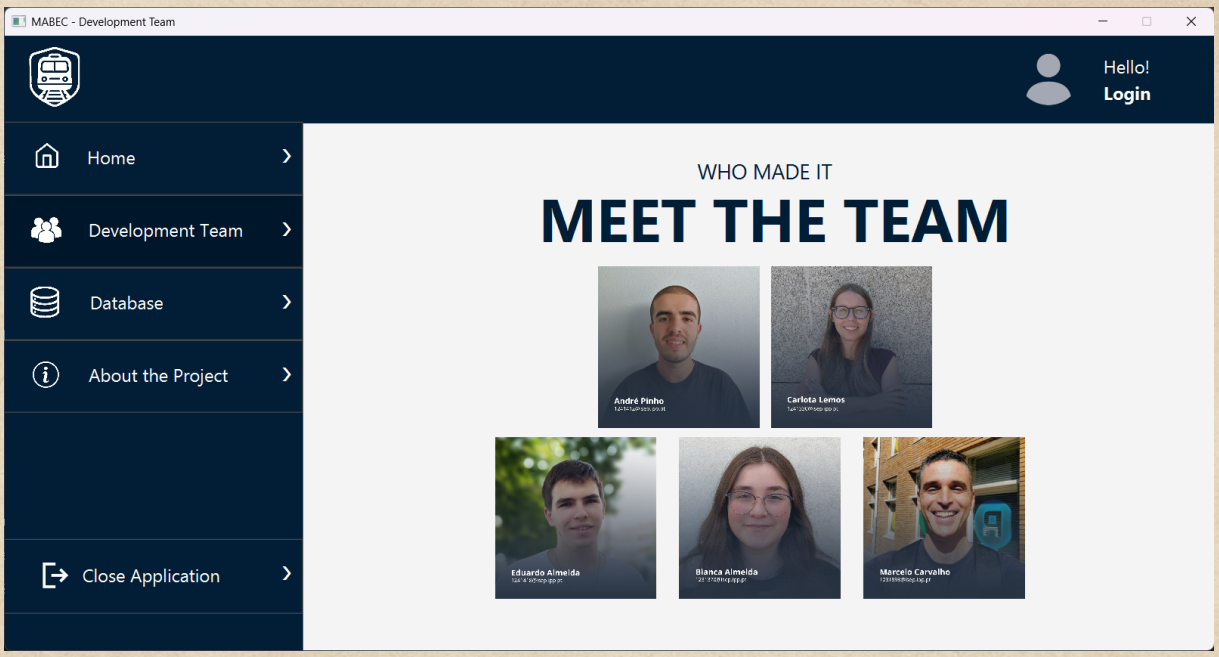

Figure 5.2: Development Team

This page allows users to identify the project members, view their photographs, and consult their institutional contact information. The team members are displayed in a grid, each with their name and academic email address associated with the project.

5.1.3 Database

The Database page provides access to the data management section of the MABEC system. Figure 5.3 shows the interface of the Database page.

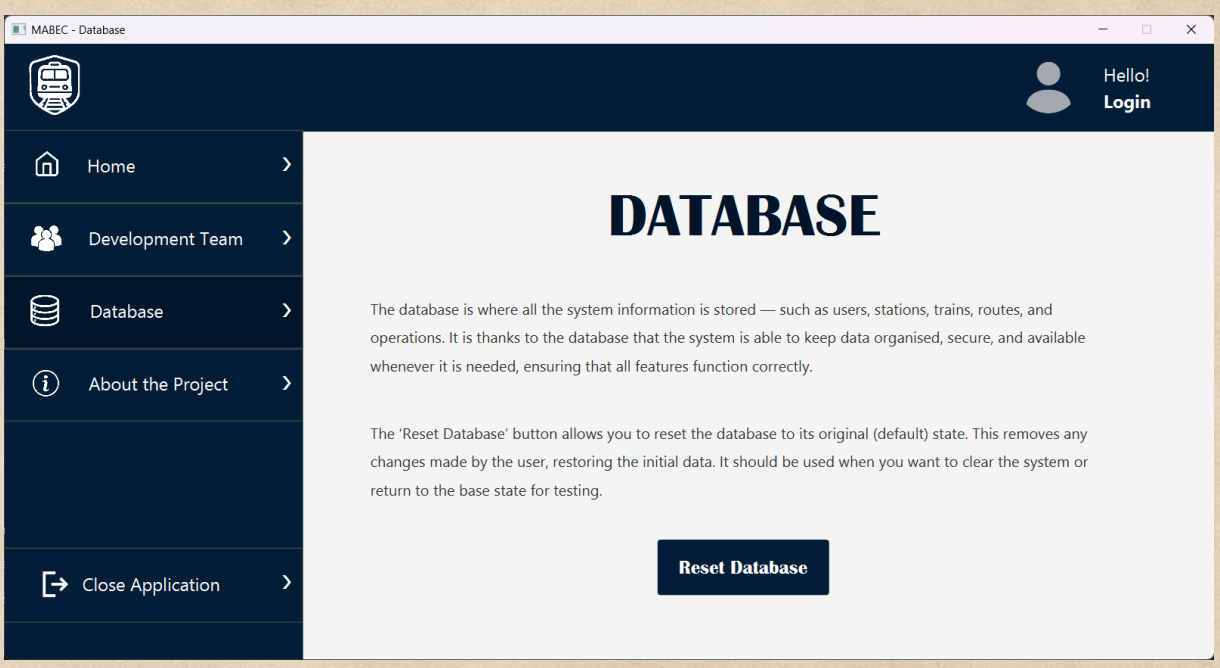

Figure 5.3: Database Page

This page explains that all system information — such as users, stations, trains, routes, and operations — is stored in the database. It highlights that the database is essential for ensuring data integrity,

availability, and correct system functionality.

Reset Database

At the bottom of the page, users will find the **Reset Database** button. Selecting this option restores the database to its default configuration, removing any changes made by the user. This is useful for testing purposes or recovering the base system state.

Figure 5.4 illustrates the confirmation window displayed during the reset process.

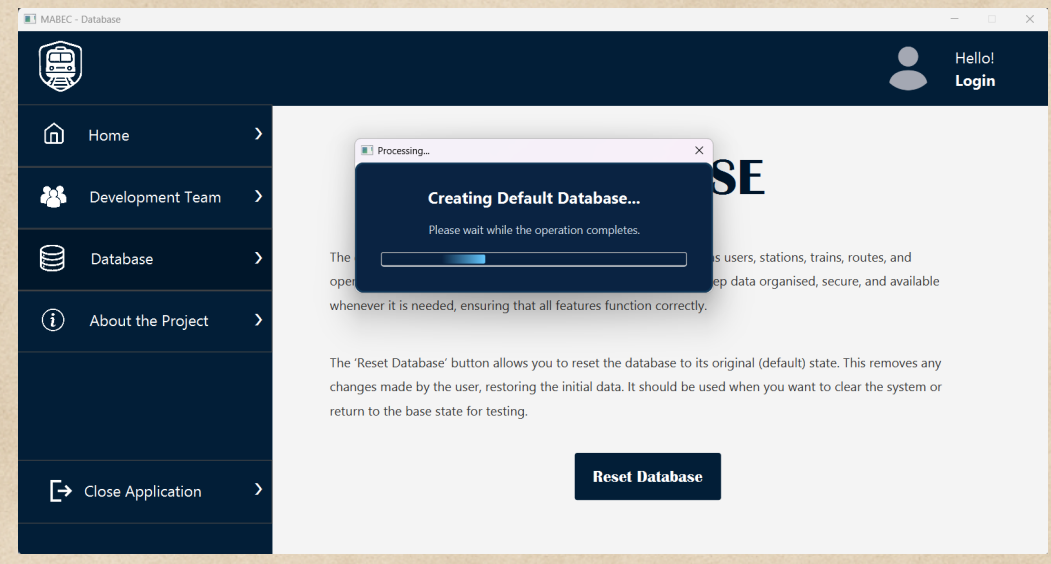

Figure 5.4: Database Reset Process

5.1.4 About the Project

The About the Project page provides an overview of the academic and technical context of the MABEC system. Figure 5.5 shows the interface of this page.

Figure 5.5: About the Project Page

This section describes the objectives of the Integrative Project, including:

- modeling and managing railway infrastructure (lines, stations, and segments),
- handling rolling stock (locomotives and wagons),
- managing cargo operations in terminals,
- designing relational databases and data models,
- developing user interfaces and domain models.

It also lists the technologies used:

- PL/SQL for database creation and management,
- Java for main business logic and application development,
- Visual Paradigm for modeling activities.

5.1.5 Login

The Login page allows registered users to authenticate and access their personal dashboard. Figure 5.6 displays the interface of the Login screen.

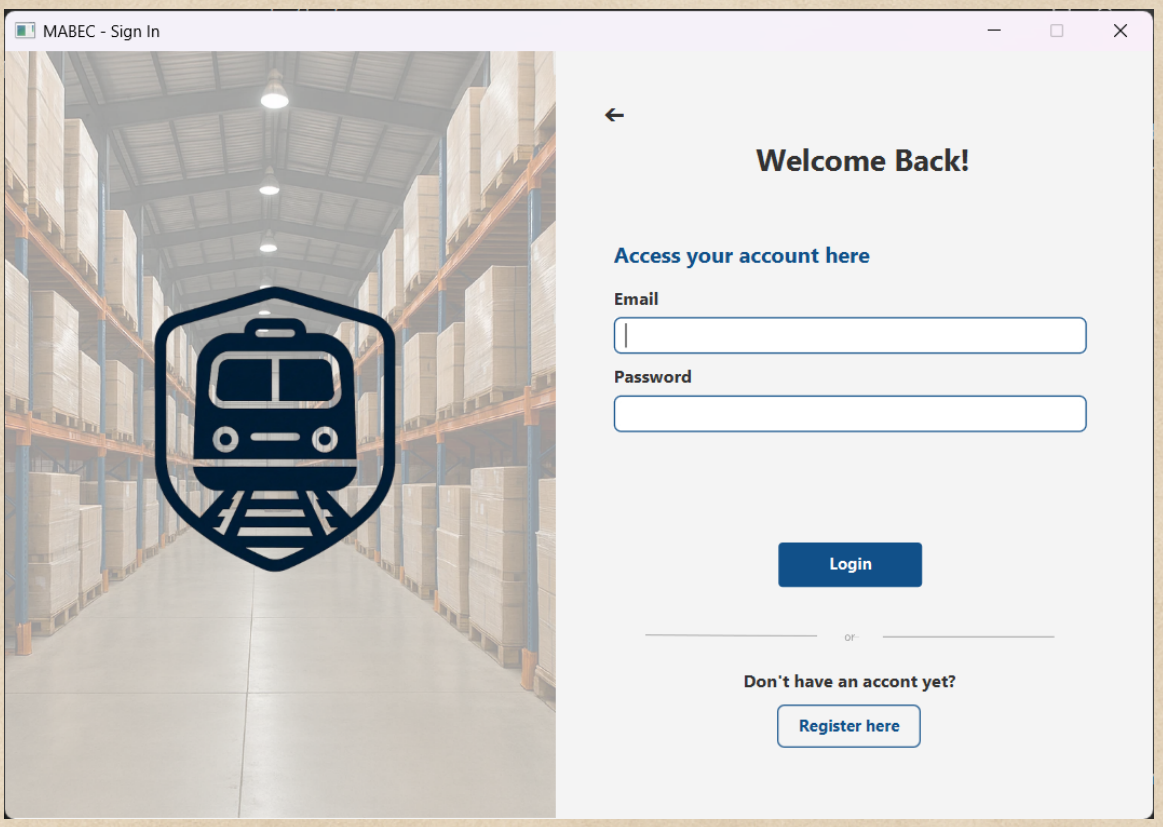

Figure 5.6: Login Page

The user must enter their email and password and then select the **Login** button. If the credentials are valid, the user is redirected to the appropriate home interface based on their assigned role.

The screen also provides a shortcut to the registration page for new users.

5.1.6 Register

The Register page allows new users to create an account. Figure 5.7 shows the registration interface.

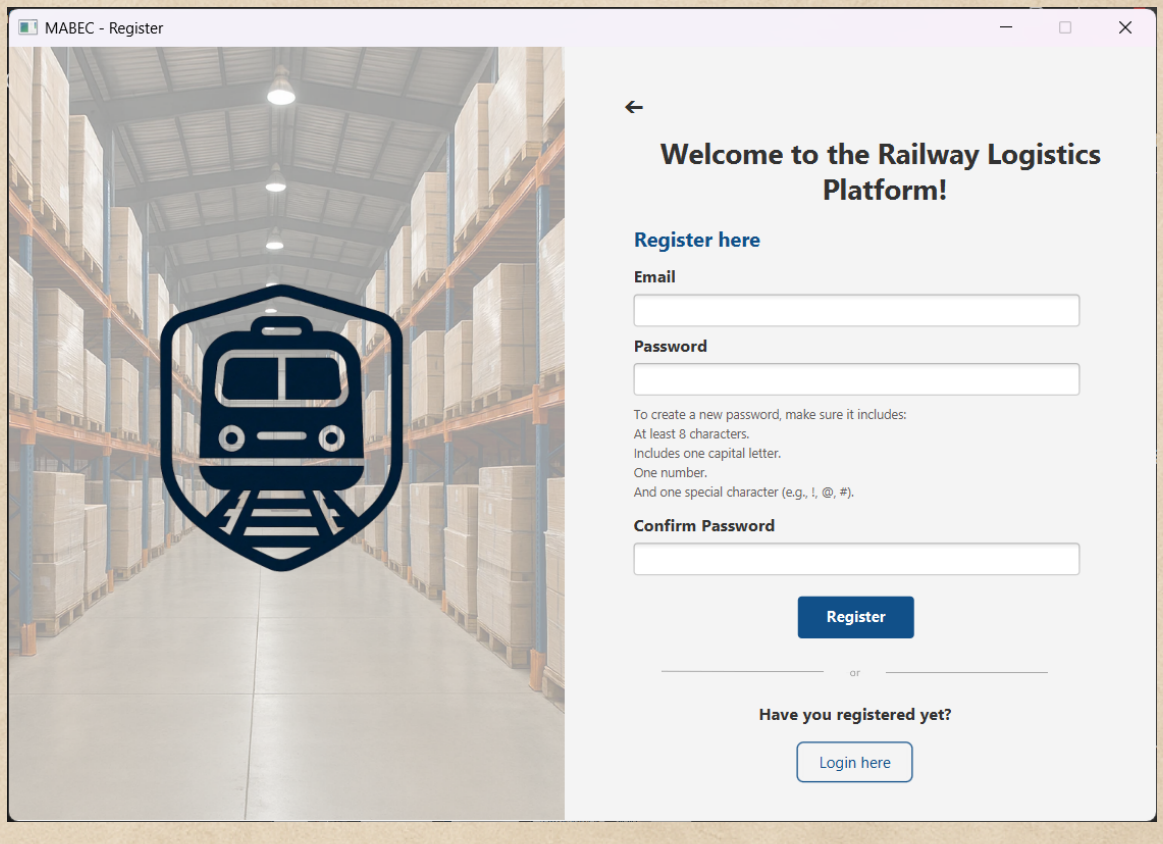

Figure 5.7: Register Page

To complete the registration process, the user must fill in:

- Email address,
- Password,
- Password confirmation.

The password creation section includes guidelines requiring at least:

- one capital letter,
- one number,
- one special character,
- and a minimum length of 8 characters.

Once submitted, the account is created and the user can proceed to the Login page.

5.2 Administrator

The Administrator role is responsible for managing the overall configuration, security, and user access of the MABEC system. This role has the highest level of permissions and oversees user management, system integrity, and operational configuration.

Figure 5.8 presents the Administrator Home Page.

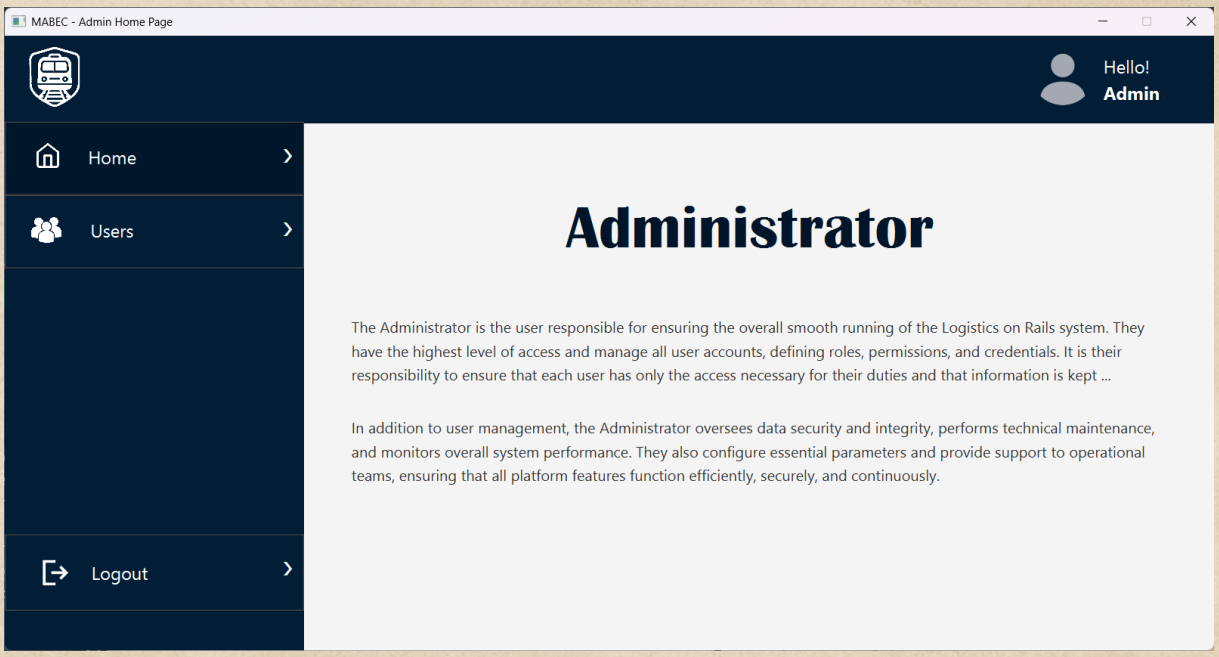

Figure 5.8: Administrator Home Page

The Administrator ensures that all users have the correct permissions for their activities, monitors platform performance, and guarantees that data and operations remain secure and consistent across the system.

5.2.1 Users Page

The Users Page allows the Administrator to view all registered accounts in the system. Figure 5.9 shows the layout of this page.

Figure 5.9: Administrator – Users Page

The table displayed includes:

- **ID** – Unique numerical identifier for each user.

- **Email** – The user's assigned login credential.
- **Status** – Indicates whether the account is Active or Inactive.
- **Edit** – A button that opens the user editing interface.

The Administrator can scroll through the table when many users are registered.

5.2.2 Edit User Page

When selecting the **Edit** button, the Administrator is redirected to the Edit User Page. Figure 5.10 shows this interface.

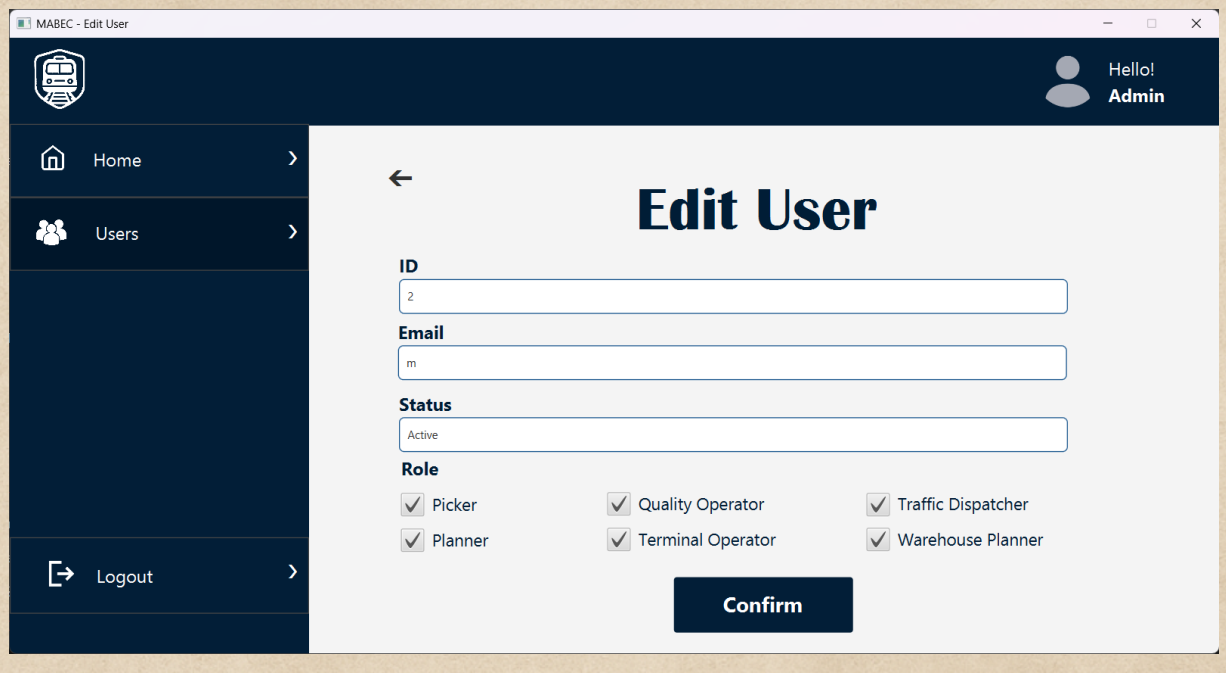

Figure 5.10: Administrator – Edit User Page

This page allows the Administrator to modify the following information:

- **ID** – The user's unique identifier (read-only).
- **Email** – The account's email address.
- **Status** – Defines whether the account is Active or Inactive.
- **Role** – A list of system roles, where the Administrator can assign or remove permissions.

Available roles include:

- Picker
- Planner
- Quality Operator
- Terminal Operator
- Traffic Dispatcher
- Warehouse Planner

After making all necessary changes, the Administrator selects the **Confirm** button to save the updated information.

5.2.3 Logout

The Administrator menu also includes a **Logout** option, which safely ends the session and returns the user to the Home Page.

5.3 Analyst

The Analyst role is responsible for transforming system data into meaningful information to support operational and strategic decision-making. In the Logistics on Rails project, Analysts use data structures implemented by the Data Engineer — such as the 2D-Tree — to perform proximity searches and identify stations nearest to a given geographic point.

Figure 5.11 shows the Analyst Home Page.

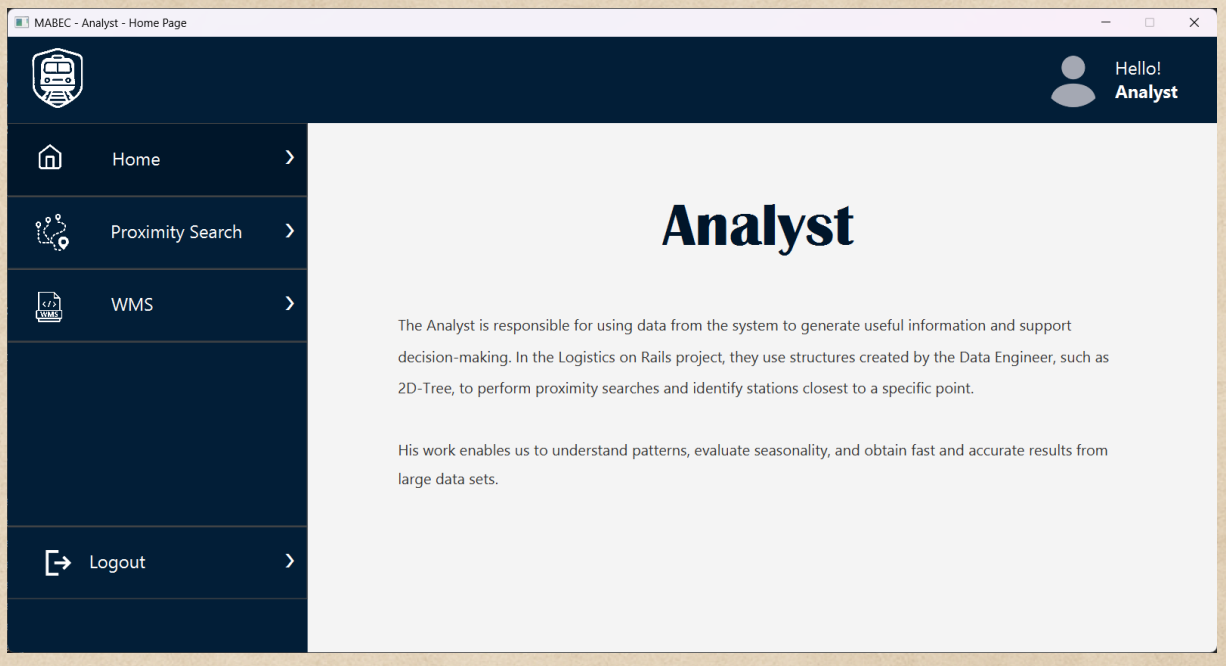

Figure 5.11: Analyst Home Page

Through their work, Analysts enable pattern identification, seasonal trend evaluation, and fast retrieval of insights from large data sets.

5.3.1 Proximity Search

The Proximity Search feature allows the Analyst to search for stations closest to a specific latitude and longitude. This tool uses a 2D-Tree structure to efficiently locate and sort nearby stations.

Figure 5.12 displays the interface of the Proximity Search page.

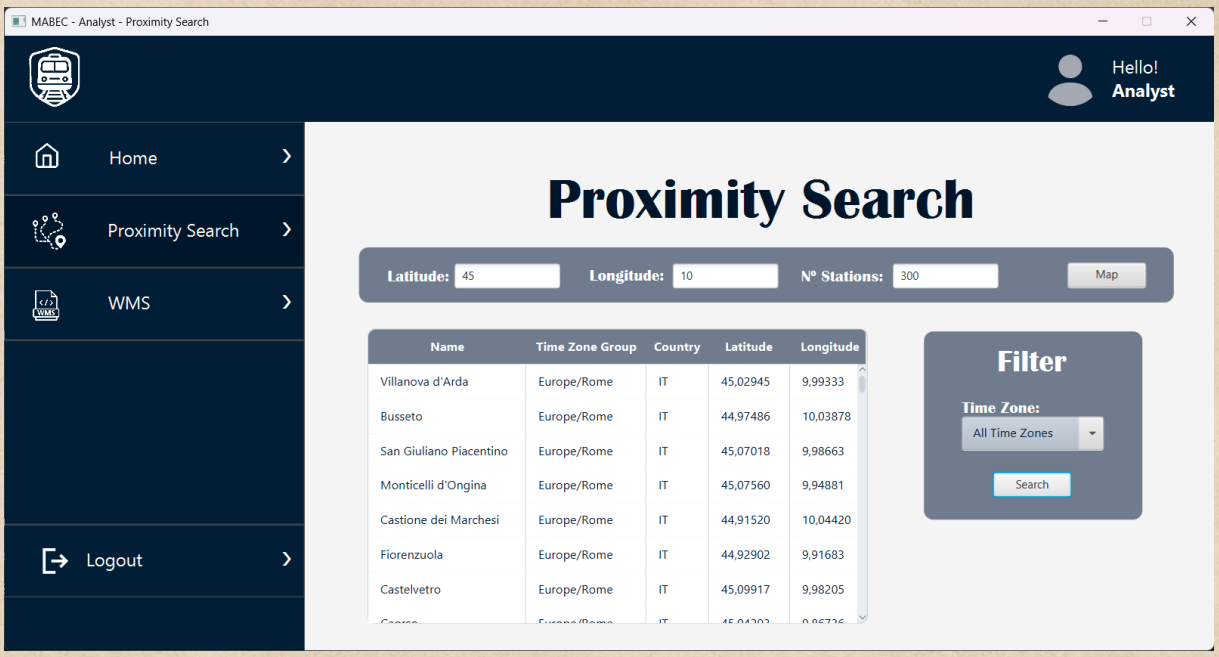

Figure 5.12: Proximity Search Page

The interface includes the following input fields:

- **Latitude** – Starting reference latitude.
- **Longitude** – Starting reference longitude.
- **Nº Stations** – Maximum number of nearby stations to list.

