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DELIVERABLE D6.9
REQUIREMENT SPECIFICATION FOR SERVICES IN REGIONAL LINES (ALPHA RELEASE)

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[1] PU: Public; SEN: Sensitive, only for members of the consortium (including Commission Services)

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Document history

Date	Name	Affiliation	Position/Project Role	Action/ Short Description
12/01/2024	Ira Kataria	HACON	Project Manager/WP leader	Author. Description of the implementation WP6
12/01/2024	Dr. Christoph Höggerl	ÖBB-Infra (d-fine)	Author and Task leader 6.8	Author. Contribution to the whole document
12/01/2024	Anne-Kathrin Westen	ÖBB-Infra (d-fine)	Author	Author. Contribution to the whole document
12/01/2024	Felix Schlemmer	ÖBB-Infra (d-fine)	Author	Author. Contribution to the whole document
20/12/2024	Matthias Walter	HACON	Author	Contribution to functional, non-functional, operational and performance requirements
19/12/2023	Michel Meyer zu Hörste	DLR	Contributor	Author. Use cases and Test Cases final description
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	Łukasiewicz			Modifications including expert's reviews.
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1 Executive Summary

As of today, the European railways are suffering from several systemic challenges. One of them addresses the cross-border compatibility arising from different standards and expectations from the European infrastructure managers, railway undertakings and partners from the industry. Another problem to tackle involves the competition with other modes of transport such as private car travel, and the profitability of medium route distances.

Therefore, within the Flagship Project 6, a key element is to foster the collaboration among all European partners to achieve the overall objective of revitalising regional railways. It is paramount to connect regional railways with other modes of travel that are being used for first and last mile services. This enables a new competitiveness for regional railways and contributes to improved cross-border compatibility in Europe which leads to the reduction of capital expenditures and operating expenses, enhanced productivity (unit costs per train kilometre) and improved customer satisfaction. However, it is important to note that these goals are competing against each other.

As a part of the Flagship Project 6, Work Package 6 deals with the conceptualisation of a multimodal travel solution providing requirement specifications. Several advancements should be introduced here, including the usage of demand-related capacity information, congestion monitoring and the utilisation of regional lines for freight transport.

An orientation is provided by the technology of a Mobility-as-a-Service (MaaS) solution which aims at consolidating multiple modes of travel into a single platform. In that way, it is possible to plan journeys across all modes of transportation.

The goal of Deliverable 6.9 (Task 6.8) is to specify requirements, acceptance criteria and a test strategy. To achieve this, use cases based on relevant personas using the frontend and/or backend services were identified. Important actors within the system are commuters, travellers/tourists, and persons with reduced mobility. The backend services are primarily influenced by administrators. Additionally, an analytics platform establishes a connection between business intelligence analysts and personas from infrastructure management and railway undertakings, such as the traffic manager.

The prepared use cases helped with the design of the requirements questionnaire and allowed the expansion of the requirement specification by user requirements from infrastructure managers (IMs) and railway undertakings (RUs). Requirements are ranging from the interface design and user interaction to the querying of reports for insights into passenger behaviour accompanied by addressing data backup, logging of failures and redundancy of the system.

Several use cases that have been documented in the deliverable potentially overlap with main line use cases. For the alpha release of the requirement specification, this is considered acceptable. During development of the final release, it will be clarified if a use case has a regional focus or if it applies to main line as well. In the latter case, synergies can be leveraged.

To ensure that the implemented solutions comply with the requirement specification defined in Work Package 6, a testing strategy and respective test cases are provided.

2 List of abbreviations, acronyms, and definitions

Table 1: Abbreviations and Acronyms

Abbreviation / Acronym	Definition
BIA	Business Intelligence Analyst
B2B	Business to Business
CAPEX	Capital expenditure
CEP	Courier, Express and Parcel Services
CMS	Capacity Management and Planning System
DRT service	Demand responsive transport service
Dx.y	Deliverable No. y from WPx, Example: D6.9 (Deliverable No. 9 from WP6)
EPF	European Passengers' Federation
ETA	Estimated Time of Arrival
ERJU	Europe's Rail Joint Undertaking
FP	Flagship Project
GDPR	General Data Protection Regulation
ID	Unique Identifier
IM	Infrastructure Manager
IP4	Innovation programme 4
JU	Joint Undertaking
MaaS	Mobility-as-a-Service
ML	Machine Learning
MAWP	Multi-Annual Work Program
OJP	Open API for distributed journey planning
OPEX	Operational expenditure
OSRM	Open-Source Routing Machine

PIS	Passenger Information System
PRM	Person with reduced mobility
RU	Railway Undertaking
S2R	Shift2Rail
TC	Test Case
TMS	Traffic Management System
Traffic Manager	TraMa
TSP	Travel Service Provider
UC	Use Case
WP	Work Package

3 Introduction

For increasing mobility needs, individual measures from single actors such as increased frequency of regional trains are not sufficient anymore. Existing mobility modes need to be investigated from a holistic point of view. Intelligent and resilient mobility solutions require a stronger integration between different actors of the mobility ecosystem.

A crucial role is taken up by regional rail services. Their link to other public transport and to first and last mile services, such as bike sharing, cycling, walking, or driving, to get from stations to final remote locations and vice versa is essential. Due to the neglect of regional railway lines in the past, their long-term viability is no longer guaranteed. Flagship Project 6 (FP6) "FutuRe" aims to revitalise regional railway services by reducing the total cost of ownership.

Within FP6, Work Package 6 (WP6) focuses on the requirements for a multimodal travel solution, which will be developed and demonstrated according in WP11. If requirements are identified that are not within the scope of WP6, these requirements will be considered as potential requirements for the next phases after WP6.

The developed requirements are a set of European standard requirements establishing a connection from regional rail services to first and last mile travel for passengers and freight. The solution includes, for example, demand-related capacity information and the integration of traffic management systems (TMS) and passenger information systems (PIS). The requirements specified in this deliverable provide a basis for both the implementation of demonstrators, which is the scope of WP11, as well as European standard requirements.

- In the following, Chapter 4 provides an overview of the methodology used for the requirements engineering process.
- Chapter 5 gives a short introduction on previous projects on which WP6 will be based.
- In Chapter 6 the use case definition is explained, including the methodology for deriving use cases. It provides a consolidation of the use cases from task 6.1, 6.2, 6.4, 6.5 and 6.6 expanded by those from an infrastructure manager’s (IM) and railway undertaking’s (RU) point of view from task 6.8.
- Chapter 7 summarizes the methodology that was applied to specify the requirements and provides a set of functional, non-functional, end user, operational, performance, regulatory and compliance requirements as well as requirements on documentation and training.
- Chapter 0 features the description of the acceptance criteria derived for the requirements.
- The testing strategy and test cases are documented in Chapter 9.
- A conclusion from the gained insights of the deliverable is provided in Chapter 11.

Furthermore, alignment with FP6 WP2 and the system pillar as well as with FP1 (Destination 1) is ensured. The development of the requirements was guided by a set of high-level requirements from WP2 and the system pillar. WP2 provides the operational and functional system architecture for all WPs and ensures exchange, alignment, and harmonization with the system pillar.

4 Requirements Engineering Process Methodology

Effective requirement specification is a cornerstone of successful software development and ensures that the final product aligns with user needs and expectations. It seeks to mitigate ambiguity, improve communication, and ultimately deliver a software solution that serves its intended purpose while satisfying stakeholder needs.

The requirement engineering process starts with the identification of relevant personas and their needs regarding the software solution.

The following personas (profiles) were identified for task 6.8 use cases and requirements:

- Traveller/Tourist, person which is not familiar with the local area
- Commuter, person who is regularly commuting the same route
- Person with reduced mobility (PRM), a person who is dependent in certain technical infrastructure like elevators, certain types of train doors, escalators to use the train service
- Business intelligence analyst (BIA), person who is employed as a business intelligence analyst and has accordingly certain access rights within the developed system
- Traffic manager, person who is employed as a traffic manager and has accordingly certain access rights within the developed system
- End-user, any end-user of the journey planning service
- Administrator, person who has administrator rights for the developed system
- Backend-service-user

Based on the needs of these personas the use cases are derived by detailing the system behaviour and user interaction. The use cases are followed by requirements delivering concrete specifications for the corresponding use case.

To check whether an implemented solution fulfils the requirements, acceptance criteria are developed using the scenario-based approach template “**Given** [how things begin], **when** [action taken], **then** [outcome of taken action]”.

The evaluation of the implementation is done during the test phase. The test cases provided are based on the developed testing strategy and the acceptance criteria.

At the end of the requirements engineering process, there is a complete, clear, and consistent specification of all requirements which aims at reducing development costs, errors, and incorporates stakeholder expectations.

5 Interrelated Projects

As stated in the WP6 objectives in the Grand Agreement, the results from the S2R innovation programme four (IP4) shall be considered and strengthened. S2R was the predecessor of Europe's Railway Joint Undertaking (ERJU) and was structured around five asset specific IPs. IP4 had the focus of developing IT solutions to make railway services more attractive.

ExtenSive[2] is the latest and last project within IP4 of S2R. It was completed in 2023 and had the objective to improve and enhance functionalities which were defined within previous projects in IP4 in S2R and explore synergies between all IPs in S2R. In the ExtenSive project, diverse use cases for a journey planning system were already defined, which are here used as foundation for the use cases in Chapter 6 expanding them further.

To identify the functionalities which have already been specified in ExtenSive, task 6.8 is using the publicly available deliverable document "D11.1 – Use Case Updates" from the ERJU's homepage[3].

Furthermore, there exist synergies between FP6 and FP1 since FP1 also covers the specification of a multimodal travel solutions to improve the attractiveness of Europe's railways. Thus, some of the use cases which were specified in FP1 are the basis for an FP6 use case or vice versa.

The use cases from FP1 and the ExtenSive Project which were considered as basis for the development of WP6 use cases are listed in Table 2.

As explained in Chapter 4, the derived use cases are based on the needs of predefined personas, with one of them being PRMs. The identification of travel needs for PRM was, among other methods, carried out by literature review of the previous Shift2Rail projects: COHESIVE ([COH-D3.4, Deliverable 3.4 of CoHESIVE]), SMaRTE ([SMaRTE-D3.1, Deliverable D3.1 of SMaRTE]) and Near2050 ([NEAR-D4.4, Deliverable 4.4 of NEAR2050]).

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[2] For detailed information about the ExtenSive research program,
https://projects.shift2rail.org/s2r_ip4_n.aspx?p=EXTENSIVE

[3] EXS-D11.1, Deliverable 11.1 of ExtenSive, Use Cases update, 2022,
https://projects.shift2rail.org/download.aspx?id=6bcb3e9f-1b69-43cd-b60c-5ce1a84e6d7c

Table 2: Use Cases from FP1 and ExtenSive

Deliverable	Use Case ID	Use Case Name
FP1 D2.3	UC-FP1-WP19-01	Journey Planning as a B2B intermodal service
FP1 D2.3	UC-FP1-WP19-44	Alert for Possible Overcrowding Situations based on Occupancy Forecast Data
FP1 D2.3	UC-FP1-WP19-49	Forecast Occupancy of Vehicles using Journey Planning Requests Data
FP1 D2.3	UC-FP1-WP19-50	Display Forecasted Occupancy Information to Travelers when Planning Trips
FP1 D2.3	UC-FP1-WP19-54	Analysis of Travel Demand Data based on Forecasted Data
ExtenSive D11.1	UC_TD4.2_04	Multi-criteria Pareto-optimal Travel Shopping
ExtenSive D11.1	UC_TD4.2_09	Including Individual Transport for door-to-door Travel
ExtenSive D11.1	UC_TD4.5_14	Subcluster & Cluster for Trip Planning
ExtenSive D11.1	UC_TD4.24	Dynamic Display of map content

6 Use Case Definition

6.1 Methodology

To create a comprehensive catalogue of use cases, requirements, acceptance criteria and test cases, the use cases, developed in tasks 6.1, 6.2 and 6.4 to 6.6, are expanded by those of IMs and RUs based on each user personas needs as described in Chapter 4. To cumulate many different opinions and views, a questionnaire was developed and sent out to all stakeholders, as discussed in Chapter 7.1.1. This was a combined effort of Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR), Ferrovie dello Stato Italiene (FS), Hacon Ingenieurgesellschaft mbH (HACON), Ground Transportation Systems Portugal SA (GTSP), Trafikverket, ÖBB-Infrastruktur AG (ÖBB-Infra) and d-fine[4].

Throughout the project's duration, the partnering companies involved held one or both of the following roles:

- **Author Group:** The Author Group assumed the responsibility of content creation using the approach described in Chapter 4.
- **Review Group:** The members of the Review Group were tasked with quality assurance for each of the intermediate releases and final release.

To improve readability and comparability the use cases are recorded using a template comprising the following fields:

Name	*Descriptive Name of the Use Case*
ID	*ID of the Use Case "UC-FP6-WP6-number"*
Description	*Short description of the Use Case*
Related to task/subtask(s)	*Precise task/subtask that this Use Case relates to (specification/implementation/demonstration)*
Impact on other task(s)	*Indicate tasks that may depend on the results of this Use Case (dependencies identification)*
Interactions SP/FP	*Indicate when applicable the interactions with the System Pillar or other Flagship Projects*
Actor(s)	*Involved actors (active and passive ones)*
Trigger	*Action or event that trigger the Use Case*
Pre-Condition(s)	*Preconditions of the Use Case / what is the state of the system, which allows to perform the Use Case*
Input	*Required input to execute the use case*
Result/Requirement	*What will be the expected result of the Use Case*
Sequence	*List steps of the Use Case (to be filled during specification phase)* 1. *Step x* 2. *Step y* 3. *Step z*

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[4] For more detailed information on the FP6 partners see https://projects.rail-research.europa.eu/eurail-fp6/partner/

Involved components (System)	*List the software/hardware components that will be involved to run the Use Case (to be filled during specification phase)*
Responsible partner/person	*Company and/or main contact who is responsible to describe this Use Case*
Notes	*Additional notes for the Use Case*

6.2 Use cases Task 6.1.1

Task 6.1.1 deals with the integration of DRT services into a PIS. Upon a trip search request made by a user, the PIS shall provide trip options that may include a DRT service for the first and/or last mile. A DRT service can significantly improve the comfort of travelling as it facilitates a door-to-door service without requiring individual means of transport such as an own car. To ensure that the capacity of the DRT service matches demand, a simulation will be run to determine an optimal offer. Furthermore, task 6.1.1 will enable the information about DRT services in distributed journey planning systems using the OJP protocol.

The subsequent sections will detail each use case pertaining to task 6.1.1, along with the corresponding requirements, acceptance criteria, and test cases. A comprehensive overview of these use cases' architectural design can be found in Deliverable D6.1 of WP6.

6.2.1 UC-FP6-WP6-1.1.1.

Name	Travel planning for regional lines including a demand responsive transport (DRT) service for first/last mile
ID	UC-FP6-WP6-1.1.1
Description	User of the journey planning application does a trip search and gets trip options that include DRT for first/last mile. The user could be a traveller/tourist in a region where the density of population is low, and the offer of classic public transit (rail, bus) is limited but where DRT is operating.
Related to task/subtask(s)	T6.1.1
Impact on other task(s)	T6.1.2
Interactions SP/FP	FP1 WP20 Task 20.1
Actor(s)	Traveller, Transport Service Provider (TSP) for Rail, TSP for DRT
Trigger	Traveller wants to plan a door-to-door trip
Pre-Condition(s)	• Available timetable data includes railway timetable data and information about DRT services (service area, operating hours etc.) • Availability of an API of the DRT system that can check the actual availability of a DRT vehicle for a specified trip leg • Availability of trip planning application
Input	Trip Origin, Trip destination, Departure/Arrival Time

Result/Requirement	Trip options delivered to the traveller that include DRT options for first or last mile
Sequence	1. Traveller enters origin, destination (both not necessarily covered by rail or bus) and desired departure/arrival time on a journey planning application. 2. Traveller triggers trip search 3. The journey planning algorithm seeks trips considering the requirements set by the traveller 4. Traveller receives trip options
Involved components (System)	Journey planning application, TSP system, System of DRT service provider
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.2.2 UC-FP6-WP6-1.1.2

Name	Travel planning for regional lines taking into account rules of competition for public transit and DRT
ID	UC-FP6-WP6-1.1.2
Description	User of the journey planning application does a trip search and gets trip options that include DRT only if a DRT leg is in line with the rules of competition
Related to task/subtask(s)	T6.1.1
Impact on other task(s)	T6.1.2
Interactions SP/FP	FP1 WP20 Task 20.1
Actor(s)	Traveller, TSP for Public Transit, TSP for DRT
Trigger	Traveller enters origin, destination (both not necessarily covered by rail or bus) and desired departure/arrival time on a journey planning application.
Pre-Condition(s)	• Available timetable data includes public transit timetable data and information about DRT services (service area, operating hours etc.) • Data defining the rules of competition that are in force for the TSP (public transit) and the DRT service provider • Availability of an API of the DRT system that can check the actual availability of a DRT vehicle for a specified trip leg • Availability of trip planning application
Input	Trip Origin, Trip destination, Depart/Arrival Time
Result/Requirement	Trip options delivered to the traveller that include DRT options for first or last mile only if in line with the rules of competition
Sequence	1. Traveller enters origin, destination, and desired departure/arrival time on a journey planning application 2. Traveller triggers trip search 3. The journey planning algorithm seeks trips considering the requirements set by the traveller 4. Traveller receives trip options
Involved components (System)	Journey planning application, TSP system for public transit and DRT, System of DRT service provider
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.2.3 UC-FP6-WP6-1.1.3

Name	Simulation of required DRT capacity based on predicted travel demand
ID	UC-FP6-WP6-1.1.3
Description	DRT service provider runs simulations to determine the optimal capacity offer (number of vehicles, seats per vehicle) for an area where a DRT service shall be set up or to optimize the capacity offer in an area with already existing DRT service
Related to task/subtask(s)	T6.1.1
Impact on other task(s)	T6.1.2, T6.4
Interactions SP/FP	-
Actor(s)	TSP for DRT, TSP for Rail, Traveller
Trigger	DRT service provider runs simulation to determine the capacity offer
Pre-Condition(s)	• Journey planning application for public transit in the area under consideration (area where a DRT service shall be set up or has already been set up) • Simulation system for DRT
Input	• Scenarios for DRT simulation system (origin-destination demand data) derived from output data of T6.4 • Other parameters (e.g., fleet size, maximum waiting time)
Result/Requirement	Optimal capacity offers of the DRT service (number of vehicles, seats per vehicle) that can be used for the operational phase of the DRT service.
Sequence	1. DRT service provider sets up the simulation via the frontend of the simulation system, configures input parameters and loads origin-destination demand data into the simulation system 2. DRT service provider runs simulation based on the derived demand for different scenarios reflecting different capacity offers with the click of a button in the frontend 3. DRT service provider analyses simulation results and derives optimal capacity offer for the DRT service.
Involved components (System)	Journey planning application, TSP system, DRT simulation system
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.2.4 UC-FP6-WP6-1.1.4

Name	Support Open API for distributed Journey Planning (OJP) trip search requests and include DRT in the response

ID	UC-FP6-WP6-1.1.4
Description	External journey planning system (MaaS platform) can send a trip search request where start and destination are within the area of the FutuRe journey planning system. Via OJP, a corresponding request is sent to the FutuRe journey planning system that provides a response to the external system via OJP including public transit and DRT for last or first mile. So, the regional services of FP6 can be interfaced by FP1.
Related to task/subtask(s)	T6.1.1
Impact on other task(s)	-
Interactions SP/FP	FP1 WP20 Task 20.1
Actor(s)	Traveller, External Journey Planning System (MaaS platform), TSP for Rail (in the FutuRe area), TSP for DRT (in the FutuRe area)
Trigger	Traveller wants to plan a trip in the FutuRe area but uses an external journey planning application
Pre-Condition(s)	• Available timetable data for the FutuRe area includes railway timetable data and information about DRT services (service area, operating hours etc.) • Availability of trip planning system for the external area and the FutuRe area; both have to support OJP
Input	Trip Origin, Trip destination, Depart/Arrival Time
Result/Requirement	In the external journey planning system, the traveller receives trip options in the FutuRe area that include DRT for the first or last mile
Sequence	1. Traveller enters origin, destination, and desired departure/arrival time in the external journey planning application 2. Traveller triggers trip search 3. External journey planning system (MaaS platform) sends trip request via OJP to the journey planning system for the FutuRe area 4. The journey planning system for the FutuRe area seeks trips considering the constraints set by the traveller 5. Journey planning system for the FutuRe area sends trip options via OJP to the external journey planning system 6. Traveller receives trip options in the external journey planning system
Involved components (System)	External journey planning system (MaaS platform), Journey planning system for FutuRe area, TSP system, System of DRT service provider
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3 Use cases task 6.1.2

Task 6.1.2 covers two main topics. The first topic is the integration of real-time data such as delay data and compute trip options based on real-time so that travellers get an up-to-data guidance. The second main topic is the support of PRM when planning trips by integrating station facility data such as stairs and elevators and by offering profiles for the trip search that cover different types of PRM. The profiles make it easier for a PRM to find trip options that meet his/her needs.

The subsequent sections will detail each use case pertaining to task 6.1.2, along with the corresponding requirements, acceptance criteria, and test cases. A comprehensive overview of these use cases' architectural design can be found in Deliverable D6.2 of WP6.