After entering the search parameters, selecting the **Map** button displays the selected stations on a geographic map. Figure 5.13 illustrates a sample map view.

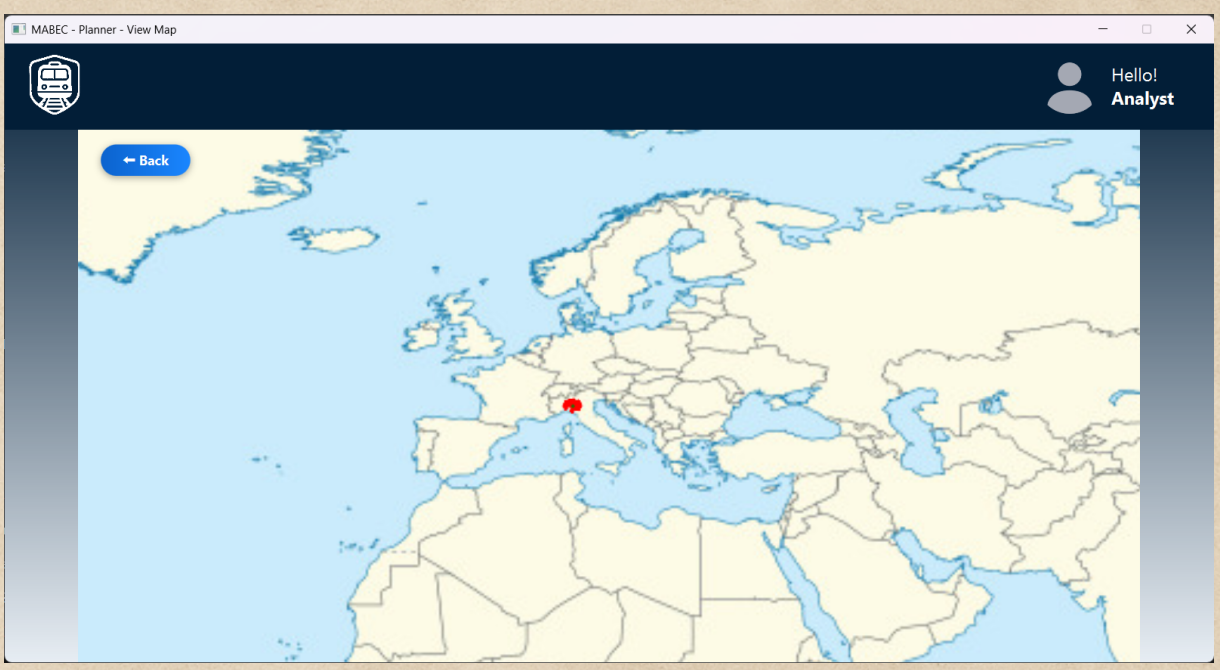

Figure 5.13: Map View of Proximity Search Results

A filter panel enables further refinement of results by selecting a specific **Time Zone**. Selecting **Search** updates the results table accordingly.

5.3.2 WMS

The WMS (Warehouse Management System) button provides access to the user's activity logs. This section records user actions related to warehouse management operations and is available to all user roles.

Its purpose is purely informational, allowing the user to view their interaction history within the platform.

5.3.3 Logout

The **Logout** button safely ends the session and returns the user to the Login page.

5.4 Data Engineer

The Data Engineer role is responsible for designing and maintaining the data structures that enable all geographic queries and large-scale data operations within the MABEC system. In the Logistics on Rails project, the Data Engineer develops balanced spatial structures, such as the 2D-Tree, which organise stations by latitude and longitude. These structures allow the system to efficiently locate nearest stations, perform spatial queries, and maintain high performance even when processing large datasets.

Figure 5.14 presents the Data Engineer Home Page.

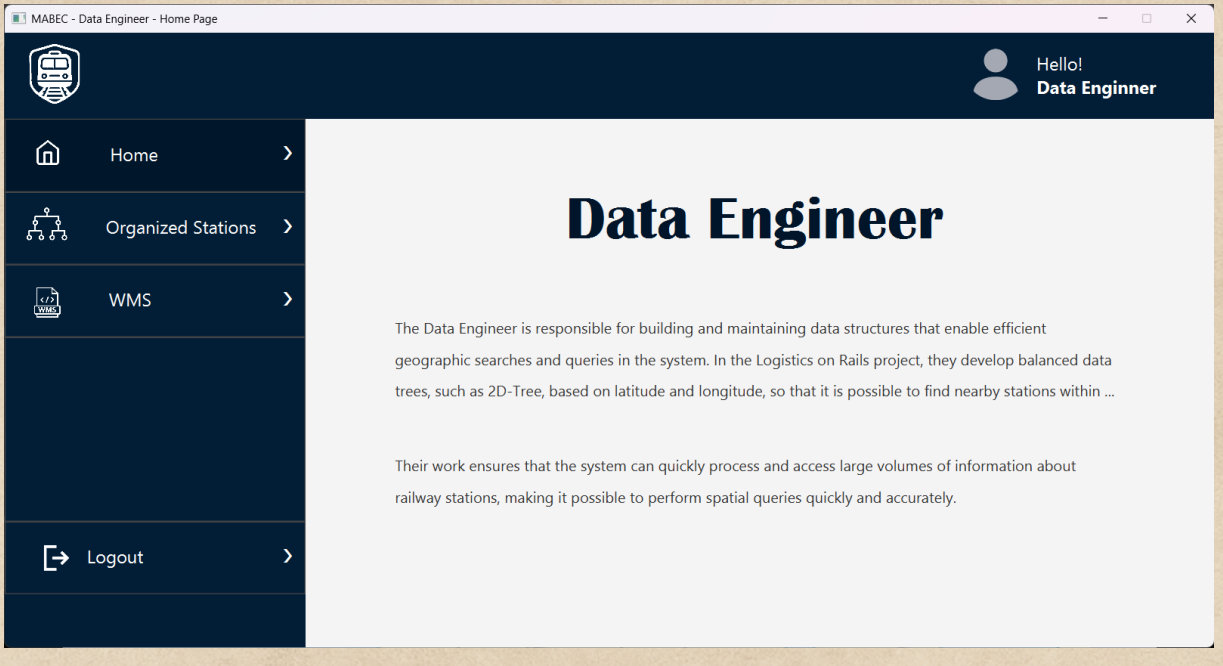

Figure 5.14: Data Engineer Home Page

The work of the Data Engineer ensures that all system queries, including proximity search, sorting, classification, and filtering, operate accurately and efficiently.

5.4.1 Organized Stations

The **Organized Stations** page displays all nodes of the 2D-Tree generated from the European railway station dataset. Each line of the table corresponds to a node in the tree, containing structured information about the stations grouped within that node.

Figure 5.15 shows the initial interface of the Organized Stations page.

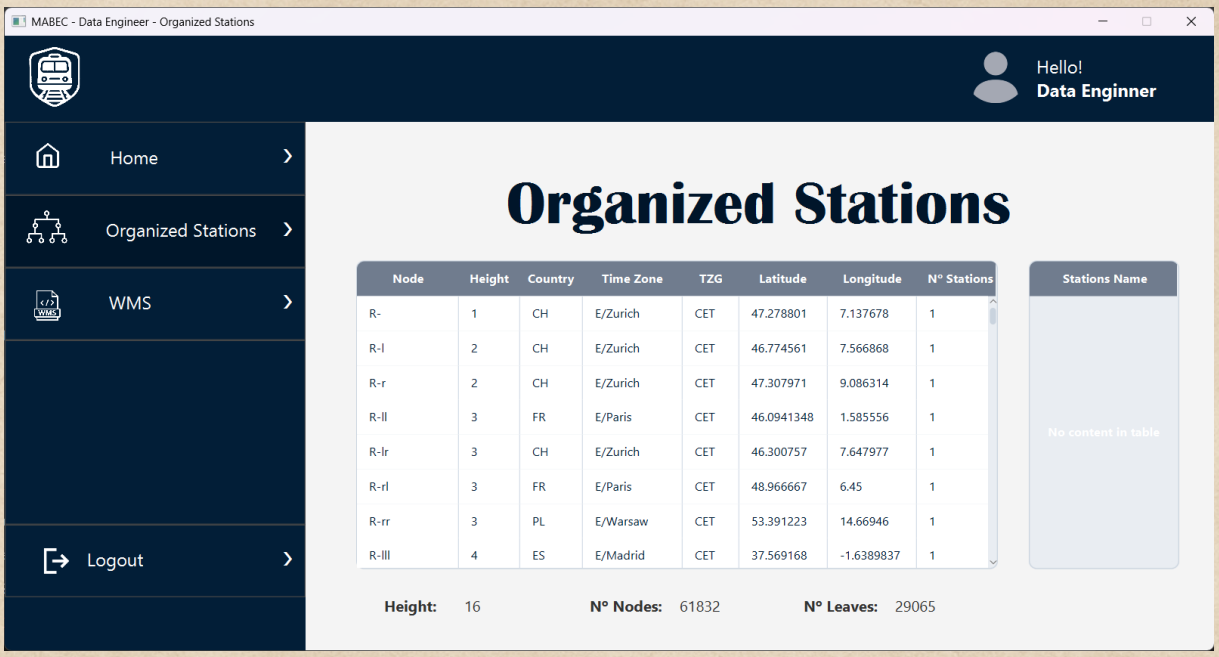

Figure 5.15: Organized Stations Page

The main table includes the following columns:

- **Node** – Unique path identifier representing the position of the node in the 2D-Tree.
- **Height** – Height level of the node in the structure.
- **Country** – Country code of the station group.
- **Time Zone** – The time zone associated with the stations.
- **TZG** – Time Zone Group.
- **Latitude / Longitude** – Representative geographical coordinates.
- **Nº Stations** – Number of stations contained in that node.

Below the table, global structure metrics are also displayed:

- **Height** – Maximum depth of the tree.
- **Nº Nodes** – Total number of nodes in the structure.
- **Nº Leaves** – Number of leaf nodes.

Viewing Stations Inside a Node

When the user selects a row from the main table, the system displays, on the right side of the screen, a list of all stations contained within the selected node. Figure 5.16 shows an example of this updated view after a node has been selected.

Figure 5.16: Stations List Updated After Node Selection

This functionality allows the Data Engineer to analyse how stations are distributed within each node of the 2D-Tree, and to verify whether the spatial partitioning of the structure is balanced and correctly implemented.

5.4.2 WMS

The WMS (Warehouse Management System) page provides a log of all actions performed by the user. Although the Data Engineer does not directly manage warehouse operations, this log is included for consistency across all system roles.

The WMS records:

- user interaction history,
- internal actions processed by the system,
- activity timestamps.

It serves as an audit and traceability tool.

5.4.3 Logout

The **Logout** button ends the user session securely and returns the user to the Login page.

5.5 Freight Manager

The Freight Manager is responsible for planning, coordinating, and supervising freight transportation operations within the railway network. This role focuses on defining freight routes, managing cargo dispatch, and ensuring that freight trains operate efficiently while respecting network constraints and operational rules.

Figure 5.17 shows the Freight Manager Home Page.

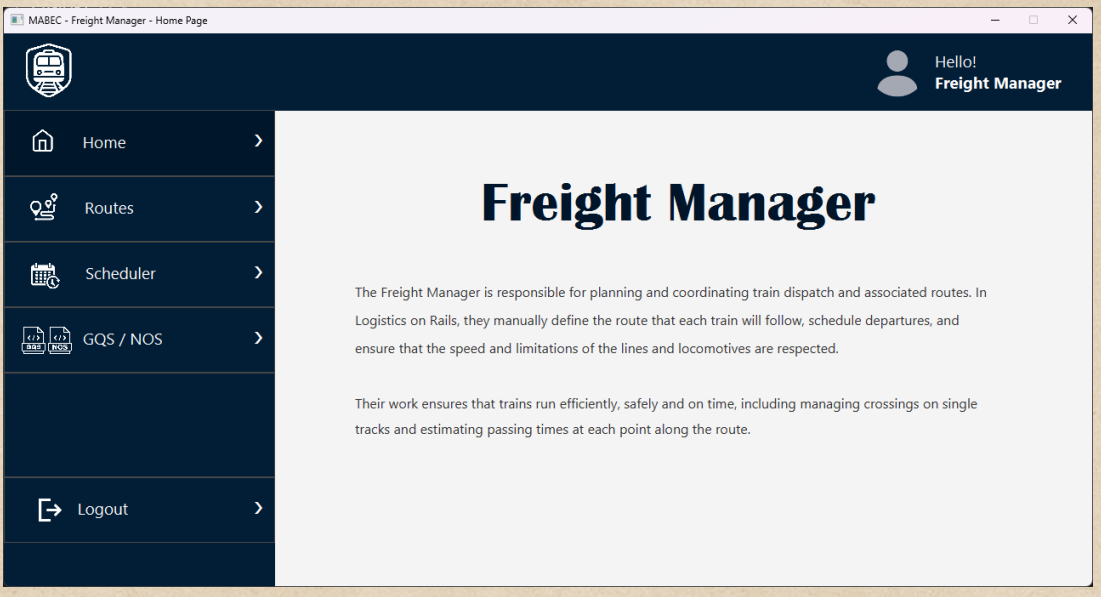

Figure 5.17: Freight Manager Home Page

By using the system, the Freight Manager manually defines the paths that freight trains will follow, organises freight orders, and analyses schedules to guarantee safe and timely delivery of goods. This role plays a key part in ensuring efficient logistics operations and optimising the use of railway infrastructure.

5.5.1 Routes

The **Routes** section allows the Freight Manager to create and manage freight routes within the system. Figure 5.18 shows the Routes page.

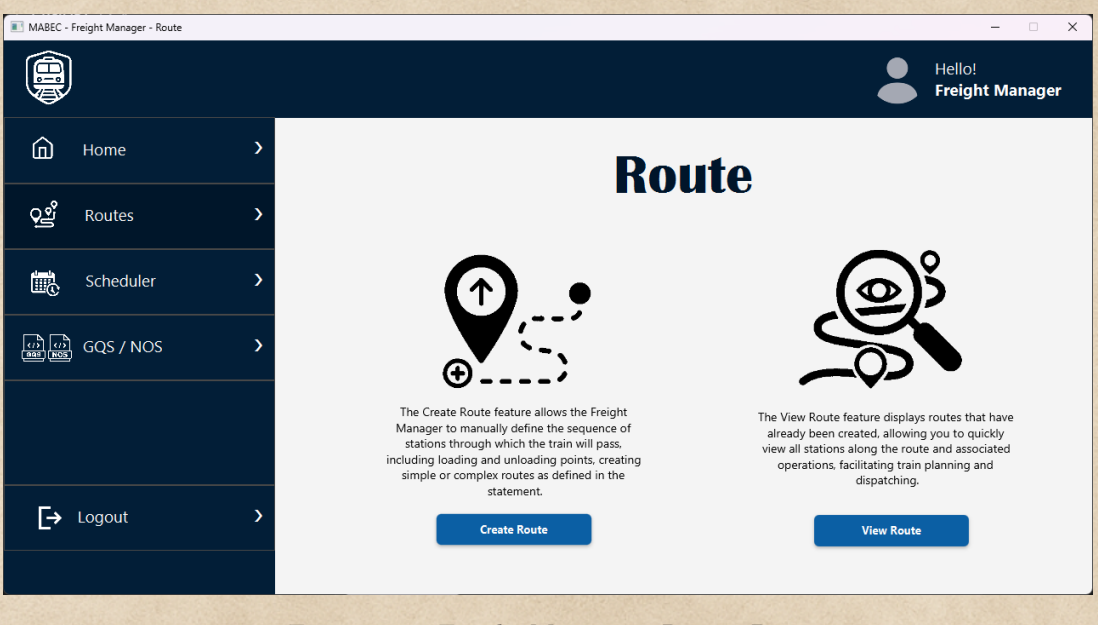

Figure 5.18: Freight Manager – Routes Page

This section is divided into two main functionalities:

- **Create Route** – allows the Freight Manager to manually define the sequence of stations that a freight train will pass through, including origin and destination stations, dates, and wagon quantities.
- **View Route** – enables the consultation of previously created routes, displaying route identifiers, freight quantities, associated stations and wagon assignments.

These features support accurate route planning and provide visibility over existing freight operations.

5.5.2 Create Route

The **Create Route** page enables the Freight Manager to construct a new freight route by selecting freight orders from the available freight list. Figure 5.19 illustrates this interface.

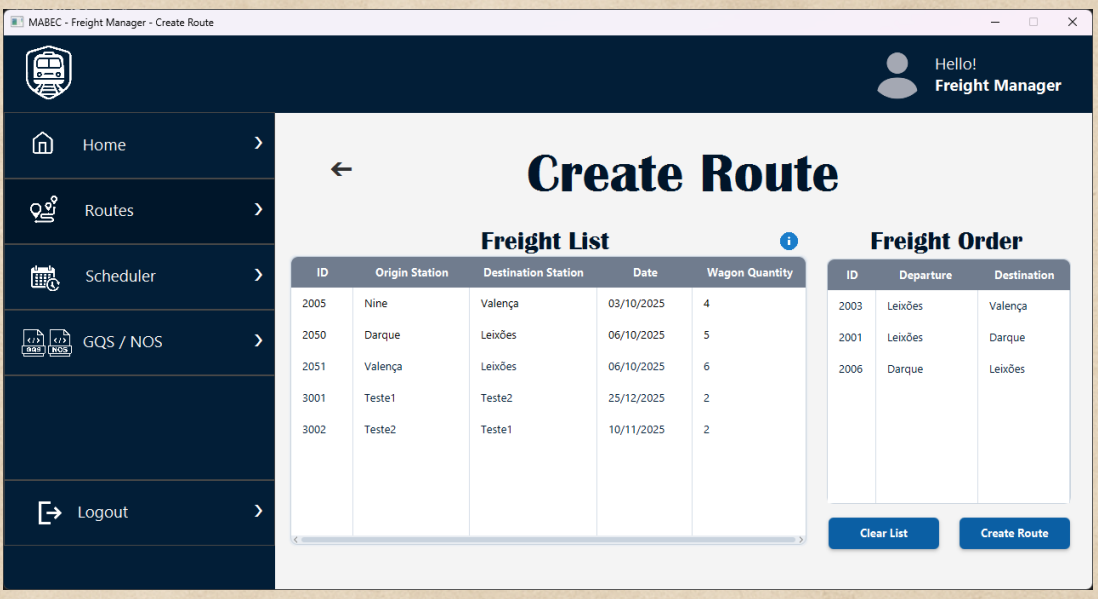

Figure 5.19: Freight Manager – Create Route Page

The Freight Manager selects freight orders, organises them into a freight order list, and generates a route based on the chosen sequence. Once validated, the route is created and stored in the system, becoming available for scheduling and execution.

5.5.3 View Route

The **View Route** page allows the Freight Manager to consult routes that were previously created in the system. Figure 5.20 shows this interface.

Figure 5.20: Freight Manager – View Route Page

On the left side, the **Routes** table lists the available routes with their identifiers and the corresponding freight quantity. When a route is selected, the **Details** table displays the associated freight orders, including departure and destination stations, as well as the wagons assigned to each order.

At the bottom of the page, the system indicates whether the selected route already has an assigned path, supporting the Freight Manager in tracking route readiness for scheduling and dispatch.

5.5.4 Scheduler

The **Scheduler** section allows the Freight Manager to analyse and visualise train schedules. Figure 5.21 shows the Scheduler page.

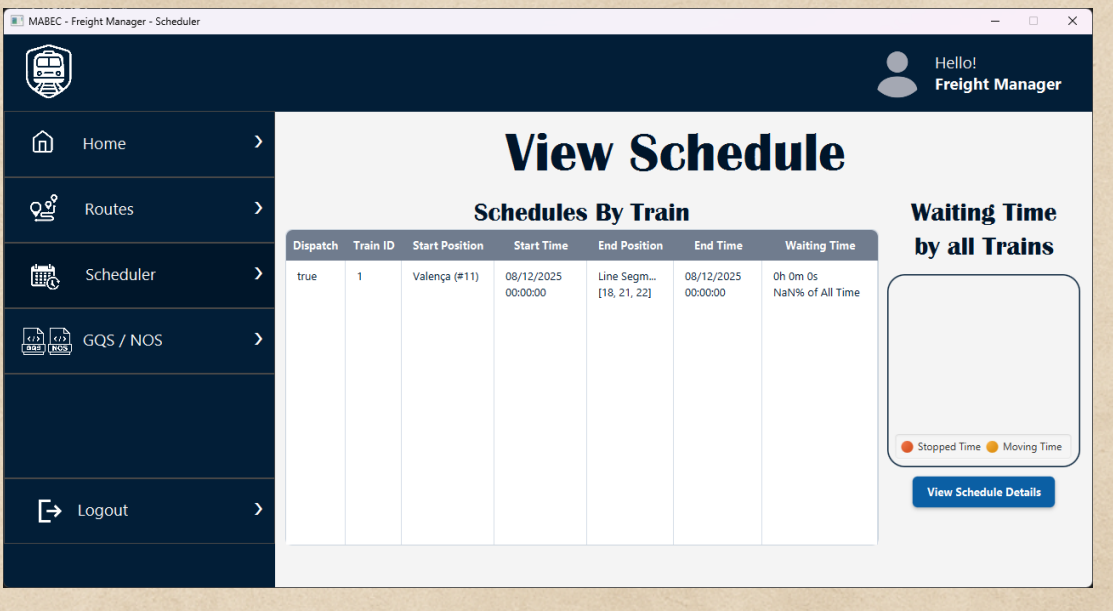

Figure 5.21: Freight Manager – Scheduler Page

This page displays schedules by train, including start and end positions, movement types, start and end times, and waiting times. Detailed schedule information can be consulted for individual trains, supporting operational monitoring and improving freight dispatch efficiency.

5.5.5 GQS / NOS

The **GQS / NOS** (Geospatial Query System / Network Optimization System) page provides access to system logs related to freight operations. Figure 5.22 shows this interface.

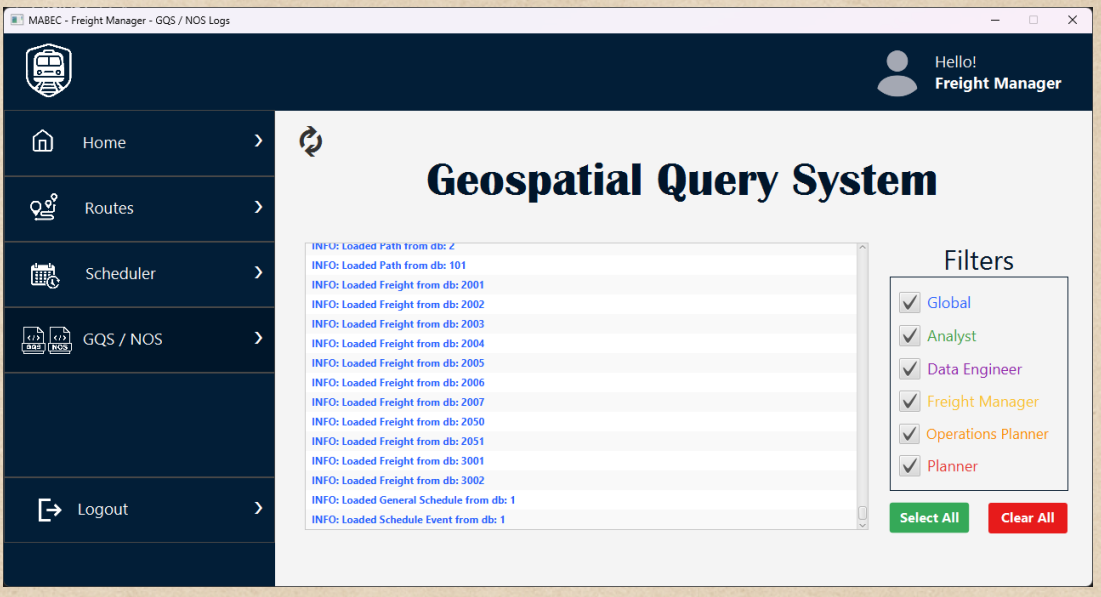

Figure 5.22: Freight Manager – GQS / NOS Page

This section allows the Freight Manager to monitor information loaded from the database, including freight data, routes, and schedules. Filtering options enable the analysis of logs relevant to specific roles, supporting transparency and traceability of freight-related operations.

5.5.6 Logout

Selecting the **Logout** option ends the current Freight Manager session and returns the user to the Login page.

5.6 Infrastructure Planner

The Infrastructure Planner is responsible for analysing and planning railway infrastructure, including stations, railway lines, and the connections between them. This role uses the system to study the existing network and support decisions related to maintenance, expansion, or improvement of the infrastructure.

Figure 5.23 shows the Infrastructure Planner Home Page.

Figure 5.23: Infrastructure Planner Home Page

The Infrastructure Planner evaluates how infrastructure elements interact, identifies dependencies between stations, and analyses the impact of potential upgrades. Their work supports structured planning of interventions, ensuring a more efficient, reliable, and resilient railway network.

From the Home Page, the Infrastructure Planner can access the following modules:

- **Upgrade Plan**
- **Baseline Cost**
- **NOS**

5.6.1 Upgrade Plan

The **Upgrade Plan** page allows the Infrastructure Planner to analyse the railway network and compute improvement plans based on capacity and flow constraints. Figure 5.24 shows this interface.

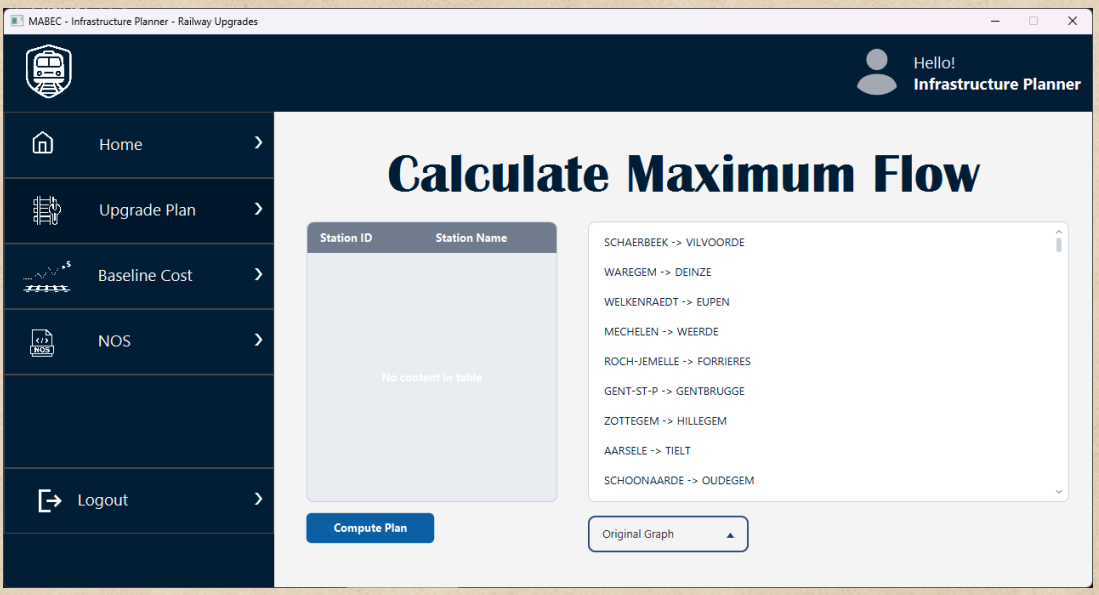

Figure 5.24: Infrastructure Planner – Upgrade Plan Page

This module focuses on identifying network segments that may limit overall capacity. By analysing flows between stations, the system supports decisions regarding where infrastructure upgrades would have the greatest operational impact.

The planner may select different analysis modes and compute upgrade plans that help improve throughput, reduce bottlenecks, and increase network robustness.