6.3.1 UC-FP6-WP6-1.2.1

Name	Synchronization of operational processes among regional rail operators to adjust ad-hoc timetables
ID	UC-FP6-WP6-1.2.1
Description	Realtime information of (at least) two rail operators is processed so that ad-hoc timetables and resulting trip options that take delays and cancellations of public transit services into account can be presented to travellers.
Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Rail operator 1, rail operator 2, journey planning system
Trigger	Journey planning system receives updates to the timetable according to the real-time situation from the connected operators.
Pre-Condition(s)	• Realtime information from rail operator 1 and 2 (e.g., delay information, cancellations, platform changes) • Availability of journey planning system • Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2
Input	Static timetable data (schedule data), real-time data (delays, cancellations)
Result/Requirement	The journey planning system can provide trip options that take real-time data from rail operator 1 and 2 into account
Sequence	1. Journey planning system consumes real-time data of rail operator 1 and rail operator 2 2. Journey planning system matches real-time data with static timetable data 3. Journey planning system constructs ad-hoc timetable based on static and real-time data

Involved components (System)	Journey planning system, real-time data source of rail operator 1 and real-time data source of rail operator 2
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3.2 UC-FP6-WP6-1.2.2

Name	Synchronization of operational process among regional rail operators and other services to adjust ad-hoc timetables
ID	UC-FP6-WP6-1.2.2
Description	Realtime information of (at least) two rail operators is processed together with data from bus and DRT services so that ad-hoc timetables and resulting trip options that take delays and cancellations of public transit services and availabilities of DRT services into account can be presented to travellers upon a trip request.
Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Rail operator 1, rail operator 2, bus operator and DRT operator, journey planning system
Trigger	Journey planning system receives updates to the timetable according to the real-time situation from the connected operators
Pre-Condition(s)	• Rail operator 1 and 2 provide real-time information for their respective trains • Bus operator provides real time information for its buses/DRT service provider can respond to requests for a vehicle needed within the current/next hour • Availability of journey planning system • Journey planning system is equipped with static timetable data of rail operator 1, rail operator 2, bus operator, and some necessary data from DRT service provider (e.g., service area, operating hours)
Input	Static timetable data (schedule data), real-time data of rail and bus operators (delays, cancellations); access to DRT service platform (i.e., ability to send a request and receive DRT service availability)
Result/Requirement	The journey planning system can provide trip options that take real-time data from rail operators and bus operator/DRT service provider into account
Sequence	1. Journey planning system consumes real-time data of rail operator 1, rail operator 2 and bus operator 2. Journey planning system matches real-time data with static timetable data 3. Journey planning system constructs ad-hoc timetable based on static and real-time data

	4. Availability of DRT service is checked ad-hoc upon trip request (if DRT is part of the calculated journey)
Involved components (System)	Journey planning system, real-time data source of rail operator 1, real-time data source of rail operator 2, real-time data source of bus operator/DRT system
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3.3 UC-FP6-WP6-1.2.3

Name	Trip search based on the ad-hoc timetable
ID	UC-FP6-WP6-1.2.3
Description	Traveller does a trip search and gets results that take into account the real-time situation
Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Traveller, journey planning system
Trigger	Traveller requests a trip by entering parameters that indicate a start within the next hour(s) or traveller wants to be informed about the current situation of a trip
Pre-Condition(s)	• Availability of journey planning system • Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 and of other service providers such as a bus operator or a DRT service provider • Journey planning system consumes real-time information for services of rail operator 1 and 2 and for bus and/or DRT
Input	Static timetable data (schedule data), real-time data of rail and bus operators (delays, cancellations); access to DRT service platform (i.e., ability to send a request and receive DRT service availability)
Result/Requirement	The journey planning system can provide trip options that take real-time data into account
Sequence	1. Traveller enters origin, destination, and desired departure/arrival time within the next hour(s) on a journey planning application. 2. Traveller triggers trip search 3. The journey planning algorithm seeks trips based on static timetable (in case that real-time data is not available) and based on ad-hoc timetable 4. Traveller receives trip options
Involved components (System)	Journey planning system, real-time data source of rail operator 1, real-time data source of rail operator 2, real-time data source of bus operator/DRT system
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3.4 UC-FP6-WP6-1.2.4

Name	Passenger information portal providing personalized details about regional connections and services at stations

ID	UC-FP6-WP6-1.2.4
Description	Traveller does a trip search with individual settings and gets corresponding trip options as a result
Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Traveller, journey planning system
Trigger	Traveller enters origin, destination, and desired departure/arrival time on the journey planning application.
Pre-Condition(s)	• Availability of journey planning system • Journey planning system is equipped with static timetable data
Input	Static timetable data (schedule data) Station facility data (where relevant data exists); if possible, data can come from TSP
Result/Requirement	The journey planning system can provide trip options that take the individual setting of the user into account.
Sequence	1. Traveller enters origin, destination, and desired departure/arrival time on the journey planning application. 2. Traveller sets individual search parameters (e.g., exclusion of certain types of vehicles, e.g., no bus, or exclusion of facilities that are not appropriate for PRM such as stairs) 3. Traveller triggers trip search 4. The journey planning algorithm seeks trips taking the individual settings into account 5. Traveller receives trip options
Involved components (System)	Journey planning system
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3.5 UC-FP6-WP6-1.2.5

Name	Passenger information portal provides a map showing Points of Interest that can be individually filtered by category
ID	UC-FP6-WP6-1.2.5
Description	Traveller can view Points of Interest (POIs) on a map, show/hide POIs and select POIs as start/destination of a trip search
Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Traveller, journey planning system
Trigger	Traveller opens the map of the passenger information portal
Pre-Condition(s)	• Availability of journey planning system • Journey planning system is equipped with static timetable data and with POI data
Input	Static timetable data (schedule data), POI data
Result/Requirement	The map of the journey planning system can show POIs and allows the user to select a POI as start or destination for a trip search
Sequence	1. Traveller opens the map of the passenger information portal 2. Traveller activates the display of the desired category of POIs, e.g., restaurant, hotel, etc. 3. Traveller selects a POI and chooses the POI as start or destination
Involved components (System)	Journey planning system
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3.6 UC-FP6-WP6-1.2.6

Name	Travel planning for specific user groups with reduced mobility (Selection of a default profile)
ID	UC-FP6-WP6-1.2.6
Description	User of the journey planning application can provide information on their specific travel needs (e.g., by choosing a profile for specific PRMs), and the resulting trips take these specific needs into account (if supported in the data).
Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	PRM Traveller, TSP
Trigger	Traveller enters origin, destination, and desired departure/arrival time on a journey planning application
Pre-Condition(s)	• Availability of journey planning system • Journey planning system is equipped with static timetable data including information regarding accessibility features (esp. regarding station data, e.g., stairs/elevators) • List of predefined PRM profiles
Input	Trip Origin, Trip destination, Depart/Arrival Time, PRM profile
Result/Requirement	Trip options delivered to the traveller that take the selected PRM profile (needs) into account
Sequence	1. Traveller enters origin, destination, and desired departure/arrival time on a journey planning application. 2. Traveller triggers trip search and receives trip options 3. Traveller selects a profile from a list of PRM profiles suited to their needs so that the system considers her/his specific accessibility needs 4. The journey planning algorithm seeks trips considering the PRM profile selected by the traveller 5. Traveller receives trip options
Involved components (System)	Journey planning application, TSP System
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3.7 UC-FP6-WP6-1.2.7

Name	Journey planning for passengers with reduced mobility with a personalised profile (Adjustment of a default profile)
ID	UC-FP6-WP6-1.2.7

Description	The user of the journey planning application can choose a profile based on their specific travel needs and adjust the default settings of this profile to her/his personal needs. The resulting trip will take these specific needs into account (if supported in the data)
Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	PRM Traveller, TSP
Trigger	Traveller enters the view on settings
Pre-Condition(s)	• Available timetable data includes information regarding accessibility features. • Availability of trip planning application • List of PRM profiles • PRM not satisfied with trip option that were calculated taking into account the selected profile
Input	Journey planning request based on a PRM profile, including personal settings
Result/Requirement	Trip options that take the selected PRM needs into account
Sequence	1. Traveller enters the view on settings 2. Traveller adjusts the default settings of the previously selected profile as per their needs. 3. Traveller triggers another trip search 4. The journey planning algorithm seeks trips considering the requirements set by the traveller 5. Traveller receives trip options
Involved components (System)	Journey planning application, TSP system
Responsible partner/person	Ira Kataria, Hacon Matthias Walter, Hacon
Notes	-

6.3.8 UC-FP6-WP6-1.2.8

Name	Using pareto-search to minimize walking distance
ID	UC-FP6-WP6-1.2.8
Description	Users of the journey planning application can choose a profile for the trip search that seeks to minimize the total walking distance, i.e., trip results are computed for which the walking distance for first mile, at transfers and for last mile is as short as possible. This option would be helpful for travellers with small children or heavy luggage or travellers walking on crutches amongst others.

Related to task/subtask(s)	T6.1.2
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	PRM Traveller, Transport Service Provider
Trigger	Traveller wants to plan a trip that considers her/his specific accessibility needs (e.g., traveller with small children or heavy luggage or traveller walking on crutches)
Pre-Condition(s)	• Availability of journey planning system • Journey planning system is equipped with static timetable data • List of predefined PRM profiles plus at least one profile (not limited to PRM) that triggers a trip search aiming at a minimum walking distance
Input	Trip Origin, Trip destination, Depart/Arrival Time, PRM profile
Result/Requirement	Trip options delivered to the traveller that take the selected profile (needs) into account
Sequence	1. Traveller enters origin, destination, and desired departure/arrival time on a journey planning application. 2. Traveller triggers trip search and receives trip options 3. Traveller selects a profile from a list of profiles suited to their needs and including the minimum walk optimization so that the system considers her/his specific accessibility needs 4. The journey planning algorithm seeks trips considering the PRM profile selected by the traveller 5. Traveller receives trip options
Involved components (System)	Journey planning application, TSP System
Notes	-

6.4 Use cases task 6.2

Task 6.2 specifies an interface between Traffic Management Systems (TMS) and Passenger Information Systems (PIS). The interface has a twofold purpose. On the one hand, it facilitates to provide demand forecast data for train services from a PIS to a TMS so that on TMS side short-term traffic control actions can be taken and long-term replanning decisions can be made; on the other hand, the interface enables the TMS to send information about timetable updates via the interface to the PIS so that travellers can be informed in real time about changes impacting their journeys.

The TMS-PIS interface is specified based on four use cases. Three use cases are concerned with transferring demand forecast data for regional train services from the PIS to the TMS, one use case describes that timetable updates on TMS side are transferred to the PIS.

The subsequent sections will detail each use case pertaining to task 6.2, along with the corresponding requirements, acceptance criteria, and test cases. A comprehensive overview of these use cases' architectural design can be found in Deliverable D6.3 of WP6.

6.4.1 UC-FP6-WP6-2.1

Name	Sending updated operational plan and calculated forecast provided by the TMS to passenger information services/systems (PIS)
ID	UC-FP6-WP6-2.1
Description	Following the updates of the operational plan and the calculated forecast in the TMS, specific relevant information is derived and sent to the PIS: • Expected delay in arrival and departure times of the trains; • Platform track changes; • Full or partial cancellations; • Incident information in relation to trains;
Related to task/subtask(s)	T6.2
Impact on other task(s)	T6.1.1, T6.4
Interactions SP/FP	FP1 WP12 Task 12.2.7
Actor(s)	Traffic Controller, TMS, PIS end user
Trigger	TMS receives updated operational plan and calculated forecast
Pre-Condition(s)	• Available operational plan including trains and operational restrictions (planned or incident based) impacting trains, • Availability of TMS, • Availability of integrated PIS / traveller application for the area covered by the TMS.
Input	• Baseline data for network topology and train characteristics, • Public timetable containing the trains of the TMS area, • Train position feeds (simulated), • Trip request.
Result/Requirement	Delay, track change and incident information delivered to the PIS.

Sequence	1. (simulated) Train positions fed into TMS leading to the need for intervention by the Traffic Controller. 2. Update of operational plan in the TMS initiated by Traffic Controller. 3. Train running forecast calculation performed in TMS. 4. Information derived from operational plan and train running forecast is transferred via interface to the PIS. 5. Information received by PIS. 6. PIS End user receives information in conjunction with his trip information.
Involved components (System)	TMS, PIS, Journey planning application
Responsible partner/person	Rolf Gooßmann, Hacon
Notes	-

6.4.2 UC-FP6-WP6-2.2

Name	Usage of the number of expected travellers for timetable planning or traffic dispatching
ID	UC-FP6-WP6-2.2
Description	As part of the demand forecast information, the TMS or Capacity Management and Planning System (CMS) receives the number of expected travellers from A to B in defined time windows being visualized for decision support in (re-) planning the timetable in CMS and/or changing the Operational Plan in TMS.
Related to task/subtask(s)	T6.2
Impact on other task(s)	T6.1.1, T6.4
Interactions SP/FP	FP1 WP6 Task 6.3.1, WP7 Task 7.5.1 and 7.6 FP1 WP12
Actor(s)	Timetable/Traffic Planner, Traffic Controller, TMS, PIS
Trigger	Scheduled trigger in TMS or CMS for looking up newly delivered input being available.
Pre-Condition(s)	• Available timetable (CMS) and related Operational Plan (TMS) including trains for which demand forecast information is available, i.e., expected travellers for relation A-B where A and B are starting and destination stations of the trains, • Availability of CMS and related TMS, • Availability of integrated PIS providing demand forecast for the area covered by the CMS/TMS.
Input	• Baseline data for network topology and train characteristics. • Public timetable containing the trains of the CMS/TMS area, • Source data allowing to derive demand forecast for at least a part of the network covered with planned timetables for trains.
Result/Requirement	Changes applied to the timetable (CMS), or the Operational Plan (TMS) based on forecasted demand.
Sequence	1. The number of expected travellers from A to B in a defined time window is received by CMS. 2. Travel/transport demand window is generated in the CMS as part of the planning data and is available to CMS system logic and to the users of the CMS. 3. Different timetable change options are applied involving CMS timetable planner and the CMS: a) Let the planning system generate (an) extra train(s) from A to B with defined seat capacity. b) Decide a (partial) cancellation of a service due to non-sufficient demand.

	c) Decide on reducing or increasing the number of coaches for existing service(s) from A to B matching the demand. 4. CMS implements the change in the planned timetable. 5. CMS forwards the changed plan to TMS (if changes to be included in the current Operational Plan). 6. TMS updates Operational Plan (if changes to be included in the current Operational Plan).
Involved components (System)	CMS, TMS, PIS, Integration Platform
Responsible partner/person	Rolf Gooßmann, Hacon
Notes	-

6.4.3 UC-FP6-WP6-2.3

Name	Receiving and using the number of expected travellers between subsequent stops of a given train for timetable planning or traffic dispatching
ID	UC-FP6-WP6-2.3
Description	As part of the demand forecast information, the TMS/CMS receives the number of expected travellers between subsequent stops of a given train being visualized for decision support in (re-) planning the timetable in CMS and/or changing the Operational Plan in TMS.
Related to task/subtask(s)	T6.2
Impact on other task(s)	T6.1.1, T6.4
Interactions SP/FP	FP1 WP6 Task 6.3.1, WP7 Task 7.5.1 and 7.6 FP1 WP12
Actor(s)	Timetable/Traffic Planner, Traffic Controller, TMS, PIS
Trigger	Scheduled, regular trigger in TMS or CMS for looking up newly delivered input being available.
Pre-Condition(s)	• Available timetable (CMS) and related Operational Plan (TMS) including trains for which demand forecast information is available, i.e., expected travellers between subsequent stops A-B of a given train, • Availability of CMS and related TMS, • Availability of integrated PIS providing demand forecast for the area covered by the CMS/TMS.
Input	• Baseline data for network topology and train characteristics. • Public timetable containing the trains of the CMS/TMS area, • Source data allowing to derive demand forecast for at least a part of the network covered with planned timetables for trains.
Result/Requirement	Changes applied to the timetable (CMS), or the Operational Plan (TMS) based on forecasted demand.
Sequence	1. The number of expected travellers between subsequent stops of a given train is received by CMS. 2. The information is generated in the CMS and assigned to the respective train and its respective journey section A-B as part of the planning data. The information is available to CMS system logic and to the users of the CMS. 3. Timetable change involving CMS timetable planner and the CMS based on occupancy information between stops, decide on prioritization of trains and related re-planning (e.g., changing train sequence).

	4. CMS implements the change in the planned timetable. 5. CMS forwards the changed plan to TMS (if changes to be included in the current Operational Plan). 6. TMS updates Operational Plan (if changes to be included in the current Operational Plan).
Involved components (System)	CMS, TMS, PIS
Responsible partner/person	Rolf Gooßmann, Hacon
Notes	-

6.4.4 UC-FP6-WP6-2.4

Name	Receiving and using the number of expected travellers embarking/disembarking at the stops/stations of a given train for timetable planning or traffic dispatching
ID	UC-FP6-WP6-2.4
Description	As part of the demand forecast information, the TMS/CMS receives the number of expected travellers embarking/disembarking at the stations being visualized for decision support in (re-) planning the timetable in CMS and/or changing the Operational Plan in TMS.
Related to task/subtask(s)	T6.2
Impact on other task(s)	T6.1.1, T6.4
Interactions SP/FP	FP1 WP6 Task 6.3.1, WP7 Task 7.5.1 and 7.6 FP1 WP12
Actor(s)	Timetable/Traffic Planner, Traffic Controller, TMS, PIS
Trigger	Scheduled, regular trigger in TMS or CMS for looking up newly delivered input being available.
Pre-Condition(s)	• Available timetable (CMS) and related Operational Plan (TMS) including trains for which demand forecast information is available, i.e., expected travellers between subsequent stops A-B of a given train, • Availability of CMS and related TMS, • Availability of integrated PIS providing demand forecast for the area covered by the CMS/TMS.
Input	• Baseline data for network topology and train characteristics. • Public timetable containing the trains of the CMS/TMS area, • Source data allowing to derive demand forecast for at least a part of the network covered with planned timetables for trains.
Result/Requirement	Changes applied to the timetable (CMS), or the Operational Plan (TMS) based on forecasted demand.
Sequence	1. The number of expected travellers embarking/disembarking at the stops A, B, C, … of a given train is received by CMS. 2. The information is generated in the CMS and assigned to the respective train and its respective journey stops A, B, C, … as part of the planning data. The information is available to CMS system logic and to the users of the CMS. 3. Timetable change involving CMS timetable planner and the CMS decide on required exceptional dwell time at stations for consideration of unexpected number of people embarking/disembarking at the station.

	4. CMS implements the change in the planned timetable. 5. CMS forwards the changed plan to TMS (if changes to be included in the current Operational Plan). 6. TMS updates Operational Plan (if changes to be included in the current Operational Plan).
Involved components (System)	CMS, TMS, PIS
Responsible partner/person	Rolf Gooßmann, Hacon
Notes	-

6.5 Use cases task 6.4

Task 6.4 is concentrated on short- and long-term travel demands calculation. The focus lies in developing machine learning algorithms capable of calculating demand forecasts using data available from PIS. By doing so, providing demand information to the transportations stakeholders (like TMS systems), we enable a more dynamic response to changing demand patterns, allowing for adjustments in planned rail services and other modes of transportation. This flexibility is essential to avoid costly operations and enhance overall efficiency.

The subsequent sections will detail each use case pertaining to task 6.4, along with the corresponding requirements, acceptance criteria, and test cases. A comprehensive overview of these use cases' architectural design can be found in Deliverable D6.5 of WP6.

6.5.1 UC-FP6-WP6-4.1

Name	Forecast Occupancy of Vehicles using Journey Planning Requests Data
ID	UC-FP6-WP6-4.1
Description	This use case involves predicting the occupancy of transportation vehicles (like trains, buses, DRT vehicles) based on journey planning requests data (or other sources), which includes information about the origin, destination, and expected time of travel for customers.
Related to task/subtask(s)	T6.4
Interactions SP/FP	Possible interaction with FP1 to align specification between main line and regional lines
Actor(s)	MaaS platform
Trigger	New journey planning requests data received
Pre-Condition(s)	Journey planning request data (origin, destination, expected travel time)
Input	Journey planning request data (origin, destination, time of departure or arrival)
Result/Requirement	Predicted occupancy for specific routes and time slots
Sequence	List steps of the Use Case (to be filled during specification phase) 1. The MaaS platform process and provide new journey planning requests data, including origin, destination, and time of departure or arrival, during time interval (e.g., daily). 2. The data analytics platform gathers the new data 3. The data analytics platform considering historical vehicle occupancy data and journey planning request data, analysis the new data, training the model. 4. The system updates the trained occupancy model of the transport network.

	5. Store the forecasted occupancy model for future reference.
Involved components (System)	Data Analytics Platform, Machine Learning Model
Responsible partner/person	Marco Ferreira (HACON)
Notes	The accuracy of the occupancy forecast may vary based on the quality and completeness of the journey planning request data.

6.5.2 UC-FP6-WP6-4.2

Name	Display Forecasted Occupancy Information to Travelers when Planning Trips
ID	UC-FP6-WP6-4.2
Description	This use case involves displaying forecasted vehicle occupancy information to travellers when they plan their trips through a trip planning interface.
Related to task/subtask(s)	T6.4
Interactions SP/FP	Possible interaction with FP1 to align specification between main line and regional lines
Actor(s)	Travellers
Trigger	Traveller initiates the trip planning process
Pre-Condition(s)	Traveller uses journey planning tool Forecasted vehicle occupancy data is available
Input	Journey planning request data (origin, destination, time of departure or arrival)
Result/Requirement	Display of forecasted vehicle occupancy information for the proposed journeys to travellers
Sequence	List steps of the Use Case (to be filled during specification phase) 1. Traveller enters their origin, destination, and time of departure or arrival. 2. The trip planning interface displays several trip option and fetches forecasted vehicle occupancy information for the journeys. 3. Display the forecasted vehicle occupancy to the traveller on the trip planning interface.
Involved components (System)	Journey Planning app, Data Analytics Platform
Responsible partner/person	Marco Ferreira (HACON)
Notes	The displayed forecasted occupancy information is for planning purposes and may not reflect real-time changes in vehicle availability.

6.5.3 UC-FP6-WP6-4.3

Name	Estimation of Mobility Demand beyond Rail (First/Last Mile Analysis)
ID	UC-FP6-WP6-4.3
Description	This use case involves estimating mobility demand beyond rail transportation by conducting a first/last mile analysis. Travel Service Providers can analyse areas with high demand and low offering. On basis of this analysis demand gaps can be identified and reported to travel service providers. This allows them to create adapted offers for seamless transportation connections between rail stations and surrounding locations.
Related to task/subtask(s)	T6.4
Interactions SP/FP	Possible interaction with FP1 to align specification between main line and regional lines
Actor(s)	Travel Service Providers (Rail and others)
Trigger	Travel Service Provider requests a report about demand gaps
Pre-Condition(s)	Journey planning requests data are available, historical travel demand data is collected
Input	Journey planning requests data, historical travel demand data
Result/Requirement	Estimated mobility demand for first/last mile connections and identification of areas with high demand and low offering is provided to Transport service providers.
Sequence	1. Collect rail transportation data, including station locations, schedules. 2. Collect historic travel demand data based on journey planning requests data 3. Train the machine learning model using historical travel demand data combining rail and other modes in the surrounding areas. 4. Estimate the mobility demand for first/last mile connections between rail stations and surrounding locations. 5. Identify areas with high demand and low offering based on the analysis results. 6. Provide data insights for travel service providers through the demand analytics dashboard. 7. Give the travel transport providers the option to extract/download estimations for first/last mile travel demand
Involved components (System)	Data Analytics Platform, Demand analytics dashboard

Responsible partner/person	Marco Ferreira (HACON)
Notes	The accuracy of the demand estimation depends on the quality and completeness of the available data.

6.5.4 UC-FP6-WP6-4.4

Name	Detection and Characterization of Abnormal Train Usage Peaks
ID	UC-FP6-WP6-4.4
Description	This use case focuses on identifying abnormal peaks in train usage by analysing historical train occupancy data alongside influencing factors such as weather conditions and public/disruptive events. By using machine learning techniques designed for anomaly detection and prediction, it is expected to identify not only the regular peaks driven by daily commuter patterns, but also unusual peak times caused by external factors. The identified anomalies can then be provided to the TMS with all the necessary context to support informed decision-making for potential service adjustments.
Related to task/subtask(s)	T6.4
Interactions SP/FP	-
Actor(s)	TMS
Trigger	Scheduled, based on weather forecast data frequency, public/disruptive events
Pre-Condition(s)	Availability of train schedule data. Access to weather data, public or disruptive events. Forecasted (or observed) vehicle occupancy data is available.
Input	Train schedule data. Weather condition data. Public/disruptive events information. Output from the vehicle occupancy forecast system (or historical occupancy data).
Result/Requirement	Detection of abnormal train usage peaks. Insights into how weather conditions, and public/disruptive events interact to provoke these anomalies.
Sequence	1. Weather forecast data (depending on data source release frequency), public and disruptive events, and forecast occupancy of vehicles (or observed) are collected and pre-processed. 2. Considering the historical and newly added data, the ML component performs a training process to adjust models' parameters (anomaly detection and anomaly prediction models). 3. The trained ML model for anomaly prediction is used to identify new anomalies based on upcoming weather and events.

	4. Anomaly contextual information covering weather conditions, nearby events and historical comparisons with similar conditions are gathered and compiled. 5. The compiled information is sent to the Data Analytics Platform to be integrated into an anomaly structured message. 6. The anomaly structured message is delivered to the TMS for further analysis.
Involved components (System)	Data Analytics Platform Forecast Occupancy of Vehicles using Journey Planning Requests Data (T6.4) Anomaly Detection and Prediction Component
Responsible partner/person	GTSP
Notes	The accuracy of detecting train usage peaks depends heavily on the quality and completeness of the available data. The contextual data for anomalies can be further enhanced by incorporating, if available, additional complementary information such as train composition details, trending passenger feedback, and other relevant factors.

6.6 Use cases task 6.5

Task 6.5 focuses on passenger congestion monitoring to enhance the efficiency and service quality of regional railway networks in Europe. It includes detailed specifications such as the use cases which are listed below, system actors, and algorithms to develop a robust monitoring system, aimed at reducing congestion and improving the quality of service on regional railways and their connections to main lines.

The subsequent sections will detail each use case pertaining to task 6.5, along with the corresponding requirements, acceptance criteria, and test cases. A comprehensive overview of these use cases' architectural design can be found in Deliverable D6.6 of WP6.

6.6.1 UC-FP6-WP6-5.1

Name	Impact of weather and train composition on train schedules and delays
ID	UC-FP6-WP6-5.1
Description	Using a Machine Learning model that integrates weather data (temperature, precipitation, wind speed, etc.) with train schedules and compositions, the goal is to predict potential delays caused by adverse weather conditions and its impact on congestion.
Related to task/subtask(s)	T6.5
Impact on other task(s)	T6.4
Interactions SP/FP	No interaction.
Actor(s)	Rail operator, weather forecast provider.
Trigger	Scheduled, based on weather forecast data frequency.
Pre-Condition(s)	Historical weather data; Historical train schedule data; Historical train composition information; Observed train delays;
Input	Train scheduled data; Train composition information; Weather condition data (forecast and observed).
Result/Requirement	Characterization (e.g., expected impact, time delay, congestion period, station affected, ...) of a predicted delay, including the impact, in terms of forecasted congestion variation. Future delays and congestions which might result from current and predicted weather are forecasted and can be used to identify actions to avoid these congestions.
Sequence	1. Weather forecast data is collected depending on data source release frequency; 2. The ML model is applied to a dataset, which was updated with the latest weather data, predicting potential delays; 3. If a delay is predicted, the system should perform the characterization of forecasted congestion.

	4. If no delay is predicted, no output from the system is expected
Involved components (System)	Data Manager, Machine Learning Delay Impact (DI) model
Responsible partner/person	GTSP/Tiago Fonseca
Notes	Real time train data and forecasted vehicle occupancy information (UC-FP6-WP6-4.2) would improve the accuracy of the results.

6.6.2 UC-FP6-WP6-5.2

Name	Synchronization between train and regional bus schedules
ID	UC-FP6-WP6-5.2
Description	The synchronization of interfacing operators' timetables highly affects congestion at stations and the perceived Quality of Service (QoS). This use case involves a detection system for timeframes where synchronization between interfacing operators could be improved. These detected timeframes can then be delivered to TMSs to further improve timetables synchronization.
Related to task/subtask(s)	T6.5
Impact on other task(s)	No impact.
Interactions SP/FP	No interaction.
Actor(s)	Rail Operator, Regional Bus Operator, TMS
Trigger	Periodically, depending on Train and Regional bus schedule updates.
Pre-Condition(s)	Availability of identified input data.
Input	Train scheduled and observed data; Bus scheduled and observed data;
Result/Requirement	The identified timeframes, where synchronization between train and bus schedules could be improved, are delivered to the TMSs.
Sequence	1. Collect Train scheduled and observed data; 2. Collect Bus scheduled and observed data; 3. Analyse collected data to identify time gaps (timeframes) between interfacing services; 4. Deliver the identified timeframes to TMSs to further improve timetables synchronization.
Involved components (System)	Data Manager, Synchronization Component
Responsible partner/person	GTSP/Tiago Fonseca
Notes	The accuracy of these UC result will depend on the quality and completeness of the available data.

6.6.3 UC-FP6-WP6-5.3

Name	Traveller feedback for congestion analysis
ID	UC-FP6-WP6-5.3
Description	Using the traveller as a sensor, the system collects information about occupancy on train vehicles and stations. The collected information is then aggregated and processed, improving its accuracy and later usability. This processed information is made available for the TSP, empowering it with more information related to network congestion.
Related to task/subtask(s)	T6.5
Impact on other task(s)	No impact
Interactions SP/FP	No interaction.
Actor(s)	Traveller and TSP
Trigger	Periodically, depending on the number of traveller's feedback received.
Pre-Condition(s)	Available mobile application
Input	Traveller feedback
Result/Requirement	Processed congestion related to traveller feedback available for TSP.
Sequence	1. User sends feedback about the surroundings (train vehicle or station): a. After receiving a request for feedback notification. b. After the traveller takes the initiative to provide feedback. 2. After receiving the traveller feedback, the collected information is analysed and processed according to specific rules (location, service, …) 3. The processed information is made available for TSP to use.
Involved components (System)	Feedback Processor, Reporting Tool
Responsible partner/person	GTSP/Tiago Fonseca
Notes	

6.6.4 UC-FP6-WP6-5.4

Name	Train Platform Allocation Problem
ID	UC-FP6-WP6-5.4
Description	It is a system that efficiently assigns trains to railway station platforms using MILP optimization algorithms with the aim of increasing operational efficiency, optimizing the distance between connecting trains' platform and therefore improving the overall user experience. Using MILP algorithms to model the optimal platforming problem, starting from a timetable and a geometric configuration of a railway station, we find the setting able to maximize the time available to passengers for inter-platform movement, also considering train punctuality.
Related to task/subtask(s)	T6.5
Impact on other task(s)	No impact
Interactions SP/FP	No interaction
Actor(s)	Rail Operator
Trigger	Periodically or on-demand, depending on agreements with the infrastructure manager or on business needs.
Pre-Condition(s)	Access to timetable, punctuality, infrastructure, and demand data; possibility of proposing new configurations to infrastructure manager.
Input	Timetable, punctuality data, infrastructure, and demand data.
Result/Requirement	Maximize the available transfer time for passengers.
Sequence	1. Acquisition of timetable data from GTFS format, demand, and infrastructure data from various sources to the database. At the same time, acquisition of punctuality and platforming data in a data analysis tool. 2. Ingestion of the above-mentioned data in the optimization model and current scenario evaluation. 3. Run of the optimization algorithm. 4. Generation of the optimized scenario. 5. KPIs and visualizations for results' validation
Involved components (System)	Database, Optimization Software, Data Analysis Tool
Responsible partner/person	Trenitalia: Giovanni Luca Giacco
Notes	-

6.7 Use cases task 6.6

Task 6.6 considers the transport of freight in passenger trains. The use cases focus on the planning phase where a PIS is queried if and when a transport option is available. The underlying

scenarios cover private persons who want to ship a single parcel from A to B and parcel delivery companies that want to send containers of parcels in a passenger train.
The subsequent sections will detail each use case pertaining to task 6.6, along with the corresponding requirements, acceptance criteria, and test cases. A comprehensive overview of these use cases' architectural design can be found in Deliverable D6.7 of WP6.

6.7.1 UC-FP6-WP6-6.1

Name	User plans to ship a single parcel from station A to station B without transfer possibility (must stay on the train) and with mandatory personal drop off and pick-up
ID	UC-FP6-WP6-6.1
Description	Existing journey planning applications shall be enhanced to provide potential users (individuals or shops) with information which trains (existing train services) can transport easy-to-handle freight like parcels. The users cannot or will not travel with the same train but will bring their parcel to the train. In the train, the conductor will place the parcel in a minor modified (locked) compartment. At the destination (a regional stopping point/station), an identified person picks up the parcel from the conductor of the train when it stops. The journey planner will return suitable trains from the starting station to the end station. Since there will not be additional staff, the usage of transfer connections is not possible. *This use case is to be seen in addition to industrial parcel delivery concepts, which require dedicated significant modifications of existing waggons or building new flexible waggons to automate the pick-up, transport, and delivery of complete parcel boxes to regional stations.*
Related to task/subtask(s)	T6.6
Impact on other task(s)	-
Interactions SP/FP	Interaction with FP5 (intermodal trip search) -> both need a trip search for freight transportation considering capacities
Actor(s)	User (end customer), Transport Service Provider for Rail
Trigger	User wants to send a parcel from station A to station B by train
Pre-Condition(s)	• Available railway timetable data • Available information on which trains can be used for freight transportation • Available information on pick-up/drop-off locations (track/waggon) and times • Availability of trip planning application

	• External identification system for the person who is authorized for pick-up
Input	Origin, destination, Depart/Arrival Time
Result/Requirement	Trip options that are available for freight transport and there is a “Booking” button leading to an external booking system with capacity and price information
Sequence	1. User enters origin, destination, and desired departure/arrival time for the shipment on a journey planning application 2. User triggers trip search 3. The journey planning algorithm seeks trips for the parcels considering the requirements set by the user 4. User receives trip options and prices 5. User is connected to external booking system
Involved components (System)	Journey planning application, TSP system
Responsible partner/person	Thomas Walker, Hacon Lars Deiterding, Hacon
Notes	-

6.7.2 UC-FP6-WP6-6.2

Name	User plans to ship a single parcel within a region from address A to address B via parcel lockers
ID	UC-FP6-WP6-6.2
Description	The user wants to send a single parcel from (address) point A to (address) point B and uses drop-off/pick-up points (e.g. a parcel locker) close to points A and B (directly at the station) for this. The transport between the drop-off and the pick-up location will be done by regional passenger trains. All parcels from the drop-off location are collected, transferred to a container, and transported with the train to the next transhipment point where the parcels are transhipped to other trains. Trains starting at transshipment points can deliver a container with parcels to a station where the container is unloaded, and parcels are filled in a parcel locker from where recipients can pick up their parcel. Workers of a parcel delivery company process the parcels at the drop-off/pick-up and transhipment points. The trip planning application provides information on which routes such services can be offered as the respective (connected) trains are equipped and included in this specific service offer. The trip planer returns the train trip the parcel will take as well as the route for walking/car from address A to the drop-off point and from the pick-up point to address B. The scheduled departure and arrival time and basic tariff information are shown, and the end customer can click on a button to open the external booking system. Potentially such services could be offered also multimodally with buses or other means of transportation.
Related to task/subtask(s)	T6.6
Impact on other task(s)	-
Interactions SP/FP	Interaction with FP5 (intermodal trip search) -> both need a trip search for freight transportation considering capacities
Actor(s)	User (end customer), Transport Service Provider for Rail, CEP-company
Trigger	User wants to send a parcel from address A to address B by train
Pre-Condition(s)	• Available timetable includes railway timetable data and information for each train whether it can transport a container/box with parcels • In addition, for each train data whether a container/box can be unloaded/loaded at a station or not

	- If containers/boxes can be loaded, data on the latest drop-off time, and if containers can be unloaded, data on the earliest pick-up time
Input	Origin, destination, Depart/Arrival Time
Result/Requirement	Trip options that represent the trip of the parcel or a message that a trip could not be found, first and last mile routes for walking or car, link to external booking system with price and capacity information
Sequence	1. End customer enters input data on a journey planning application 2. User triggers trip search for parcels 3. Journey planning algorithm seeks trips for a parcel shipment considering the requirements set by the user, calculates first and last mile routes for different modes of transport, and determines the prices 4. End customer receives trip options for a parcel shipment
Involved components (System)	Journey planning system, TSP system
Responsible partner/person	Thomas Walker, Hacon Matthias Walter, Hacon
Notes	-

6.7.3 UC-FP6-WP6-6.3

Name	CEP company plans to install a regional collection- and distribution network for parcels. This use case includes the shipment of single parcels within the region (see UC-FP6-WP6-6.2)
ID	UC-FP6-WP6-6.3
Description	Existing regional train services and existing journey planning applications shall be enabled for “freight transport”. CEP companies can use regional train lines to serve inner cities. Therefore, they use a regional distribution centre outside the inner-city located close to a station at the regional line. Standardised swap bodies or entire parcel lockers are to be transported with the regional train into the city with parcels that have their destination inside the city, and vice versa, parcels that have their origin in the city are to be transported out of the city. In both cases, a worker of the CEP company must take the swap body/parcel locker from the train and ensure the further processing. Swap bodies can be transported to a delivery base in the city which serves as a basis for the delivery to the addressee, mobile parcel lockers can be placed directly at the intermediate stations (on the train route from/towards the city centre) where they are taken out of the train and end customers can pick-up and drop-off their parcels there. The journey planning application will help the CEP company to find suitable regional trains that can be used for parcel delivery. *This use case is less connected to a daily use of an end customer who wants to ship some parcels, but more to the use of the HAFAS algorithm for the identification and planning of possible train connections which can be used by the professional CEP companies to reach/operate local parcel lockers in an optimised way. And the respective frontend used in this region (the respective HAFAS journey planer WebApp) can be used to show the end customers the parcel lockers on a map, e.g. as POIs.* *This use case should be led by DLR as it includes a piloting exercise (study) to analyse the hardware requirements/development needs to implement such concept.*
Related to task/subtask(s)	T6.6
Impact on other task(s)	-
Interactions SP/FP	Interaction with FP5 (intermodal trip search) -> both need a trip search for freight transportation considering capacities

Actor(s)	Transport Service Provider for rail, CEP company (with existing inner-city collection and distribution network)
Trigger	A CEP company wants to transport parcels in a sustainable way using existing passenger train services from a regional distribution/consolidation centre to distribution hubs in metropolitan areas or in the opposite direction.
Pre-Condition(s)	• Availability of suitable railway vehicles/trains for freight transport (suitable multi-purpose compartments for mixed use); • Availability of suitable railway vehicles/trains used in regional trains for handling standardised swap-bodies/mobile packaging stations (transhipment on/off railway vehicles/trains, door width and height and load securing); • Availability of suitable railway stations/platforms for transhipment and handling of swap-bodies/mobile packaging stations (level or hight-free transhipment, security aspects); • Available railway timetable data that include data from CEP company about freight transport feasibility • Availability of trip planning application
Input	Origin, destination, Depart/Arrival Time, number, and type of swap bodies
Result/Requirement	Trip options that are available for freight transport are shown to the CEP company
Sequence	*1. CEP company enters origin, destination, desired departure/arrival time, and number and type of swap bodies for the shipment on a journey planning application* *2. CEP company triggers trip search* *3. The journey planning algorithm seeks trips for the swap bodies considering the requirements set by the CEP company* *4. CEP company receives trip options*
Involved components (System)	*Journey planning application, TSP system*
Responsible partner/person	*Thomas Walker, Hacon* *Lars Deiterding, Hacon*
Notes	-

6.8 Use cases task 6.8

In this section all task 6.8 use cases which were derived from the perspective of passengers, infrastructure managers (IMs) and railway undertakings (RUs) are listed.

6.8.1 UC-FP6-WP6-8.1

Name	Business intelligence analysis for operational insights
ID	UC-FP6-WP6-8.1
Description	Without coding knowledge, several possibilities to generate graphs should be available. This is realised via a dedicated Analytics section in the backend. Using buttons an BIA could choose from various graphs and data sets. Graphs could display, but are not limited to information regarding most searched route requests, availability of requested routes, demand for certain MaaS solutions, demand forecast, etc
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	BIA
Trigger	The BIA selects a visualisation feature (graph-type) to generate a report
Pre-Condition(s)	The system historicizes data about the question at hand
Input	Timeseries on data required for the report
Result/Requirement	The BIA obtains a graph based on the data selected within the tool's backend
Sequence	1. A BIA specifies the visualisation type 2. They query the data to be portrayed 3. The tool generates a report and/or graphs of the data set
Involved components (System)	TMS and Historic Data Storage, PIS
Responsible partner/person	DLR
Notes	Potential demonstration in discussion

6.8.2 UC-FP6-WP6-8.2

Name	Demand based adjustment to train schedules
ID	UC-FP6-WP6-8.2
Description	Based on historic data demand forecasts for all lines are performed and frequencies adjusted accordingly
Related to task/subtask(s)	6.2 and 6.4
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Transport Planner
Trigger	A timetable adjustment is pending and/or a railway undertaking plans new services or want to cut services
Pre-Condition(s)	The system must have collected historic up to up-to-date information about on-demand and train use
Input	Time series on journey planning data.
Result/Requirement	The transport planner successfully develops an adjusted offer for the travellers based on the demand forecast
Sequence	1. A transport planner asks a BIA to generate a demand forecast for all lines in the network 2. The BIA queries the solution for the forecast (data is retrieved automatically) 3. The tool uses historic data for the forecast and provides the forecast as a report to the BIA 4. The BIA hands over the report to the transport planner
Involved components (System)	TMS & On-demand services
Responsible partner/person	DLR
Notes	Related to UC-FP6-WP6-8.1 (generation of reports by BIA) Will not be part of the demonstrator

6.8.3 UC-FP6-WP6-8.3

Name	Service feedback from customers
ID	UC-FP6-WP6-8.3
Description	A train operation manager needs to guarantee high service quality on trains. They rely inter alia on customer feedback for issue identification. Issue handling can then be prompted.
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Traffic Manager
Trigger	Train operation manager approaches BIA.
Pre-Condition(s)	Customer feedback can be provided via the solution
Input	Users are providing feedback via the solution
Result/Requirement	The train operation manager is empowered to react to issues on the train, which are consolidated in a report
Sequence	1. A train operation manager approaches the BIA for near-real time customer feedback on issues on their train lines 2. The BIA generates a report for the lines in question and subscribes the train operation manager. 3. The train operation manager receives the customer feedback concerning their train lines as a report (on a e.g., monthly basis)
Involved components (System)	TMS & Feedback system
Responsible partner/person	DLR
Notes	Feedback loop to UC-FP6-WP6-8.1 to be defined Not necessarily part of demonstrator

6.8.4 UC-FP6-WP6-8.4

Name	Documentation of software configurations, procedures, and changes
ID	UC-FP6-WP6-8.4
Description	The administrator documents and then maintains accurate information on configurations, procedures, and changes to provide reference for new team members
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Administrator
Trigger	Initial set-up of software or when change occurs
Pre-Condition(s)	The administrator created a document to track configurations, procedures, and changes
Input	Changes in configurations and procedures
Result/Requirement	The documentation for software configuration, procedures and changes is up to date
Sequence	1. The software is set-up initially OR the changes are made 2. The administrator updates the document with the initial settings OR with any changes that occurred
Involved components (System)	Backend of the software
Responsible partner/person	ÖBB-Infra (d-fine)
Notes	The main focus of the solutions in WP6/11 is on the journey planning/TMS features. The requirements for hosting and operation will be met by the PIS. Will not be part of the demonstrator

6.8.5 UC-FP6-WP6-8.5

Name	Data backup
ID	UC-FP6-WP6-8.5
Description	The administrator is responsible for preventing data loss. They ensure that by backing up data regularly. According to the company's data retention policy the administrator can set back-up frequency depending on the type of data
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Administrator
Trigger	Data back-ups are triggered according to the back-up frequency set by the administrator
Pre-Condition(s)	Available space on the back-up drive OR connectivity to the cloud storage
Input	Data to be backed up
Result/Requirement	A copy of the data (full/incremental) is created
Sequence	1. Data selected automatically according to back-up settings 2. Data copied to the back-up drive / cloud storage 3. Administrator checks that the back-up was successful
Involved components (System)	Backend of the software
Responsible partner/person	ÖBB-Infra (d-fine)
Notes	The main focus of the solutions in WP6/11 is on the journey planning/TMS features. The requirements for hosting and operation will be met by the PIS. Will not be part of the demonstrator

6.8.6 UC-FP6-WP6-8.6

Name	Data retrieval from backup
ID	UC-FP6-WP6-8.6
Description	The administrator is responsible for preventing data loss. They ensure that by testing and defining a data retrieval method, it is possible to retrieve data from backups when the system fails
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Administrator
Trigger	Data retrieval from backup is triggered by a system failure
Pre-Condition(s)	Active connection to the backup data and functioning retrieval method
Input	Backup data
Result/Requirement	Most recent backup has been restored
Sequence	1. System failure is detected 2. Admin initiates overwriting of existing data with backup data via data retrieval 3. Administrator checks if data retrieval was successful
Involved components (System)	Backend of the software
Responsible partner/person	ÖBB-Infra (d-fine)
Notes	Will not be part of the demonstrator

6.8.7 UC-FP6-WP6-8.7

Name	Logging, auditing, and compliance
ID	UC-FP6-WP6-8.7
Description	The administrator needs to ensure compliance of the software with standards, rules, and laws. For this purpose, critical information and behaviour must be logged for auditing purposes.
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Administrator
Trigger	The administrator needs to provide a compliance report
Pre-Condition(s)	● Critical information has been logged and can be audited. ● Compliance criteria were defined, and a report template generated
Input	Depends on the standard, rule, or law.
Result/Requirement	The administrator receives a report with red flags for violations which is generated by the system
Sequence	1. The administrator triggers the report generation using one of the existing templates (alternatively, they generate a new reporting template) 2. The software provides the report.
Involved components (System)	-
Responsible partner/person	ÖBB-Infra (d-fine)
Notes	The main focus of the solutions in WP6/11 is on the journey planning/TMS features. The requirements for hosting and operation will be met by the PIS. Will not be part of the demonstrator

6.8.8 UC-FP6-WP6-8.8

Name	Cross-border journey planning
ID	UC-FP6-WP6-8.8
Description	The end user would like to travel between countries (or despite travelling between points within the same country the most feasible route requires to cross borders) and requests a feasible route for the trip
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	End user
Trigger	Trip request where starting and end point of the journey are not in the same country / require crossing borders
Pre-Condition(s)	On-demand and train services are considered for route planning regardless of origin, considering only the service area
Input	Starting and end point
Result/Requirement	Suggestion of feasible route
Sequence	1. End user requests route between starting and end point 2. System considers all feasible routes and proposes the most suited one(s)
Involved components (System)	PIS, DRT services
Responsible partner/person	ÖBB-Infra (d-fine)
Notes	Will not be part of the demonstrator

6.8.9 UC-FP6-WP6-8.9

Name	Performance requirements and concurrency
ID	UC-FP6-WP6-8.9
Description	End users need to be able to use the software concurrently and without noticeable reduction in user experience during peaks
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	End user
Trigger	End user interacts with the software
Pre-Condition(s)	-
Input	-
Result/Requirement	The end user can use the software without restriction
Sequence	1. The administrator chooses the system architecture to allow for concurrent use by the estimated number of parallel users
Involved components (System)	all
Notes	Will not be part of the demonstrator

6.8.10 UC-FP6-WP6-8.10

Name	Software availability
ID	UC-FP6-WP6-8.10
Description	Administrator is responsible for the availability of the software. They need a strategy to guarantee high levels of availability
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Administrator
Trigger	-
Pre-Condition(s)	-
Input	-
Result/Requirement	The system is available 99.9% of the time
Sequence	1. The system architecture is chosen to guarantee the necessary levels of availability of the software (99.9%)
Involved components (System)	all
Responsible Institution	ÖBB-Infra (d-fine)
Notes	Will not be part of the demonstrator

6.8.11 UC-FP6-WP6-8.11

Name	Redundancy of system components
ID	UC-FP6-WP6-8.11
Description	Administrator is responsible for the availability of the software. Redundancy of system components is used to ensure availability
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Administrator
Trigger	-
Pre-Condition(s)	-
Input	-
Result/Requirement	The system is available 99.9% of the time
Sequence	1. The system architecture is chosen to guarantee the necessary levels of availability of the software (99.9%)
Involved components (System)	all
Responsible partner/person	ÖBB-Infra (d-fine)
Notes	Will not necessarily be part of the demonstrator

6.8.12 UC-FP6-WP6-8.12

Name	Analysing the acceptance of the service
ID	UC-FP6-WP6-8.12
Description	The marketing manager performs an analysis to better understand the product / service acceptance, so that the pricing and / or the number of products can be adjusted accordingly. Without deep coding knowledge, possibilities to generate different graphs should be available. This is realised via a dedicated analytics section in the backend of the software. Via an interface an BIA shall be able to generate a customized dashboard for the marketing manager.
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Marketing Manager, BIA
Trigger	The marketing manager / specialist selects the time period, the data, which should be visualised, and the graph type to generate a graph in the dashboard provided by the BIA
Pre-Condition(s)	The system historicises data about the particular question at hand
Input	Selecting the time period, data type and graph type
Result/Requirement	The marketing manager obtains a graph based on the selected data within the dashboard in the tool's backend
Sequence	1. A marketing manager / specialist selects the desired time period and data, which the graph should visualise 2. The marketing manager chooses the graph type 3. The marketing manager queries the data to be portrayed in the dashboard 4. The tool generates a graph visualising the data
Involved components (System)	Booking data, PIS, analytics capabilities/tool integrated in the backend of the software
Responsible partner/person	DLR
Notes	Potential demonstration in discussion