5.6.2 Baseline Cost

The **Baseline Cost** page provides access to the **Minimal Backbone Network** functionality. This module is available in the system but is not yet fully documented in this version of the User Manual.

At this stage, it is intended to support the analysis of a minimal infrastructure backbone that maintains network connectivity while optimising overall cost.

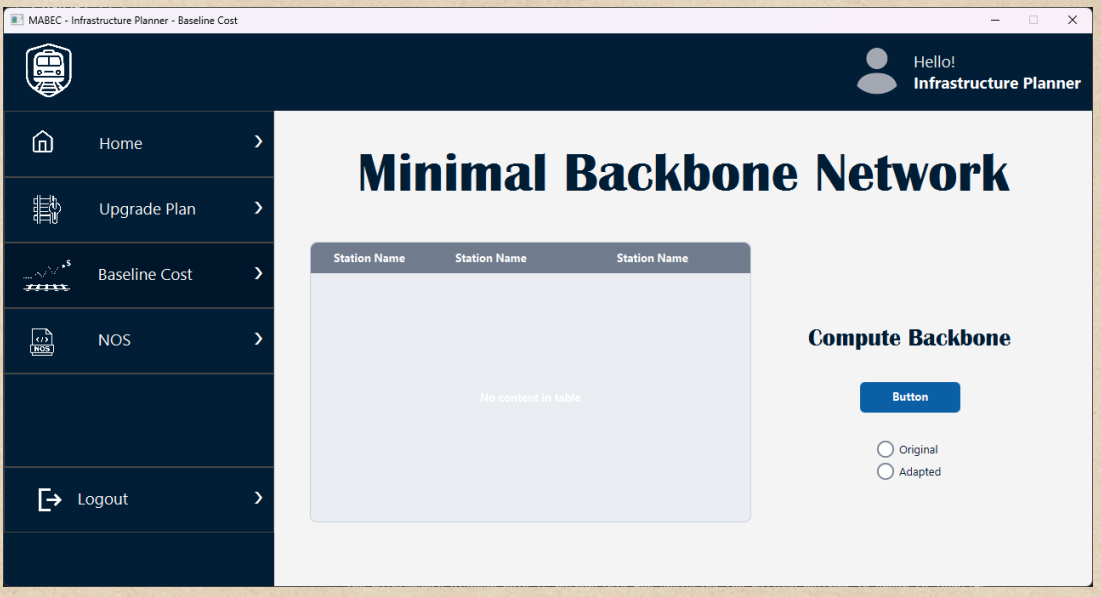

Figure 5.25: Infrastructure Planner – Baseline Cost

5.6.3 NOS

The **NOS** (Network Optimization System) page provides a detailed log of system actions and analytical operations related to infrastructure planning. Figure 5.26 shows the NOS Logs interface.

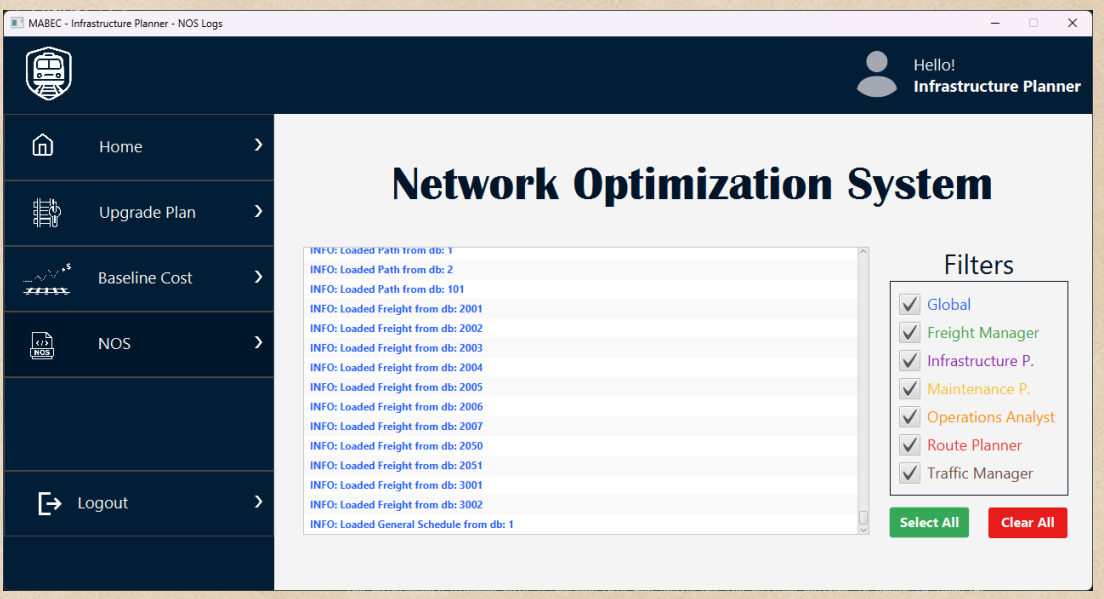

Figure 5.26: Infrastructure Planner – NOS Logs

The log panel displays messages related to path loading, freight processing, schedule analysis, and infrastructure computations. A filter panel on the right allows the Infrastructure Planner to refine logs by role or module, enabling focused analysis and traceability.

5.6.4 Logout

Selecting the **Logout** option ends the current Infrastructure Planner session and returns the user to the Login page.

5.7 Maintenance Planner

The Maintenance Planner role is responsible for analysing the railway network in order to identify critical infrastructure elements that require maintenance, monitoring, or prioritised intervention. This role focuses on evaluating stations, rail lines, and connections based on their operational importance, usage intensity, and vulnerability within the network.

Figure 5.27 shows the Maintenance Planner Home Page.

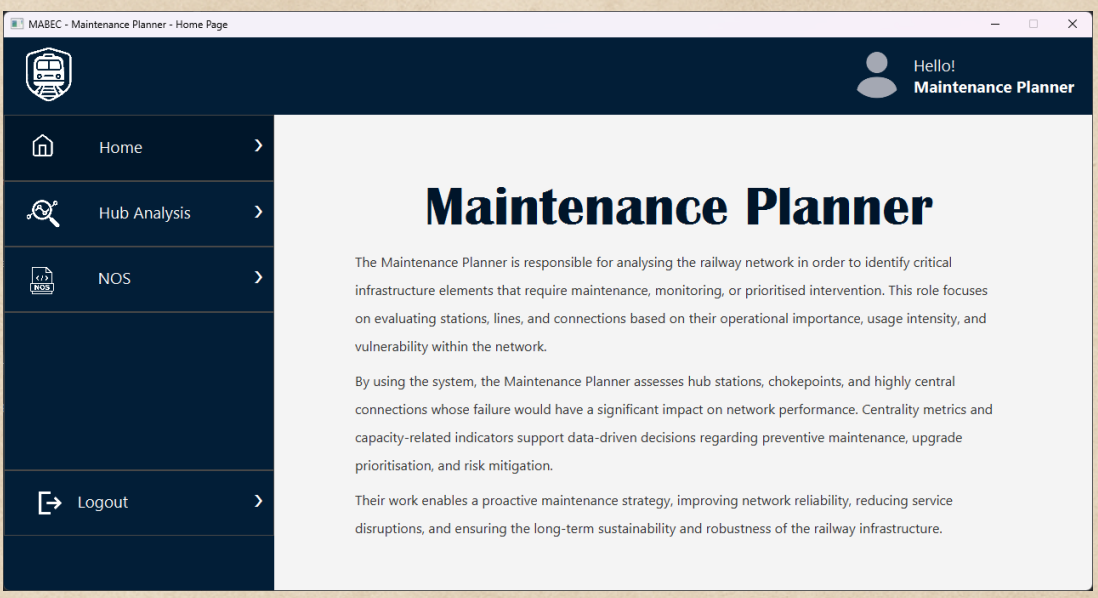

Figure 5.27: Maintenance Planner Home Page

From the Home Page, the Maintenance Planner can access the following main modules:

- **Hub Analysis**
- **NOS**

By analysing hub stations, chokepoints, and highly central connections, the Maintenance Planner supports data-driven decisions related to preventive maintenance, infrastructure upgrades, and risk mitigation. This contributes to improved network reliability, reduced service disruptions, and long-term infrastructure sustainability.

5.7.1 Hub Analysis

The **Hub Analysis** page allows the Maintenance Planner to identify and rank the most critical stations in the railway network using graph-based centrality metrics.

Figure 5.28 presents the Hub Analysis interface.

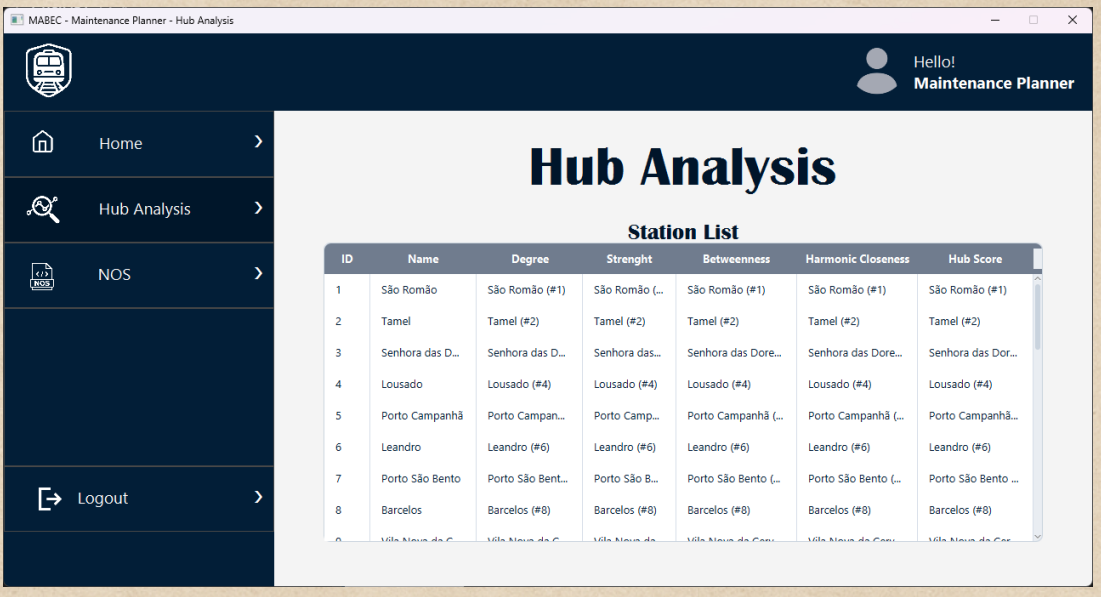

Figure 5.28: Maintenance Planner – Hub Analysis Page

The main table lists all stations and includes the following indicators:

- **Degree** – Measures the number of direct connections a station has.
- **Strength** – Considers the weighted importance of those connections.
- **Betweenness** – Identifies stations that frequently act as intermediaries in paths.
- **Harmonic Closeness** – Measures how easily a station can reach all others.
- **Hub Score** – Aggregated metric representing the overall strategic importance of the station.

These metrics help identify:

- critical hubs whose failure would significantly impact network performance,
- stations that should be prioritised for maintenance or monitoring,
- infrastructure elements with high operational risk.

This analysis supports preventive maintenance planning and strategic investment decisions.

5.7.2 NOS

The **NOS** (Network Optimization System) page provides access to system logs related to infrastructure analysis and optimisation processes.

Figure 5.29 shows the NOS interface for the Maintenance Planner.

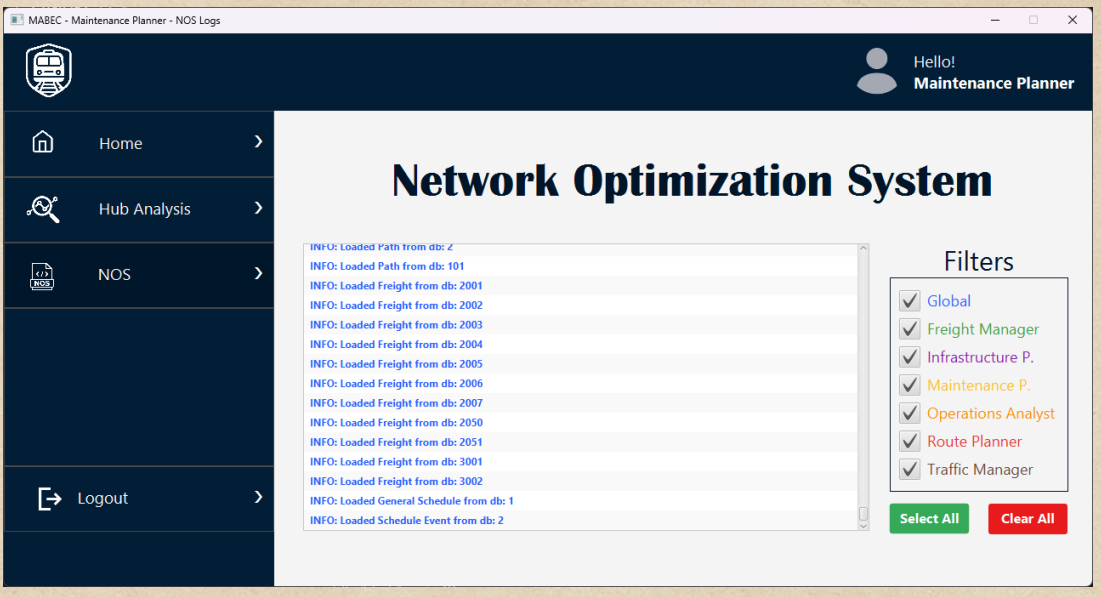

Figure 5.29: Maintenance Planner – Network Optimization System Logs

The central panel displays chronological log entries generated by the system, such as:

- data loading events,
- hub analysis calculations,
- interactions performed by different system roles.

On the right side, a filter panel allows the user to filter logs by role, including:

- Global
- Freight Manager
- Infrastructure Planner
- Maintenance Planner
- Operations Analyst
- Route Planner
- Traffic Manager

The **Select All** and **Clear All** buttons allow quick management of the filters, enabling the Maintenance Planner to focus only on relevant events.

5.7.3 Logout

Selecting the **Logout** option ends the Maintenance Planner session securely and returns the user to the Login page.

5.8 Operations Analyst

The Operations Analyst role is focused on analysing the railway network capacity and evaluating how efficiently trains can be routed through the system. This role supports strategic and operational decision-making by identifying capacity bottlenecks and assessing the impact of infrastructure constraints.

Figure 5.30 shows the Operations Analyst Home Page.

Figure 5.30: Operations Analyst Home Page

Upon accessing the system, the Home Page provides a brief explanation of the purpose of the Operations Analyst role. It highlights that this analysis calculates the maximum possible throughput between two selected stations, taking into account the capacity limits of each railway segment.

From this page, the Operations Analyst can access the following main modules:

- **Calculate Max Flow**
- **NOS**

This analysis helps validate operational schedules, detect capacity bottlenecks, and identify areas of the network that may require prioritised upgrades or optimisation.

5.8.1 Calculate Max Flow

The **Calculate Max Flow** page allows the Operations Analyst to compute the maximum number of trains that can be routed between two selected stations, considering all network capacity constraints. Figure 5.31 shows the Calculate Max Flow interface.

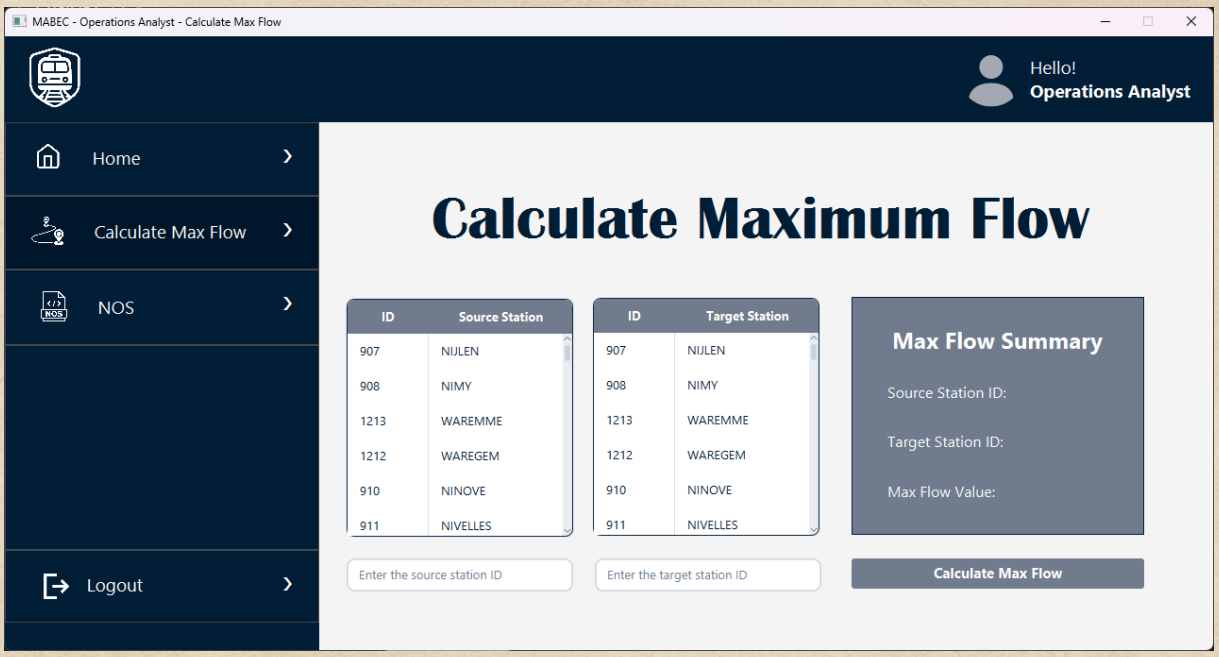

Figure 5.31: Calculate Maximum Flow Page

The interface is divided into three main sections:

- **Source Station Table** – located on the left, listing all available stations that can be selected as the source.
- **Target Station Table** – located in the centre, listing all stations that can be selected as the destination.
- **Max Flow Summary** – located on the right, displaying the calculation results.

Below the tables, the user may manually enter the **Source Station ID** and **Target Station ID** using the input fields.

Max Flow Calculation Result

After selecting the source and target stations, the user presses the **Calculate Max Flow** button. Once the calculation is completed successfully, a confirmation message is displayed at the top of the screen, as shown in Figure 5.32.

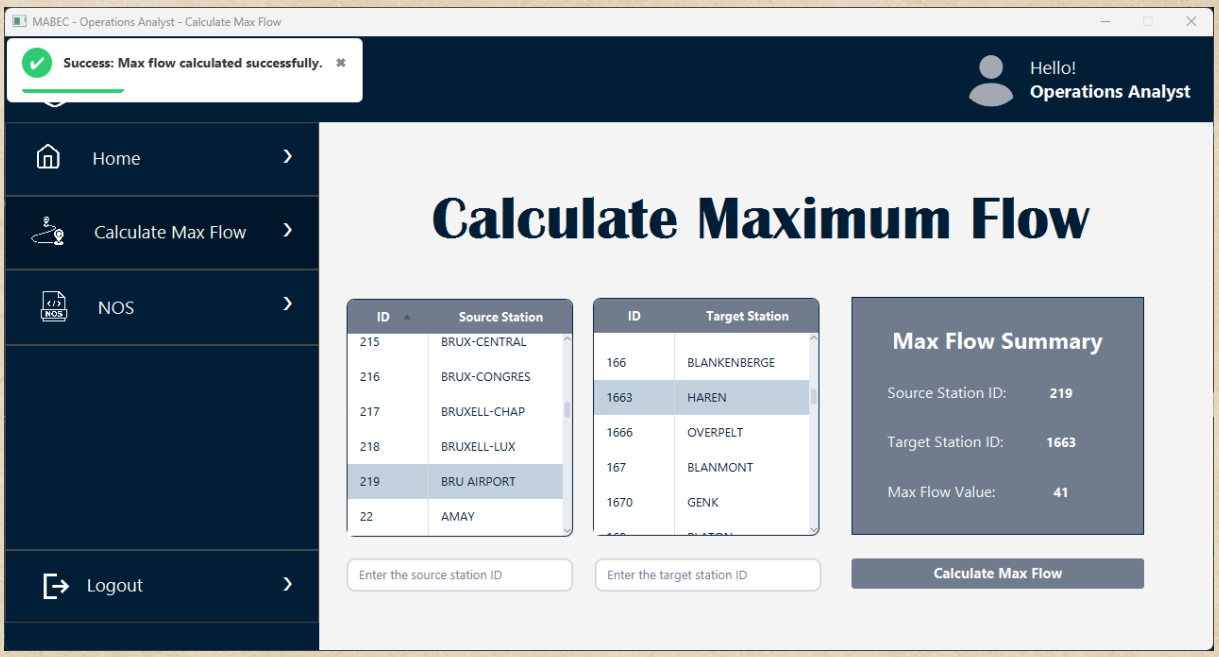

Figure 5.32: Max Flow Calculation Result

The **Max Flow Summary** panel is updated with:

- Source Station ID,
- Target Station ID,
- Max Flow Value.

This value represents the theoretical upper bound on the number of trains that can circulate between the two stations within the given network constraints.

5.8.2 NOS

The **NOS** (Network Optimisation System) page provides access to detailed system logs related to network operations and analytical calculations. Figure 5.33 shows the NOS interface.

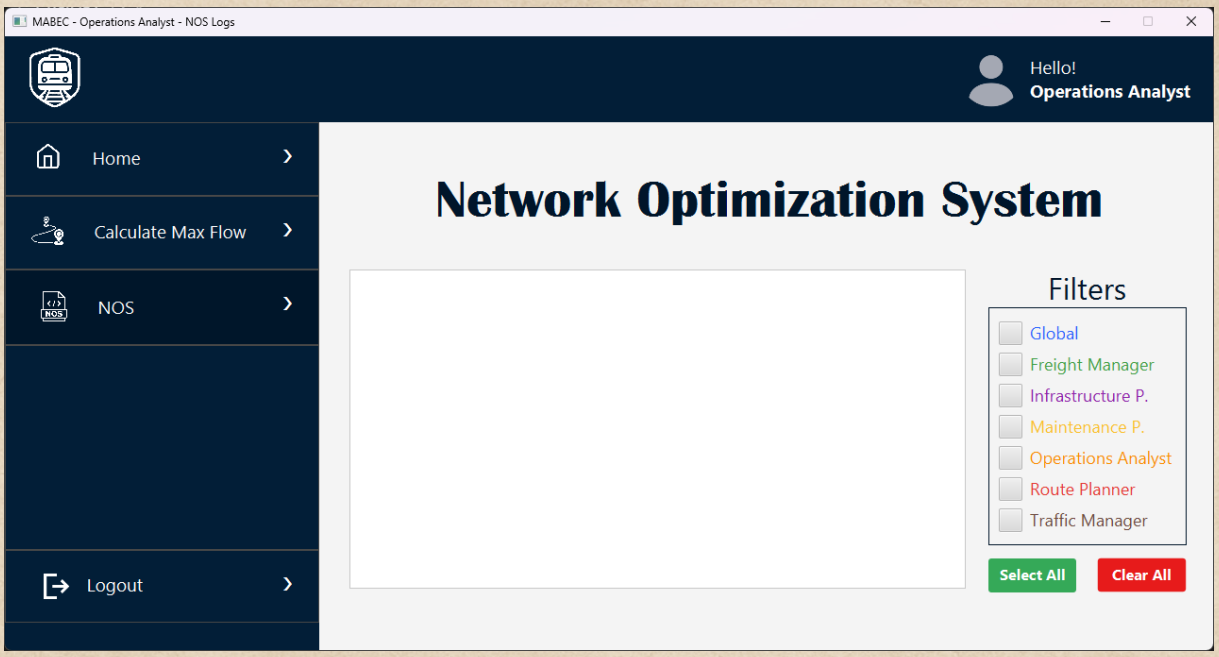

Figure 5.33: Network Optimisation System Logs

The central panel displays a chronological list of log messages generated by the system, including information about loaded paths, freight data, and calculated max flow results.

Log Filters

On the right side of the screen, a filter panel allows the user to filter log messages by module or user role, including:

- Global
- Freight Manager
- Infrastructure Planner
- Maintenance Planner
- Operations Analyst
- Route Planner
- Traffic Manager

The **Select All** and **Clear All** buttons allow quick activation or removal of all filters, helping the Operations Analyst focus only on the most relevant information.

5.8.3 Logout

Selecting the **Logout** option from the side menu ends the current session and returns the user to the Login page.

5.9 Operations Planner

The Operations Planner analyses station locations and their geographical distribution to support strategic decisions. In the Logistics on Rails project, this role uses radius and proximity searches to identify all stations within a given distance and obtain summaries by country or station type.

Figure 5.34 presents the Operations Planner Home Page.

Figure 5.34: Operations Planner Home Page

The Operations Planner helps assess regional coverage, identify areas with higher or lower rail density, and support operational planning based on real data.

5.9.1 Radius Search

The Radius Search tool allows the Operations Planner to obtain all stations located within a specific distance from a reference coordinate (latitude and longitude).

Figure 5.35 shows the main Radius Search interface.

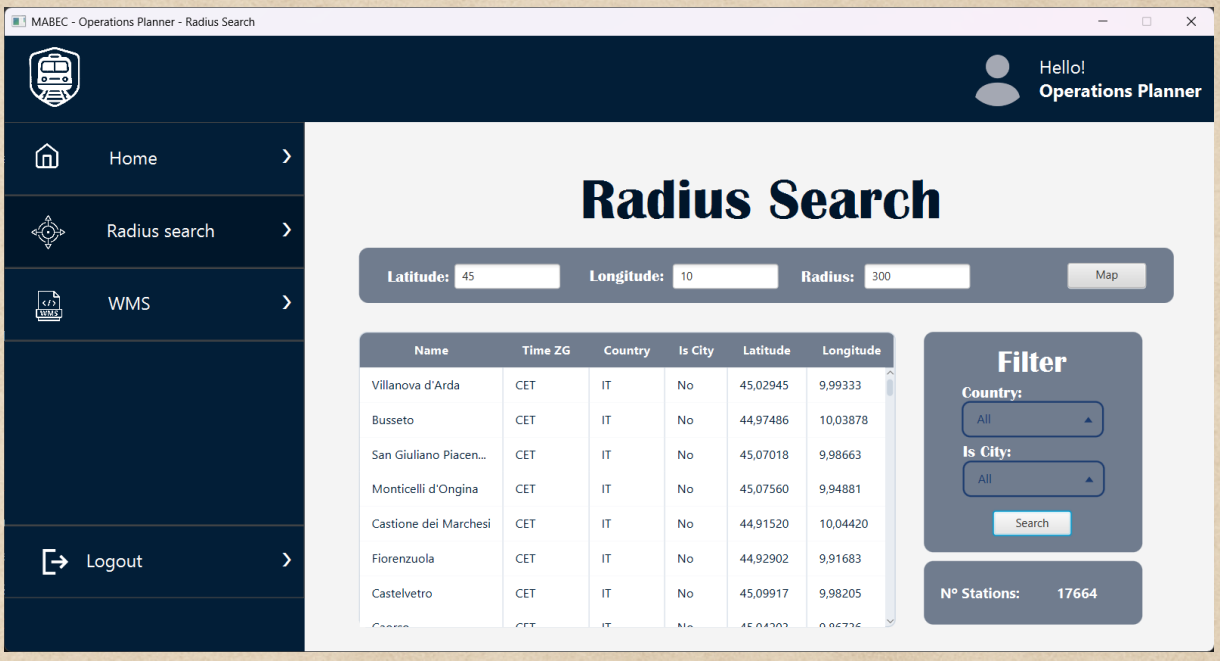

Figure 5.35: Radius Search Page

The interface includes the following input fields:

- **Latitude** – Starting latitude for the search.

- **Longitude** – Starting longitude for the search.
- **Radius** – Search radius in kilometres.

Selecting the **Map** button displays the matching stations on an interactive map.
On the right side of the page, the **Filter** panel allows additional filtering:

- **Country** – Filters stations by selected country code.
- **Is City** – Distinguishes between major cities and smaller localities.