6.8.13 UC-FP6-WP6-8.13

Name	Analysis for infrastructure expansion or adoption by the network planner
ID	UC-FP6-WP6-8.13
Description	The network planner analyses the need for existing infrastructure services and future infrastructure requirements, so that infrastructure expansions/adaptations can be planned accordingly. Without coding knowledge, possibilities to generate different graphs to generate business insights should be available. This is realised via a dedicated analytics section in the backend of the software. Via an interface a BIA shall be able to generate a customized dashboard for the network planner.
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Network Planner
Trigger	The Network Planner selects the time period, the data which should be visualised, and the graph type to generate a graph in the dashboard provided by the BIA
Pre-Condition(s)	The system historicises data about the particular question related to infrastructure at hand.
Input	Selecting time period, data type and graph type
Result/Requirement	The Network Planner obtains a graph based on the data selected within the dashboard of the tool's backend.
Sequence	1. A network planner selects the desired time period and data, which the graph should visualise 2. The network planner chooses the graph type 3. The network planner queries the data to be portrayed in the dashboard 4. The tool generates a graph which visualises the data
Involved components (System)	Usage data (e.g., from TMS), maybe additionally PIS, analytics capabilities/tool integrated in the backend of the software
Responsible partner/person	DLR
Notes	Potential demonstration in discussion

6.8.14 UC-FP6-WP6-8.14

Name	Staff demand planning based on forecasted demand
ID	UC-FP6-WP6-8.14
Description	A train operation manager needs to predict or be informed about predictions of the future demand, so that the staff numbers can be adjusted accordingly.
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Train operation manager, BIA
Trigger	After receiving a request from the train operation manager, a business analyst starts to generate a report of the forecasted demand by using the backend analytics tool of the software. For starting, the BIA chooses a dataset.
Pre-Condition(s)	Demand data available
Input	Historical demand data
Result/Requirement	The train operation manager can plan staff based on demand which is reported to him/her by the BIA
Sequence	1. A BIA chooses the journey leg (station A to station B), data sets (e.g. ticket sales, journey planning requests, actual usage, etc.), other constraints (e.g. time usage time, departure time, etc.) and forecasting time period for which demand predictions shall be generated within the analytics section of the software in order to create a report for the train operation manager 2. The BIA starts using the forecasting feature of the analytics section to derive a report for the train operation manager based on historical demand data 3. The BIA derives a final report of the demand prediction over time and journey leg and forwards it to the train operation manager
Involved components (System)	Booking data, PIS, analytics capabilities/tool integrated in the backend of the software
Responsible partner/person	DLR
Notes	Feedback loop to UC-FP6-WP6-8.1 to be defined Potential demonstration in discussion

6.8.15 UC-FP6-WP6-8.15

Name	Forecasted demand for train fleet size
ID	UC-FP6-WP6-8.15
Description	A rolling stock engineer plans or amends plannings for the acquisition of new trains based on demand forecasts.
Related to task/subtask(s)	-
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	Rolling stock engineer, BIA
Trigger	After receiving a request from the rolling stocks engineer, the business analyst starts to generate a report of the forecasted demand by using the backend analytics tool of the software. For starting, the BIA chooses a dataset.
Pre-Condition(s)	Demand data available
Input	Historical demand data
Result/Requirement	The rolling stock engineer can plan or amend planning for train acquisition according to future demand
Sequence	1. A BIA chooses a journey leg (station A to station B), data sets (e.g. ticket sales, journey planning requests, actual usage, etc.), other constraints (e.g. time usage time, departure time, etc.) and the forecasting time period for which demand predictions shall be generated within the analytics section of the software in order to create a report for the rolling stock engineer 2.The BIA starts using the forecasting feature of the analytics section to derive a report for the rolling stock engineer based on historical demand data 3. The BIA derives a final report of the demand prediction over time and line and forwards it to the rolling stock engineer
Involved components (System)	Booking data, PIS, TMS, analytics capabilities/tool integrated in the backend of the software
Responsible partner/person	DLR
Notes	Feedback loop to UC-FP6-WP6-8.1 to be defined Potential demonstration in discussion

6.8.16 UC-FP6-WP6-8.16

Name	Travel service notifications
ID	UC-FP6-WP6-8.16
Description	Users get notified about any changes of their planned travel, which includes, but is not limited to, delays and cancellations.
Related to task/subtask(s)	6.1
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	End user (traveller)
Trigger	A change in the planned journey occurred
Pre-Condition(s)	End user registered, logged in and travel plan exists, push or e-mail notifications are enabled
Input	-
Result/Requirement	Notification of changes to a planned travel
Sequence	1. A change in the planned journey occurred and triggers notification 2. A notification is sent to the user identifying the condition and impact 3. The end user is given two options: 3A. Accept the current conditions and continue his/her journey as affected by the change 3B. Ask for alternatives for the continuation of the journey 4. Both options summarize the impact compared to the initial plan 5. The end user selects preferred option Note: replanning is part of another use case
Involved components (System)	PIS
Responsible partner/person	GTSP/ÖBB-Infra (d-fine)
Notes	Changes to a planned travel may happen at any time until the planned travel is completed. Changes to a planned journey may be followed by suggestions to overcome the change Will not be part of the demonstrator

6.8.17 UC-FP6-WP6-8.17

Name	DRT service provider demonstrates interest to join ecosystem
ID	UC-FP6-WP6-8.17
Description	DRT service provider registers his interest and fills a registration form
Related to task/subtask(s)	6.1
Impact on other task(s)	-
Interactions SP/FP	-
Actor(s)	DRT service provider
Trigger	Request for registration on the platform
Pre-Condition(s)	Information related to service provider and respective services and conditions
Input	Services data
Result/Requirement	Register completed successfully
Sequence	1. Service provider registers in the platform 2. Registration conditions accepted 3. form(s) and information needed, provided by service provider 4. Data uploaded successfully
Involved components (System)	PIS
Responsible partner/person	GTSP/ÖBB-Infra (d-fine)
Notes	Will not be part of the demonstrator

7 Requirements

7.1 Methodology

This chapter delineates a systematic and structured approach used to identify, analyse, and document the requirements for the multimodal travel solution of WP6. The software solution must tackle both

1. The overall purpose to guarantee seamless multimodal journey planning by building a synthesis of different information systems, and
2. Various conflicting subgoals like decreasing the costs for capillary railway routes and increasing the quality of customer services, which must be reflected and balanced by the requirements.

The approach follows the idea of harmonization and standardization to mitigate the challenges for operating railway traffic in rural areas to make local connections more profitable for RUs. Additional to multimodal passenger travel, the requirements in WP6 are aimed at expanding regional lines for freight transportation.

To create a comprehensive catalogue of requirements applicable to all of Europe, additionally to the internal expertise from all task leaders and participants from WP6 the project sought external expertise from both European passengers as well as IMs and RUs. To utilize the knowledge and experience from IMs and RUs in the best way possible a questionnaire was created on which requirements for task 6.8 are based.

7.1.1 Development of the questionnaire

The questionnaire was created for querying the European Passengers' Federation (EPF) and railway companies (RUs and IMs) such as INECO, FSE, SNCF and ÖBB-Infra for their requirements on a multimodal travel solution. It was based on task 6.8 use cases listed in Chapter 6 where the questions posed were grouped as follows:

- Functional requirements,
- Non-functional requirements,
- Operational requirements,
- Performance requirements,
- Regulatory and Compliance requirements and
- Documentation and Training requirements.

Functional requirements (FRQ)

Functional requirements query the fundamental actions the system must perform, focusing on tasks, services, and operations. The questions in this section comprise trip planning, registration, end-user feedback, notifications, data management, data exchange, analytics, forecasting and localization. End-user requirements are mostly functional requirements and thus part of this section.

Non-functional requirements (NFRQ)

This section of the questionnaire was concerned with non-functional requirements, the intention being to specify a set of requirements ensuring that the software system meets certain standards and qualities beyond its basic functionalities. Accordingly, the questions in this section were divided into security and access control, reliability, interoperability, compatibility, interface usability and calculation duration.

Operational requirements (ORQ)

Operational requirements are essential to ensure that the software system is not only functionally capable but also fits well within its intended operational environment and meets the practical needs of day-to-day operations. The questionnaire comprises the topics installation and deployment, maintenance and software updates, data backup and recovery, monitoring and reporting, user groups and permissions, audit and logging, downtime as well as notifications.

Performance requirements (PRQ)

These requirements help ensure that the system operates efficiently, reliably and can handle the expected workload without degradation in user experience. Topics discussed in the questionnaire are response time, throughput, scalability, resource utilization, concurrency, data transfer rates, caching and optimization, latency, peak load, data retrieval, data processing, optimization of critical functions.

Regulatory and Compliance requirements (RCRQ)

To make sure that the software complies with national and international regulations as well as internal policies, regulatory and compliance requirements must be collected.

Documentation and Training requirements (DTRQ)

The documentation and training requirements query questions about the contents and accessibility of user manual and on technical documentation.

The full questionnaire was distributed to all RUs and IMs, whereas a condensed version was given to the EPF. The EPF version primarily focused on queries needing the passenger's insight. In order to address these passenger-specific questions, a workshop was held among EPF members, and a definitive report was produced incorporating their insights. The main findings from the EPF report, combined with the railway companies' responses, are outlined in the subsequent chapter.

7.1.2 Conclusions from questionnaire answers

Responses received from four railway companies along with one passenger representative have aided considerably in shaping the requirements for task 6.8. Noteworthy concerns raised through the questionnaire are categorized in the perspective of RU’s and IM’s and the perspective of passengers.

RU’s and IM’s perspective

The analysis of responses concludes a high priority being given to regulatory compliance within the realm of RUs and IMs. Accordingly, it is crucial that any solution drafted for RUs and IMs meets all regulatory requirements, which must already be incorporated in the planning and developing phase. Although this is beyond the scope of WP6 we derived a requirement (T6.8_UC8.7_RCRQ01) which has been included in D6.9 to mark the importance of this area. Another emphasis was on the necessity for comprehensive software documentation. Similar to the aspect of regulatory compliance the aspect of documentation also exceeds the scope for WP6. However, to reflect the importance of the need for extensive documentation for RUs and IMs we derived a general documentation requirement (T6.8_UC8.4_DTRQ01) in task 6.8.

Passenger's perspective
The feedback from the passenger's perspective provided considerable insight into user interface details, communication preferences, and ways to handle unforeseen journey disruptions. Two particular topics not covered by the existing use cases stood out.

1. Connection safety is vital for passengers in Europe, especially in regions which experience higher frequencies of delayed arrivals. The use cases and requirements from task 6.1.2 address system-passenger communication when a connecting option might be missed or was missed. Suggestions were to extend this by offering decision-making insights, such as historical data on connection misses due to delays which can help passengers to assess risks associated with particular routes. Additionally, a feature in which the implications of missing a connecting transport are communicated was mentioned. This is especially interesting for rural areas where missed connections can result in lengthy wait times. Because these extensive insights were communicated at a later stage in the project timeline and WP6's strict scope, these additional ideas couldn't be translated into specific requirements.
2. The EPF recommended implementing the Web Content Accessibility Guidelines (WCAG 2.2) for international web content accessibility. While these standards have already been known and are used by task leaders and task participants from WP6, EPF's suggestions underscored their significance, and thus, they are explicitly stated in this deliverable. Since developing a specific UI for blind users is not within the scope for WP6 the importance of accessibility is considered during the specification phase.

While some findings from our questionnaire couldn't be directly included in the WP6 deliverable, they provide potential considerations for future ERJU projects or initiatives.

7.1.3 Requirement consolidation and analysis

The initial requirements questionnaire was distributed to the participating companies listed above in Chapter 7.1.1 for feedback. Once the completed questionnaires were returned the requirements were consolidated by validating the answers, clarifying ambiguities, and removing duplicates. Moreover, they were linked to the corresponding use case via the use case id.

Similarly, to the use cases the identified requirements were prepared using a standardized template simplifying their comparison and improving transparency. The template consists of the following fields.

Field	**Description**
Requirement ID	A unique identifier for the requirement
Requirement Name	A brief description of the requirement
Use Case ID	Link to the corresponding use case
Category	Category of requirement (function, operational etc.)
Priority	The priority of the requirement: "MUST" or "Nice-to-have with high priority"

Main goal	A detailed description of the requirement - what it is and why it is needed
Assumptions	Assumption for the requirement
Specification	A detailed description of the requirement, and how it should work.
Additional Notes	Any additional notes about the requirement, such as risks, dependencies, or constraints

Note that the "Requirement ID" gives insights about the category of requirement and the use case it was derived from. As illustrated in Table 3 and described in the following paragraph the "Requirement ID" consists of three parts, separated by an underscore symbol.

Table 3: Example of requirement ID

T6.1_UC1.1.3_FRQ02		
T6.1	**UC1.1.3**	**FRQ02**
Indicates what task in WP6 derived the requirement Here: **Task 6.1**	Indicates the use case and task the requirement was derived from; Here: **Third use case from task 6.1.1**	Indicates the requirement category as described in Chapter 7.1.1 and number; Here: **Second functional requirement** from UC1.1.3

The ID "T6.1_UC1.1.3_FRQ02", says that this is the second functional requirement of the third use case from task 6.1.1. All IDs start with the task from WP6 within which the requirement was created. In the example above "T6.1" indicated that this requirement was developed in task 6.1. After the underscore the use case from which the requirement was derived is stated. "UC1.1.3" stands for the third use case of task 6.1.1. The next letters indicate the category of the requirements as explained in Chapter 7.1.1. The following number is counting the requirements which refer to a specific use case.

7.2 Requirements task 6.1.1

7.2.1 T6.1_UC1.1.1_FRQ01

Requirement ID	T6.1_UC1.1.1_FRQ01
Requirement Name	Collection of data by the system
Use Case ID	UC-FP6-WP6-1.1.1
Category	Functional
Priority	MUST
Main goal	The system must be able to gather data from public TSP system (timetable data) and DRT service provider system (including service area and operating hours)
Assumptions	The data are provided and made accessible by the public TSP and DRT service provider
Specification	The system receives files containing TSP timetable data and DRT data in a specified format and converts the files into a suitable format used by the trip search engine.
Additional Notes	-

7.2.2 T6.1_UC1.1.1_FRQ02

Requirement ID	T6.1_UC1.1.1_FRQ02
Requirement Name	Computation of multimodal trips
Use Case ID	UC-FP6-WP6-1.1.1
Category	Functional
Priority	MUST
Main goal	The journey planning application must be able to compute and display trips that combine public transport legs with DRT legs for first and/or last mile.
Assumptions	Data from TSP and DRT service provider are available, trip request is specified by user
Specification	The journey planning application chooses public transit stops around the start location and the destination location as mode change points and computes partial trips covering the legs and combines those legs to (complete) trips.
Additional Notes	-

7.2.3 T6.1_UC1.1.1_FRQ03

Requirement ID	T6.1_UC1.1.1_FRQ03
Requirement Name	Trip planning user interface with location suggestions
Use Case ID	UC-FP6-WP6-1.1.1
Category	Functional
Priority	MUST
Main goal	The journey planning application must have a user interface allowing travellers to input their origin, destination, and desired departure/arrival time. The system should suggest matching locations for the origin and destination based on the user's input.
Assumptions	-

Specification	Upon typing a location's name, the system suggests matching locations (stops, addresses, POIs) from which the user can select the desired location.
Additional Notes	-

7.2.4 T6.1_UC1.1.1_FRQ04

Requirement ID	T6.1_UC1.1.1_FRQ04
Requirement Name	Integration of API of the DRT system
Use Case ID	UC-FP6-WP6-1.1.1
Category	Functional
Priority	MUST
Main goal	The system shall be able to integrate with the API of the DRT system to check the availability of a DRT vehicle for a specified trip leg
Assumptions	A documented API is provided by the DRT service provider.
Specification	The system sends a request to the API of the DRT system that specifies a start and end location for the DRT trip and a desired departure or arrival time.
Additional Notes	-

7.2.5 T6.1_UC1.1.1_PRQ01

Requirement ID	T6.1_UC1.1.1_PRQ01
Requirement Name	Performance of the system
Use Case ID	UC-FP6-WP6-1.1.1
Category	Performance
Priority	Nice-to-have with high priority
Main goal	The trip search functionality should provide responses within a reasonable duration to ensure timely retrieval of trip options
Assumptions	-
Specification	The time between querying a route and the feasible routes being displayed does not exceed 3 seconds on average between incoming request and outgoing response. When the validation of DRT trip legs is included (i.e., checking of the actual availability of a vehicle), the time shall not exceed 5 seconds on average.
Additional Notes	The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

7.2.6 T6.1_UC1.1.2_FRQ01

Requirement ID	T6.1_UC1.1.2_FRQ01
Requirement Name	Collection of data regarding rules of competition by the system
Use Case ID	UC-FP6-WP6-1.1.2
Category	Functional
Priority	MUST
Main goal	The system must be able to gather data defining the rules of competition for public transit and DRT services.
Assumptions	The data is provided manually in a structured data format by the DRT

	and PT providers
Specification	A data format for rules of competition has to be defined. Data provided in this format has to be converted into a binary format used by the trip search engine.
Additional Notes	-

7.2.7 T6.1_UC1.1.2_FRQ02

Requirement ID	T6.1_UC1.1.2_FRQ02
Requirement Name	Computation of trips in accordance with the rules of competition
Use Case ID	UC-FP6-WP6-1.1.2
Category	Functional
Priority	MUST
Main goal	The system must be able to compute trips that stick to the rules of competition (e.g., no DRT offer parallel to a public transit service)
Assumptions	-
Specification	Trip search algorithm has to consider the rules of competition when computing trip options.
Additional Notes	-

7.2.8 T6.1_UC1.1.2_PRQ01

Requirement ID	T6.1_UC1.1.2_PRQ01
Requirement Name	Performance of the system including rules of competition
Use Case ID	UC-FP6-WP6-1.1.2
Category	Performance
Priority	Nice-to-have with high priority
Main goal	The system should integrate and process the data within a reasonable amount of time and with accuracy, to provide reliable trip options, without discrepancies.
Assumptions	-
Specification	Considering rules of competition increases average computation time by at most 150%, i.e., the time between querying a route and the feasible routes being displayed does not exceed 7,5 seconds on average between incoming request and outgoing response. When the validation of DRT trip legs is included (i.e., checking of the actual availability of a vehicle), the time shall not exceed (2 seconds + 3 seconds) * (100% + 150%) on average.
Additional Notes	The impact of rules of competition on the performance is hard to estimate and also hard to measure because the impact depends on the share of requests for which DRT is found and on the value of several parameters that specify a concrete type of a rule of competition. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

7.2.9 T6.1_UC1.1.3_FRQ01

Requirement ID	T6.1_UC1.1.3_FRQ01
Requirement Name	Simulation system for DRT
Use Case ID	UC-FP6-WP6-1.1.3
Category	Functional
Priority	MUST
Main goal	There must be a simulation system specifically designed for DRT services.
Assumptions	-
Specification	The simulation system must consider demand (i.e., DRT trip requests), supply (vehicles), compute how a DRT production system would likely react with this demand and supply and calculate resulting metrics.
Additional Notes	The metrics are defined in T6.1_UC1.1.3_FRQ03.

7.2.10 T6.1_UC1.1.3_FRQ02

Requirement ID	T6.1_UC1.1.3_FRQ02
Requirement Name	Simulation of a DRT fleet serving trip requests
Use Case ID	UC-FP6-WP6-1.1.3
Category	Functional
Priority	MUST
Main goal	The simulation system must process travel demand data and assign a given set of vehicles to DRT trip requests derived from the travel demand data.
Assumptions	-
Specification	The simulation system must derive a list of DRT trip requests specified by origin, destination, departure time from travel demand data and assign vehicles of a given fleet to trip requests considering the availability of vehicles
Additional Notes	-

7.2.11 T6.1_UC1.1.3_FRQ03

Requirement ID	T6.1_UC1.1.3_FRQ03
Requirement Name	Calculation of metrics
Use Case ID	UC-FP6-WP6-1.1.3
Category	Functional
Priority	MUST
Main goal	The simulation system must provide metrics after a simulation run that allows to assess the service quality reached for a given scenario.
Assumptions	-
Specification	The simulation system has to calculate metrics that indicate the quality of service regarding different dimensions, e.g., user experience indicators: share of demand covered, average waiting time for pick up after requested departure time deviation indicators: detour rate by time and by distance

	operational indicators: total distance covered by each vehicle, including commercial and non-commercial distances, maximum number of passengers on board (in order to determine vehicle size) performance indicators: pooling rate, number of passengers per vehicle hour
Additional Notes	-

7.2.12 T6.1_UC1.1.4_FRQ01

Requirement ID	T6.1_UC1.1.4_FRQ01
Requirement Name	Receiving OJP trip search requests
Use Case ID	UC-FP6-WP6-1.1.4
Category	Functional
Priority	MUST
Main goal	The system must be able to receive a trip search request from an external system via the OJP protocol and process it internally.
Assumptions	OJP version 2.0 is used because former versions do not support DRT.
Specification	The system provides an endpoint for receiving OJP trip search requests. The receiving component (passive server adapter) must convert the request into the (proprietary) format of the underlying journey planning application and forward it to this application.
Additional Notes	-

7.2.13 T6.1_UC1.1.4_FRQ02

Requirement ID	T6.1_UC1.1.4_FRQ02
Requirement Name	Answering OJP trip search requests with trip options
Use Case ID	UC-FP6-WP6-1.1.4
Category	Functional
Priority	MUST
Main goal	The system must be able to send a response for a trip search request containing trip options to an external system via the OJP protocol.
Assumptions	OJP version 2.0 is used because former versions do not support DRT.
Specification	The Passive Server Adapter must convert the response of the journey planning application into the OJP format and send the response to the Active Server Adapter of the calling system.
Additional Notes	-

7.2.14 T6.1_UC1.1.4_FRQ03

Requirement ID	T6.1_UC1.1.4_FRQ03
Requirement Name	DRT options are reachable using the OJP
Use Case ID	UC-FP6-WP6-1.1.4
Category	Functional
Priority	MUST

Main goal	The system must be able to support the OJP protocol not only for public transit but also for DRT.
Assumptions	OJP version 2.0 is used because former versions do not support DRT.
Specification	The Passive Server Adapter supports DRT when receiving requests (in case the requests permit the mode DRT) and when sending the response (i.e., when a trip option in the response includes DRT).
Additional Notes	-

7.2.15 T6.1_UC1.1.4_PRQ01

Requirement ID	T6.1_UC1.1.4_PRQ01
Requirement Name	Performance of the OJP component
Use Case ID	UC-FP6-WP6-1.1.4
Category	Performance
Priority	Nice-to-have with high priority
Main goal	The system should integrate with the external journey planning system in a robust and reliable manner.
Assumptions	Assumption for the requirement
Specification	The OJP component of the journey planning application shall be able to process 100 incoming requests per minute (receive from external system, convert into proprietary format for journey planning application and send to journey planning application) and 100 outgoing responses per minute (receive from journey planning application, convert into OJP format, and send to external journey planning application).
Additional Notes	-

7.3 Requirements task 6.1.2

7.3.1 T6.1_UC1.2.1_FRQ01

Requirement ID	T6.1_UC1.2.1_FRQ01
Requirement Name	The system must be able to interface with real-time data feeds of rail operators.
Use Case ID	UC-FP6-WP6-1.2.1
Category	Functional
Priority	MUST
Main goal	The journey planning system is able to fetch real-time data and convert the relevant data into the internal data structure in the backend of journey planning system.
Assumptions	• Real-time information from rail operator 1 and 2 (e.g. delay information, cancellations, platform changes) are available. • Availability of journey planning system. • Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2.
Specification	The process can be broken down into the following steps: • Fetch real-time data regarding arrival times from relevant sources from operator 1 and operator 2. • Convert the data format to the format that can be used to construct ad-hoc timetable. • Link data from operator 1 and operator 2 into the same backend database so that route search can be performed based on both.
Additional Notes	-

7.3.2 T6.1_UC1.2.1_FRQ02

Requirement ID	T6.1_UC1.2.1_FRQ02
Requirement Name	The system must be able to process real-time data feeds and match real-time data to static timetable data.
Use Case ID	UC-FP6-WP6-1.2.1
Category	Functional
Priority	MUST
Main goal	The journey planning system can construct ad-hoc timetable by modifying the static timetable, mark the vehicles that are delayed and retrieve the arrival time for all subsequent stations of a given line.
Assumptions	Real-time information from rail operator 1 and 2 (e.g., delay information, cancellations, platform changes) are available Availability of journey planning system Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2
Specification	• Match the real-time journey data to static timetable to identify if the given vehicle is delayed or on-time • Calculate the expected arrival time for all subsequent stations of a given line based on the delay at the current moment (if delays for subsequent stations are not provided in the real-time feed). • Create routing graph using the calculated arrival time, i.e., ad-hoc timetable that can be used for the routing.
Additional Notes	-

7.3.3 T6.1_UC1.2.1_NFRQ01

Requirement ID	T6.1_UC1.2.1_NFRQ01
Requirement Name	The system must process and match real-time data quickly and with high frequency.
Use Case ID	UC-FP6-WP6-1.2.1
Category	Non-Functional
Priority	MUST
Main goal	Real-time information is fetched at the backend on a regular basis and thus the matching between real-time data and static timetable data must be done quickly so that the users will get up-to-date real-time information to avoid possible confusions to the users.
Assumptions	Real-time information from rail operator 1 and 2 (e.g., delay information, cancellations, platform changes) are available Availability of journey planning system Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 Train delays from the second order effect will be addressed through operator 1 and 2’s internal coordination and thus the delay information will be available directly from operator 1 and 2. The journey planning system will not calculate second order effect.
Specification	It is required that the fetching of real-time information will be carried out within 1 min interval and the process to match real-time data to update static timetable will be carried out in several seconds.
Additional Notes	-

7.3.4 T6.1_UC1.2.1_FRQ03

Requirement ID	T6.1_UC1.2.1_FRQ03
Requirement Name	The constructed ad-hoc timetable must correctly capture delay at subsequent stations
Use Case ID	UC-FP6-WP6-1.2.1
Category	Functional
Priority	MUST
Main goal	The constructed ad-hoc timetable involves predictions of arrival time for all subsequent stations of a given line based on the delay at the current moment. Thus, an algorithm maybe needed to provide such predictions. The difficulty part lies on the ability to take into account second order effect. One example is that train A is delayed and thus the time to traverse a given single track is delayed. This leads to the fact that train B that will also traverse that single track will need to wait and thus delayed since its scheduled time to traverse that single track conflicts with the actual time train A is traversing (due to delay). In this context, it is important to clarify that the real-time information fetched from the operators will already include the arrival time for all subsequent stations of a given line.
Assumptions	• Real-time information from rail operator 1 and 2 (e.g. delay information, cancellations, platform changes) are available. • Availability of journey planning system. • Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2. • Train delays from the second order effect will be addressed through operator 1 and 2's internal coordination and thus the delay information will be available directly from operator 1 and 2. The journey planning system will not calculate second order effect.
Specification	The journey planning system will constantly request real-time information from operator 1 and operator 2 and construct ad-hoc timetable for the next hour based on real-time information at current hour.
Additional Notes	-

7.3.5 T6.1_UC1.2.2_FRQ01

Requirement ID	T6.1_UC1.2.2_FRQ01
Requirement Name	The system must be able to interface with real-time data feeds of bus operators.
Use Case ID	UC-FP6-WP6-1.2.2
Category	Functional
Priority	MUST
Main goal	The journey planning system is able to fetch real-time data regarding arrival time from both rail and bus operators and convert the relevant data into the internal data structure in the backend of the journey planning system. Then the system can perform route search based on the ad-hoc timetable that is constructed based on these data.
Assumptions	• Real-time information from rail operator 1 and 2 are available. • Bus operator provides real-time information for its buses/DRT service provider can respond to requests for a vehicle needed within the current/next hour. • Availability of journey planning system. • Journey planning system is equipped with static timetable data of rail operator 1, rail operator 2, bus operator, and some necessary data from DRT service provider (e.g., service area, operating hours).
Specification	The process can be broken down into the following steps: • Fetch real-time data from relevant sources from rail operator 1, rail operator 2 and bus operator • Convert the data format collected from above to the format that can be used to construct ad-hoc timetable. • Link data from rail operator 1, rail operator 2, bus operator information into the same backend database so that route search can be performed based on them.
Additional Notes	

7.3.6 T6.1_UC1.2.2_FRQ02

Requirement ID	T6.1_UC1.2.2_FRQ02
Requirement Name	The system must be able to interface with the system of a DRT service provider for checking latest availability of data.
Use Case ID	UC-FP6-WP6-1.2.2
Category	Functional
Priority	MUST
Main goal	The journey planning system is able to fetch feeds from DRT service provider and convert the relevant data into the internal data structure in the backend of journey planning system. Then the system can perform route search based on the ad-hoc timetable that is constructed based on these data.
Assumptions	• API or feeds from DRT service providers are available. • Availability of journey planning system. • Journey planning system is equipped with static timetable data of rail operator 1, rail operator 2, bus operator, and some necessary data from DRT service provider (e.g. service area, operating hours).
Specification	The process can be broken down into the following steps: • Send and receive information regarding DRT service offer. • Convert the data format collected from above to the format that can be used to construct ad-hoc timetable. • Link data from rail operator 1, rail operator 2, bus operator and DRT availability information into the same backend database so that route search can be performed based on them. • If potential trip options contain DRT leg(s) within the next hour, check via API of DRT service provider if vehicle will actually be available before presenting trip option to the user.
Additional Notes	

7.3.7 T6.1_UC1.2.3_FRQ01

Requirement ID	T6.1_UC1.2.3_FRQ01
Requirement Name	The system must be able to inform users when there is no real-time information available.
Use Case ID	UC-FP6-WP6-1.2.3
Category	Functional
Priority	Nice-to-have with high priority
Main goal	For the end user, it would be beneficial if they can get informed about which part of the journey has/has not real-time information when they perform a trip search and receive a trip search result. It increases the credibility of the trip search and helps end users to adjust their expectation on the reliability of the trip search result.
Assumptions	• Availability of journey planning system. • Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 and of other service providers such as a bus operator or a DRT service provider. • Ad-hoc timetable may not be available on certain lines due to lack of real-time data.
Specification	This requirement can be realized with dynamically tracking availability of real-time information on each line and allowing the availability to be visualized at the frontend on the line level.
Additional Notes	

7.3.8 T6.1_UC1.2.3_FRQ02

Requirement ID	T6.1_UC1.2.3_FRQ02
Requirement Name	The system must be able to calculate trip options that are feasible regarding static timetable data as well as trip options that are feasible with respect to real-time data.
Use Case ID	UC-FP6-WP6-1.2.3
Category	Functional
Priority	MUST
Main goal	If real-time data is not available, the journey planning system should still work with the data from static timetables
Assumptions	• Availability of journey planning system. • Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 and of other service providers such as a bus operator or a DRT service provider. • Ad-hoc timetable is not available at some lines due to lack of real-time data.
Specification	The requirement can be fulfilled by using both static timetable and real-time in constructing ad hoc timetable. Specifically, the expected arrival time can be calculated for each vehicle at each stop while real-time information is available while for the lines where real-time information not available, the arrival time can be fetched directly from static timetable. An ad-hoc timetable then can be constructed based on the calculated arrival times and arrival times from static timetable.
Additional Notes	This requirement is dependent on UC-FP6-WP6-1.2.2-Req2

7.3.9 T6.1_UC1.2.3_PRQ01

Requirement ID	T6.1_UC1.2.3_NFRQ01
Requirement Name	The system must respond to trip requests with a desired departure time within the relevant time window for real-time data almost as fast as to trip requests for tomorrow or yesterday, which are searched on static timetable data.
Use Case ID	UC-FP6-WP6-1.2.3
Category	Non-functional
Priority	Nice-to-have with high priority
Main goal	Ensure that the system provides timely and accurate information about trip options based on the desired departure times
Assumptions	The system has access to real time and static timetable data
Specification	The trip requests may vary in terms of temporal proximity to the current time. It should be able to process immediate, near future, and historical trip requests efficiently to provide a seamless user experience.
Additional Notes	

7.3.10 T6.1_UC1.2.4_FRQ01

Requirement ID	T6.1_UC1.2.4_FRQ01
Requirement Name	The system must be able to process user input, including origin, destination, and preferred time of travel and additional individual settings.
Use Case ID	UC-FP6-WP6-1.2.4
Category	Functional
Priority	MUST
Main goal	The system should have a well-designed frontend so that users can enter trip information including origin, destination, and preferred time of travel and additional individual settings with ease. This will be developed based on the existing product for frontends.
Assumptions	None
Specification	The system allows users to specify trip related information as well as individual user settings. The users are allowed to specify their individual settings such as preferred modes of transport, individual walking speed, maximum walking distance to/from stop and an (optional) PRM profile.
Additional Notes	

7.3.11 T6.1_UC1.2.4_FRQ02

Requirement ID	T6.1_UC1.2.4_FRQ02
Requirement Name	The system must be able to provide trip options that correspond to the user’s input.
Use Case ID	UC-FP6-WP6-1.2.4
Category	Functional
Priority	MUST
Main goal	The system should accurately understand and interpret the user’s requests and provide relevant trip suggestions accordingly
Assumptions	The system has access to the necessary data and algorithms to analyse the user’s input and produce relevant trip recommendations
Specification	The system must accurately interpret user input regarding trip details such as departure location, destination, and preferred departure time. It should generate relevant trip options based on the interpreted input, presenting them clearly to the user with essential details such as departure times, travel durations, and transportation modes.
Additional Notes	

7.3.12 T6.1_UC1.2.4_FRQ03

Requirement ID	T6.1_UC1.2.4_FRQ03
Requirement Name	System can facilitate trip search in case where relevant facility data is missing.
Use Case ID	UC-FP6-WP6-1.2.4
Category	Functional
Priority	MUST
Main goal	The system must be able to perform trip search in situation that information about station facility is not available. This is essential because data about station facilities are often not structured and the risk of having missing data at certain stations is high. The functionality thus ensure that a travel solution is still produced without considering the specific facilities at the stations.
Assumptions	Station facility data is already collected for certain stations and data can be converted into a structured data format that can be imported into the journey planning system.
Specification	This requirement can be achieved by determining the correct data format to store/update/remove the relevant information. Given that information of certain facilities may be available at one station and information of other facilities may be available at another station. It is essential for the backend system to handle missing data and make the trip search algorithm aware that requested facility data may be missing and thus trip search can still be performed in case of missing data.
Additional Notes	

7.3.13 T6.1_UC1.2.4_FRQ04

Requirement ID	T6.1_UC1.2.4_FRQ04
Requirement Name	Properties of station facilities can be considered during route planning
Use Case ID	UC-FP6-WP6-1.2.4
Category	Functional
Priority	MUST
Main goal	The solutions helping PRM to overcome barriers at platforms and stations are crucial for another stage of the travel, including the last mile. Station facilities are essential to assess the transfer accessibility for people with disabilities, including PRM. Thus, the route planning application shall be able to consider properties of station facilities, to adjust routes for special needs (e.g. PRM).
Assumptions	The list of station facilities is already stored at backend of the journey planning system. PRM travellers are digitally literal and can use the journey planning system. For blind people, it is assumed that voice assistant system is available, so that they can specify their inputs with the help of the system.
Specification	Depending on the availability of data identified in the demonstration phase, a subset of station facilities where relevant data is available will be considered. Relevant station facility data will be imported as static data. Depending on the user's chosen PRM profile, station facility data relevant for the given profile will be used in the route planning, generating travel solutions considering the availability of the given facility. A complete list station facilities that are relevant for each PRM profile is provided in Section **Error! Reference source not found.**
Additional Notes	This requirement is dependent on the size of the station. In rural areas it is possible there is no station, just stop.

7.3.14 T6.1_UC1.2.4_FRQ05

Requirement ID	T6.1_UC1.2.4_FRQ05
Requirement Name	PRM user will get notified about the existing transfer solution at station that helps PRM to have a smooth transfer at station
Use Case ID	UC-FP6-WP6-1.2.4
Category	Functional
Priority	Nice-to-have with high priority
Main goal	Existing solutions to help PRM to have a smooth transfer at station can be stored at the backend of journey planning system, and PRM users can get notified about the solutions at a given station when they receive a trip search result that includes the given station.
Assumptions	Existing solutions at different stations are already collected through field survey or browsing relevant data from local statistics.
Specification	For a given station in the trip search result generated by the journey planning system, the existing solution at that station, if data is available, will be visualized as an icon or a text message for a given station, e.g. a staff icon or text: “Staff available” in the frontend. A summary of existing solutions available at station can be found in Section **Error! Reference source not found.Error! Reference source no t found.**.
Additional Notes	Existing solutions depend on how big the location is, and the station related with it.

7.3.15 T6.1_UC1.2.4_FRQ06

Requirement ID	T6.1_UC1.2.4_FRQ06
Requirement Name	System’s ability to allow users to exclude a given transport mode or a given stop as transfer stop in trip search.
Use Case ID	UC-FP6-WP6-1.2.4
Category	Functional
Priority	Nice-to-have with high priority
Main goal	The user of journey planning system may have a need to manually exclude a specific transport mode due to their personal preferences or a stop where the user does not want to transfer. The system should have the functionality to allow users to select such transport mode or stop and mark them as unavailable for trip search.
Assumptions	None
Specification	This requires the journey planning system to have the relevant functionality to allow users in the frontend to activate/deactivate a specific transport mode or stop in the backend and thus temporally activate/deactivate them in the ad-hoc timetable and trip search algorithm.
Additional Notes	

7.3.16 T6.1_UC1.2.5_FRQ01

Requirement ID	T6.1_UC1.2.5_FRQ01
Requirement Name	The system must feature a map view that presents Points of Interest (POIs) to the user
Use Case ID	UC-FP6-WP6-1.2.5
Category	Functional
Priority	MUST
Main goal	The main goal is to enable the users to see, search and filter POIs for a given address or current location entered in the trip search frontend window.
Assumptions	None
Specification	The system's map view should display relevant POIs to the user, including at least the POI address, denoting their locations. Users should be able to filter POIs based on their function, for e.g. hotel, museum, restaurant, etc.
Additional Notes	

7.3.17 T6.1_UC1.2.5_FRQ02

Requirement ID	T6.1_UC1.2.5_FRQ02
Requirement Name	The system must be able to show/hide POIs depending on their category when the user activates/deactivates the display for the respective category of POIs.
Use Case ID	UC-FP6-WP6-1.2.5
Category	Functional
Priority	MUST
Main goal	Customisation by allowing users to selectively view POIs based on their category preferences
Assumptions	The system categorises POIs into distinct categories, and the system has the capability to dynamically adjust the display of POIs based on user preferences.
Specification	Upon user activation or deactivation of a POI category, the system should promptly update the map view to show/hide the relevant POIs
Additional Notes	

7.3.18 T6.1_UC1.2.5_FRQ03

Requirement ID	T6.1_UC1.2.5_FRQ03
Requirement Name	The system must offer the option to select a POI in the map view as start or destination for the next trip search.
Use Case ID	UC-FP6-WP6-1.2.5
Category	Functional
Priority	MUST
Main goal	The main goal is to enable the users to select a POI in the map view as start or destination for the next trip search. This functionality allows the user to plan their trip to the POIs suggested to them.
Assumptions	None
Specification	The system should provide an interactive map interface that allows users to click or tap on a POI marker to select it as either the start or destination point for their trip search. After selecting a POI as the start or destination point, the system should transition to the trip search interface, where users can further refine their search criteria (such as arrival/departure time) and initiate the trip planning process.
Additional Notes	

7.3.19 T6.1_UC1.2.5_NFRQ01

Requirement ID	T6.1_UC1.2.5_NFRQ01
Requirement Name	The map must not be cluttered by icons representing POIs.
Use Case ID	UC-FP6-WP6-1.2.5
Category	Non-Functional
Priority	MUST
Main goal	Ensure a clean and uncluttered map view for users, promoting ease of navigation and improved visual clarity.
Assumptions	None
Specification	To prevent map clutter, the system should load and display POI icons only when the zoom level is appropriate, i.e. when user has zoomed in.
Additional Notes	

7.3.20 T6.1_UC1.2.6_FRQ01

Requirement ID	T6.1_UC1.2.6_FRQ01
Requirement Name	The system must provide a view that provide different types of PRM profiles from which one profile can be selected by the user.
Use Case ID	UC-FP6-WP6-1.2.6
Category	functional
Priority	MUST
Main goal	The user of journey planning system should be able to choose from a set of predefined PRM profiles that best match their mobility needs. Thus, the PRM profiles should be categorised according to different PRM types, e.g. blind people and people with mobility restriction.
Assumptions	PRM travellers are digitally literal and are able to use the journey planning system Existing digital tool support system for blind people will be utilized so that they will be able to use the journey planning system on various devices.
Specification	The users are presented by the complete list of PRM profiles and are asked to select one of the profiles matching their mobility conditions. A detailed description of classified PRM profiles is documented in Section **Error! Reference source not found.**.
Additional Notes	-

7.3.21 T6.1_UC1.2.6_FRQ02

Requirement ID	T6.1_UC1.2.6_FRQ02
Requirement Name	Depending upon the selected profile, the system must apply corresponding parameter values for the trip search request.
Use Case ID	UC-FP6-WP6-1.2.6
Category	functional
Priority	MUST
Main goal	The user of journey planning system should be able to consider specific route choice needs and preferences. For instance, the system can provide different walking speed options based on the chosen PRM profile which are then applied in the route search. The PRM specific route choice preferences should be specified for each PRM profile and used for PRM specific routing.
Assumptions	• PRM travellers are digitally literal and can use the journey planning system. • For blind people, it is assumed that voice assistant system is available so that they can specify their inputs with the help of the system.
Specification	A pre-defined routing parameter values are specified given the PRM profiles. The routing engine then will utilize the parameter values to generate the route search solutions. A detailed list/table of parameters can be found in Section **Error! Reference source not found.**.
Additional Notes	-

7.3.22 T6.1_UC1.2.6_FRQ03

Requirement ID	T6.1_UC1.2.6_FRQ03
Requirement Name	The user must be made aware that a certain profile is active for his/her trip searches.
Use Case ID	UC-FP6-WP6-1.2.6
Category	Functional
Priority	MUST
Main goal	If a user selected a PRM profile, the user will be made aware of this when the results of a trip search are displayed. This is to remind the user that trip search results may be adjusted according to the selected PRM profile.
Assumptions	• PRM travellers are digitally literal and can use the journey planning system. • For blind people, it is assumed that voice assistant system is available so that they can specify their inputs with the help of the system.
Specification	When a PRM profile was selected for a trip search, this will be indicated when the resulting trip options are displayed. For the case that the user is not satisfied with the results, the user will have the option to deactivate the profile, adjust it or select another profile before she/he can trigger a new trip search.
Additional Notes	-

7.3.23 T6.1_UC1.2.7_FRQ01

Requirement ID	T6.1_UC1.2.7_FRQ01
Requirement Name	The system must enable a user to change default parameter values that are associated with a profile.
Use Case ID	UC-FP6-WP6-1.2.7
Category	Operation
Priority	MUST
Main goal	The system will allow users to browse the PRM profile and modify the default setting of traveller needs that are registered in the PRM profile, by activating or deactivating certain traveller needs (e.g. elevator, no stairs, etc.).
Assumptions	• PRM travellers are digitally literal and are able to use the journey planning system. • For blind people, it is assumed that voice assistant system is available so that they can specify their inputs with the help of the system.
Specification	The system at frontend should include an option (a clickable button) to the end user when the journey results are presented to them. Through clicking the button, the user is brought to a new window that allows them to specify the default setting of traveller needs of the given PRM profile. The default setting of PRM profiles is already specified in section 2.2: Demand related information including those for person with reduced mobility (PRM).
Additional Notes	-

7.3.24 T6.1_UC1.2.7_FRQ02

Requirement ID	T6.1_UC1.2.7_FRQ02
Requirement Name	If a user profile was selected and parameter values have been adjusted, the system must apply the parameter values of the selected profile considering the adjusted values for the trip search request.
Use Case ID	UC-FP6-WP6-1.2.7
Category	Operation
Priority	MUST
Main goal	A trip search can be performed by the origin, destination and departure time specified by the user and the parameter values in the adjusted PRM profile. This functionality ensures that the user can get new trip results based on the previously set personalized PRM profile.
Assumptions	• PRM travellers are digitally literal and can use the journey planning system. • For blind people, it is assumed that voice assistant system is available so that they can specify their inputs with the help of the system
Specification	When the user realizes that the initial trip search result is not satisfactory, she/he can access the selected PRM profile and adjust the default setting of the PRM profile. The default setting of PRM profiles is presented in Section **Error! Reference source not found.**.
Additional Notes	-

7.3.25 T6.1_UC1.2.7_FRQ03

Requirement ID	T6.1_UC1.2.7_FRQ03
Requirement Name	The system must offer the option to reset changed parameter values of a profile to their default value.
Use Case ID	UC-FP6-WP6-1.2.7
Category	Functional
Priority	Nice-to-have with high priority
Main goal	The system must offer the option to reset changed parameter values of a PRM profile to their default value. This functionality ensures the user that if their personalized PRM profile does not yield better trip search results and they would like to fall back to using default PRM profile, they have such an option in the journey planning system.
Assumptions	• PRM travellers are digitally literal and can use the journey planning system. • For blind people, it is assumed that voice assistant system is available so that they can specify their inputs with the help of the system
Specification	The users can access their selected and adjusted “PRM profile” where a button shall exist that allows the user to restore the default setting.
Additional Notes	-

7.3.26 T6.1_UC1.2.7_FRQ04

Requirement ID	T6.1_UC1.2.7_FRQ04
Requirement Name	The user must be made aware when parameter values of the selected profile deviate from their default value.
Use Case ID	UC-FP6-WP6-1.2.7
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	Ensure transparency and user awareness by informing users when parameter values of the selected profile deviate from their default values.
Assumptions	• PRM travellers are digitally literal and can use the journey planning system. • For blind people, it is assumed that voice assistant system is available so that they can specify their inputs with the help of the system.
Specification	Whenever parameter values of the selected profile deviate from their default values, the system should clearly indicate which parameters have been adjusted. The indication should be clear, concise, and prominently displayed within the user interface to ensure that users easily notice and understand the deviations from default parameter values.
Additional Notes	-

7.3.27 T6.1_UC1.2.7_NFRQ01

Requirement ID	T6.1_UC1.2.7_NFRQ01
Requirement Name	System's visualization of journey search results to the end user should be clear and easy to understand
Use Case ID	UC-FP6-WP6-1.2.7
Category	Non-functional
Priority	Nice-to-have with high priority
Main goal	The visualization of journey search results should be clear and easy to understand.
Assumptions	• PRM travellers are digitally literal and can use the journey planning system. • For blind people, it is assumed that voice assistant system is available so that they can specify their inputs with the help of the system.
Specification	It is however utterly important to strike a balance between items to be displayed to avoid overwhelming the user. The users will have a view of suggested trips with minimal important information.
Additional Notes	-