Pressing the **Search** button refreshes the table with the filtered results.
At the bottom of the filter section, the total number of stations found is displayed for quick reference.

Map View

After selecting the **Map** button, the system opens a visual representation of all stations inside the selected radius.

Figure 5.36 shows the map view.

Figure 5.36: Map View of Radius Search Results

All stations matching the criteria are highlighted in red. The **Back** button in the top-left corner returns the user to the search interface.

5.9.2 WMS

The WMS (Warehouse Management System) page provides access to the user's activity logs. Although not directly related to operational planning, this feature ensures transparency and traceability of all actions taken within the system.

The WMS logs include:

- internal actions performed by the user,
- time-stamped activity records,
- system-level operations processed automatically.

5.9.3 Logout

Selecting the **Logout** button ends the session and returns the user to the Login page.

5.10 Picker

The Picker receives a picking plan — a list of bays (warehouse locations) where boxes must be collected. Before starting the route, any duplicate bays (same coordinates) are merged, with their quantities summed. The Picker's goal is to collect all boxes while travelling the shortest possible route.

Figure 5.37 shows the Picker Home Page.

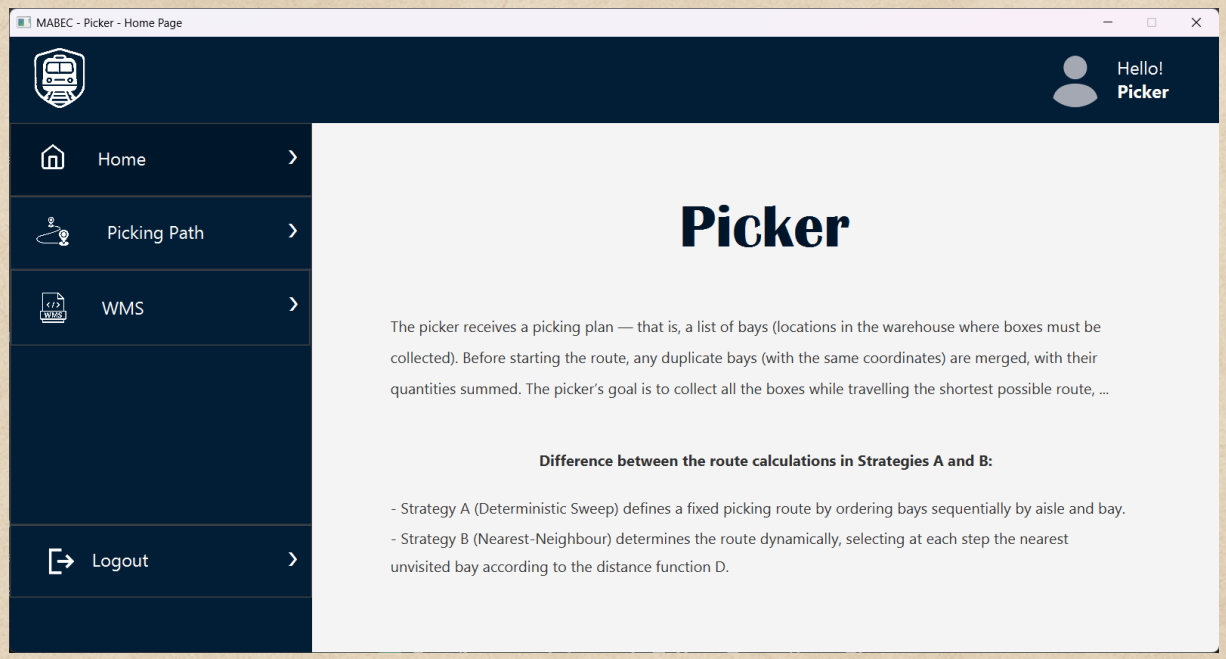

Figure 5.37: Picker Home Page

The initial section also explains the difference between the two route–calculation strategies:

- **Strategy A – Deterministic Sweep**: defines a fixed picking route by ordering all bays sequentially by aisle and bay.
- **Strategy B – Nearest–Neighbour**: dynamically determines the route, selecting at each step the nearest unvisited bay according to the distance function D.

5.10.1 Picking Path

The **Picking Path** page allows the Picker to select an available picking plan and view its detailed information. Figure 5.38 shows the main interface.

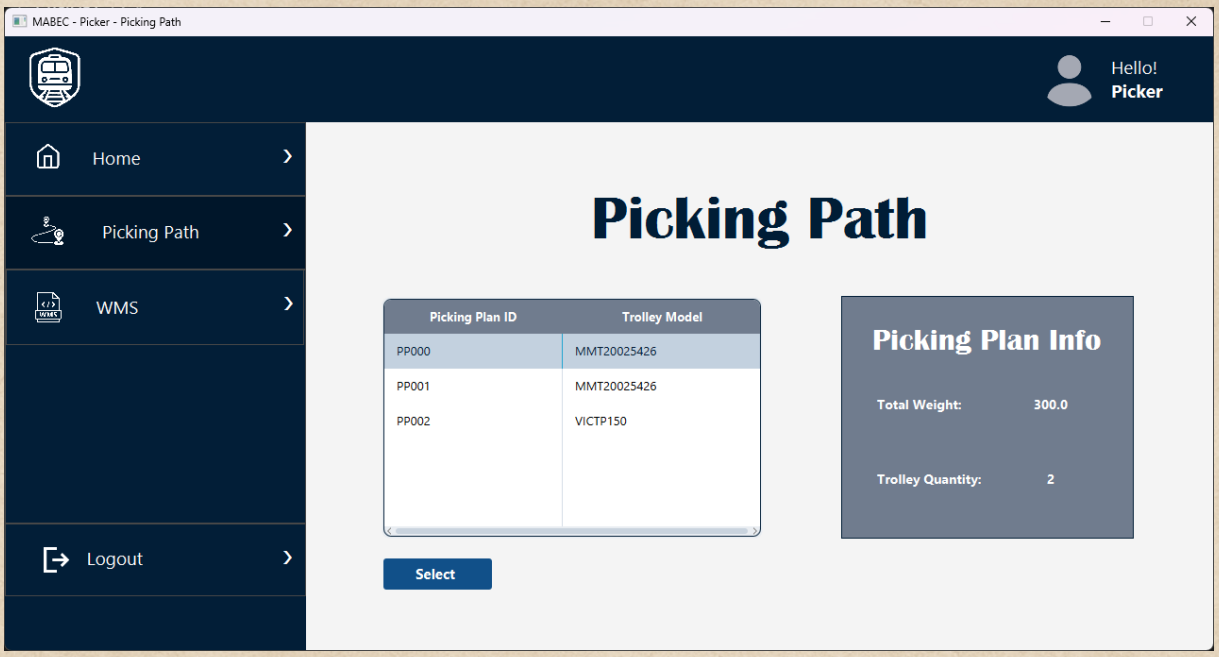

Figure 5.38: Picking Path Page

The table on the left displays all available picking plans, including:

- **Picking Plan ID** – Unique identifier of the picking plan.
- **Trolley Model** – Model of the trolley assigned to the plan.

If picking plans are available, they are listed automatically. When the user selects a plan from the table, the panel on the right — **Picking Plan Info** — is updated with:

- **Total Weight** – Total weight of the items to be picked.
- **Trolley Quantity** – Number of trolleys required to execute the plan.

Selecting a Picking Plan

After selecting a plan, the Picker may press the **Select** button to proceed to the next page. This action redirects the user to the **Calculate Paths – Strategies** interface, shown in Figure 5.39.

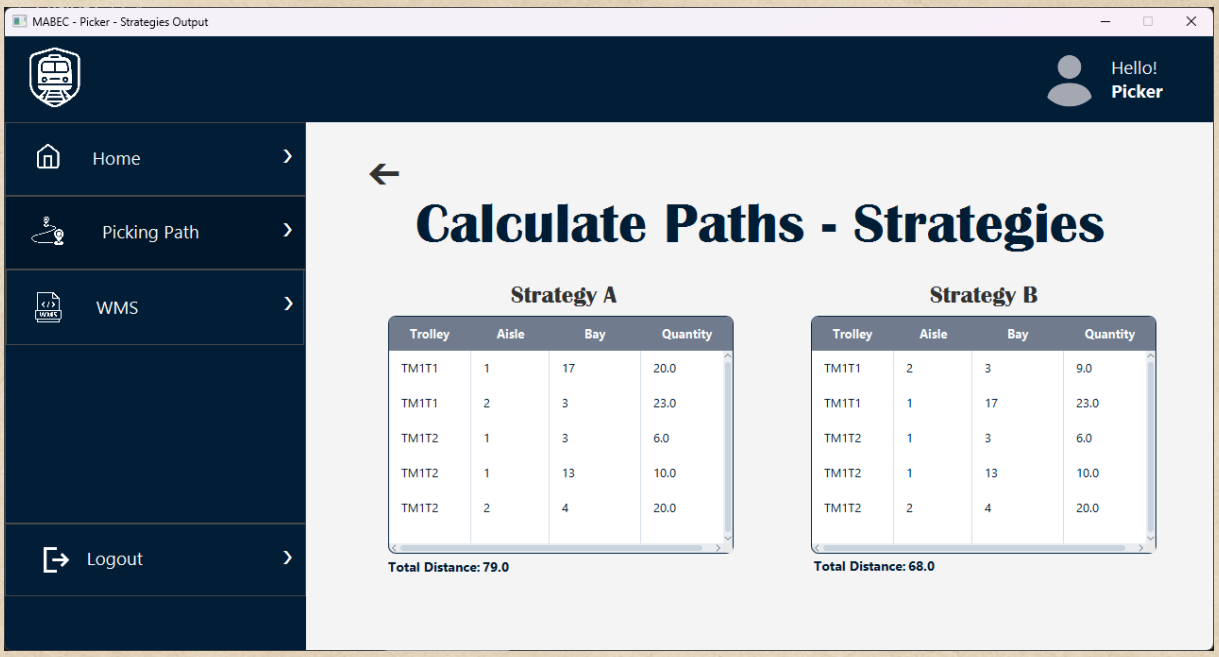

Figure 5.39: Picking Path Strategies Comparison

On this page, the system calculates and presents two alternative picking routes for the selected plan:

- **Strategy A**
- **Strategy B**

Each strategy is displayed in a separate table, detailing for each movement:

- **Trolley** – Identifier of the trolley performing the task.
- **Aisle** – Aisle where the picking operation occurs.
- **Bay** – Specific bay to be accessed.
- **Quantity** – Quantity picked at that location.

At the bottom of each table, the **Total Distance** travelled for the corresponding strategy is shown. This allows the Picker to directly compare the efficiency of both strategies and select the route that minimises travel distance and operational effort.

By providing alternative picking paths, the system supports more efficient warehouse navigation and helps optimise picking operations.

5.10.2 Logout

Selecting the **Logout** button ends the session and returns the user to the Login page.

5.11 Planner

The Planner is responsible for allocating order lines into trolleys while respecting weight constraints and ensuring an efficient distribution of all items. Each trolley has a predefined maximum weight capacity, and the Planner's task is to minimise the number of trolleys used while maximising space utilisation.

Figure 5.40 presents the Planner Home Page.

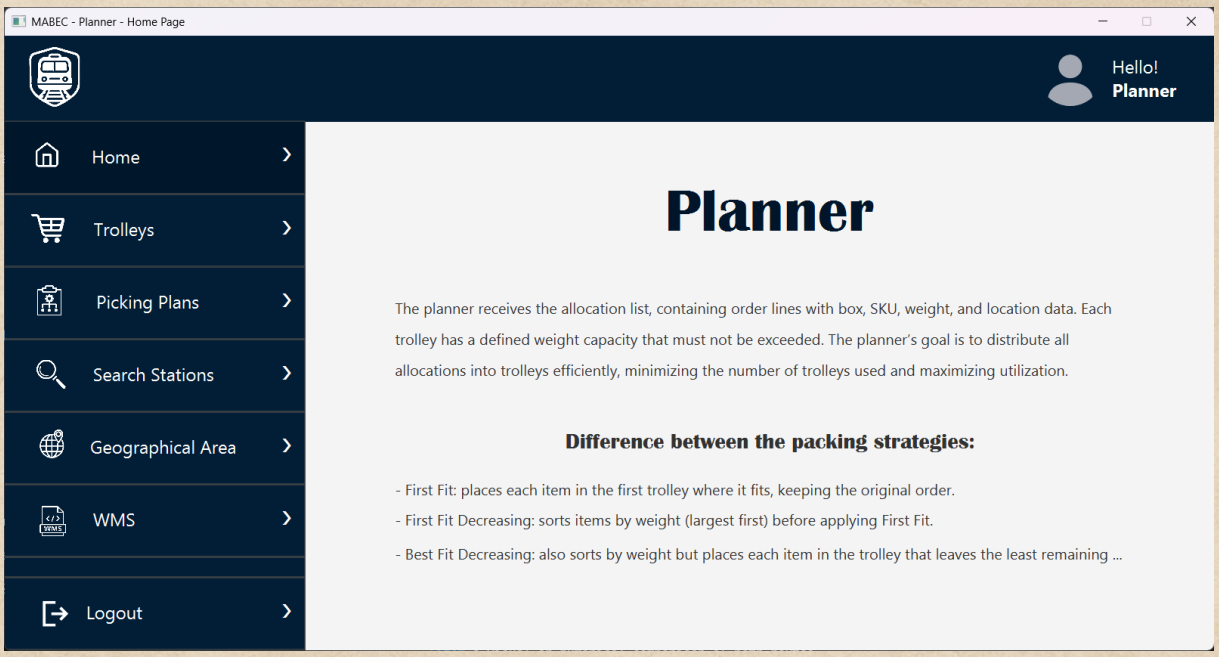

Figure 5.40: Planner Home Page

The introduction also highlights the differences between the available packing strategies:

- **First Fit**: Items are placed in the first trolley where they fit, following their original order.
- **First Fit Decreasing**: Items are sorted by decreasing weight before applying the First Fit method.
- **Best Fit Decreasing**: Items are sorted by decreasing weight and placed in the trolley that leaves the least remaining space.

These strategies allow the Planner to adjust how allocations are computed depending on operational requirements.

5.11.1 Trolleys

The **Trolleys** page enables the Planner to create new trolleys by defining their model and maximum weight capacity. Figure 5.41 shows the interface.

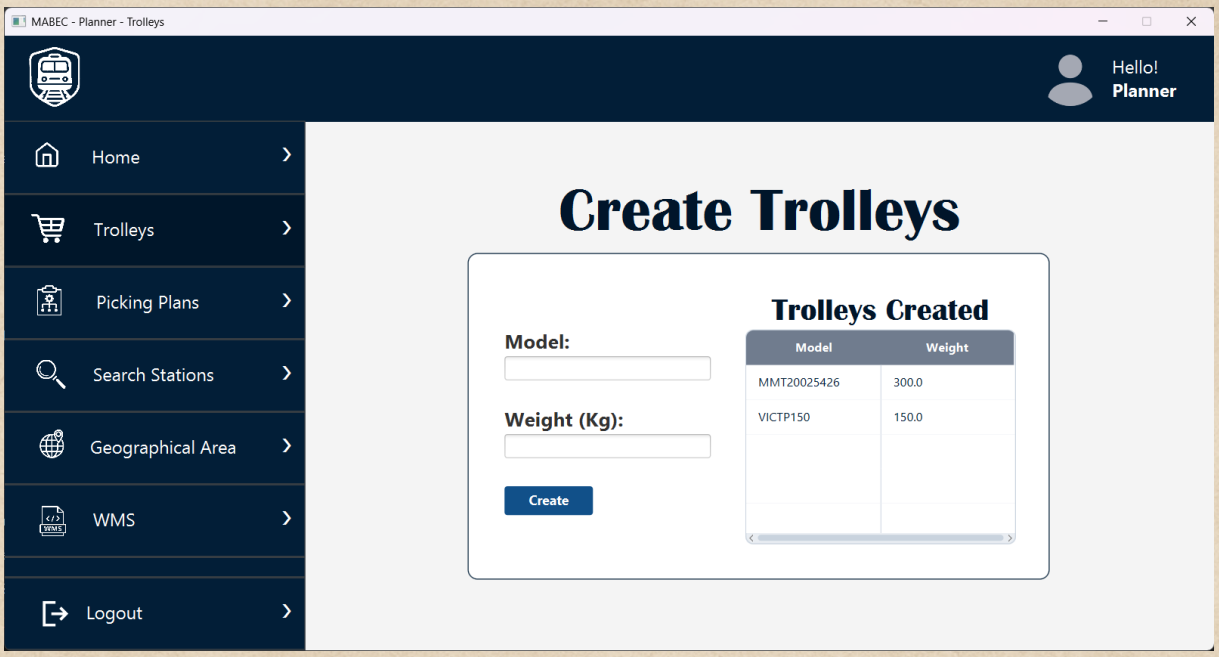

Figure 5.41: Create Trolleys Page

To create a trolley, the user must fill in:

- **Model** – Identifier of the trolley type.
- **Weight (kg)** – Maximum weight capacity allowed.

After selecting the **Create** button, the trolley is added to the list on the right. All created trolleys remain available for later allocation in the Picking Plans module.

5.11.2 Picking Plans

The **Picking Plans** page displays all order lines allocated for packing. Figure 5.42 illustrates this interface.

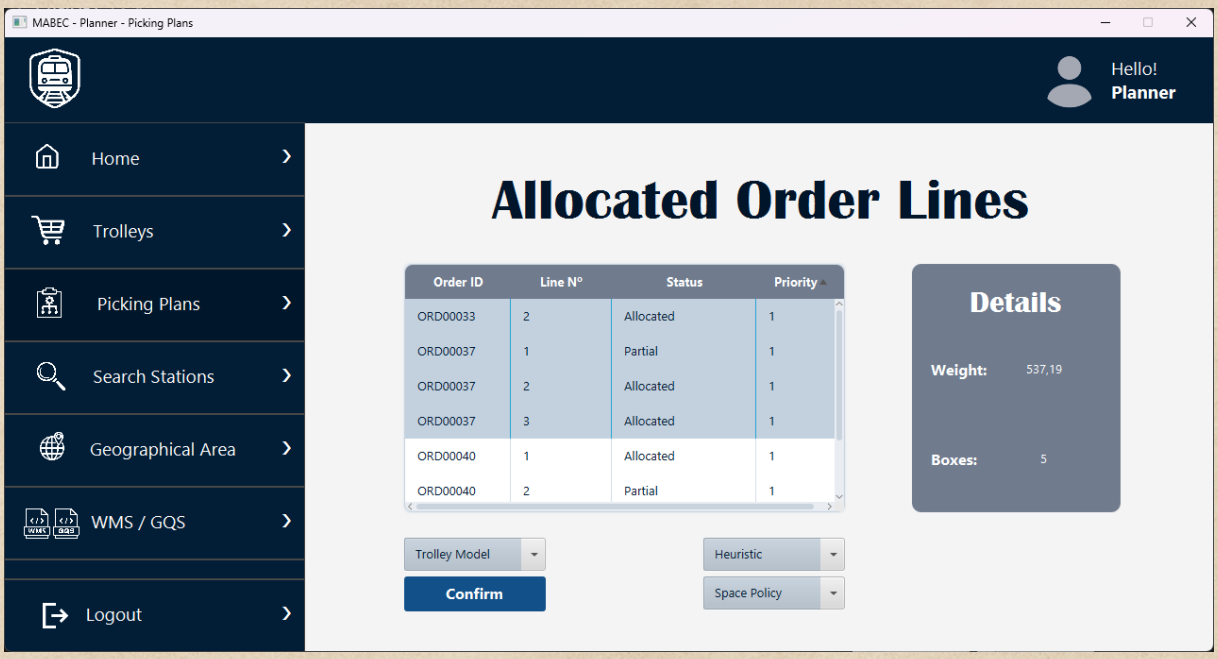

Figure 5.42: Allocated Order Lines Page

The table shows:

- **Order ID** – Identification of the order.
- **Line Nº** – The specific order line.
- **Status** – Allocation status.
- **Priority** – Picking priority value.

On the right side, the **Details** panel displays:

- **Total Weight** of the selected plan.
- **Total Boxes**.

Below the table, the user selects:

- a **Trolley Model** to use for allocation,
- a **Heuristic** (First Fit, First Fit Decreasing, or Best Fit Decreasing),
- a **Space Policy**.

Pressing **Confirm** performs the allocation of all order lines into trolleys according to the chosen strategy.

5.11.3 Search Stations

The **Search Stations** feature allows the Planner to locate stations using three different search structures: **Latitude Tree**, **Longitude Tree**, and **Time Zone Group Tree**. All search modes support map visualisation.

Latitude Tree Search

When selecting the **Latitude Tree** option, the system organises stations by latitude. The user enters two values:

- **Lower Value** – minimum latitude,
- **Higher Value** – maximum latitude.

Pressing the **Search** button filters the list to display only stations within this latitude interval. Figure 5.43 shows the interface of the Latitude Tree search.

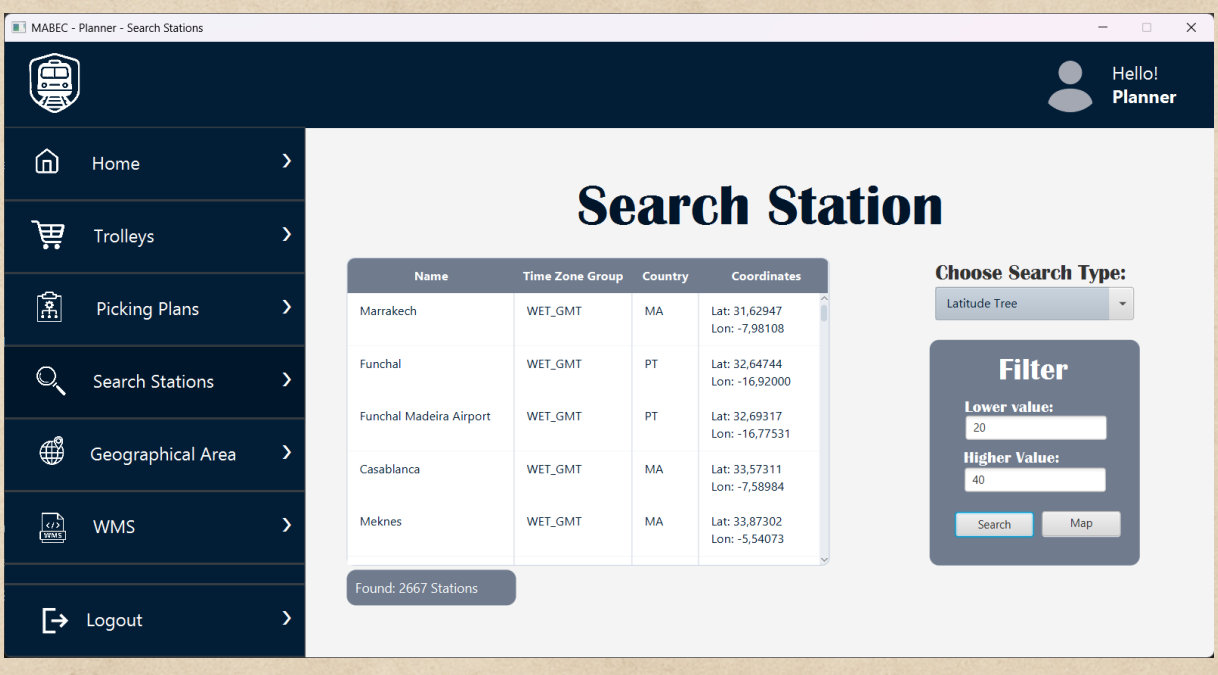

Figure 5.43: Search Stations – Latitude Tree Search

The **Map** button displays the filtered stations on a geographical world map. Figure 5.44 illustrates an example of this map view.

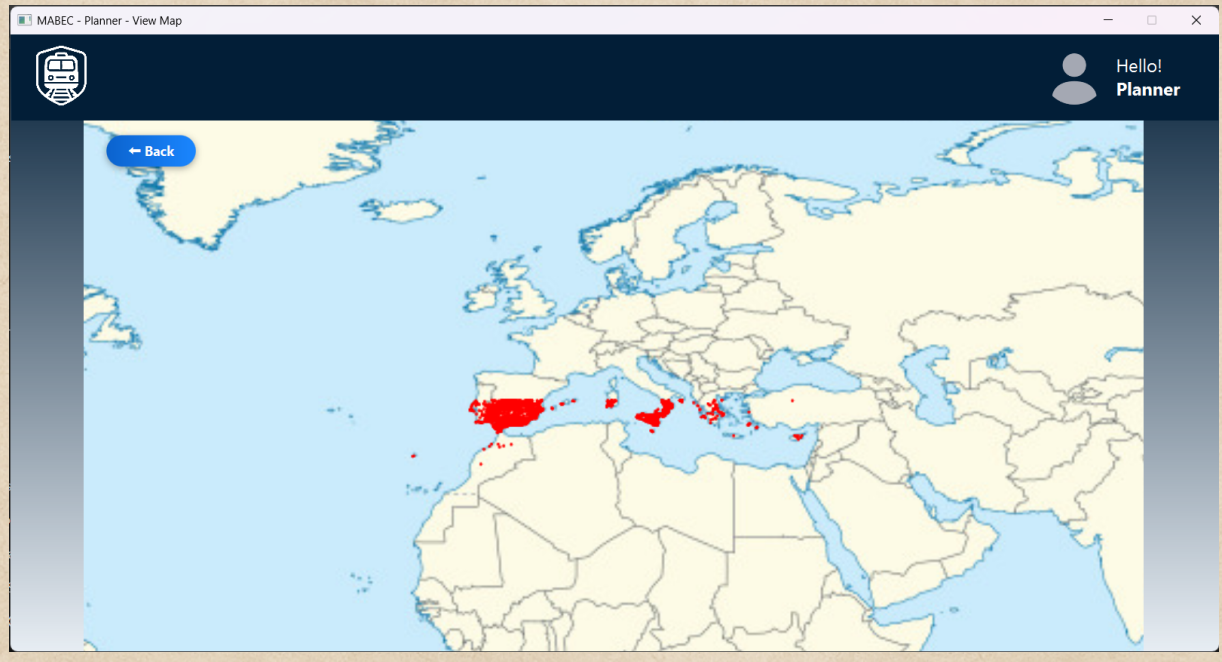

Figure 5.44: Map Visualisation – Latitude Tree Search

Longitude Tree Search

The **Longitude Tree** search follows the exact same logic as the Latitude Tree search. The only difference is that the user enters a minimum and maximum **longitude** instead of latitude.

This mode is useful for identifying stations located within a specific vertical geographic region.

The results can also be displayed on the map using the **Map** button.

Time Zone Group Tree Search

The **Time Zone Group Tree** search allows the Planner to refine the results based on temporal and geographic criteria. When this option is selected, additional filters become available:

- **Country**
- **Time Zone 1**
- **Time Zone 2**

Figure 5.45 shows this search mode.