7.3.28 T6.1_UC1.2.8_FRQ01

Requirement ID	T6.1_UC1.2.8_FRQ01
Requirement Name	The routing algorithm must support the goal of minimizing total walking distance
Use Case ID	UC-FP6-WP6-1.2.8
Category	functional
Priority	MUST
Main goal	The routing algorithm shall be capable to provide trip options where the total distance of walks is minimized.
Assumptions	The routing algorithm applies a multi-criteria pareto-optimal search method. It seeks for fastest trip options, most comfortable trip options (i.e. for trip options with a minimum number of transfers) and shall now also search for trips with minimum walking distance. A trip option is pareto-optimal if no criterion can be improved without sacrificing another criterion.
Specification	The routing algorithm will consider the walking distance as one goal amongst others and determine pareto-optimal solutions where the total walking distance is minimized. The total walking distance is the sum of the distances of the first mile walk, the walks at transfers and the last mile walk. The routing algorithm will remove pareto-optimal solutions from the set of returned solutions if a threshold for a criterion is violated. For example, a trip search result with shortest walking distance will not be returned if the duration of this trip exceeds the duration of the fastest trip by a specified factor.
Additional Notes	-

7.3.29 T6.1_UC1.2.8_FRQ02

Requirement ID	T6.1_UC1.2.8_FRQ02
Requirement Name	The routing algorithm must offer two alternative options for the trip search: • option 1: trip search including the goal of minimizing walking distance • option 2: trip search not including the goal of minimizing walking distance (i.e. including only the goals of minimizing trip duration and number of transfers)
Use Case ID	UC-FP6-WP6-1.2.8
Category	Functional
Priority	MUST
Main goal	The routing algorithm shall be capable to be called in two different modes so that the goal of minimizing walking distance is an optional additional goal.
Assumptions	The routing algorithm applies a multi-criteria pareto-optimal search method. It can consider the criteria trip duration, comfort (i.e. number of transfers) and total walking distance.
Specification	The routing algorithm can be called in “classic mode” where only fastest and most comfortable trip options are determined and in a new mode where additionally the goal of minimizing the total walking distance is considered.
Additional Notes	-

7.3.30 T6.1_UC1.2.8_FRQ03

Requirement ID	T6.1_UC1.2.8_FRQ03
Requirement Name	There must be at least one profile offered in the PIS Frontend that triggers a trip search aiming at minimizing total walking distance
Use Case ID	UC-FP6-WP6-1.2.8
Category	Functional
Priority	MUST
Main goal	A traveller can select a profile that leads to trip options with minimum walking distance.
Assumptions	There is a list of profiles available which are associated with predefined parameters. If such a profile is activated, the parameters will be applied to the following trip searches.
Specification	Among the profiles available there is at least one profile that triggers a trip search that also aims at trip options with minimum walking distance. The profile can be a profile explicitly addressing PRM but can also be a profile not explicitly addressing PRM.
Additional Notes	-

7.4 Requirements task 6.2

7.4.1 T6.2_UC2.1_FRQ01

Requirement ID	T6.2_UC2.1_FRQ01
Requirement Name	TMS data provision to PIS
Use Case ID	UC-FP6-WP6-2.1
Category	Functional
Priority	MUST
Main goal	The TMS needs to provide specific up-to-date information to the PIS. Passengers need to be informed about the latest status of their trains, possible incidents of relevance and the forecasted delay to adapt their personal travel plans or inform others about their travel status and related individual impact on private or business plans and activities.
Assumptions	TMS and PIS are available; Available operational plan including trains and operational restrictions (planned or incident based) impacting trains; Availability of integrated PIS / end customer application for the area covered by the TMS.
Specification	Following the updates of the operational plan and the calculated forecast in the TMS, specific relevant information shall be derived and sent to the PIS: Expected delay in arrival and departure times of the trains; Platform track changes; Full or partial cancellations; Incident information in relation to trains; As far as possible, the existing SIRI standard shall be used for the data transmission.
Additional Notes	The SIRI standard possibly needs enhancement to especially cover appropriate incident information

7.4.2 T6.2_UC2.1_FRQ02

Requirement ID	T6.2_UC2.1_FRQ02
Requirement Name	PIS data receipt from TMS
Use Case ID	UC-FP6-WP6-2.1
Category	Function
Priority	MUST
Main goal	The PIS needs to allow for receiving specific up-to-date information from the TMS. Passengers need to be informed about the latest status of their trains, possible incidents of relevance and the forecasted delay to adapt their personal travel plans or inform others about their travel status and related individual impact on private or business plans and activities.
Assumptions	PIS and TMS are available. TMS has sent the relevant information, see T6.2_UC2.1_FRQ01.

	Availability of integrated PIS / end customer application for the area covered by the TMS.
Specification	After TMS has send the following information, the PIS shall receive and process it: Expected delay in arrival and departure times of the trains; Platform track changes; Full or partial cancellations; Incident information in relation to trains; As far as possible, the existing SIRI standard shall be used for the data transmission.
Additional Notes	The SIRI standard possibly needs enhancement to especially cover appropriate incident information.

7.4.3 T6.2_UC2.1_NFRQ01

Requirement ID	T6.2_UC2.1_NFRQ01
Requirement Name	Frequency TMS data provision to PIS
Use Case ID	UC-FP6-WP6-2.1
Category	Non-Functional
Priority	MUST
Main goal	The TMS needs to provide specific up-to-date information to the PIS with a specified minimum frequency to allow for up-to-date information required by the end users.
Assumptions	TMS and PIS are available; Available operational plan including trains and operational restrictions (planned or incident based) impacting trains; Availability of integrated PIS / end customer application for the area covered by the TMS.
Specification	The transfer frequency of updated information to be sent from TMS to PIS shall be higher or equal to every 30 seconds.
Additional Notes	Depending on the traffic load, the minimum frequency threshold value could be varying in relation to different regional railways, areas or the current daytime, weekday, or period.

7.4.4 T6.2_UC2.2_FRQ01

Requirement ID	T6.2_UC2.2_FRQ01
Requirement Name	PIS traveller demand data provision to TMS/CMS
Use Case ID	UC-FP6-WP6-2.2
Category	Functional
Priority	MUST
Main goal	The PIS demand forecast module needs to provide specific up to date traveller demand information to the TMS/CMS. To support TMS decision making and to ensure appropriate transport capacity being made available by the CMS, the up to date traveller demand data for two weeks before the current time is to be transferred to the Traffic Management and Capacity Planning and Management Systems.

Assumptions	TMS/CMS and PIS demand forecast module are available; Travel demand forecast is available in PIS for two weeks ahead of current daytime;
Specification	The PIS demand forecast shall send the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the current time to the TMS and CMS.
Additional Notes	Since SIRI is not covering this kind of information and is anyway relevant only for a timeframe of two hours before current time, a separate protocol for transmission is required.

7.4.5 T6.2_UC2.2_FRQ02

Requirement ID	T6.2_UC2.2_FRQ02
Requirement Name	TMS/CMS receives traveller demand data from PIS demand forecast.
Use Case ID	UC-FP6-WP6-2.2
Category	Functional
Priority	MUST
Main goal	The TMS/CMS needs to allow for receiving specific up to date traveller demand information from the PIS demand forecast module. To support TMS decision making and to ensure appropriate transport capacity being made available by the CMS, the up to date traveller demand data for two weeks before the current time is to be transferred to the Traffic Management and Capacity Planning and Management Systems.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has sent the relevant information, see T6.2_UC2.2_FRQ01. Travel demand forecast is available in PIS for two weeks ahead of current daytime;
Specification	The TMS/CMS shall allow to receive the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the current time from the PIS demand forecast module.
Additional Notes	Since SIRI is not covering this kind of information and is anyway relevant only for a timeframe of two hours before current time, a separate protocol for transmission is required.

7.4.6 T6.2_UC2.2_NFRQ01

Requirement ID	T6.2_UC2.2_NFRQ01
Requirement Name	Frequency for provision of traveller demand data to TMS/CMS
Use Case ID	UC-FP6-WP6-2.2
Category	Non-Functional
Priority	MUST
Main goal	The PIS needs to provide specific up-to-date information to the TMS/CMS with a specified minimum frequency to allow for up-to-

	date information required by TMS/CMS users.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has sent the relevant information, see T6.2_UC2.2_FRQ01. Travel demand forecast is available in PIS for two weeks ahead of current daytime;
Specification	The transfer frequency of updated information to be sent from PIS to TMS/CMS shall be higher or equal every 15 minutes providing that new data updates are available.
Additional Notes	Depending on the traffic demand, the minimum frequency threshold value may vary in relation to different regional railways, areas or the current daytime, weekday, or period.

7.4.7 T6.2_UC2.2_NFRQ02

Requirement ID	T6.2_UC2.2_NFRQ02
Requirement Name	Provision of anonymised information about traveller demand to TMS/CMS
Use Case ID	UC-FP6-WP6-2.2
Category	Non-Functional
Priority	MUST
Main goal	The PIS needs to provide anonymized up-to-date information to the TMS/CMS.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has sent the relevant information, see T6.2_UC2.2_FRQ01. Travel demand forecast is available in PIS for two weeks ahead of current daytime;
Specification	The updated demand forecast information to be sent from PIS to TMS/CMS shall be anonymized i.e., no personal details shall be included.
Additional Notes	-

7.4.8 T6.2_UC2.3_FRQ01

Requirement ID	T6.2_UC2.3_FRQ01
Requirement Name	PIS numbers of expected travellers in trains provision to TMS/CMS
Use Case ID	UC-FP6-WP6-2.3
Category	Functional
Priority	MUST
Main goal	The PIS demand forecast module needs to provide specific up-to-date numbers of expected travellers in the trains. To support TMS decision making and to ensure appropriate transport capacity being made available by the CMS, the up-to-date numbers of expected travellers in the trains between subsequent stops are to be transferred to the Traffic Management and Capacity Planning and Management Systems.

Assumptions	TMS/CMS and PIS demand forecast module are available; Numbers of expected travellers in the trains are available in PIS demand forecast module for at least 2 hours ahead of current daytime;
Specification	The PIS demand forecast module shall send the number of expected travellers in the trains between subsequent stops in a timeframe of at least 2 hours ahead of the current time to the TMS and CMS.
Additional Notes	Since SIRI is not covering this kind of information and is anyway relevant only for a timeframe of two hours before current time, a separate protocol for transmission is required.

7.4.9 T6.2_UC2.3_FRQ02

Requirement ID	T6.2_UC2.3_FRQ02
Requirement Name	TMS/CMS receives numbers of expected travellers in trains from PIS demand forecast module
Use Case ID	UC-FP6-WP6-2.3
Category	Functional
Priority	MUST
Main goal	The TMS/CMS needs to allow for receiving specific up-to-date numbers of expected travellers in the trains. To support TMS decision making and to ensure appropriate transport capacity being made available by the CMS, the up-to-date numbers of expected travellers in the trains between subsequent stops are to be transferred to the Traffic Management and Capacity Planning and Management Systems.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has send the relevant information, see T6.2_UC2.3_FRQ01. Numbers of expected travellers in the trains are available in PIS demand forecast module for at least 2 hours ahead of current daytime;
Specification	The TMS/CMS shall allow to receive the number of expected travellers in the trains between subsequent stops in a timeframe of at least 2 hours ahead of the current time from the PIS demand forecast module.
Additional Notes	Since SIRI is not covering this kind of information and is anyway relevant only for a timeframe of two hours before current time, a separate protocol for transmission is required.

7.4.10 T6.2_UC2.3_NFRQ01

Requirement ID	T6.2_UC2.3_NFRQ01
Requirement Name	Frequency for provision of numbers of expected travellers in trains to TMS/CMS
Use Case ID	UC-FP6-WP6-2.3
Category	Non-Functional
Priority	MUST

Main goal	The PIS needs to provide specific up-to-date information to the TMS/CMS with a specified minimum frequency to allow for up-to-date information required by TMS/CMS users.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has sent the relevant information, see T6.2_UC2.3_FRQ01. Numbers of expected travellers in trains are available in PIS for at least 2 hours ahead of current daytime;
Specification	The transfer frequency of updated information about expected numbers of travellers in trains to be sent from PIS to TMS/CMS shall be higher or equal every 5 minutes providing that new data updates are available.
Additional Notes	Depending on the traffic demand, the minimum frequency threshold value may vary in relation to different regional railways, areas or the current daytime, weekday, or period.

7.4.11 T6.2_UC2.3_NFRQ02

Requirement ID	T6.2_UC2.3_NFRQ02
Requirement Name	Provision of anonymised information about expected travellers in trains to TMS/CMS
Use Case ID	UC-FP6-WP6-2.3
Category	Non-Functional
Priority	MUST
Main goal	The PIS needs to provide anonymized up-to-date information to the TMS/CMS.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has send the relevant information, see T6.2_UC2.3_FRQ01. Numbers of expected travellers in trains are available in PIS for at least 2 hours ahead of current daytime;
Specification	The updated information about expected numbers of travellers in trains to be sent from PIS to TMS/CMS shall be anonymized i.e., no personal details shall be included.
Additional Notes	-

7.4.12 T6.2_UC2.4_FRQ01

Requirement ID	T6.2_UC2.4_FRQ01
Requirement Name	PIS provision of numbers of expected travellers embarking/disembarking a train at the stations to TMS/CMS
Use Case ID	UC-FP6-WP6-2.4
Category	Functional
Priority	MUST
Main goal	The PIS demand forecast module needs to provide specific up-to-date numbers of expected travellers embarking/disembarking a train at the stations. To support TMS decision making and to ensure appropriate transport capacity being made available by the CMS, the

	up-to-date numbers of expected travellers embarking/disembarking a train at the stations are to be transferred to the Traffic Management and Capacity Planning and Management Systems.
Assumptions	TMS/CMS and PIS demand forecast module are available; Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for at least 2 hours ahead of current daytime;
Specification	The PIS demand forecast module shall send the number of expected travellers embarking/disembarking a train at the stations in a timeframe of at least 2 hours ahead of the current time to the TMS and CMS.
Additional Notes	Since SIRI is not covering this kind of information and is anyway relevant only for a timeframe of two hours before current time, a separate protocol for transmission is required.

7.4.13 T6.2_UC2.4_FRQ02

Requirement ID	T6.2_UC2.4_FRQ02
Requirement Name	TMS/CMS receives numbers of expected travellers embarking/disembarking a train at the stations from PIS demand forecast module.
Use Case ID	UC-FP6-WP6-2.4
Category	Functional
Priority	MUST
Main goal	The TMS/CMS needs to allow for receiving specific up-to-date numbers of expected travellers embarking/disembarking a train at the stations. To support TMS decision making and to ensure appropriate transport capacity being made available by the CMS, the up-to-date numbers of expected travellers embarking/disembarking a train at the stations are to be transferred to the Traffic Management and Capacity Planning and Management Systems.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has send the relevant information, see T6.2_UC2.4_FRQ01. Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for at least 2 hours ahead of current daytime;
Specification	The TMS/CMS shall allow to receive the number of expected travellers embarking/disembarking a train at the stations in a timeframe of at least 2 hours ahead of the current time from the PIS demand forecast module.
Additional Notes	Since SIRI is not covering this kind of information and is anyway relevant only for a timeframe of two hours before current time, a separate protocol for transmission is required.

7.4.14 T6.2_UC2.4_NFRQ01

Requirement ID	T6.2_UC2.4_NFRQ01

Requirement Name	Frequency for provision of numbers of expected travellers embarking/disembarking a train at the stations to TMS/CMS
Use Case ID	UC-FP6-WP6-2.04
Category	Non-Functional
Priority	MUST
Main goal	The PIS needs to provide specific up-to-date information to the TMS/CMS with a specified minimum frequency to allow for up-to-date information required by TMS/CMS users.
Assumptions	• TMS/CMS and PIS demand forecast module are available; • PIS demand forecast module has sent the relevant information, see T6.2_UC2.4_FRQ01. • Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS for at least 2 hours ahead of current daytime;
Specification	The transfer frequency of updated information about expected numbers of expected travellers embarking/disembarking a train at the stations to be sent from PIS to TMS/CMS shall be higher or equal every 5 minutes providing that new data updates are available.
Additional Notes	Depending on the traffic demand, the minimum frequency threshold value may vary in relation to different regional railways, areas or the current daytime, weekday, or period.

7.4.15 T6.2_UC2.4_NFRQ02

Requirement ID	T6.2_UC2.4_NFRQ02
Requirement Name	Provision of anonymised information about expected travellers embarking/disembarking a train at the stations to TMS/CMS
Use Case ID	UC-FP6-WP6-2.04
Category	Non-Functional
Priority	MUST
Main goal	The PIS needs to provide anonymized up-to-date information to the TMS/CMS.
Assumptions	TMS/CMS and PIS demand forecast module are available; PIS demand forecast module has sent the relevant information, see T6.2_UC2.4_FRQ01. Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS for at least 2 hours ahead of current daytime;
Specification	The updated information about expected travellers embarking/disembarking a train at the stations to be sent from PIS to TMS/CMS shall be anonymized i.e., no personal details shall be included.
Additional Notes	-

7.5 Requirements task 6.4

7.5.1 T6.4_UC4.1_FRQ01

Requirement ID	T6.4_UC4.1_FRQ01
Requirement Name	The system must be able to gather data relevant for occupancy forecast
Use Case ID	UC-FP6-WP6-4.01
Category	Functional
Priority	MUST
Main goal	The system must be able to gather data relevant for occupancy forecast: • Journey planning requests (including origin, destination, and preferred time of travel • Vehicle occupancy sensor data (optional) • Other relevant data (optional)
Assumptions	• The system assumes that a journey planning system is available. • The system assumes that journey planning requests will be made by users and provide information such as origin, destination, and preferred time of travel. • The system assumes that the data received will be sufficient and accurate for demand forecasting purposes.
Specification	• The system should have the capability to receive and process journey planning requests data from users, including the origin, destination, and preferred time of travel. • If available, the system should be able to collect and utilize vehicle occupancy sensor data to further enhance the accuracy of the occupancy forecast. • The system should also be able to handle other relevant data (like historical data or ticketing data), if provided, in order to improve the accuracy of the occupancy forecast.
Additional Notes	Additional quality sources may help to improve the quality of the forecast.

7.5.2 T6.4_UC4.1_NFRQ01

Requirement ID	T6.4_UC4.1_NFRQ01
Requirement Name	The system must be able to receive and process the collected data in a reasonable time
Use Case ID	UC-FP6-WP6-4.01
Category	Non-Functional

Priority	MUST
Main goal	The system must be able to receive data (such as journey planning requests, vehicle occupancy, and other relevant data) from a journey planning system or other systems and process it in a reasonable time frame. The processed data will be consumed by demand forecast algorithms.
Assumptions	• The system assumes that data will be received from a journey planning system or other systems. • The availability and format of the received data will be compatible with the system's processing capabilities. • The definition of "reasonable time" may vary depending on the specific requirements and expectations of the final application. • Other data may be available (like disruptions or delays information, occupancy sensors on the train)
Specification	• The system should have the capability to receive data from a journey planning system or other systems. The data can include journey planning requests, vehicle occupancy information, and other relevant data. • The received data should be processed efficiently and effectively within a reasonable time frame. The reasonable timeframe should include the receival process and end as soon as the received data is formatted and ingested by the system. • The system should have the capability to handle and process large volumes of data to ensure accurate demand forecasting. • The processed data should be made available for consumption by demand forecast algorithms. • The complete recalculation of the demand on the network is only performed daily • Journey planning requests should be processed to update the demand forecast information on a daily basis • Other data considered by the algorithms (disruptions, delays, counter), which have a higher frequency (real-time data), may lead to partial updates of the demand forecast on the network
Additional Notes	A reasonable time may vary and depend on the expectation for the demonstration. Since the amount of journey planning requests needs to reach sufficient numbers, the forecast may be calculated on a daily basis and needs to be available within the current day for the next, meaning that the “reasonable time” may still be on average a couple of hours.

	For data with higher frequency, this should be processed in few seconds, but will lead to small updates of the demand forecast model.

7.5.3 T6.4_UC4.1_FRQ02

Requirement ID	T6.4_UC4.1_FRQ02
Requirement Name	The system must be able to train a machine learning model using journey planning request data and historical vehicle occupancy data.
Use Case ID	UC-FP6-WP6-4.01
Category	Functional
Priority	MUST
Main goal	Train a machine learning model using journey planning request data and historical vehicle occupancy data
Assumptions	• The system assumes that journey planning request data and historical vehicle occupancy data will be available for training the machine learning model. • The availability and quality of the training data will impact the accuracy and effectiveness of the trained model. • The system assumes that the machine learning model will be trained using appropriate algorithms and techniques to achieve the desired forecasting outcomes.
Specification	• The received data should be pre-processed and transformed into a suitable format for training the model. • The system should utilize appropriate machine learning algorithms and techniques to train the model based on the provided data. • The trained model should be able to analyse and make accurate predictions based on new journey planning request data and current vehicle occupancy data. • The demand forecast precision should achieve 50% precision in the average forecast 1 week in advance and achieve 65% precision in the forecast at 1 hour. • The trained machine learning model should be stored and made available for future demand forecasting purposes.
Additional Notes	• The availability and quality of the training data will significantly impact the accuracy and effectiveness of the trained machine learning model. • The system should provide mechanisms for monitoring and evaluating the performance of the trained model to ensure its effectiveness over time.

7.5.4 T6.4_UC4.1_FRQ03

Requirement ID	T6.4_UC4.1_FRQ03
Requirement Name	The system must be able to process new data and retrain the occupancy model considering historic data.
Use Case ID	UC-FP6-WP6-4.01
Category	Functional
Priority	MUST
Main goal	To keep the demand forecast model up to date, the system must be able to process the expected input of journey planning request data and historical vehicle occupancy data automatically.
Assumptions	• The system assumes that new data, including journey planning requests and vehicle occupancy information, will be available for updating the occupancy model. • The availability and quality of the new data will impact the accuracy and effectiveness of the updated model. • The system assumes that historical data will be used as a reference for updating the occupancy model.
Specification	• The system should have the capability to receive new data, such as journey planning requests and vehicle occupancy information, for updating the occupancy model. • The received new data should be pre-processed and integrated with the existing historical data to create an updated dataset. • The system should utilize appropriate techniques and algorithms to update the occupancy model based on the new and historical data. • The updated occupancy model should take into account the patterns and trends observed in the historical data, as well as the new data, to provide accurate predictions. • The updated occupancy model will overwrite old models and made available for future demand forecasting and analysis. • The trained model should be regularly updated and refined to improve the accuracy of the vehicle occupancy predictions.
Additional Notes	• The availability and quality of the training data will significantly impact the accuracy and effectiveness of the trained machine learning model. • The system should provide mechanisms for monitoring and evaluating the performance of the trained model to ensure its effectiveness over time.

7.5.5 T6.4_UC4.1_FRQ04

Requirement ID	T6.4_UC4.1_FRQ04
Requirement Name	The system must be able to receive a new journey planning request and apply the trained model to predict vehicle occupancy for the requested journey.
Use Case ID	UC-FP6-WP6-4.01
Category	Functional
Priority	MUST
Main goal	Predict vehicle occupancy for the requested journey
Assumptions	• The system assumes that a trained model for predicting vehicle occupancy based on journey planning requests and historical data is available. • The accuracy of the trained model will impact the accuracy of the occupancy prediction for the requested journey. • The system assumes that the journey planning request will provide the necessary information for predicting vehicle occupancy, such as origin, destination, and preferred time of travel.
Specification	• The system should have the capability to receive a new journey planning request, which includes information such as origin, destination, and preferred time of travel. • The received journey planning request should be processed and utilized by the trained model to predict the vehicle occupancy for the requested journey. • The system should apply the trained model to analyse the journey planning request and provide an accurate prediction of the expected vehicle occupancy. • The prediction of vehicle occupancy should consider the patterns and trends observed in the historical data used to train the model. • The system should provide the predicted vehicle occupancy information in a format that can be easily communicated to the user or integrated with other systems.
Additional Notes	• The accuracy of the occupancy prediction will depend on the availability and quality of the trained model and the data used for training.