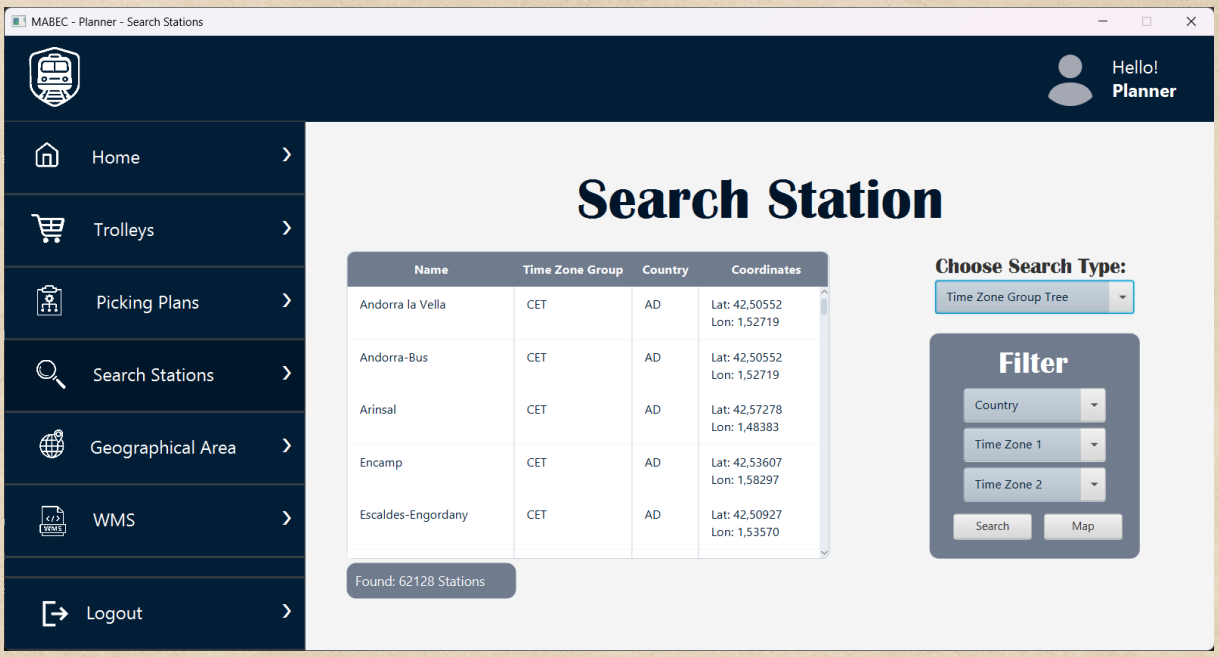

Figure 5.45: Search Stations – Time Zone Group Tree Search

This search is especially useful for planning operations involving multiple regions or countries with shared time zones. The **Map** button again allows the user to visualise all filtered stations geographically.

Map Visualisation for All Search Types

Regardless of the selected search mode — **Latitude Tree**, **Longitude Tree**, or **Time Zone Group Tree** — the user may at any time press the **Map** button to obtain a global map showing all matching stations.

This consistent visual output helps the Planner interpret results more easily, understand geographic density, and better support operational decisions.

5.11.4 Geographical Area

The **Geographical Area** page allows the Planner to search for stations inside a defined geographic rectangle based on latitude and longitude boundaries.

Figure 5.46 shows the interface.

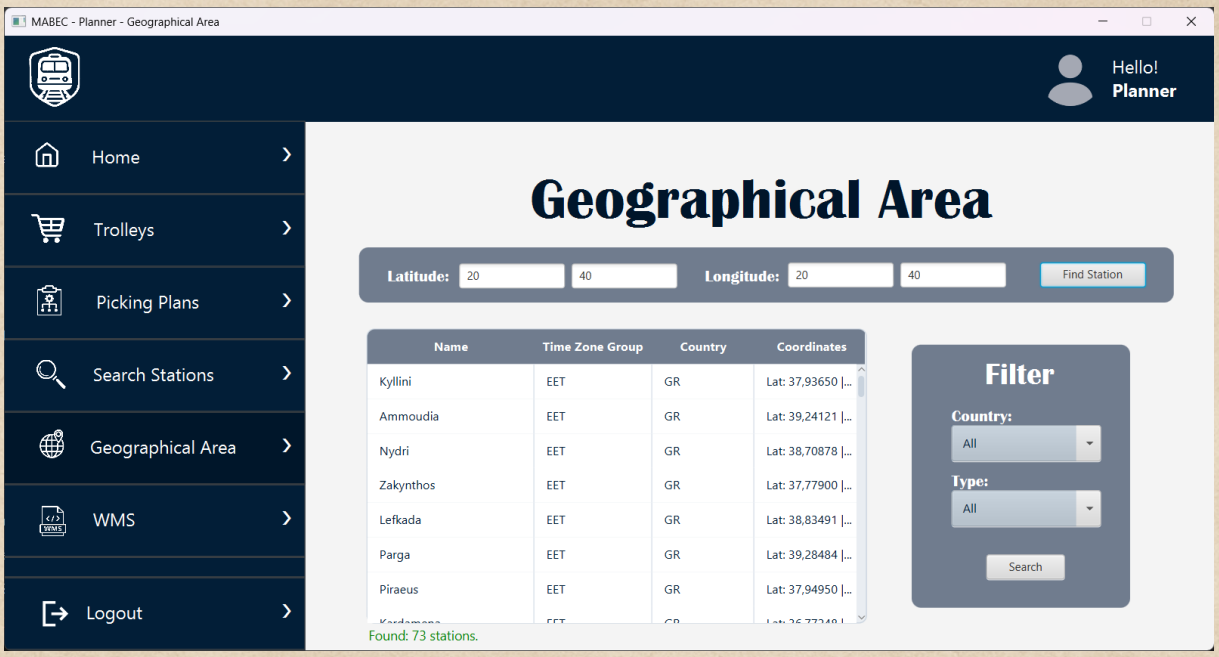

Figure 5.46: Geographical Area Search Page

The user defines:

- **Latitude Range** (min and max),
- **Longitude Range** (min and max).

Pressing **Find Station** lists all stations located within that geographical area. Filters on the right allow refinement by:

- **Country**,
- **Type** (city or non-city station).

The total number of results is displayed at the bottom.

5.11.5 WMS

As with all roles, the **WMS** (Warehouse Management System) section provides access to the user's activity log. This record includes timestamps and all operations performed within the system, ensuring traceability and accountability.

5.11.6 Logout

Selecting the **Logout** button ends the current session and returns the user to the Login page.

5.12 Quality Operator

The Quality Operator is responsible for managing returned goods within the warehouse. All returned items are first placed in **quarantine** to ensure quality and safety before they can re-enter inventory. This prevents damaged, expired, or otherwise unsuitable products from being mixed with usable stock.

During inspection, returns are processed in reverse order of arrival (latest first). Depending on their condition and the reason for the return, items may be:

- **Restocked** — placed back into inventory following FEFO/FIFO rules,
- **Discarded** — removed from the warehouse if not suitable for reuse,

- **Partially Restocked** — when a box contains multiple units and only a subset is suitable for restocking.

Each inspection generates a detailed audit entry recording:

- timestamp,
- return ID,
- SKU,
- action taken (Restocked, Partial Restock, or Discarded),
- quantity.

Figure 5.47 shows the Quality Operator Home Page.

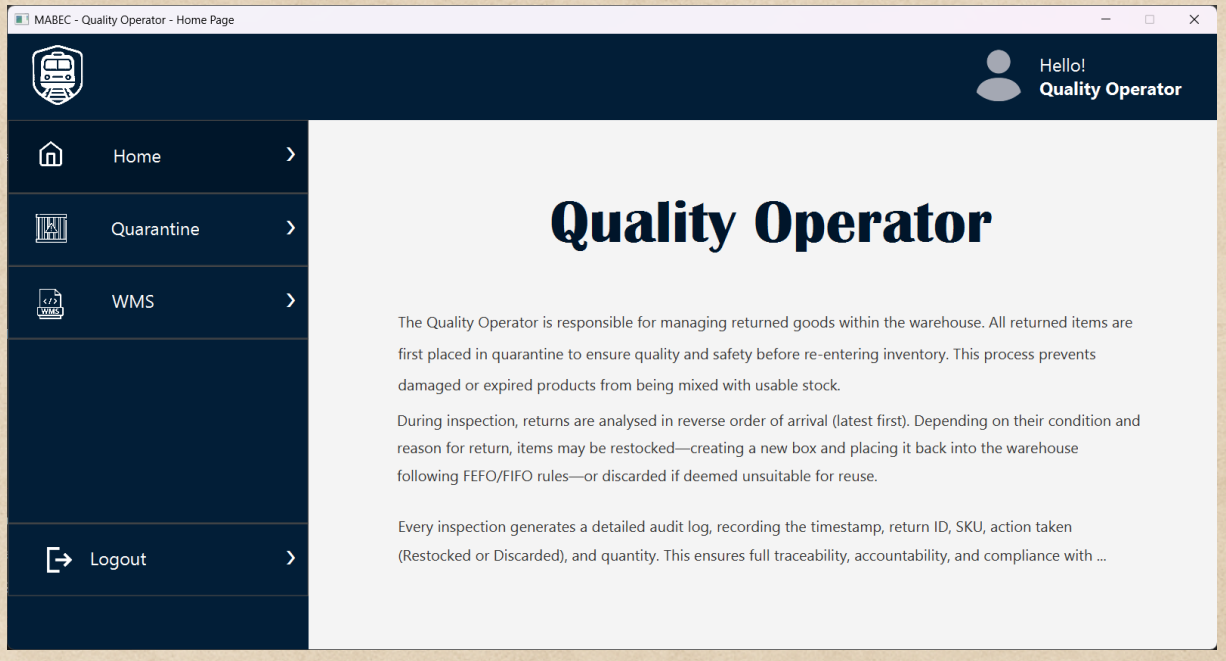

Figure 5.47: Quality Operator Home Page

5.12.1 Quarantine

The **Quarantine List** page displays all returned items that are awaiting inspection by the Quality Operator. Figure 5.48 shows this interface.

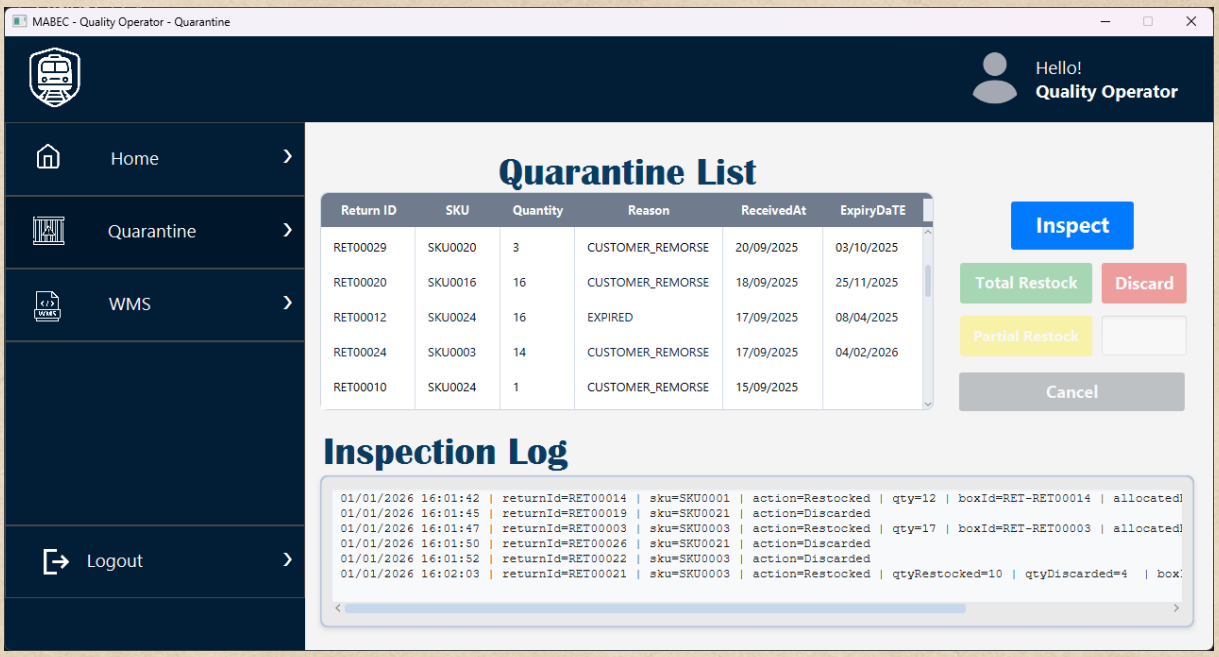

Figure 5.48: Quarantine List Page

The table presents detailed information for each returned item, including:

- **Return ID** – Unique identifier of the return.
- **SKU** – Identifier of the returned product.
- **Quantity** – Number of units returned.
- **Reason for Return** – Reason associated with the return (e.g., expired, customer remorse).
- **Received At** – Date when the return was received.
- **Expiry Date** – Expiration date of the product.

To start the inspection process, the Quality Operator selects an item from the table and presses the **Inspect** button.

Inspection Actions

After pressing **Inspect**, the inspection actions become available:

- **Total Restock** – The entire quantity is suitable and is returned to inventory.
- **Discard** – The entire quantity is unsuitable and is permanently removed from the warehouse.
- **Partial Restock** – Used when only part of the returned quantity can be safely restocked.

Items immediately discarded Some returned items, such as expired products, damaged packaging, or perishable goods showing signs of deterioration, are automatically unsuitable for reuse. In these cases, the Quality Operator selects **Discard**, and the full quantity is removed from usable inventory.

Items eligible for restocking If the returned goods meet quality requirements, the Quality Operator may select **Total Restock**. The system creates a new box record and places the items back into inventory, respecting FEFO/FIFO rules.

Boxes with multiple units (Partial Restock) Returned boxes may contain several units. If only part of the quantity is compliant, the operator specifies the amount to restock, while the remaining units are discarded. This guarantees that only products meeting quality standards are returned to inventory.

Inspection Log

At the bottom of the page, the **Inspection Log** displays all completed inspections in chronological order. Each log entry includes:

- Return ID,
- SKU,
- Action taken,
- Quantities processed,
- Timestamp.

This log ensures full traceability, accountability, and compliance with warehouse quality and safety standards.

5.12.2 Logout

Selecting the **Logout** button ends the current session and returns the user to the Login page.

5.13 Route Planner

The Route Planner is responsible for defining and analysing routes that trains can follow between two stations, supporting freight delivery planning and network validation. Figure 5.49 shows the Route Planner Home Page.

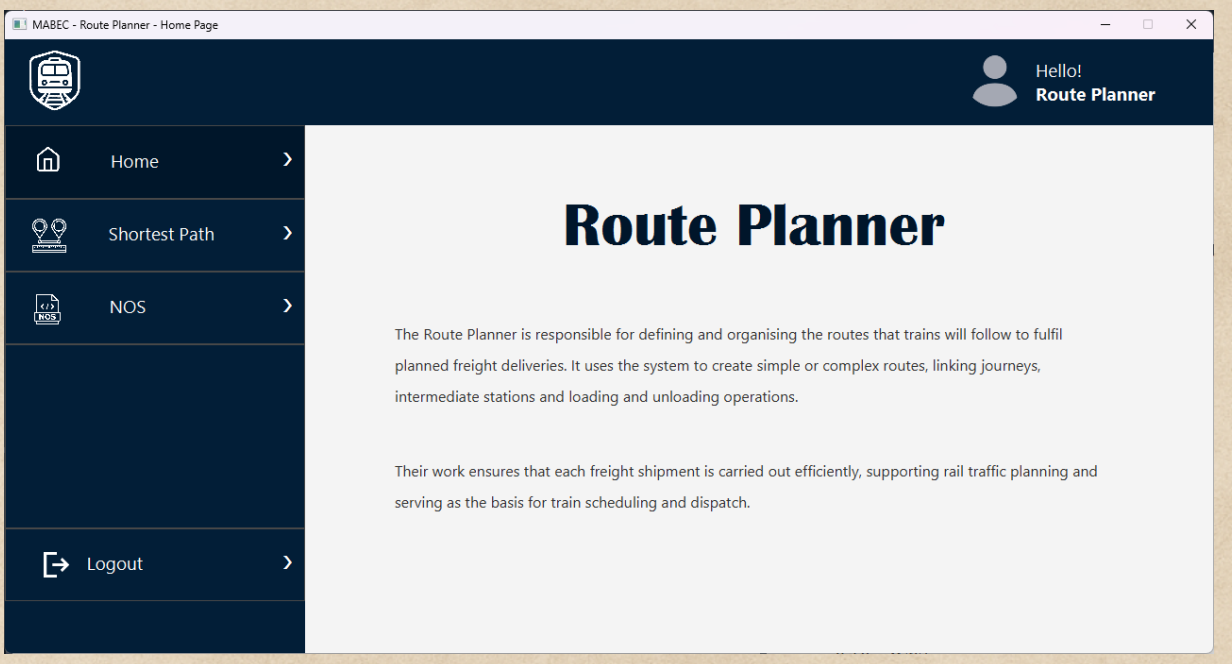

Figure 5.49: Route Planner Home Page

From the side menu, the Route Planner can access:

- **Shortest Path** – to calculate and visualise the best route between two stations.
- **NOS** – to consult system logs and filter events by role.

5.13.1 Shortest Path

The **Shortest Path** page allows the Route Planner to compute the best route between an initial station and a final station, based on the network cost values. Figure 5.50 shows the main interface.

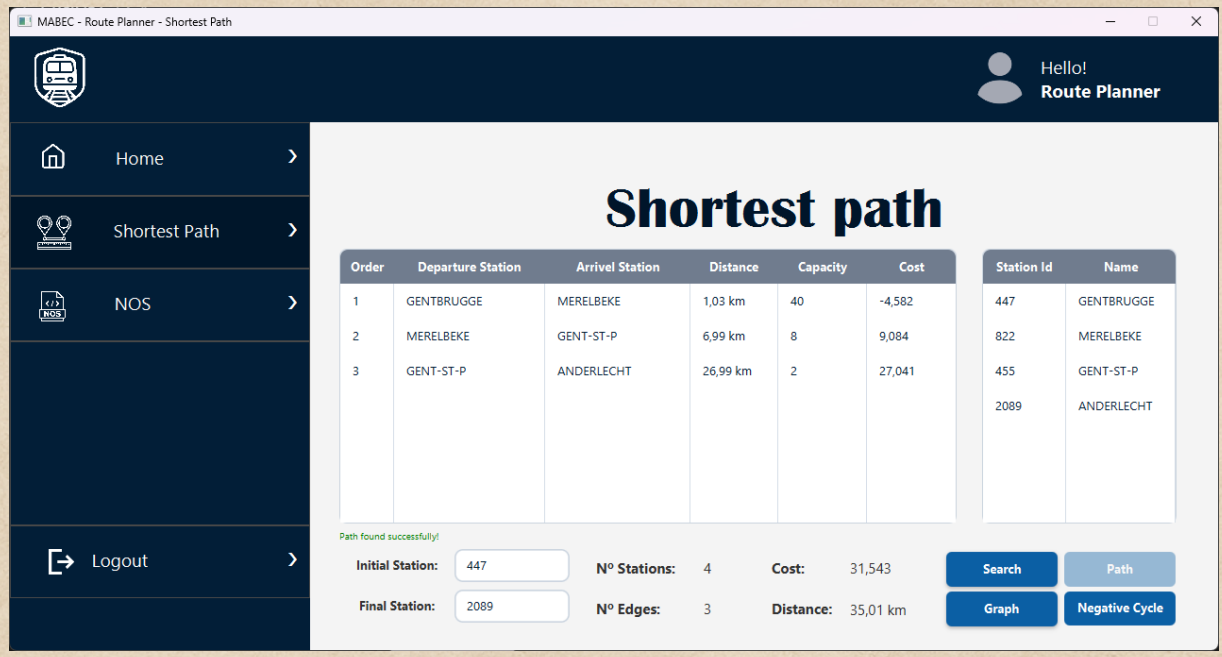

Figure 5.50: Shortest Path Page

The results area is composed of:

- A table with the route steps (*Order*, *Departure Station*, *Arrival Station*, *Distance*, *Capacity*, *Cost*).
- A station list on the right with each station **ID** and **Name**.

At the bottom of the page, summary fields present:

- **Nº Stations**, **Nº Edges**,
- total **Cost** and total **Distance**.

Search and Route Actions

The page provides input fields for:

- **Initial Station** (ID),
- **Final Station** (ID).

The available buttons are:

- **Search** – used when the user wants to calculate a route for different initial/final station IDs.
- **Path** – generates/displays the route path (this option may already be active when entering the page, but can be recalculated when new stations are chosen).
- **Graph** – opens a graphical representation of the computed path.
- **Negative Cycle** – checks whether the chosen path/network contains a negative cycle (when applicable).

Graph View

When selecting **Graph**, the system opens a visual representation of the route, showing the stations as nodes and the connections as edges with their respective cost values. Figure 5.51 illustrates this view.

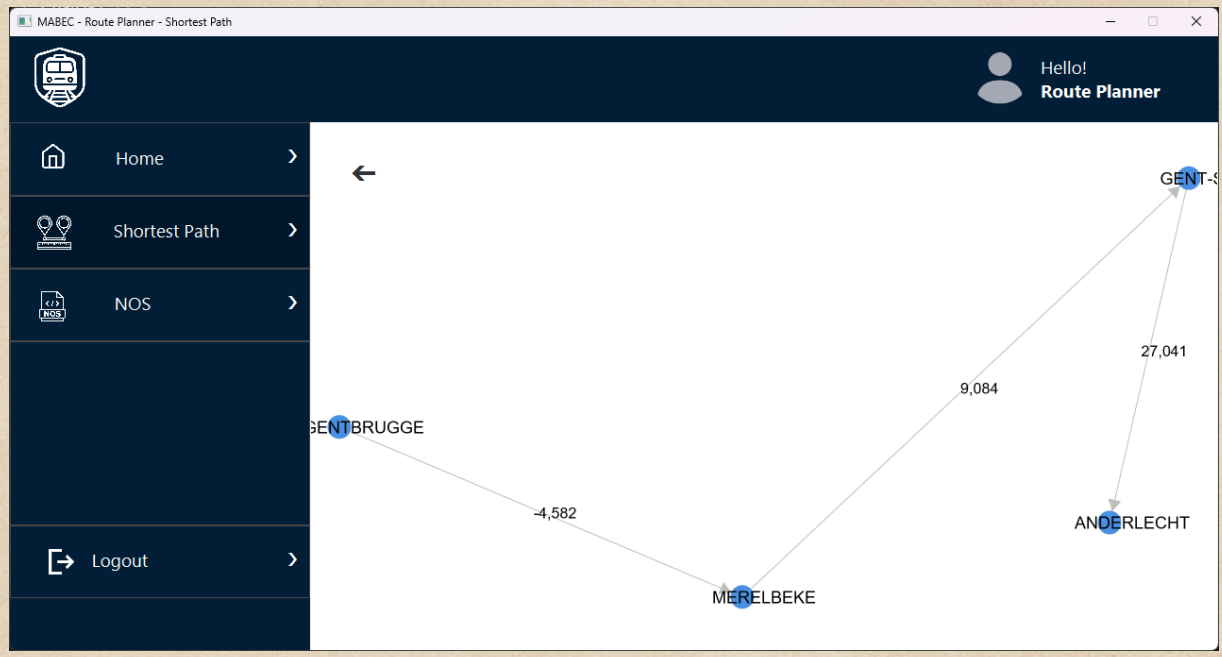

Figure 5.51: Graph View of the Calculated Path

The **Back** arrow in the top-left corner returns the user to the Shortest Path interface.

Negative Cycle Result

The **Negative Cycle** option allows the Route Planner to detect whether the selected route is affected by a negative cycle. Figure 5.52 shows an example where a negative cycle is identified, and the results become undefined (e.g., cost as $-\infty$).

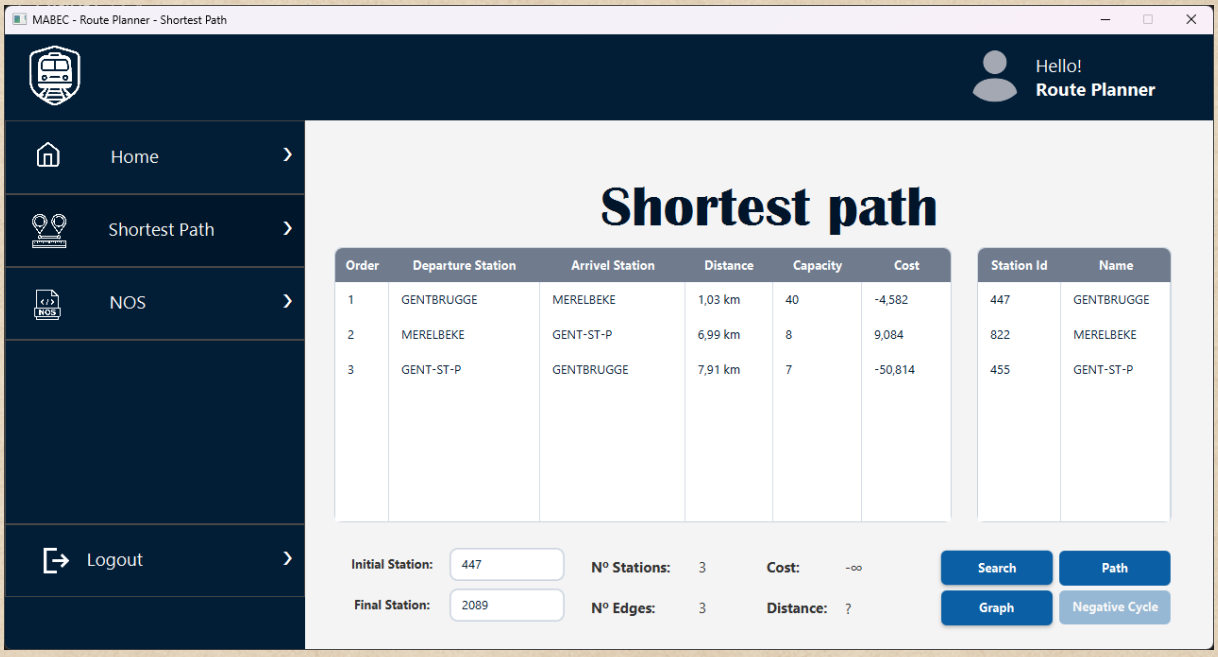

Figure 5.52: Negative Cycle Detection Example

5.13.2 NOS

The **NOS** (Network Optimization System) page displays logs generated by the system and allows filtering by role. Figure 5.53 shows the NOS Logs interface.

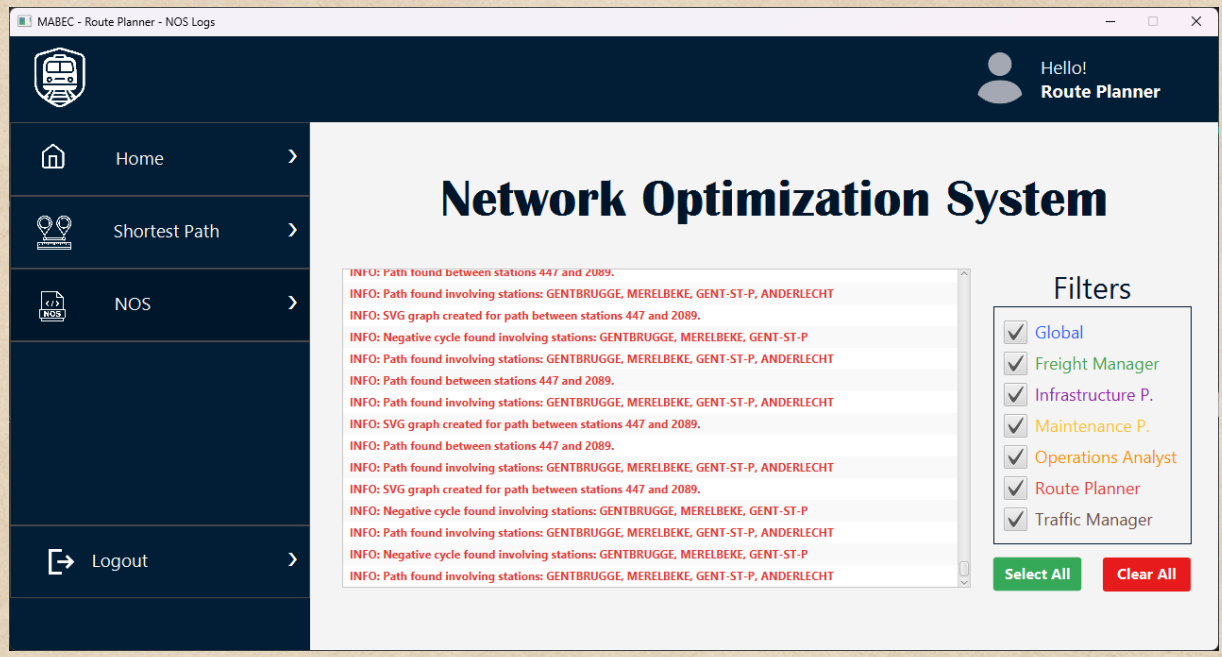

Figure 5.53: NOS Logs Page

The filters can be selected individually, or managed using:

- **Select All** – selects all filters at once.
- **Clear All** – removes all selected filters.

This page helps the Route Planner track executed operations such as path searches, graph generation, and negative cycle detection, improving traceability and debugging.

5.13.3 Logout

Selecting the **Logout** button ends the session securely and returns the user to the Login page.

5.14 Terminal Operator

The Terminal Operator is responsible for unloading wagons and correctly storing their boxes within the warehouse bays, ensuring proper stock organisation and rotation. Figure 5.54 shows the Terminal Operator Home Page.

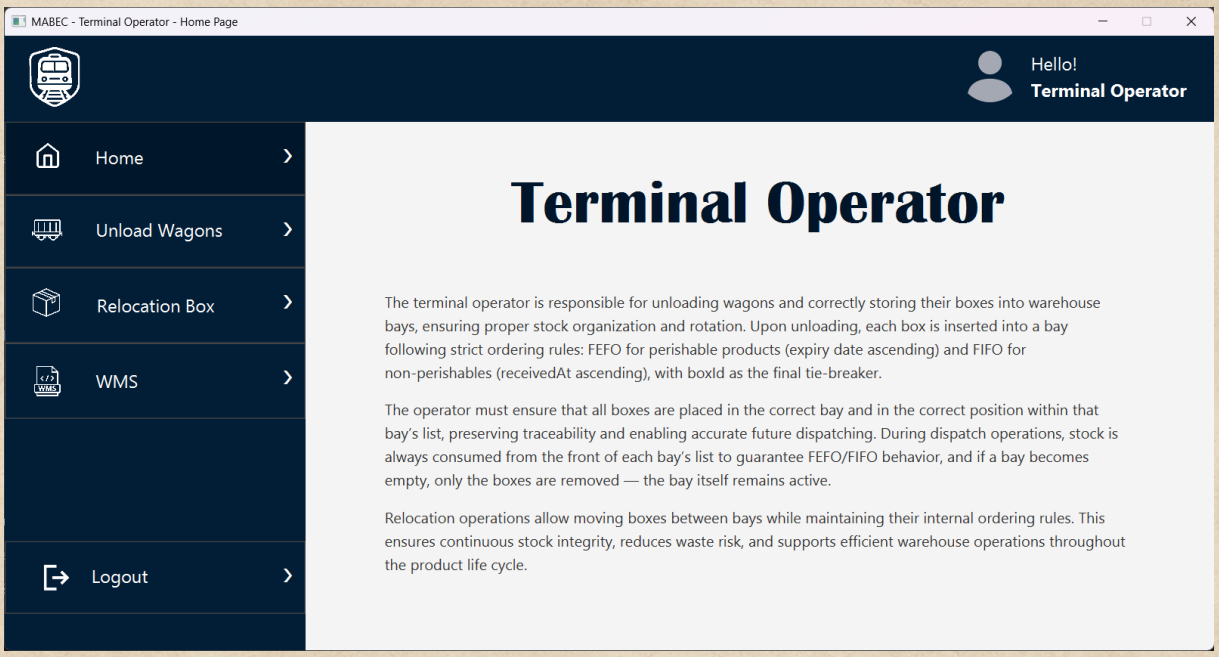

Figure 5.54: Terminal Operator Home Page

Upon accessing the system, the Home Page provides an overview of the Terminal Operator's responsibilities, including box insertion rules, stock integrity, and bay rotation policies. It also serves as the entry point to the three main operational modules:

- **Unload Wagons**
- **Relocation Box**
- **WMS**

Boxes are inserted into bays using strict FEFO/FIFO rules:

- **FEFO** (expiry date ascending) for perishables,
- **FIFO** (receivedAt ascending) for non-perishables,
- **boxId** acts as a final tie-breaker.

This ensures accurate rotation, traceability, and efficient dispatching throughout the warehouse.

5.14.1 Unload Wagons

The **Unload Wagons** page lists all wagons currently ready to be unloaded into a chosen warehouse. Figure 5.55 shows this interface.

Figure 5.55: Unload Wagons Page

Each entry contains:

- **Wagon ID**,
- **Box Quantity**,
- **Select** checkbox.

The operator may unload a single wagon or multiple wagons at once using **Select All**. Before confirming, a warehouse must be selected from the dropdown menu.

Box and SKU Overview

When wagons are selected:

- A **pie chart** appears in the centre, showing the SKU distribution by total item quantity.
- The right panel lists all SKUs loaded in the selected wagons, including:
  - SKU,
  - Number of boxes,
  - Total quantity of items.

This overview helps anticipate warehouse bay allocation, especially for highly represented SKUs.

Pressing **Confirm** unloads the selected wagons, inserting each box into the correct bay according to FEFO/FIFO ordering rules.

5.14.2 Relocation Box

The **Relocation Box** page enables box movements between bays while preserving internal ordering logic. Figure 5.56 shows the initial automatic relocation interface.

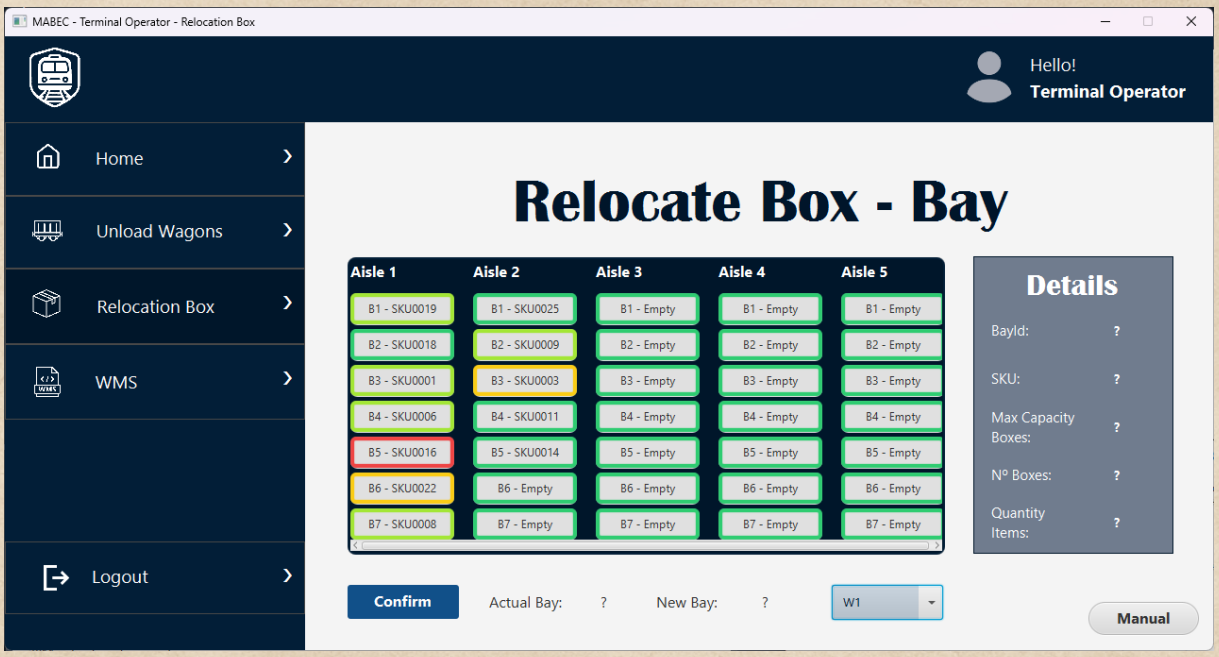

Figure 5.56: Relocate Box Page – Automatic Mode

Warehouse Overview with Bay Status Colours

After selecting a warehouse, all bays are displayed with colour-coded shading indicating current capacity:

- **Green** – Bay with plenty of space available.
- **Yellow** – Bay partially filled.
- **Light Red** – Bay nearing capacity.
- **Dark Red** – Bay completely full.

These colour indicators help the operator quickly identify suitable bays for relocation.

Automatic Relocation

The automatic workflow consists of:

1. Selecting a box.
2. Viewing its **Current Bay** and choosing a **New Bay**.
3. Pressing **Confirm** to move the box while maintaining FEFO/FIFO order.

After pressing **Confirm**, the system redirects the user to the **Relocate Box – Box Selection** page, shown in Figure 5.57.

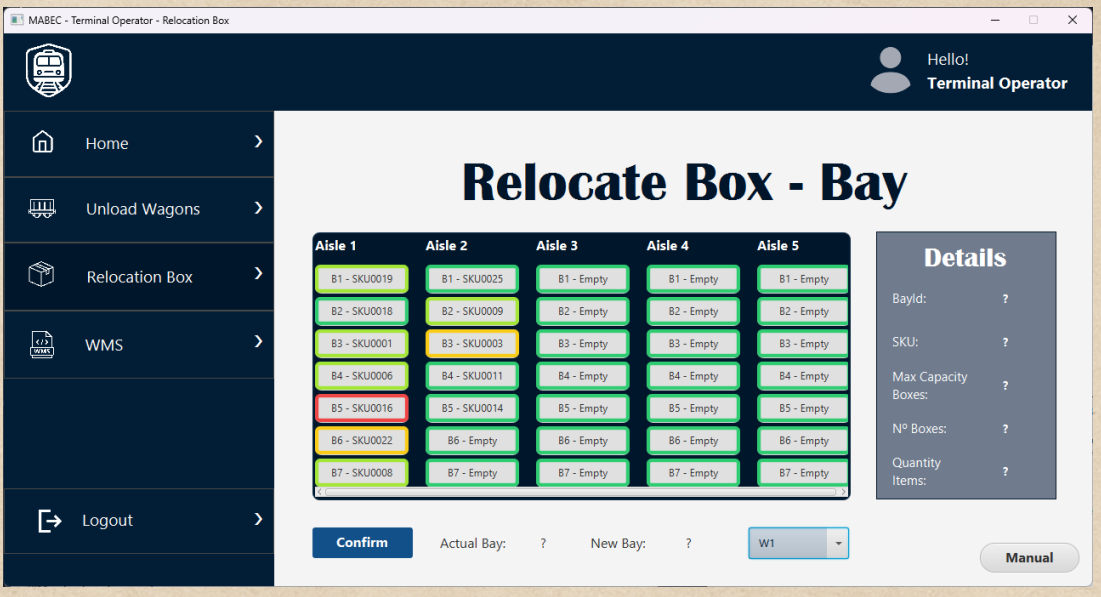

Figure 5.57: Relocate Box – Box Selection Page

This page displays a detailed list of all boxes currently stored in the selected bay. For each box, the following information is presented in a table:

- **Box ID** – Unique identifier of the box,
- **SKU** – Product identifier contained in the box,
- **Quantity** – Number of units stored in the box,
- **Expiry Date** – Expiration date of the products (when applicable),
- **Received Date** – Date and time when the box was received into the warehouse.

On the right side of the screen, a bar chart provides a visual comparison of the quantities stored in each box, helping the Terminal Operator quickly assess stock distribution and identify suitable candidates for relocation.

The Terminal Operator selects the box to be relocated and may then choose one of the available actions:

- **Confirm** – relocates the selected box to the previously chosen bay, ensuring that FEFO/FIFO ordering rules are preserved,
- **Relocate All** – relocates all listed boxes to the selected destination bay in a single operation, maintaining the correct insertion order.

Once the relocation is completed, a confirmation message is displayed, and the system updates the bay contents accordingly.

Manual Relocation Mode

The **Manual** button opens a detailed interface for full manual control, shown in Figure 5.58.

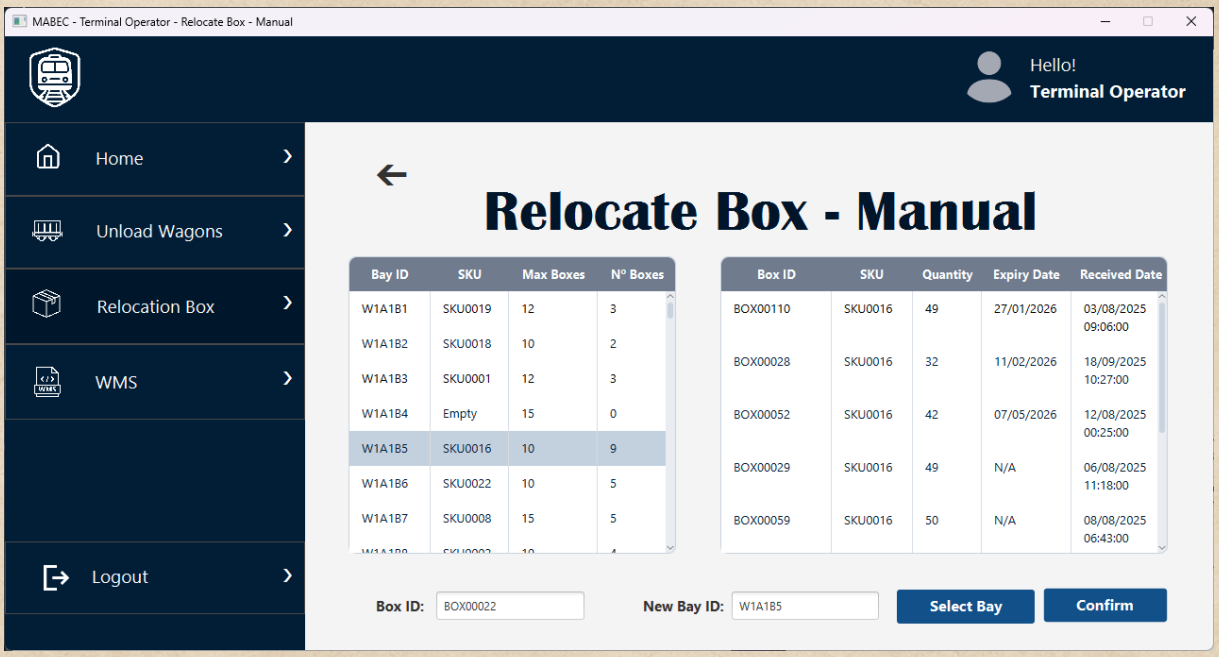

Figure 5.58: Relocate Box – Manual Mode

This mode includes two tables:

- **Bay Table** – lists all bays of the warehouse (Bay ID, SKU, max capacity, number of boxes).
- **Box Table** – shows all boxes inside the selected bay (Box ID, SKU, quantity, expiry date, received date).

Two workflows are available:

1. **Selection Workflow** Click a bay → click a box → fields **Box ID** and **New Bay ID** are filled automatically.
2. **Typing Workflow** The operator may manually enter:
   - Box ID,
   - New Bay ID,

   and press **Confirm**.

The system relocates the box and inserts it correctly into the destination bay's ordered list.

5.14.3 WMS

The **WMS** section displays all logged actions performed by the Terminal Operator, including unload operations and relocation tasks. It ensures traceability, accountability, and auditing within the warehouse.

5.14.4 Logout

Selecting the **Logout** button ends the current session and returns the operator to the Login page.

5.15 Traffic Dispatcher

The Traffic Dispatcher is responsible for calculating the estimated travel time between two stations that are directly connected by the railway network. Using the infrastructure data and line characteristics, this role identifies the relevant line segments, applies the allowed speed for each section, and computes the total travel time assuming instantaneous acceleration.

Figure 5.59 shows the Traffic Dispatcher Home Page.

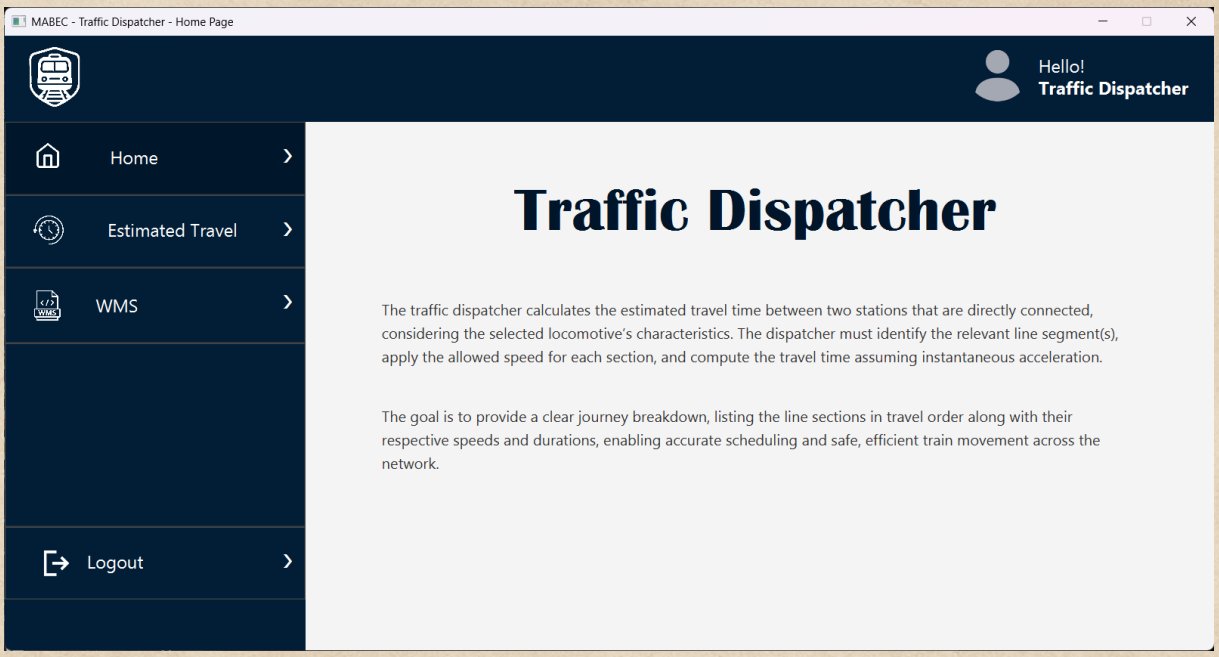

Figure 5.59: Traffic Dispatcher Home Page

This page briefly introduces the goal of the module: to provide a clear journey breakdown, listing all line sections in order of travel with their respective speeds, distances, and durations. This information supports accurate scheduling and safe, efficient train movement across the network.

5.15.1 Estimated Travel Time

The **Estimated Travel Time** page allows the Traffic Dispatcher to select a start station and an end station and obtain the detailed journey between them.

Figure 5.60 shows the initial view of this page.

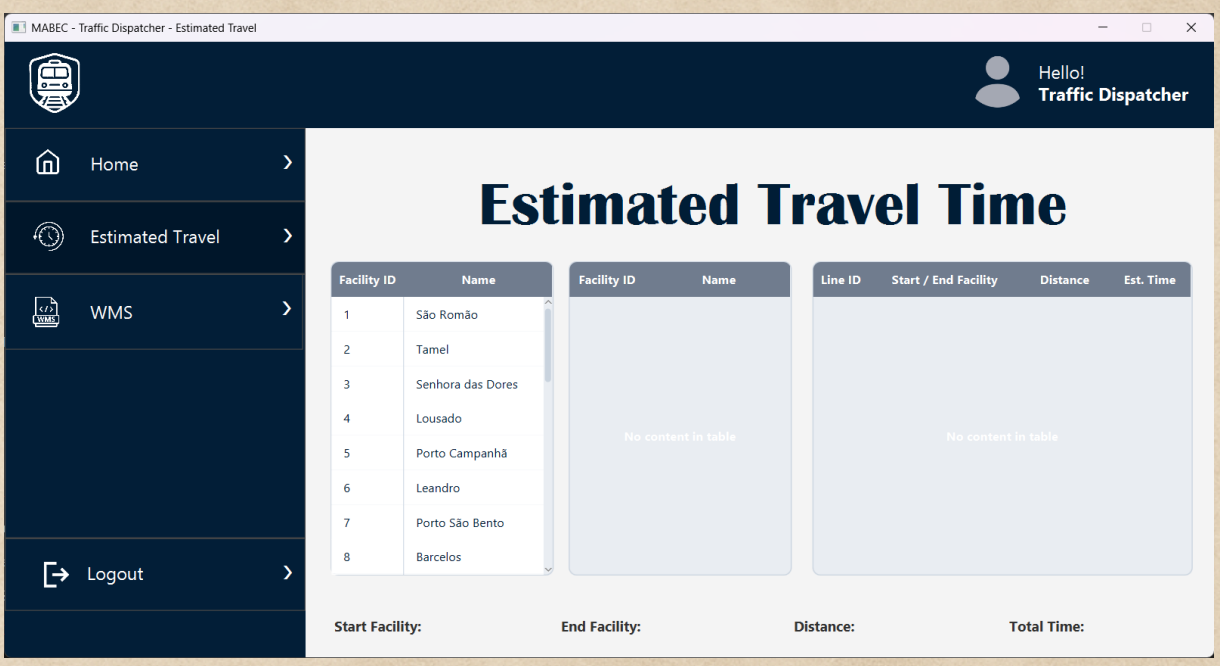

Figure 5.60: Estimated Travel Time Page – Initial View

The screen contains three main tables:

- **Start Facility** (left table) – Lists all available facilities (stations, terminals, depots).

- **End Facility** (centre table) – Lists facilities that can be reached from the selected start facility.
- **Line Segments** (right table) – Displays the detailed journey between the chosen start and end facility.

To calculate a journey:

1. The dispatcher selects the desired **Start Facility** from the left-hand table.
2. The middle table is then populated with all possible **End Facilities** reachable from that starting point.
3. After selecting an **End Facility** in the centre table, the right-hand table is filled with all line segments that connect the two facilities in travel order.

Figure 5.61 shows the interface after selecting a start facility and an end facility.

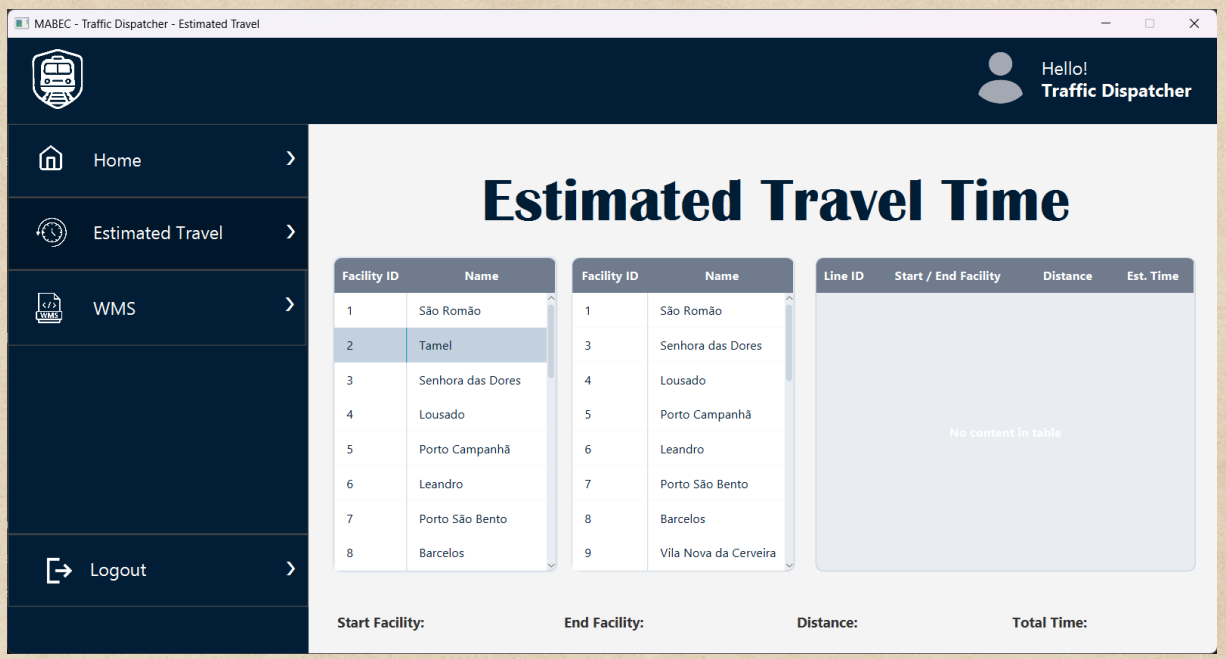

Figure 5.61: Estimated Travel Time Page – Connections

The **Line Segments** table on the right displays, for each section of the journey:

- **Line ID** – Identifier of the railway line segment.
- **Start / End Facility** – Facilities at the beginning and end of the segment.
- **Distance** – Length of the segment in kilometres.
- **Estimated Time** – Travel time required to cross the segment.

At the bottom of the page, summary fields show:

- the selected **Start Facility**,
- the selected **End Facility**,
- the total **Distance** of the journey (sum of all segments),
- and the overall **Total Time** required to travel from start to end.

This breakdown allows the Traffic Dispatcher to validate journey feasibility, compare alternative connections, and support timetable planning.

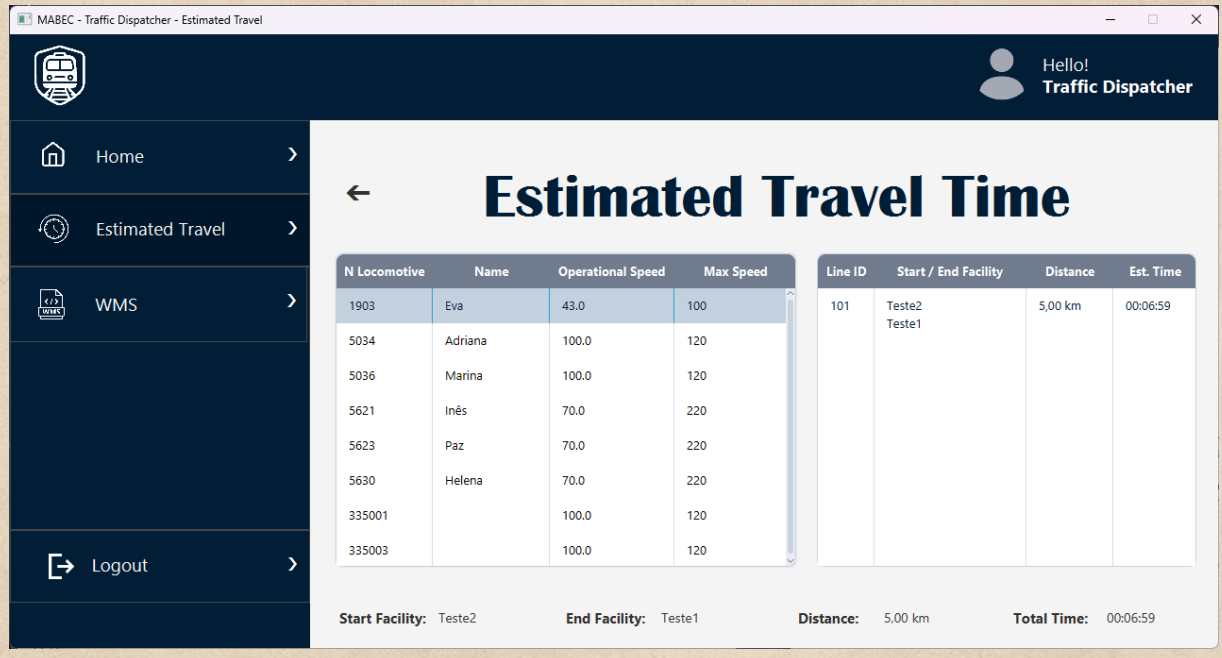

Figure 5.62: Estimated Travel Time Page – Journey Details

5.15.2 WMS

The **WMS** (Warehouse Management System) page provides access to the activity log associated with the Traffic Dispatcher. Although this role focuses on travel calculations rather than warehouse operations, the WMS log is shared across all roles to maintain a consistent audit trail.

The log records:

- user actions within the module,
- internal operations triggered by each calculation,
- and timestamps for traceability.

This information supports accountability and debugging whenever journey calculations need to be reviewed.

5.15.3 Logout

The **Logout** option safely ends the Traffic Dispatcher's session and returns the user to the Login page, ensuring that no further operations can be performed under that account until a new login occurs.