	• The system should provide mechanisms for monitoring and evaluating the performance of the predictions to ensure their effectiveness over time.

7.5.6 T6.4_UC4.1_FRQ05

Requirement ID	T6.4_UC4.1_FRQ05
Requirement Name	The system must be able to inform the Journey Planning System about a new occupancy forecast.
Use Case ID	UC-FP6-WP6-4.01
Category	Functional
Priority	MUST
Main goal	In regular time intervals, the forecasted occupancy information is extracted from the model and exported to the journey planning system. The journey planning system is then capable of using this information to enrich journey planning response with the forecasted occupancy information.
Assumptions	• The system assumes that a trained occupancy model is available and regularly updated with new data. • The journey planning system can receive and process the forecasted occupancy information provided by the system. • The availability and accuracy of the forecasted occupancy information will impact the effectiveness of the journey planning system in enriching journey planning responses.
Specification	• The system should extract forecasted occupancy information from the trained occupancy model in regular time intervals. • The extracted forecasted occupancy information should be exported to the journey planning system in a format that is compatible and easily consumable by the platform. • The exported forecasted occupancy information should be integrated into the journey planning responses provided by the journey planning system. • The system should ensure the accuracy and timeliness of the forecasted occupancy information by regularly updating the occupancy model with new data.
Additional Notes	• The effectiveness of the journey planning system in enriching journey planning responses with forecasted occupancy information will depend on the accuracy and timeliness of the exported information.

	• The system should provide mechanisms for handling any errors or inconsistencies in the exported forecasted occupancy information and ensure proper communication with the journey planning system.

7.5.7 T6.4_UC4.1_NFRQ02

Requirement ID	T6.4_UC4.1_NFRQ02
Requirement Name	The system should keep the occupancy model updated
Use Case ID	UC-FP6-WP6-4.01
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	The system should aim to keep the occupancy model updated to enable timely availability of updated and improved forecasts in the Journey Planning System, resulting in higher quality journey planning results.
Assumptions	The system assumes that the occupancy model can be updated with new data.
Specification	• The system should have mechanisms in place to regularly update the occupancy model with new data. • The system should prioritize the speed and efficiency of updating the model to ensure timely availability of updated forecasts. • The updated occupancy model should be seamlessly integrated with the Journey Planning System to provide improved journey planning results.
Additional Notes	The frequency and timing of the model updates should be balanced with the availability and quality of the new data.

7.5.8 T6.4_UC4.2_FRQ01

Requirement ID	T6.4_UC4.2_FRQ01
Requirement Name	The system must be able to process user input, including origin, destination, and preferred time of travel.
Use Case ID	UC-FP6-WP6-4.02
Category	Functional
Priority	MUST
Main goal	The system must be able to process user input, which includes origin, destination, and preferred time of travel.
Assumptions	• The system assumes that users will provide input in the form of origin, destination, and preferred time of travel.

	• The provided user input will be used for journey planning and demand forecasting purposes.
Specification	• The system should have the capability to collect and process user input, which includes origin, destination, and preferred time of travel. • The received user input should be validated to ensure it meets the required format and data constraints. • The system should utilize the processed user input for journey planning and demand forecasting purposes. • The user input should be incorporated into the data provided to algorithms and techniques used for demand forecasting.
Additional Notes	• This requirement is similar to a requirement from UC1.1.1, but includes demand forecast information on the journeys provided to the traveller • The system should provide mechanisms for error handling and feedback to the user in case of invalid or incomplete input.

7.5.9 T6.4_UC4.2_FRQ02

Requirement ID	T6.4_UC4.2_FRQ02
Requirement Name	The journey planning system must be able to fetch forecasted vehicle occupancy information for the proposed journeys based on the user's input.
Use Case ID	UC-FP6-WP6-4.02
Category	Functional
Priority	MUST
Main goal	Fetching Forecasted Vehicle Occupancy Information
Assumptions	The system assumes that there is a forecasted vehicle occupancy model available.
Specification	• The system should have the capability to fetch forecasted vehicle occupancy information for the proposed journeys based on the user's input. • The user's input, including origin, destination, and preferred time of travel, should be utilized to determine the relevant forecasted vehicle occupancy information. • The system should utilize the forecasted vehicle occupancy to generate accurate predictions for the proposed journeys.

Additional Notes	The accuracy of the fetched forecasted vehicle occupancy information will depend on the availability and quality of the forecasted vehicle occupancy model.

7.5.10 T6.4_UC4.2_NFRQ01

Requirement ID	T6.4_UC4.2_NFRQ01
Requirement Name	The trip planning interface should be user-friendly and intuitive, making it easy for travellers to enter their information
Use Case ID	UC-FP6-WP6-4.02
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	Provide a User-Friendly and Intuitive Trip Planning Interface
Assumptions	• The system assumes that there is a trip planning interface through which users can enter their information. • The usability and intuitiveness of the interface will impact the user experience and ease of information entry.
Specification	• The trip planning interface should be designed in a user-friendly manner, with clear and intuitive navigation and controls. • The interface should provide clear instructions and guidance to users on how to enter their information, including origin, destination, and preferred time of travel. • The system should provide real-time feedback and validation to users to ensure the accuracy and completeness of the entered information. • The system should consider user preferences and customization options in the design of the trip planning interface.
Additional Notes	The user-friendliness and intuitiveness of the trip planning interface can enhance the overall user experience and encourage more users to utilize the system.

7.5.11 T6.4_UC4.2_FRQ03

Requirement ID	T6.4_UC4.2_FRQ03
Requirement Name	The journey planning system must be able to consider forecasted occupancy information for the generation of trip options.
Use Case ID	UC-FP6-WP6-4.02
Category	Functional
Priority	MUST

Main goal	The system must be able to generate several trip options based on the user's input and available forecasted occupancy information.
Assumptions	• The system assumes that it has access to the user's input, including origin, destination, and preferred time of travel. • The system also assumes that it has access to the available forecasted occupancy information for the relevant vehicles or modes of transportation.
Specification	• The system should utilize the user's input, including origin, destination, and preferred time of travel, to generate several trip options. • The trip options should consider the available forecasted occupancy information, considering the predicted occupancy levels for the relevant vehicles or modes of transportation. • The generated trip options should consider factors such as travel time, comfort (number of transfers), and forecasted occupancy levels to provide a range of choices to the user. • The system should consider any additional preferences or constraints specified by the user in the input to refine the generated trip options.
Additional Notes	The accuracy and relevance of the generated trip options will depend on the availability and quality of the journey planning and forecasted occupancy information.

7.5.12 T6.4_UC4.2_FRQ04

Requirement ID	T6.4_UC4.2_FRQ04
Requirement Name	The journey planning system must be able to display the forecasted vehicle occupancy information to the traveller on the trip planning interface.
Use Case ID	UC-FP6-WP6-4.02
Category	Functional
Priority	MUST
Main goal	Displaying Forecasted Vehicle Occupancy Information
Assumptions	• The system assumes that there is forecasted vehicle occupancy information available for the relevant vehicles or modes of transportation. • The forecasted vehicle occupancy information will be relevant to the user's proposed journey based on their input.

Specification	• When planning a journey, the fetched forecasted vehicle occupancy information should be displayed to the traveller on the trip planning interface. • The system should present the generated trip options to the user in a clear and organized manner, highlighting key information such as estimated travel time, cost, and forecasted occupancy levels.
Additional Notes	• The accuracy and relevance of the displayed forecasted vehicle occupancy information will depend on the availability and quality of the forecasted occupancy model and data. • The display of the forecasted vehicle occupancy information can assist the traveller in making informed decisions about their journey and choosing the most suitable trip option.

7.5.13 T6.4_UC4.2_NFRQ02

Requirement ID	T6.4_UC4.2_NFRQ02
Requirement Name	The trip planning interface should be user-friendly and intuitive, making it easy for travellers to understand the displayed forecasted occupancy information.
Use Case ID	UC-FP6-WP6-4.02
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	User-Friendly and Intuitive Trip Planning Interface
Assumptions	The system assumes that there is a trip planning interface through which travellers can access and view the forecasted occupancy information.
Specification	• The trip planning interface should be designed in a user-friendly manner, with clear and intuitive presentation of the forecasted occupancy information. • The displayed forecasted occupancy information should be easily understandable and relevant to the traveller's journey planning needs. • The interface should provide clear explanations and visual cues to help travellers interpret and comprehend the forecasted occupancy information.
Additional Notes	The user-friendliness and intuitiveness of the trip planning interface can enhance the overall user experience and facilitate the traveller's understanding of the forecasted occupancy information.

7.5.14 T6.4_UC4.3_FRQ01

Requirement ID	T6.4_UC4.3_FRQ01
Requirement Name	The system must be able to train a machine learning model using historical travel demand data, combining rail and other modes in the surrounding areas.
Use Case ID	UC-FP6-WP6-4.03
Category	Functional
Priority	MUST
Main goal	The system must be able to train a machine learning model using historical travel demand data, combining rail and other modes (such as bus, trams, DRT, or walking) in the surrounding areas, for the purpose of estimating mobility demand beyond rail (first/last mile analysis).
Assumptions	• The system assumes that there is historical travel demand data available for the relevant areas, including rail and other modes of transportation.

	• The machine learning model will be trained using this historical data to estimate the mobility demand beyond rail, specifically for first/last mile analysis.
Specification	• The system should have the capability to access and utilize the historical travel demand data for the relevant areas. • The historical travel demand data should include information on journey request, and optionally other relevant factors for rail and other modes of transportation. • The machine learning model should be trained using the historical travel demand data, combining information from rail and other modes in the surrounding areas. • The training process should incorporate appropriate algorithms and techniques to analyse and learn from the historical data, capturing relevant patterns and trends specific to first/last mile mobility demand. • The trained machine learning model should be able to estimate the mobility demand beyond rail, providing insights and predictions for first/last mile analysis.
Additional Notes	

7.5.15 T6.4_UC4.3_FRQ02

Requirement ID	T6.4_UC4.3_FRQ02
Requirement Name	The system must be able to estimate the mobility demand for first/last mile connections between rail stations and surrounding locations.
Use Case ID	UC-FP6-WP6-4.03
Category	Functional
Priority	MUST
Main goal	Estimating Mobility Demand for First/Last Mile Connections
Assumptions	• The system assumes that it has access to relevant data such as rail station locations, surrounding locations, and journey planning requests. • The estimation of mobility demand will be based on this data to determine the level of demand for transportation options connecting rail stations and surrounding areas.
Specification	• The system should utilize available data on rail station locations and surrounding areas to estimate the mobility demand for first/last mile connections.

	- The estimation of mobility demand should consider factors such as travel patterns or other relevant variables if available (like population density or proximity to rail stations). - The system should incorporate appropriate algorithms and techniques to analyse the data and generate accurate estimates of mobility demand. - The estimation of mobility demand should provide insights into the expected volume of travellers requiring first/last mile transportation options, allowing stakeholders to understand the level of demand for first/last mile connections and make informed decisions. - The estimation of mobility demand should consider various scenarios and factors that may impact demand, such as time of day, day of the week, and special events.
Additional Notes	The accuracy and reliability of the estimated mobility demand will depend on the quality and availability of the data used in the estimation process.

7.5.16 T6.4_UC4.3_FRQ03

Requirement ID	T6.4_UC4.3_FRQ03
Requirement Name	The system must be able to export first/last mile demand forecast data.
Use Case ID	UC-FP6-WP6-4.03
Category	Functional
Priority	MUST
Main goal	Make first/last mile demand forecast data available so that it can be processed by other systems.
Assumptions	- The system has already derived first/last mile demand forecast data.
Specification	- The system must offer the user (TSP) the option to export first/last mile demand forecast data. - The system must enable the user (TSP) to specify the export, e.g., by a date range. - The export must happen in a typical and machine-readable file format such as csv or JSON.
Additional Notes	-

7.5.17 T6.4_UC4.3_NFRQ01

Requirement ID	T6.4_UC4.3_NFRQ01

Requirement Name	The system should be reliable and available for request for forecasted demand information whenever required by the TSP.
Use Case ID	UC-FP6-WP6-4.03
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	The system should be reliable and available for requests of forecasted demand information whenever required by the TSP
Assumptions	• The system assumes that there is a Transportation Service Provider who requires access to forecasted demand information. • The TSP should be able to request this information from the system whenever needed.
Specification	• The system should be designed and implemented to ensure high reliability, minimizing downtime and disruptions in providing forecasted occupancy information. • The system should have robust mechanisms for handling and processing these requests efficiently and in a timely manner (a few seconds). • The system should be able to handle multiple concurrent requests from different TSPs, ensuring fair and equitable access to the forecasted demand information.
Additional Notes	

7.5.18 T6.4_UC4.3_FRQ04

Requirement ID	T6.4_UC4.3_FRQ04
Requirement Name	The system must be able to analyse the estimation results over time and identify areas with high demand and low offering.
Use Case ID	UC-FP6-WP6-4.03
Category	Functional
Priority	MUST
Main goal	The analysis of estimation results will be performed to identify areas where there is a high demand for transportation services but a low offering or availability, or vice versa.
Assumptions	• The system assumes that it has access to the estimation results, which include information on mobility demand and available transportation services. •

Specification	• The system should analyse the estimation results to identify areas with high demand for transportation services. This analysis may consider other factors such as travel demand and population density. • The system should also assess the availability or offering of transportation services in these areas. • The analysis should compare the demand and offering in each area, allowing for the identification of areas with a significant disparity between demand and offering.
Additional Notes	• The analysis of estimation results is crucial in identifying areas where there is a mismatch between transportation demand and availability, helping to inform planning and decision-making processes. • It is important to consider the accuracy and reliability of the estimation results and ensure that the analysis takes into account any uncertainties or limitations in the data.

7.5.19 T6.4_UC4.3_FRQ05

Requirement ID	T6.4_UC4.3_FRQ05
Requirement Name	The system must provide data insights for transport service providers through a demand analytics dashboard.
Use Case ID	UC-FP6-WP6-4.03
Category	Functional
Priority	MUST
Main goal	Provision of Data Insights through a Demand Analytics Dashboard for TSPs
Assumptions	• The system assumes that there are transport service providers who require access to data insights for informed decision-making. • The data insights will be provided through a demand analytics dashboard.
Specification	• The system should have a demand analytics dashboard that presents data insights to TSPs. • The demand analytics dashboard should provide clear and understandable visualizations or reports that highlight areas with high demand and low offering of transportation services. • The data insights presented on the dashboard should be based on the analysis of estimation results, considering factors such as travel demand, population density, and other relevant variables. • The demand analytics dashboard should allow TSP to view and explore the data insights, enabling them to gain a comprehensive understanding of the demand and offering landscape. • The dashboard should provide interactive features, such as filters and drill-down capabilities, to allow users to customize their view and focus on specific areas or aspects of the data. • The system should present the results of the analysis in a clear and understandable manner, providing visualizations or reports that highlight areas with high demand and low offering.
Additional Notes	• The analysis of estimation results is crucial in identifying areas where there is a mismatch between transportation demand and availability, helping to inform planning and decision-making processes.

	- It is important to consider the accuracy and reliability of the estimation results and ensure that the analysis takes into account any uncertainties or limitations in the data. - The system should allow for a collaborative approach between transport service providers (multi tenants) in addressing areas with high demand and low offering.

7.5.20 T6.4_UC4.3_NFRQ02

Requirement ID	T6.4_UC4.3_NFRQ02
Requirement Name	The system must validate the accuracy and completeness of the available data to improve the accuracy of demand estimation.
Use Case ID	UC-FP6-WP6-4.03
Category	Non-Functional
Priority	MUST
Main goal	Accuracy and Completeness of Data for Improved Demand Estimation
Assumptions	- The system assumes that there is available data used for demand estimation. - Improving the accuracy of demand estimation relies on the accuracy and completeness of the sources of data.
Specification	- The system should implement mechanisms to validate the accuracy and reliability of the available data used for demand estimation. - This includes conducting data validation and verification processes to identify any inaccuracies or inconsistencies in the data. - The system should also incorporate data cleaning techniques to remove any irrelevant or erroneous data that may affect the accuracy of demand estimation.
Additional Notes	-

7.5.21 T6.4_UC4.4_FRQ01

Requirement ID	T6.4_UC4.4_FRQ01
Requirement Name	Data Collection and Preprocessing
Use Case ID	UC-FP6-WP6-4.04
Category	Functional
Priority	MUST

Main goal	The system must be able to collect and store the relevant data for anomaly detection and prediction
Assumptions	1) The system assumes that the following data is available: • Train Occupancy • Weather conditions • Public/disruptive events • Train Schedule • Other relevant data (optional) 2) The system assumes that the data received will be sufficient and accurate for anomaly detection and prediction
Specification	• The system should be capable of receiving data from different sources: train occupancy data (forecast or observed if available), weather data and event data. • The system should be capable of preprocessing data, including mechanisms for data cleaning and integration that combines data from different sources to provide a unified view. • The system should also be capable of handling other relevant data (e.g., train delays, historical maintenance, disruption logs, etc.) if available in order to improve the accuracy of the models.
Additional Notes	Additional quality sources may help to improve the quality of the detection and prediction.

7.5.22 T6.4_UC4.4_NFRQ01

Requirement ID	T6.4_UC4.4_NFRQ01
Requirement Name	Performance of data collection, preprocessing and storage of data for anomaly detection and prediction
Use Case ID	UC-FP6-WP6-4.04
Category	Non-Functional
Priority	MUST
Main goal	The system should be able to perform the collection, preprocessing and storage procedures in a reasonable time. The processed data will be consumed by anomaly detection and prediction models.
Assumptions	• The system assumes that data will be received from a PIS backend platform (occupancy data) and other sources that cover weather data and public/disruptive event data. • The availability and format of the received data will be compatible with the system's processing capabilities.

	- The definition of "reasonable time" may vary depending on the specific requirements and expectations of the final application. - Other data may be available (e.g., train delays, historical maintenance, disruption logs, etc.)
Specification	- The system should have the capability to receive data from a PIS backend (occupancy data) and other sources that cover weather data and public/disruptive event data. - The received data should be processed efficiently and effectively within a reasonable time frame. - The system should have the capability to handle and process large volumes of data to ensure accurate anomaly detection and prediction. - The processed data should be made available for consumption by anomaly detection and prediction models.
Additional Notes	-

7.5.23 T6.4_UC4.4_FRQ02

Requirement ID	T6.4_UC4.4_FRQ02
Requirement Name	Model training for anomaly detection
Use Case ID	UC-FP6-WP6-4.04
Category	Functional
Priority	MUST
Main goal	The system must be able to train the anomaly detection model using train occupancy data, weather data, and public/disruptive event data.
Assumptions	1. The system assumes that the following data is available for training the anomaly detection model: - Train Occupancy - Train Schedule 2. The availability and quality of the training data will impact the accuracy and effectiveness of the trained model. 3. The system assumes that the machine learning model will be trained using appropriate algorithms and techniques to achieve the desired outputs.
Specification	- The system should be capable of implementing mechanisms for data transformation (e.g., encoding) and feature engineering in order to prepare data to be used by a machine learning and/or statistical model for anomaly detection.

	• The system should utilize appropriate machine learning algorithms to train the model based on the provided data. • The trained model should be able to analyse and accurately detect anomalies based on the provided data. • The trained model should be able to produce/update a labelled dataset with a feature for the detected anomalies (e.g., a column of binary values for whether it is an anomaly).
Additional Notes	• The availability and quality of the training data will significantly impact the accuracy and effectiveness of the trained machine learning model. • In unsupervised learning techniques for anomaly detection, the term "training" is used differently compared to supervised learning. In this context, "training" often refers to the process of fitting the model to the data to learn the underlying patterns and structures.

7.5.24 T6.4_UC4.4_FRQ03

Requirement ID	T6.4_UC4.4_FRQ03
Requirement Name	Model update for anomaly detection
Use Case ID	UC-FP6-WP6-4.04
Category	Functional
Priority	MUST
Main goal	The system must be able to process the data and update the anomaly detection model considering new incoming data.
Assumptions	1. The system assumes that the following data is available for training the anomaly detection model: • Train Occupancy • Train Schedule 2. The availability and quality of the training data will impact the accuracy and effectiveness of the trained model. 3. The system assumes that historical data will be used as a reference for updating the anomaly detection model.
Specification	• The system should have the capability to receive new data, such as train occupancy data, for updating the anomaly detection model. • The received new data should be pre-processed and integrated with the existing historical data to create an updated dataset.

	- The system should utilize appropriate techniques and algorithms to update the anomaly detection model based on the new and historical data. - The updated anomaly detection model should take into account the patterns observed in the historical data, as well as the new data, to accurately detect anomalies. - The trained model should be regularly updated and refined to improve the accuracy of the detected anomalies.
Additional Notes	- The availability and quality of the training data will significantly impact the accuracy and effectiveness of the trained machine learning model.

7.5.25 T6.4_UC4.4_NFRQ02

Requirement ID	T6.4_UC4.4_NFRQ02
Requirement Name	Model update lifecycle for anomaly detection
Use Case ID	UC-FP6-WP6-4.04
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	The system should keep the anomaly detection model as updated as possible.
Assumptions	The system assumes that the anomaly detection model can be updated with new data.
Specification	- The system should have mechanisms in place to regularly update the anomaly detection model with new data. - The system should prioritize the speed and efficiency of updating the model to ensure timely availability of updated dataset containing anomaly labelled data.
Additional Notes	The frequency and timing of the model updates should be balanced with the availability and quality of the new data.

7.5.26 T6.4_UC4.4_NFRQ03

Requirement ID	T6.4_UC4.4_NFRQ03
Requirement Name	Performance evaluation of anomaly detection model
Use Case ID	UC-FP6-WP6-4.04
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	The anomaly detection model should achieve high accuracy, minimizing false positives and false negatives

Assumptions	The system should have mechanisms for evaluating the training process of the model, including accuracy metrics and validation.
Specification	• The system should be capable of conducting a series of accuracy metric tests (e.g., accuracy, precision) for the anomaly detection model. • The system should be capable of performing validation tests (e.g., Cross-Validation). • The system should be capable of fine-tuning the model parameters in order to improve its performance.
Additional Notes	-

7.5.27 T6.4_UC4.4_FRQ04

Requirement ID	T6.4_UC4.4_FRQ04
Requirement Name	Model training for anomaly prediction
Use Case ID	UC-FP6-WP6-4.04
Category	Functional
Priority	MUST
Main goal	The system must be able to train the anomaly prediction model using anomaly data, weather data, and public/event data
Assumptions	1. The system assumes that the following data is available for training the anomaly detection model: • Weather conditions • Public/disruptive events • Anomaly labelled data (dataset generated by the anomaly detection model) • Train Schedule • Other relevant data (optional) 2. The availability and quality of the training data will impact the accuracy and effectiveness of the trained model. 3. The system assumes that the machine learning model will be trained using appropriate algorithms and techniques to achieve the desired outputs.
Specification	• The system should be capable implementing mechanisms for data transformation (e.g., encoding) and feature engineering in order to prepare data to be used by a machine learning and/or statistical model for anomaly prediction. • The system should utilize appropriate machine learning algorithms to train the model based on the provided data.

	• The trained model should be able to analyse and accurately predict anomalies based on the provided data, including weather conditions and public/disruptive events data.
Additional Notes	The availability and quality of the training data will significantly impact the accuracy and effectiveness of the trained machine learning model.