5.16 Traffic Manager

The Traffic Manager is responsible for coordinating train movements across the railway network. This role focuses on defining paths, assigning trains, generating schedules, monitoring execution, and dispatching trains in a safe and efficient manner.

Figure 5.63 shows the Traffic Manager Home Page.

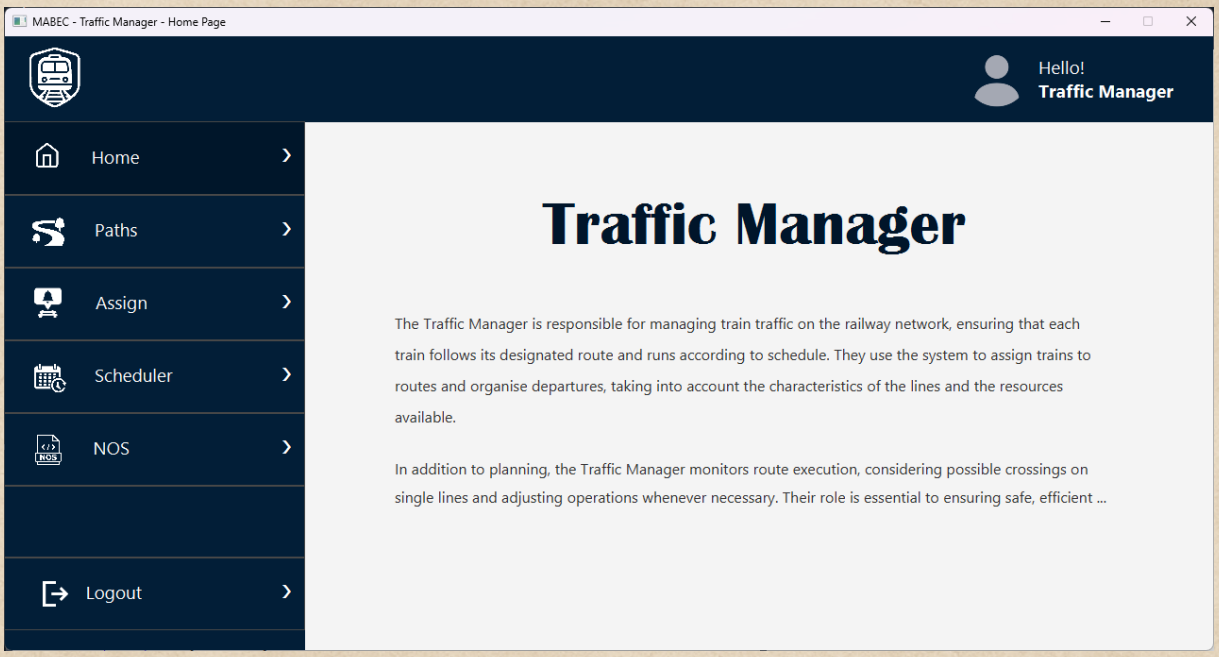

Figure 5.63: Traffic Manager Home Page

From the Home Page, the Traffic Manager can access the following modules:

- **Paths**
- **Assign**
- **Scheduler**
- **NOS**

5.16.1 Paths

The **Paths** page allows the Traffic Manager to create train routes, either manually or automatically. Figure 5.64 presents the Paths selection screen.

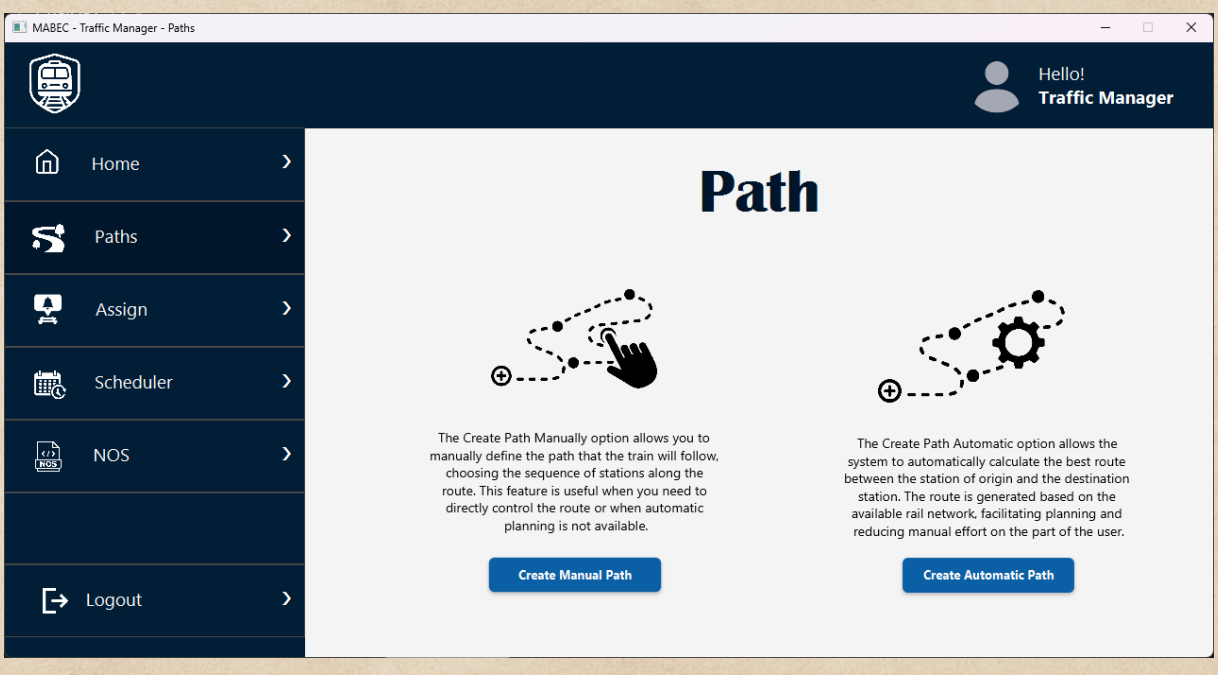

Figure 5.64: Paths Selection Page

Two creation modes are available:

- **Create Manual Path**
- **Create Automatic Path**

5.16.2 Manual Path

The **Manual Path** option allows the Traffic Manager to manually define the sequence of stations a train will follow.

Figure 5.65 shows the manual path creation interface.

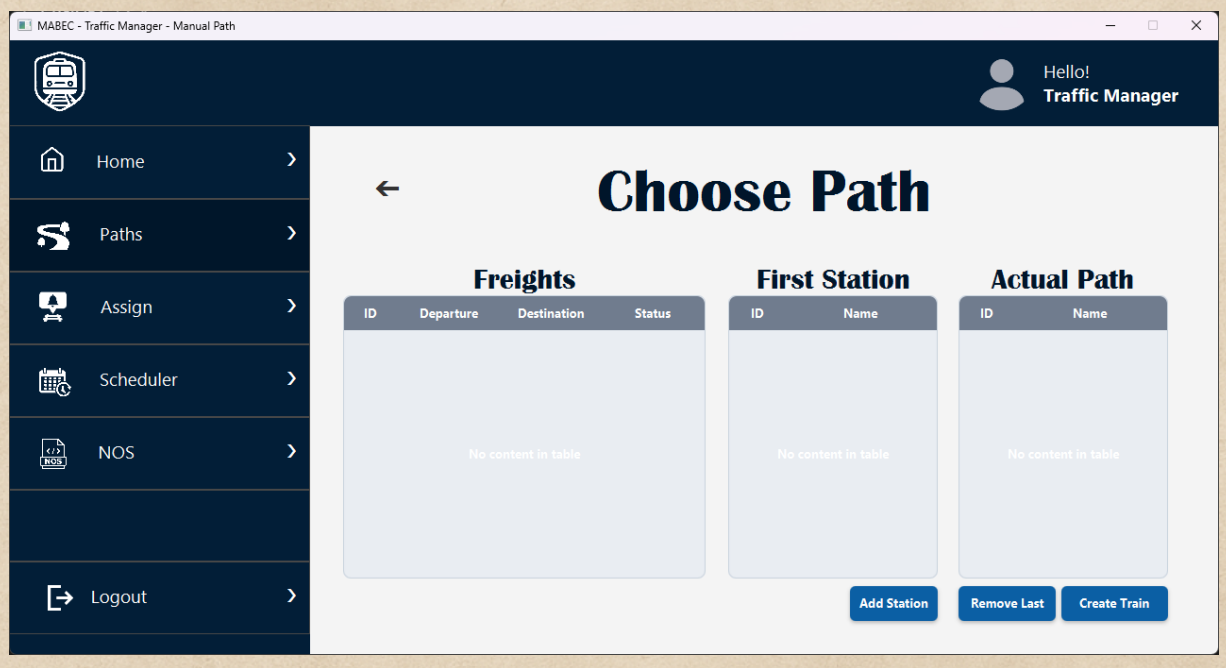

Figure 5.65: Manual Path Creation

The interface is divided into three tables:

- **Freights** – Lists available freight operations.
- **First Station** – Displays the initial station of the route.
- **Actual Path** – Shows the ordered list of stations composing the path.

Available actions include:

- **Add Station** – Appends a station to the current path.
- **Remove Last** – Removes the last added station.
- **Create Train** – Finalises the path and creates the train.

5.16.3 Automatic Path

The **Automatic Path** option automatically calculates the optimal route based on network constraints.

Figure 5.66 shows the initial Automatic Path screen.

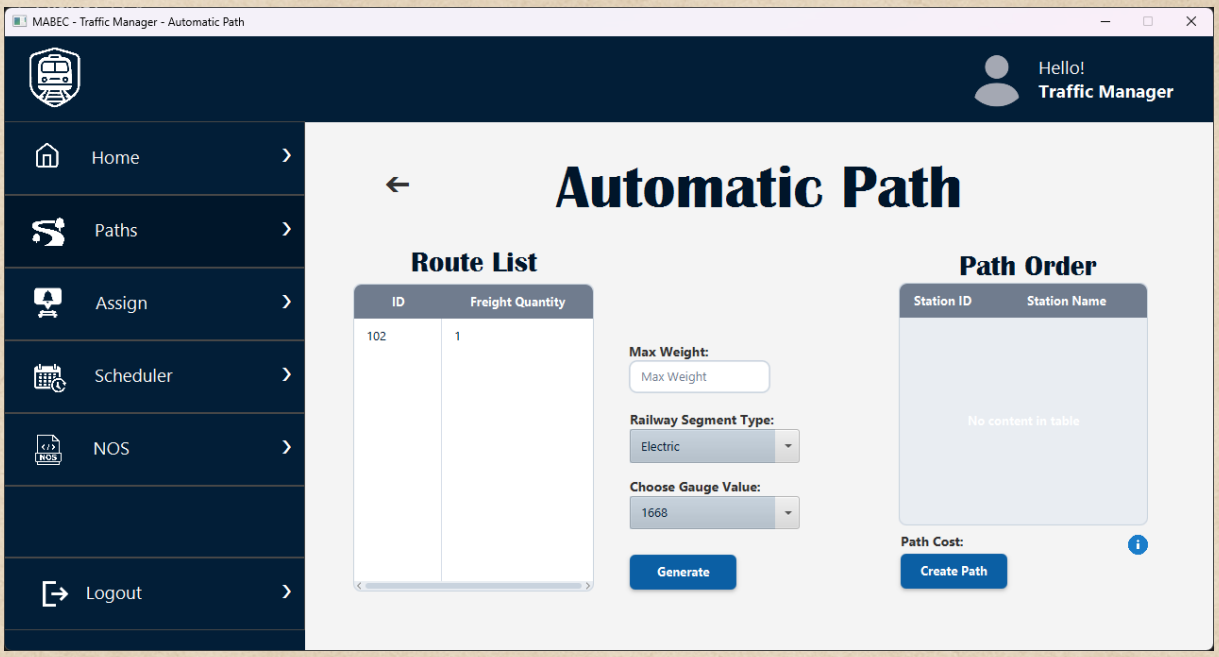

Figure 5.66: Automatic Path Page

The Traffic Manager must specify:

- **Maximum Weight**
- **Railway Segment Type**
- **Gauge Value**

After pressing **Generate**, the system calculates the path.
Figure 5.67 shows a generated automatic path.

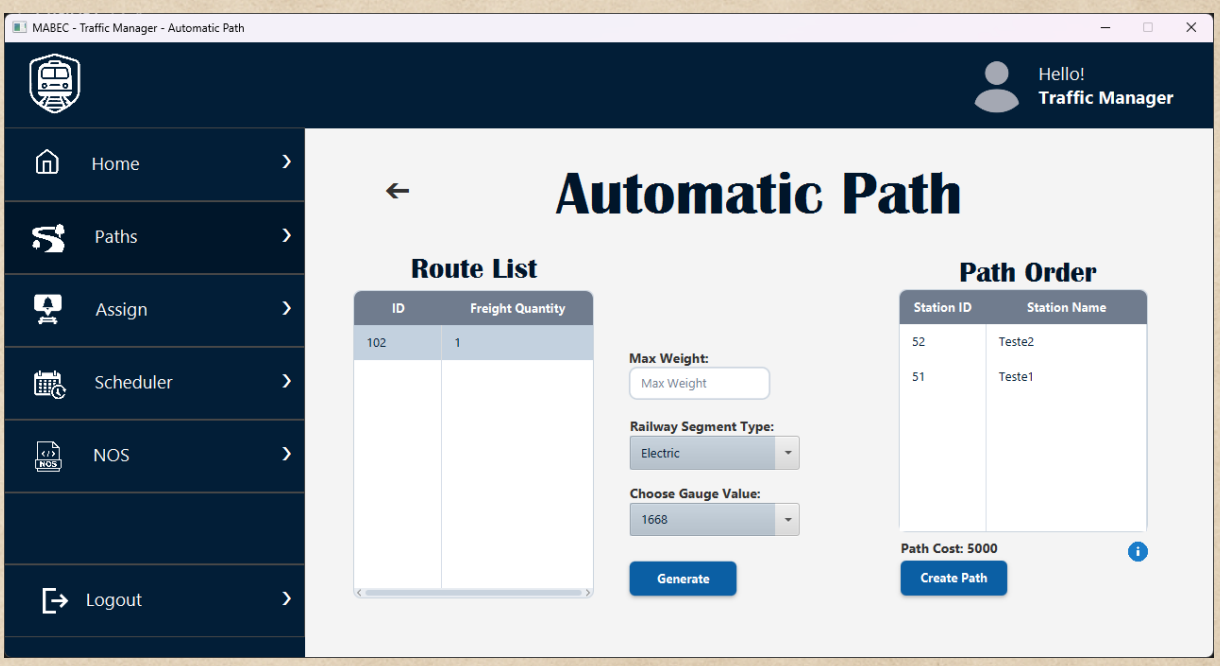

Figure 5.67: Generated Automatic Path

The calculated station order and total path cost are displayed. Pressing **Create Path** finalises the route.

5.16.4 Assign Train

The **Assign Train** page is used to finalise the operational configuration of a train before it is scheduled and dispatched. This page brings together the selected route, freight composition, wagons, locomotives, and temporal information required for execution.

Figure 5.68 shows the initial Assign Train interface.

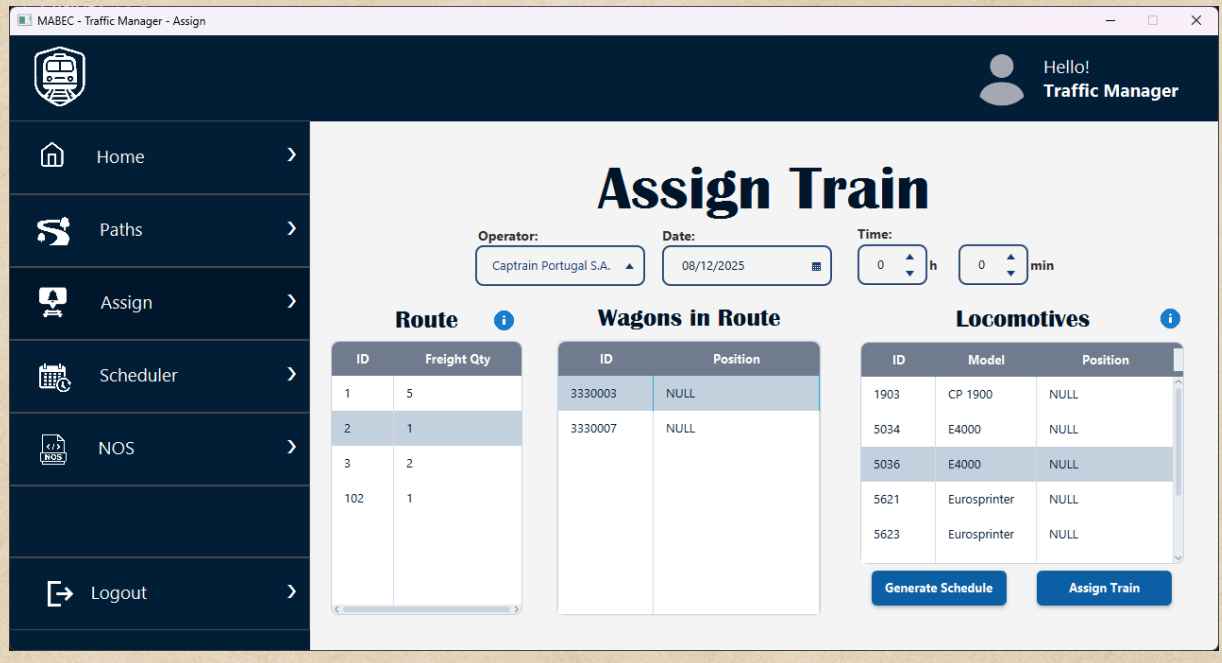

Figure 5.68: Assign Train Page

General Configuration

At the top of the page, the Traffic Manager must define the general execution context of the train:

- **Operator** – Selects the railway operator responsible for executing the service.
- **Date** – Defines the departure date of the train.
- **Time** – Specifies the planned departure time in hours and minutes.

These fields determine when and under which operator the train will be scheduled.

Route

The **Route** table lists the segments that compose the selected path, including the freight quantity associated with each route entry.

Each row contains:

- **Route ID**
- **Freight Quantity**

This table represents the logical structure of the journey that the train will perform.

Wagons in Route

The **Wagons in Route** table displays all wagons assigned to the selected route.

For each wagon, the following information is shown:

- **Wagon ID**
- **Position** – Indicates the wagon's position in the train composition (if defined).

This section allows the Traffic Manager to verify that the freight requirements of the route are correctly matched with the available wagons.

Locomotives

The **Locomotives** table lists all locomotives available for assignment.

Each entry includes:

- **Locomotive ID**
- **Model**
- **Current Position**

The Traffic Manager selects the locomotives that will be responsible for hauling the train along the defined route.

Schedule Generation

Once the operator, date, time, route, wagons, and locomotives are defined, the **Generate Schedule** button can be pressed.

This action calculates a provisional execution plan, taking into account:

- Route structure,
- Train composition,
- Segment traversal times,
- Operational constraints.

Figure 5.69 shows the schedule preview generated by the system.

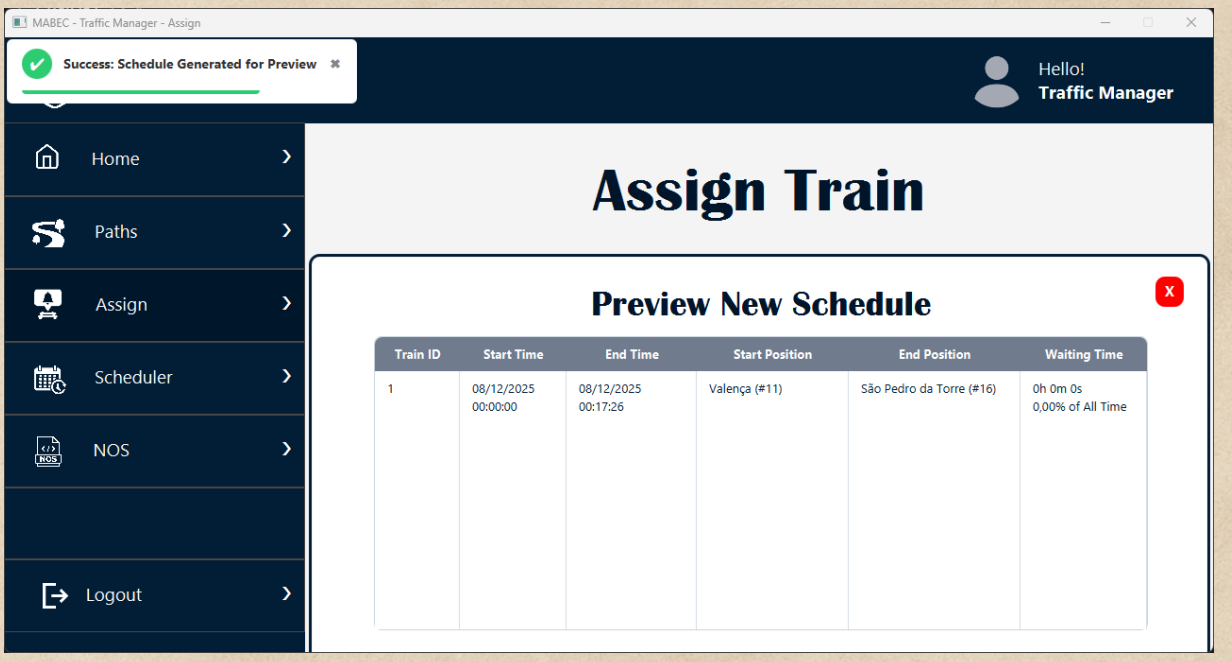

Figure 5.69: Schedule Preview

The preview displays:

- **Train ID**
- **Start Time** and **End Time**
- **Start Position** and **End Position**
- **Waiting Time**, including its percentage of total execution time

The preview can be closed to return to the Assign Train page for further adjustments.

Train Assignment

After validating the schedule preview, the Traffic Manager confirms the operation by pressing the **Assign Train** button.

Figure 5.70 shows the successful assignment confirmation.

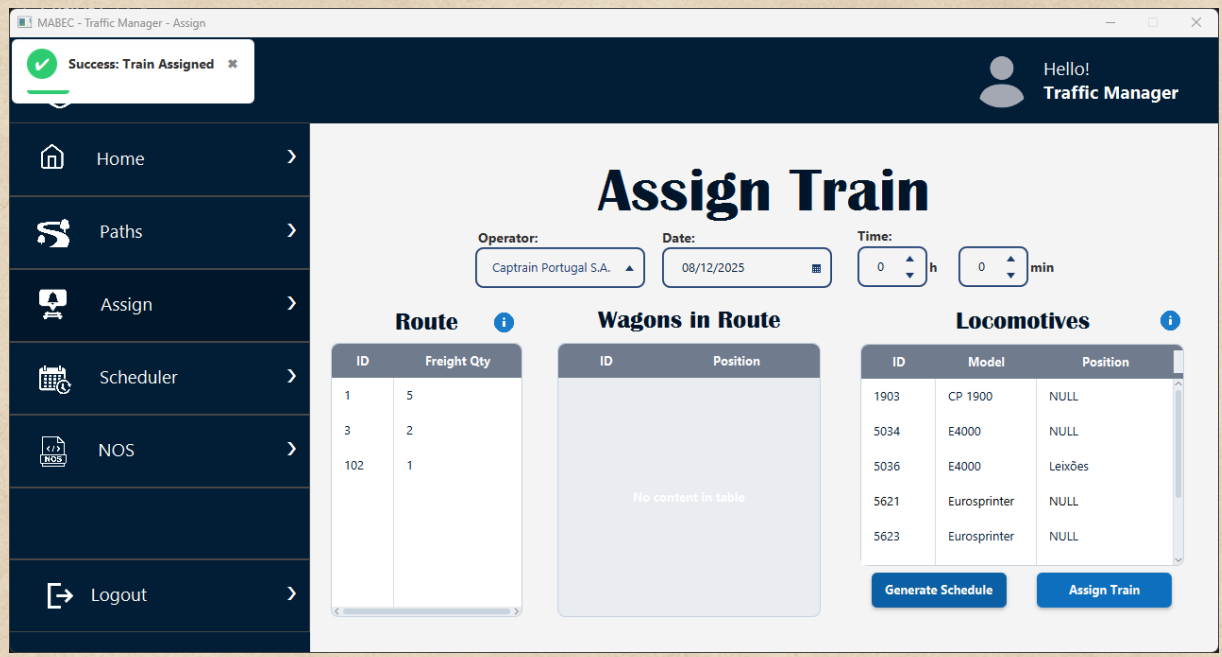

Figure 5.70: Train Assigned Successfully

At this stage, the train is fully configured and becomes available in the **Scheduler** module for monitoring and dispatching.

5.16.5 Scheduler

The **Scheduler** page allows monitoring and dispatching scheduled trains.

Figure 5.71 shows the Scheduler overview.

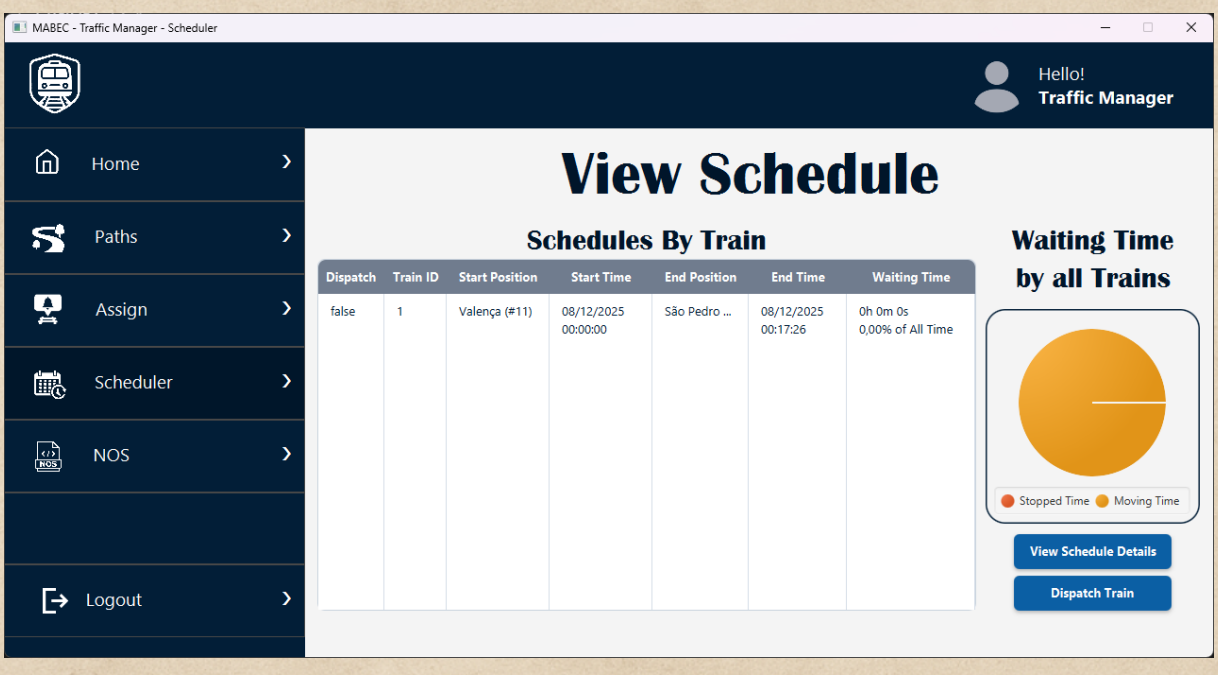

Figure 5.71: View Schedule Page

The main table lists schedules by train, including dispatch status and waiting time.
On the right side, a **circular chart** represents waiting versus moving time for all trains.

Schedule Details

Selecting **View Schedule Details** opens a detailed movement breakdown.
Figure 5.72 shows this detailed view.

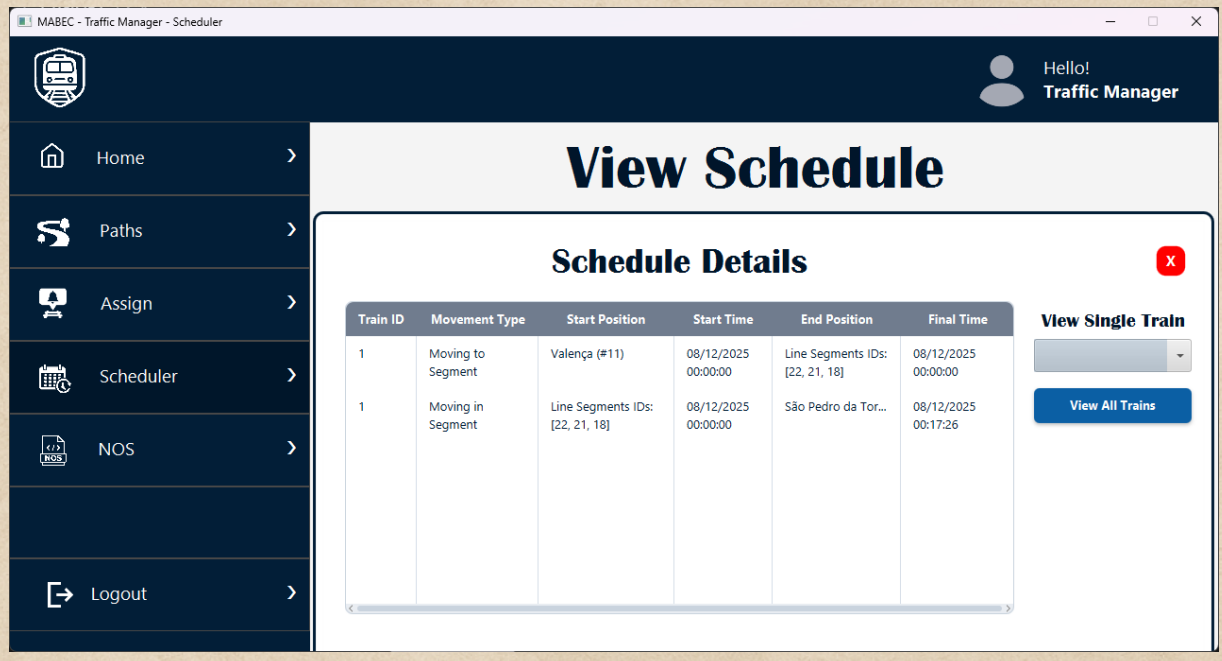

Figure 5.72: Schedule Details

Each row corresponds to a movement step, including segment transitions and timestamps.

Dispatch Train

Pressing **Dispatch Train** starts the execution of the selected train.
Figure 5.73 shows a successful dispatch confirmation.

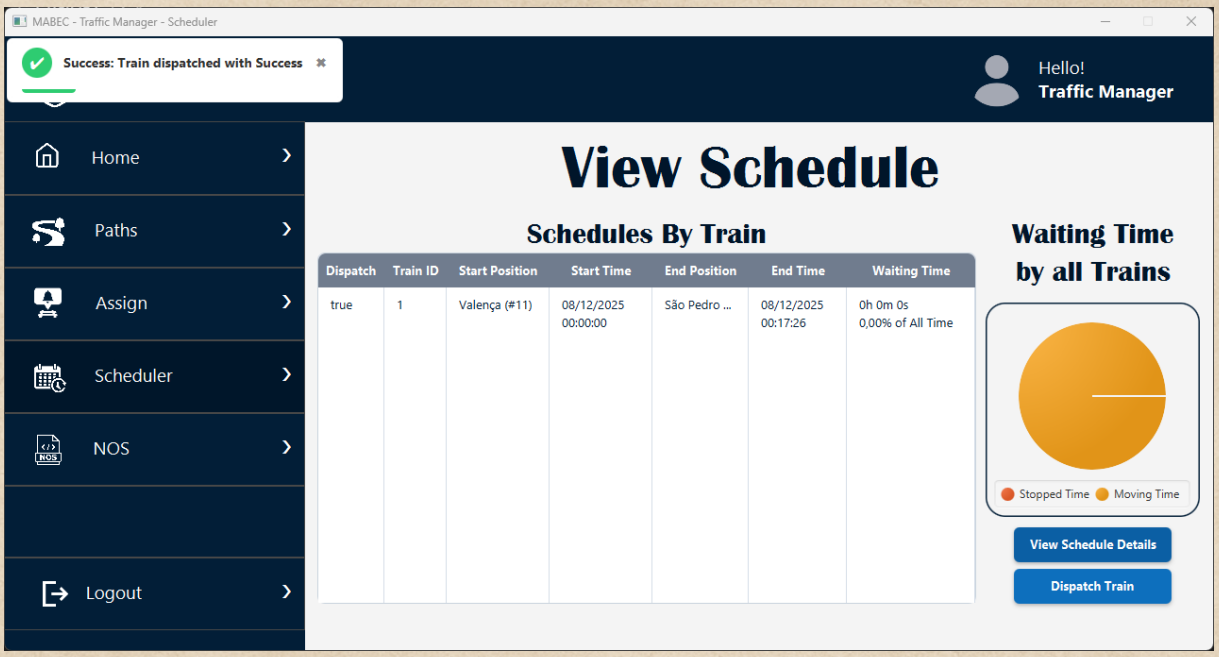

Figure 5.73: Train Dispatched Successfully

5.16.6 NOS

The **NOS** page displays system logs related to network optimisation and traffic operations.

Figure 5.74 shows the NOS Logs interface.

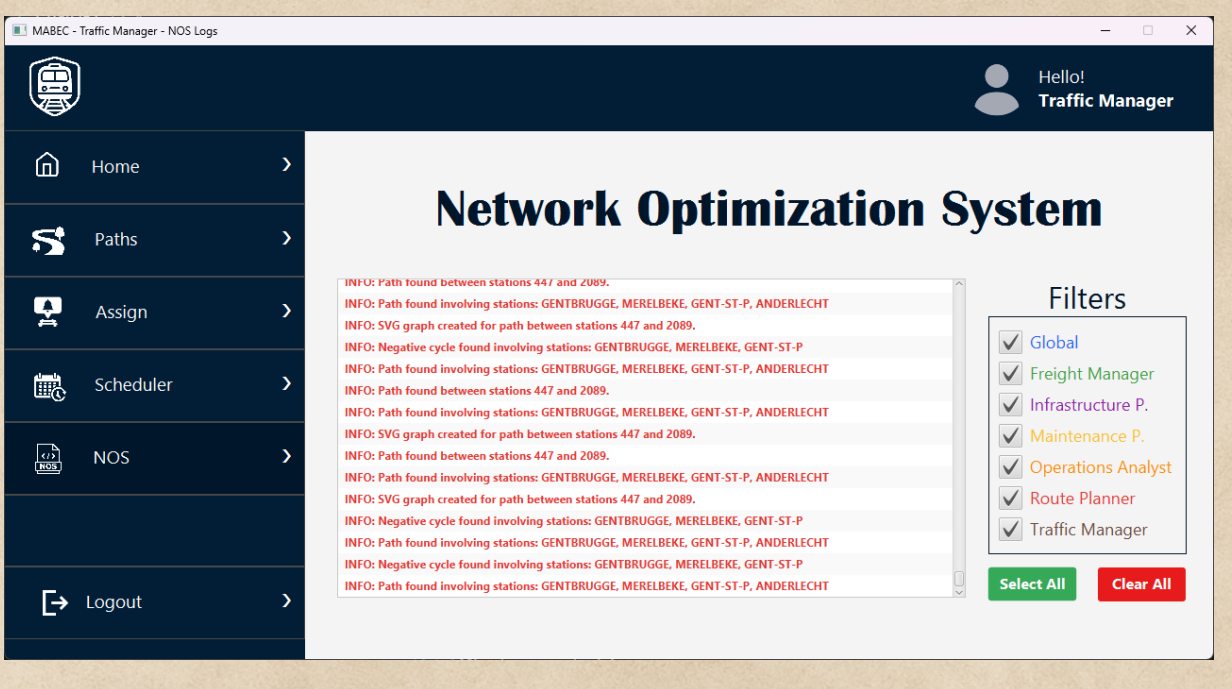

Figure 5.74: Traffic Manager NOS Logs

Logs can be filtered by role, allowing focused analysis of system events such as path calculations, negative cycles, schedule generation, and dispatch operations.

5.16.7 Logout

Selecting the **Logout** button ends the current session and returns the user to the Login page.

5.17 Warehouse Planner

The Warehouse Planner is responsible for organising and optimising all product management within the warehouse. This role analyses inventory status, checks stock availability, and plans order fulfilment efficiently and accurately. The Warehouse Planner decides from which locations products should be retrieved and in what order, applying FEFO and FIFO rules to ensure proper stock rotation and to minimise losses due to expiration or excess stock.

In addition to managing internal logistics, the Warehouse Planner coordinates picking and dispatch operations, ensuring that each order is processed within the established deadlines and with the best possible use of space and resources. Their work is essential to maintaining the smooth flow of operations at the rail terminal, ensuring that the movement of products in and out of the terminal runs safely, reliably, and efficiently.

Figure 5.75 shows the Warehouse Planner Home Page.

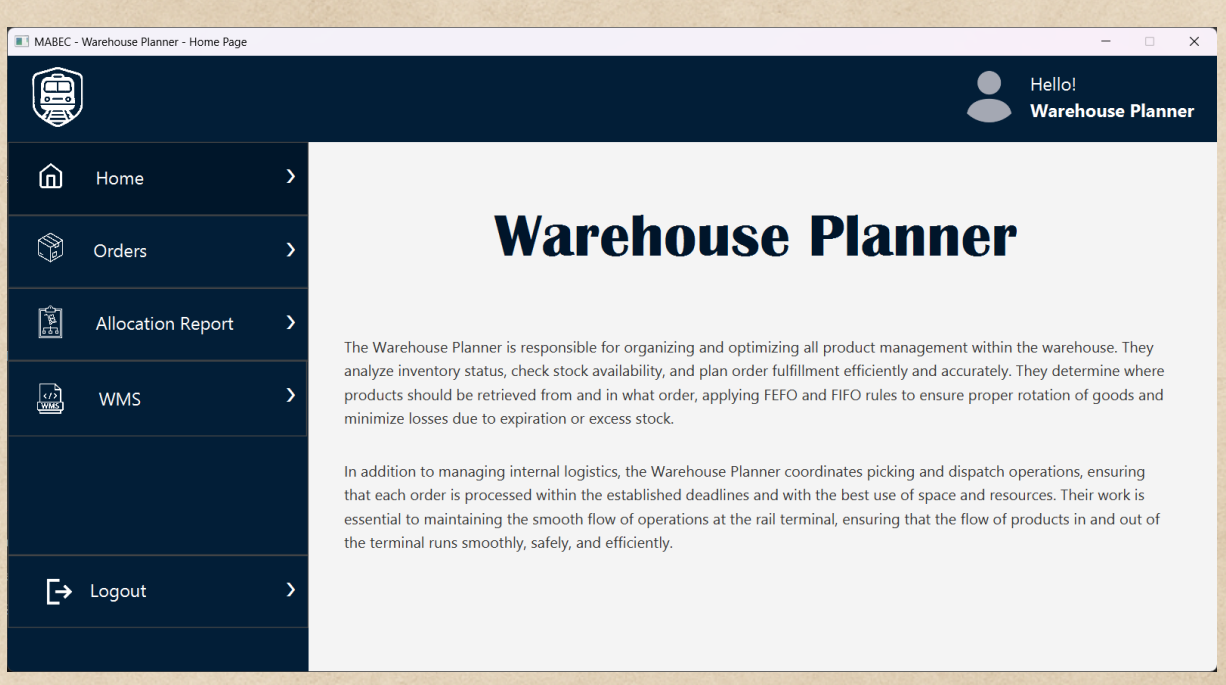

Figure 5.75: Warehouse Planner Home Page

5.17.1 Orders

The **Orders** page lists all customer orders that are ready to be analysed for stock allocation. Figure 5.76 shows the Orders interface.

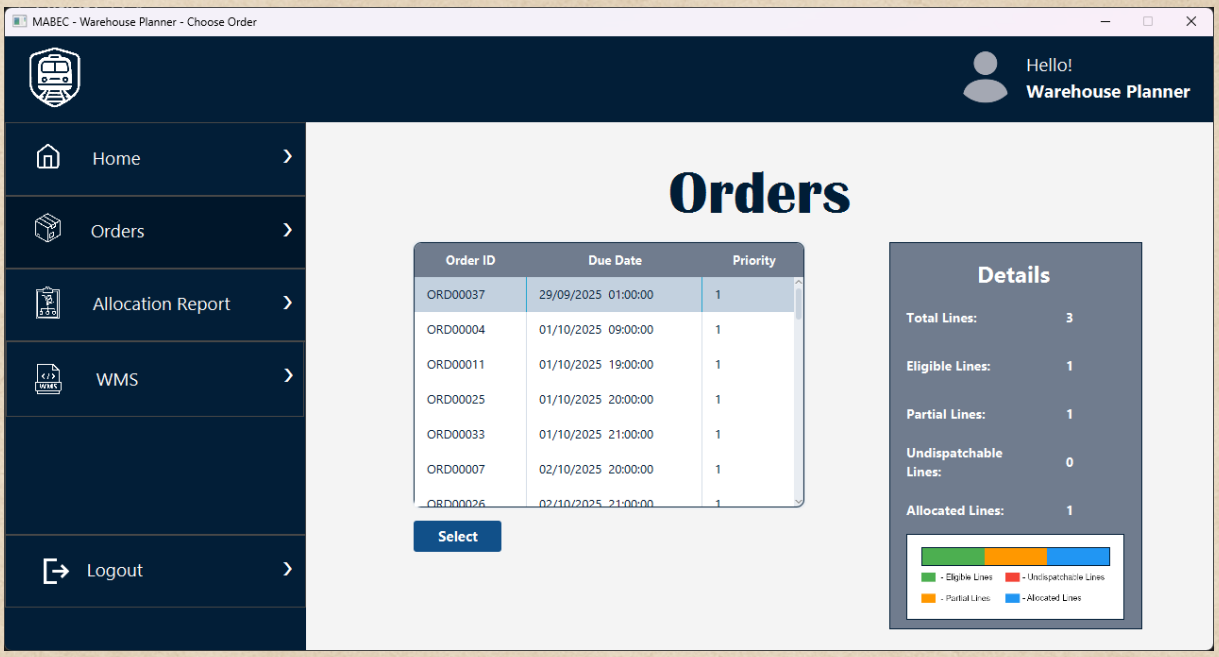

Figure 5.76: Orders Page

The main table includes, for each order:

- **Order ID** – Unique identifier of the order.
- **Due Date** – Date by which the order should be dispatched.
- **Priority** – Priority level used to handle urgent orders first.

On the right-hand side, the **Details** panel provides a summary of the current allocation status for the selected order:

- **Total Lines** – Total number of order lines.
- **Eligible Lines** – Lines that can be fully dispatched with the available stock.
- **Partial Lines** – Lines for which only part of the requested quantity can be dispatched.
- **Undispatchable Lines** – Lines for which no stock is currently available.
- **Allocated Lines** – Lines that have already been allocated to stock locations.

At the bottom of this panel, a horizontal status bar uses different colours to represent the proportion of eligible, partial, undispatchable, and allocated lines, giving a quick visual overview of the order's fulfilment status.

After selecting an order, the user clicks the **Select** button to open the detailed allocation view for that order.

5.17.2 Order Lines

After clicking **Select**, the system navigates to the **Order Lines** page, which displays the individual lines of the selected order. Figure 5.77 shows this interface.

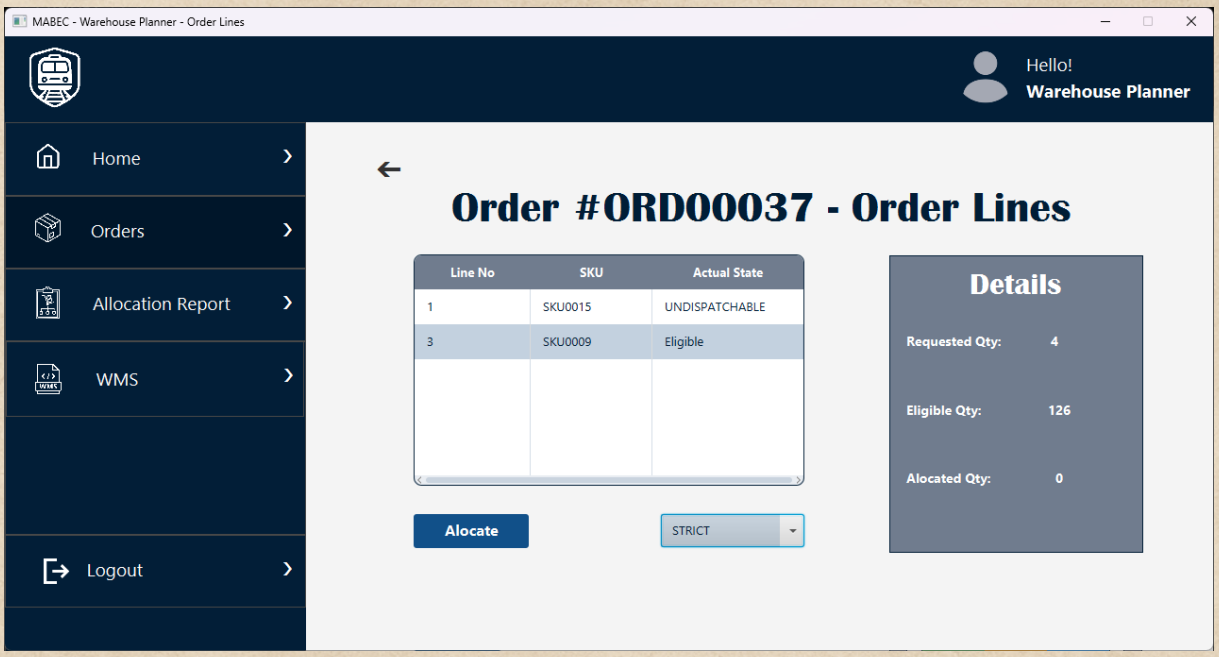

Figure 5.77: Order Lines Page

The main table lists all order lines and includes the following information:

- **Line No** – Sequential identifier of the order line.
- **SKU** – Product reference associated with the line.
- **Actual State** – Current dispatchability status of the line.

Each order line can be in one of the following states:

- **Eligible** – The requested quantity can be fully dispatched with the available stock.
- **Partial** – Only part of the requested quantity can be dispatched.
- **Undispatchable** – No stock is available to fulfil the line.

On the right-hand side, the **Details** panel shows quantitative information for the selected line, including the requested quantity, eligible quantity, and already allocated quantity.

Below the table, the user can choose the allocation mode using the **STRICT** or **PARTIAL** option:

- **STRICT mode** enforces conservative allocation rules. If a line is partially fulfilable or has insufficient stock, it is treated as *Undispatchable*, ensuring that only fully dispatchable lines are considered eligible.
- **PARTIAL mode** allows flexible allocation. In this mode, lines with limited stock are marked as *Partial*, while lines with no available stock remain *Undispatchable*.

This distinction allows the Warehouse Planner to switch between strict fulfilment policies and more flexible allocation strategies, depending on operational priorities and stock availability.

5.17.3 Order Line Allocations

The **Order Line Allocations** page displays the allocation details of all lines belonging to the previously selected order. Figure 5.78 shows this interface.

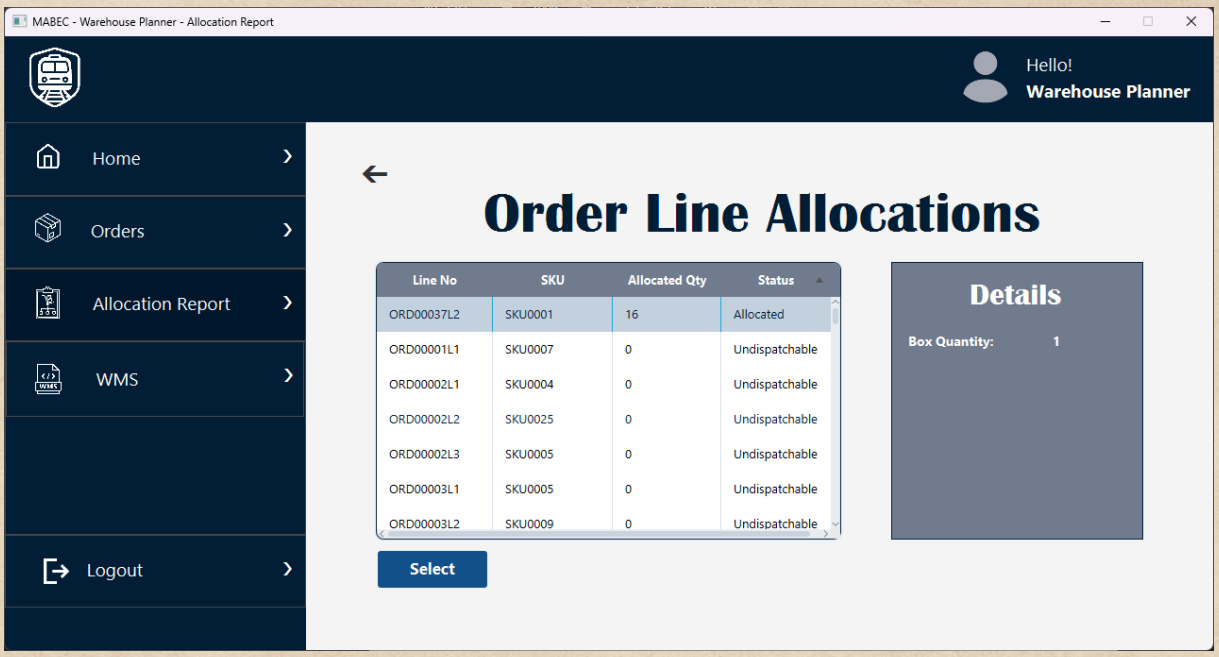

Figure 5.78: Order Line Allocations Page

The main table presents, for each order line:

- **Line No** – Line number within the order.
- **SKU** – Product identifier.
- **Allocated Qty** – Quantity of the product that has been reserved in stock.
- **Status** – Allocation status of the line, which may be *Eligible*, *Partial*, *Undispatchable*, or *Allocated*.

On the right-hand side, the **Details** panel displays complementary information about the selected line, such as the total **Box Quantity** used to fulfil that allocation.

After selecting a specific order line and pressing the **Select** button, the system navigates to a detailed view of the physical stock allocation for that line. Figure 5.79 illustrates this page.

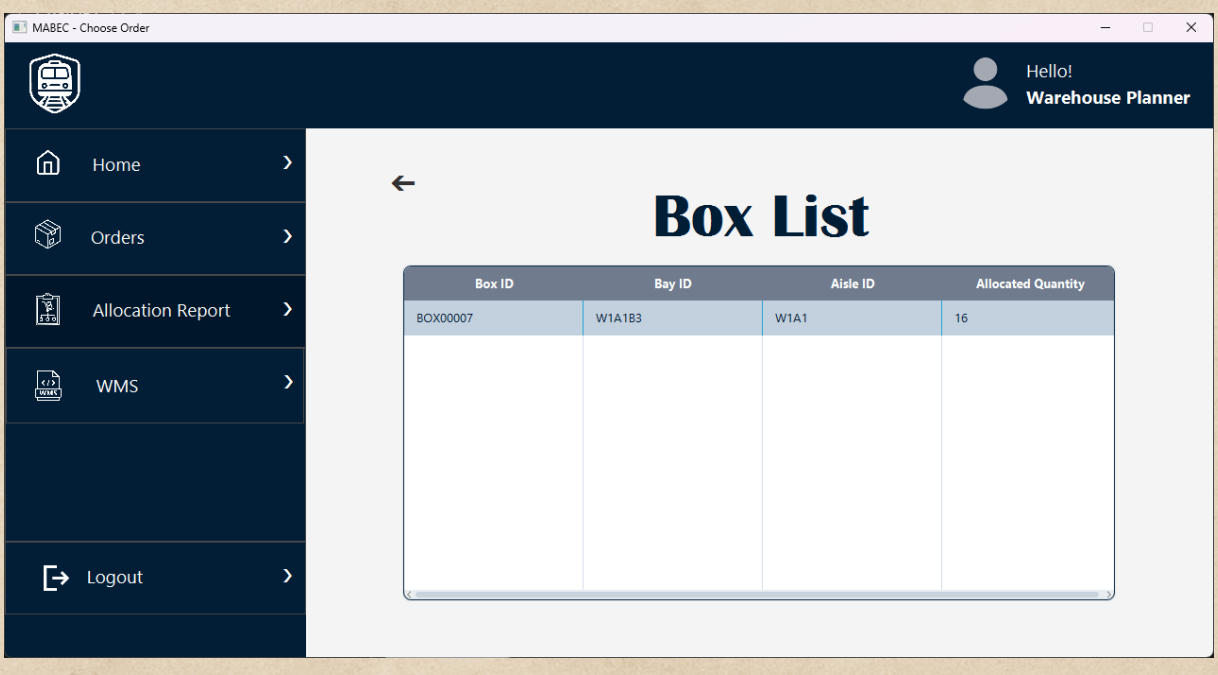

Figure 5.79: Box List Page

The **Box List** page shows exactly which boxes are used to fulfil the selected order line, including:

- **Box ID** – Unique identifier of the storage box.
- **Bay ID** – Bay where the box is stored.
- **Aisle ID** – Aisle associated with the bay.
- **Allocated Quantity** – Quantity taken from the box for this order line.

This level of detail allows the Warehouse Planner to fully trace how each order line is fulfilled at a physical warehouse level, ensuring transparency, stock traceability, and correct execution of the allocation process.

5.17.4 WMS

The **WMS** (Warehouse Management System) option opens the activity log associated with the Warehouse Planner. This log records interactions related to orders, allocations, and adjustments made within the warehouse, ensuring full traceability and accountability for all stock management operations.

5.17.5 Logout

The **Logout** option ends the current Warehouse Planner session securely and returns the user to the Login page.

Chapter 6

Troubleshooting

6.1 Issue 1 – Application does not start

- **Symptom**: The application does not launch or closes immediately.
- **Possible Cause**: Java is not installed, incorrect Java version, or missing dependencies.
- **Solution**: Install the required Java version and rebuild the project.

6.2 Issue 2 – Database connection error

- **Symptom**: Error message related to database connection.
- **Possible Cause**: Database server is not running or connection parameters are incorrect.
- **Solution**: Start the database service and verify connection credentials.

6.3 Issue 3 – No data displayed in tables

- **Symptom**: Tables appear empty after opening a page.
- **Possible Cause**: Database is empty or data was not loaded correctly.
- **Solution**: Reset or populate the database and reload the application.

6.4 Issue 4 – Login fails

- **Symptom**: User cannot log in with valid credentials.
- **Possible Cause**: Incorrect credentials or inactive user account.
- **Solution**: Verify user credentials and account status.

6.5 Issue 5 – Unexpected application behaviour

- **Symptom**: The application behaves unexpectedly or some actions do not respond.
- **Possible Cause**: Incomplete data, inconsistent state, or internal processing error.
- **Solution**: Restart the application and verify that all required data is correctly loaded.

Chapter 7

Frequently Asked Questions (FAQs)

Q.1: What is the purpose of the MABEC system?

Answer: The MABEC system supports the management and analysis of railway logistics, including infrastructure, freight transport, warehouse operations, and operational planning.

Q.2: Do I need to create an account to use the system?

Answer: Yes. Only registered users can access the system, and each user is assigned a specific role.

Q.3: Why do I see different menus after logging in?

Answer: The available menus depend on the user role and its associated permissions.

Q.4: What should I do if no data appears on the screen?

Answer: This may occur if the database is empty. Reset or repopulate the database and reload the application.

Q.5: Can multiple users access the system at the same time?

Answer: Yes. The system allows simultaneous access by multiple users with valid credentials.

Q.6: What is the purpose of the WMS option?

Answer: The WMS option provides access to user activity logs for traceability and auditing purposes.

Q.7: How can I recover from an unexpected error?

Answer: Restart the application and ensure that the database and all required services are running correctly.

Chapter 8

7. References

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