7.5.28 T6.4_UC4.4_FRQ05

Requirement ID	T6.4_UC4.4_FRQ05
Requirement Name	Model update for anomaly prediction
Use Case ID	UC-FP6-WP6-4.04
Category	Functional
Priority	MUST
Main goal	The system must be able to process the data and update the anomaly prediction model considering new incoming data.
Assumptions	1. The system assumes that the following data is available for training the anomaly detection model: • Weather conditions • Public/disruptive events • Anomaly labelled data (dataset generated by the anomaly detection model) • Train Schedule • Other relevant data (optional) 2. The availability and quality of the training data will impact the accuracy and effectiveness of the trained model. 3. The system assumes that historical data will be used as a reference for updating the anomaly prediction model.
Specification	• The system should have the capability to receive new data, such as train weather conditions and public/disruptive event data, for updating the anomaly prediction model. • The received new data should be pre-processed and integrated with the existing historical data to create an updated dataset. • The system should utilize appropriate techniques and algorithms to update the anomaly prediction model based on the new and historical data. • The updated anomaly prediction model should take into account the patterns observed in the historical data, as well as the new data, to accurately predict anomalies. • The updated anomaly prediction model should be stored and made available for future anomaly prediction and analysis.

	• The trained model should be regularly updated and refined to improve the accuracy of the predicted anomalies.
Additional Notes	The availability and quality of the training data will significantly impact the accuracy and effectiveness of the trained machine learning model.

7.5.29 T6.4_UC4.4_FRQ06

Requirement ID	T6.4_UC4.4_FRQ06
Requirement Name	Predict new anomalies for upcoming data covering weather conditions and public/disruptive events
Use Case ID	UC-FP6-WP6-4.04
Category	Functional
Priority	MUST
Main goal	The system must be able to receive a new data covering weather conditions and public/disruptive events and apply the trained model to predict new anomalies for the specified timeframe.
Assumptions	• The system assumes that a trained model for predicting anomalies based on weather conditions, public/disruptive event data and historical data is available. • The accuracy of the trained model will impact the accuracy of the anomaly prediction for the input data. • The system assumes that the data received will provide the necessary information for predicting anomalies, such as weather conditions and public/disruptive events data.
Specification	• The system should have the capability to receive new data covering weather conditions and public/disruptive events data. • The received data should be processed and utilized by the trained model to predict the anomalies for the specified timeframe. • The system should apply the trained model to provide an accurate prediction of the anomalies in the specified timeframe. • The prediction of anomalies should consider the patterns and trends observed in the historical data used to train the model. • The system should perform a contextual analysis to provide the predicted anomalies with relevant information, including weather conditions, public/disruptive events and temporal features associated with each anomaly.

Additional Notes	- The accuracy of the anomaly prediction will depend on the availability and quality of the trained model and the data used for training.

7.5.30 T6.4_UC4.4_NFRQ04

Requirement ID	T6.4_UC4.4_NFRQ04
Requirement Name	Model update lifecycle for anomaly prediction
Use Case ID	UC-FP6-WP6-4.04
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	The system should keep the anomaly prediction model as updated as possible.
Assumptions	The system assumes that the anomaly prediction model can be updated with new data.
Specification	- The system should have mechanisms in place to regularly update the anomaly prediction model with new data. - The system should prioritize the speed and efficiency of updating the model to ensure timely availability of updated predictions.
Additional Notes	The frequency and timing of the model updates should be balanced with the availability and quality of the new data.

7.5.31 T6.4_UC4.4_NFRQ05

Requirement ID	T6.4_UC4.4_NFRQ05
Requirement Name	Performance evaluation of anomaly prediction model
Use Case ID	UC-FP6-WP6-4.04
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	The anomaly prediction model should achieve high accuracy, minimizing false positives and false negatives
Assumptions	The system should have mechanisms for evaluating the training process of the model, including accuracy metrics and validation.
Specification	- The system should be capable of conducting a series of accuracy metric tests (e.g., accuracy, precision) for the anomaly prediction model. - The system should be capable of performing validation tests (e.g., Cross-Validation). - The system should be capable of fine-tuning the model parameters in order to improve its performance.

Additional Notes	-

7.5.32 T6.4_UC4.4_FRQ07

Requirement ID	T6.4_UC4.4_FRQ07
Requirement Name	Generation of structured message with contextual information for predicted anomalies
Use Case ID	UC-FP6-WP6-4.04
Category	Functional
Priority	MUST
Main goal	The system must gather contextual information on anomaly predictions covering weather conditions, public/disruptive events, and temporal features, and generate structured messages for each predicted anomaly to be delivered to the TMS
Assumptions	• The system assumes that contextual information for predicted anomalies is available. • The system assumes that contextual information is in a format that can be easily integrated in other systems.
Specification	• The system should be capable of receiving the predicted anomalies containing the contextual information covering weather conditions, public/disruptive events, and temporal features. • The data analytics platform should be capable of compiling the contextual information and structure it in a known message delivery format (e.g., JSON). • The system should be capable of delivering the structured message to the TMS, which is expected to be received by means of a notification. • The system should be capable of integrating, if available, more contextual information like historical comparisons regarding similar conditions in order to provide context on the frequency of anomalies.
Additional Notes	-

7.5.33 T6.4_UC4.4_NFRQ06

Requirement ID	T6.4_UC4.4_NFRQ06
Requirement Name	Performance of structured message generation regarding contextual information for predicted anomalies
Use Case ID	UC-FP6-WP6-4.04
Category	Non-Functional
Priority	MUST
Main goal	The system should be able to generate structured messages for predicted anomalies within a reasonable time.
Assumptions	The system assumes that contextual information for predicted anomalies is available.
Specification	• The system should be capable of implementing mechanism to automatically generate a structured message based on the predicted anomalies, ensuring that this process is completed within a reasonable timeframe. • The system should be capable of implementing a mechanism to ensure that the contextual information for predicted anomalies is interpretable.
Additional Notes	-

7.5.34 T6.4_UC4.4_NFRQ07

Requirement ID	T6.4_UC4.4_NFRQ07
Requirement Name	Flexible design for structured message generation regarding contextual information for predicted anomalies
Use Case ID	UC-FP6-WP6-4.04
Category	Non-Functional
Priority	Nice-to-have with high priority
Main goal	The system should be designed for easy maintenance and updates, allowing for the addition of new message templates.
Assumptions	The system assumes that there is a configuration-driven design, allowing the utilization of configuration files to change/update message templates.
Specification	• The system should be capable of integrating and storing new message templates to be used for generating structured messages with contextual information regarding predicted anomalies. • The system should be capable of ensuring the interpretability of the message template.

	- The system should be capable of ensuring that the format and main structure (e.g., primary fields) of the message templates does not change throughout the different versions.
Additional Notes	-

7.6 Requirements task 6.5

7.6.1 T6.5_UC5.1_FRQ01

Requirement ID	T6.5_UC5.1_FRQ01
Requirement Name	The system must be able to fetch train data from TMS and data from weather data sources to predict schedule delays.
Use Case ID	UC-FP6-WP6-5.01
Category	Functional
Priority	MUST
Main goal	The system must be able to gather relevant data to train and to apply the trained Machine Learning Model to predict delays in Regional Train services.
Assumptions	Availability of the data sources.
Specification	The system must be able to gather data relevant to predict schedule delays: • Weather data (forecast and observed weather conditions); • Train scheduled and observed data; • Train composition data.
Additional Notes	-

7.6.2 T6.5_UC5.1_FRQ02

Requirement ID	T6.5_UC5.1_FRQ02
Requirement Name	The system may be able to fetch forecasted occupancy data to improve predictions in schedule delays.
Use Case ID	T6.5_UC5.1_FRQ02
Category	Functional
Priority	Nice-to-have with high priority
Main goal	The system may be able to gather additional data to improve the training of the Machine Learning Model to predict delays in Regional Train services.
Assumptions	Availability of the additional data source.
Specification	The system may be able to gather additional data relevant to predict schedule delays: • Forecasted occupancy data.
Additional Notes	-

7.6.3 T6.5_UC5.1_PRQ01

Requirement ID	T6.5_UC5.1_PRQ01
Requirement Name	The system must be able to process the collected data within a reasonable time.

Use Case ID	UC-FP6-WP6-5.01
Category	Performance
Priority	MUST
Main goal	The processing time must be kept minimal for the output (predicted delays) of this module to be relevant and used by the TSP.
Assumptions	Reasonable processing hardware available.
Specification	The implementation of this processing module must be performed in an efficient manner, optimizing resource utilization, and minimizing processing time. A reasonable time frame for processing the collected data is less than an hour.
Additional Notes	The time measurements start with the collection of data and ends when the output is available.

7.6.4 T6.5_UC5.1_FRQ03

Requirement ID	T6.5_UC5.1_FRQ03
Requirement Name	The system must be able to train a Machine Learning model using weather data, train schedule data and, optionally, forecasted occupancy data.
Use Case ID	UC-FP6-WP6-5.01
Category	Functional
Priority	MUST
Main goal	To predict delays, a ML model will be applied to the newly collected data. This ML model must be trained using relevant data.
Assumptions	The relevant data is available.
Specification	• The received data should be processed and transformed into a suitable format for training the model • The system should utilize appropriate machine learning algorithms and techniques to train the model based on the provided data • The trained model should be able to analyse and make accurate predictions based on training data
Additional Notes	-

7.6.5 T6.5_UC5.1_FRQ04

Requirement ID	T6.5_UC5.1_FRQ04
Requirement Name	The system must be able to retrain the machine learning model with newly collected observed data.
Use Case ID	UC-FP6-WP6-5.01
Category	Functional
Priority	MUST
Main goal	The output quality (predicted delays) may be improved with new data. New data will continuously be provided to update the ML model.

Assumptions	Newly collected observed data and previously collected is available.
Specification	• The system should have the capability to receive weather, train composition, planned schedule and observed schedule data, for updating the occupancy model. • The system should utilize appropriate techniques and algorithms to update the occupancy model based on the new and historical data. • The updated occupancy model should take into account the patterns and trends observed in the historical data, as well as the new data, to provide accurate predictions. • The updated delay prediction model should overwrite old models and be made available for future delay forecasting and analysis.
Additional Notes	-

7.6.6 T6.5_UC5.1_FRQ05

Requirement ID	T6.5_UC5.1_FRQ05
Requirement Name	The system must be able to apply the trained model to predict delays.
Use Case ID	UC-FP6-WP6-5.01
Category	Functional
Priority	MUST
Main goal	The system must be able to apply the trained model to collected data in order to predict delays.
Assumptions	The system must have a trained ML model and new relevant data.
Specification	• The received request should be processed and utilized by the trained model to predict delays
Additional Notes	-

7.6.7 T6.5_UC5.1_FRQ06

Requirement ID	T6.5_UC5.1_FRQ06
Requirement Name	The system must be able to store the predicted delays.
Use Case ID	UC-FP6-WP6-5.01
Category	Functional
Priority	MUST
Main goal	The system must have the capability to store predicted delays so that this information can be accessed later.
Assumptions	The system must have enough storage capacity to store the predicted delays for a year.
Specification	A continuous storage mechanism must be implemented in order to store the predicted delays.
Additional Notes	Increasing the storage capacity for a longer period may improve the output accuracy of the system.

7.6.8 T6.5_UC5.1_FRQ07

Requirement ID	T6.5_UC5.1_FRQ07
Requirement Name	The system must provide a specific interface for the predicted delays to be fetched.
Use Case ID	UC-FP6-WP6-5.01
Category	Functional
Priority	MUST
Main goal	The main goal of UC-FP6-WP6-5.01 is to empower the TSP with improved information about the operation. The TSP must be able to collect the latest predicted delays.
Assumptions	Predicted delays must have been stored and available to be accessed.
Specification	An external authenticated interface must be implemented to facilitate access to the output of this module. The external authenticated interface provides TSPs access to the delay predictions
Additional Notes	-

7.6.9 T6.5_UC5.1_NFRQ01

Requirement ID	T6.5_UC5.1_NFRQ01
Requirement Name	The system should keep the delay prediction model as updated as possible.
Use Case ID	UC-FP6-WP6-5.01
Category	Non- Functional
Priority	Nice-to-have with high priority
Main goal	The system should retrain the delay prediction model with the most recent data available periodically. This period should be kept minimal in order to provide the best predictions possible.
Assumptions	The system must have a trained ML model and new relevant data.
Specification	When sufficient amount of new data is available the model should be retrained The performance of the updated model is tested and compared to performance of the previous model After retraining the model, it is applied as the new default model if its performance exceeds the one from the old model
Additional Notes	-

7.6.10 T6.5_UC5.2_FRQ01

Requirement ID	T6.5_UC5.2_FRQ01
Requirement Name	The system must be able to collect relevant data from Train's TMS and Bus Services.
Use Case ID	UC-FP6-WP6-5.02
Category	Functional

Priority	MUST
Main goal	The system must be able to collect relevant data to perform the identification of possible synchronization issues between timetables.
Assumptions	Availability of the data sources.
Specification	The system must be able to gather timetable data for: • Train services; • Bus services.
Additional Notes	The focus of this requirement lies in the identification of mismatches in timetables, dependencies in between stations for travel routes will not be considered.

7.6.11 T6.5_UC5.2_PRQ01

Requirement ID	T6.5_UC5.2_PRQ01
Requirement Name	The system must be able to process the collected data in a reasonable time.
Use Case ID	UC-FP6-WP6-5.02
Category	Non- Functional
Priority	MUST
Main goal	The processing time must be kept minimal for the output of this module to be relevant and used by the TMS. The output should be available within an hour of receiving new input data.
Assumptions	Reasonable processing hardware available.
Specification	The implementation of this processing module must be performed in an efficient manner, optimizing resource utilization, and minimizing processing time.
Additional Notes	The measured process starts with the receival of new data and ends when the output is available.

7.6.12 T6.5_UC5.2_FRQ02

Requirement ID	T6.5_UC5.2_FRQ02
Requirement Name	The system must be able to analyse the collected data and identify possible synchronization issues automatically.
Use Case ID	UC-FP6-WP6-5.02
Category	Functional
Priority	MUST
Main goal	The collected data must be analysed and processed so that synchronization issues can be identified.
Assumptions	The relevant data must have been collected.
Specification	The analysis is triggered by the arrival of new timetables The results of the analysis will be the identified timeframes where potential synchronization improvements can be made
Additional Notes	-

7.6.13 T6.5_UC5.2_FRQ03

Requirement ID	T6.5_UC5.2_FRQ03
Requirement Name	The system must be able to store the possible synchronization issues.
Use Case ID	UC-FP6-WP6-5.02
Category	Functional
Priority	MUST
Main goal	The system must have the capability to store the output so that this information can be accessed later.
Assumptions	The system must have enough storage capacity to store the output.
Specification	A continuous storage mechanism must be implemented in order to store the output.
Additional Notes	The data should be stored for at least 2-years to have two full annual cycles.

7.6.14 T6.5_UC5.2_FRQ04

Requirement ID	T6.5_UC5.2_FRQ04
Requirement Name	The system must be able to keep the identified synchronization issues available to be manually collected by the TMS.
Use Case ID	UC-FP6-WP6-5.02
Category	Functional
Priority	MUST
Main goal	The main goal of UC-FP6-WP6-5.02 is to empower the TMS with improved information about the operation. The TMS must be able to collect the identified synchronization issues.
Assumptions	The identified synchronization issues must have been stored and must be available to be accessed.
Specification	An external interface must be implemented to facilitate access to the output of this module.
Additional Notes	-

7.6.15 T6.5_UC5.2_PRQ02

Requirement ID	T6.5_UC5.2_PRQ02
Requirement Name	The system should be able to identify possible synchronization issues in reasonable time.
Use Case ID	UC-FP6-WP6-5.02
Category	Non- Functional
Priority	Nice-to-have with high priority
Main goal	The system should be able to identify possible synchronization issues in under an hour, to be relevant and used by the TMS.
Assumptions	Reasonable processing hardware available and relevant data available.

Specification	The processing time must be kept minimal for the output of this module to be relevant and used by the TMS.
Additional Notes	-

7.6.16 T6.5_UC5.3_FRQ01

Requirement ID	T6.5_UC5.3_FRQ01
Requirement Name	The system must be able to collect traveller feedback.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional
Priority	MUST
Main goal	The system must be able to collect traveller feedback so that it can be analysed and processed.
Assumptions	An interface with the traveller must exist and able to receive the traveller feedback.
Specification	A WebApp must be implemented to collect traveller feedback.
Additional Notes	-

7.6.17 T6.5_UC5.3_FRQ02

Requirement ID	T6.5_UC5.3_FRQ02
Requirement Name	The Traveller must be able to send feedback via the WebApp at any time.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional
Priority	MUST
Main goal	The Traveller must be able to send feedback at any time in order to improve Traveller engagement and confidence on the interface.
Assumptions	The WebApp must be available to collect Traveller feedback.
Specification	The WebApp is available via the most popular browsers at any point in time Unplanned downtimes should be minimized
Additional Notes	-

7.6.18 T6.5_UC5.3_FRQ03

Requirement ID	T6.5_UC5.3_FRQ03
Requirement Name	The system must have an interface for the TSP.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional
Priority	MUST
Main goal	The Reporting Backoffice provides an interface for the TSP to interact with the system.
Assumptions	The interface must be available. The TSP must be previously registered.

Specification	The Reporting Backoffice allows the TSP to visualize the reporting output and to request feedback from travellers based on a defined region.
Additional Notes	

7.6.19 T6.5_UC5.3_FRQ04

Requirement ID	T6.5_UC5.3_FRQ04
Requirement Name	The system should be able to request feedback from Travellers.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional
Priority	MUST
Main goal	The TSP should be able to request Traveller feedback in order to have a more complete knowledge of the network status.
Assumptions	Reporting Backoffice must be available and the WebApp must be able to receive the Traveller feedback. The Traveller must allow web browser notifications and location sharing for the WebApp, in order to receive notifications.
Specification	The TSP will have an interface (Reporting Backoffice) to notify users. The Reporting Backoffice enables the TSP to define regions in a map. All users within that region will receive the notification in the WebApp for user feedback.
Additional Notes	

7.6.20 T6.5_UC5.3_NFRQ01

Requirement ID	T6.5_UC5.3_NFRQ01
Requirement Name	The WebApp should be user-friendly and intuitive.
Use Case ID	UC-FP6-WP6-5.03
Category	Non- Functional
Priority	MUST
Main goal	To ensure that users can easily understand the interface and provide meaningful feedback.
Assumptions	The WebApp must be available to collect traveller feedback.
Specification	The WebApp adapts itself to the screen size of the device on which the WebApp is opened The WebApp is designed with an intuitive UI
Additional Notes	-

7.6.21 T6.5_UC5.3_NFRQ02

Requirement ID	T6.5_UC5.3_NFRQ02
Requirement Name	The WebApp should be compatible with most mobile devices.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional

Priority	MUST
Main goal	To guarantee the highest possible feedback rate, the WebApp must be compatible with most mobile devices.
Assumptions	The WebApp must be available to collect Traveller feedback.
Specification	A WebApp must be implemented to minimize the obstacle of reaching Travellers due to a wide range of mobile Operative Systems.
Additional Notes	-

7.6.22 T6.5_UC5.3_NFRQ03

Requirement ID	T6.5_UC5.3_NFRQ03
Requirement Name	The collected Traveller feedback scope should focus on (trains and/or station) congestion.
Use Case ID	UC-FP6-WP6-5.03
Category	Non- Functional
Priority	Nice-to-have with high priority
Main goal	To guarantee the highest possible feedback rate, the scope of the interface should be focused on congestion.
Assumptions	The WebApp must be available to collect Traveller feedback.
Specification	Travellers will provide information in a stepwise form. Questions will be about the number of persons in trains and on stations e.g., “Are there many seats available?”, “Are passengers standing?”, etc.
Additional Notes	-

7.6.23 T6.5_UC5.3_FRQ05

Requirement ID	T6.5_UC5.3_FRQ05
Requirement Name	The system must be able to store, analyse and process the collected Traveller feedback.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional
Priority	MUST
Main goal	To improve the knowledge about the network status, the collected traveller feedback must be analysed and processed based to specific parameters. Aggregating feedback from multiple travellers increases confidence in the resulting information.
Assumptions	The traveller feedback must have been collected.
Specification	Specific parameters can be time, location, date, user history, etc. The reliability of an aggregated feedback will increase with the number of travellers reporting the same feedback. A single feedback will still be a valuable information.
Additional Notes	-

7.6.24 T6.5_UC5.3_FRQ06

Requirement ID	T6.5_UC5.3_FRQ06
Requirement Name	The system must be able to store processed traveller feedback information.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional
Priority	MUST
Main goal	The system must have the capability to store the output so that this information can be accessed later.
Assumptions	The system must have enough storage capacity to store the output.
Specification	A continuous storage mechanism must be implemented in order to store the output.
Additional Notes	-

7.6.25 T6.5_UC5.3_FRQ07

Requirement ID	T6.5_UC5.3_FRQ07
Requirement Name	The Reporting Backoffice must provide an interface to facilitate access to the output for TSP.
Use Case ID	UC-FP6-WP6-5.03
Category	Functional
Priority	MUST
Main goal	The main goal of UC-FP6-WP6-5.03 is to empower the TSP with a more complete knowledge about the network status. The TSP must be able to collect the processed traveller feedback information.
Assumptions	The processed information must have been stored and available to be accessed.
Specification	An external interface must be implemented to facilitate access to the output of this module. Each TSP will only have access to the information for the area/stations they operate. The TSP will have access to the conducted feedback reporting analysis.
Additional Notes	-

7.6.26 T6.5_UC5.3_NFRQ04

Requirement ID	T6.5_UC5.3_NFRQ04
Requirement Name	The system should keep the processed congestion information as updated as possible.
Use Case ID	UC-FP6-WP6-5.03
Category	Non- Functional
Priority	Nice-to-have with high priority

Main goal	The system should keep the processed congestion information as updated as possible. The processed congestion information should be processed within thirty minutes of receiving new traveller feedback data.
Assumptions	Traveller feedback was collected.
Specification	The system should process the received traveller feedback as it is collected.
Additional Notes	-

7.6.27 T6.5_UC5.4_FRQ01

Requirement ID	T6.5_UC5.4_ FRQ01
Requirement Name	The system must be able to collect demand data.
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	MUST
Main goal	The system must be able to collect real-time or modelled passenger flow data in a database to store it and make it available for the analysis.
Assumptions	Availability of demand data.
Specification	The system must be able to collect the data from the identified sources and store it in a database.
Additional Notes	-

7.6.28 T6.5_UC5.4_FRQ02

Requirement ID	T6.5_UC5.4_ FRQ02
Requirement Name	The system must be able to collect timetable data.
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	MUST
Main goal	The system must be able to collect data of a timetable scenario in a database to store it and make it available for the analysis.
Assumptions	Availability of timetable data.
Specification	The system must be able to collect the timetable and train platforming data from our internal sources and store it in a database.
Additional Notes	-

7.6.29 T6.5_UC5.4_FRQ03

Requirement ID	T6.5_UC5.4_ FRQ03
Requirement Name	The system should be able to consider train punctuality.
Use Case ID	UC-FP6-WP6-5.04

Category	Functional
Priority	Nice-to-have with high priority
Main goal	The system should be able to consider train punctuality in the analysed station, store it in a database and make it available for the analysis.
Assumptions	Availability of train punctuality data.
Specification	The system should be able to consider train punctuality in the analysed station in order to conduct the most fitting analysis.
Additional Notes	-

7.6.30 T6.5_UC5.4_FRQ04

Requirement ID	T6.5_UC5.4_ FRQ04
Requirement Name	The system must be able to consider the station geometry and the platform configuration.
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	MUST
Main goal	The system must be able to consider the station geometry and the platform configuration, store it in a database and make it available for the analysis.
Assumptions	Availability of infrastructure data.
Specification	The system must be able to consider the station geometry and the platform configuration in the analysed station in order to conduct the most fitting analysis.
Additional Notes	-

7.6.31 T6.5_UC5.4_NFRQ01

Requirement ID	T6.5_UC5.4_ NFRQ01
Requirement Name	The system should be able to perform on different scenarios considering adapted input data updates, which are provided by railway undertakings
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	Nice-to-have with high priority
Main goal	The system should be able to simulate different scenarios and conduct gap analysis.
Assumptions	Generation of different scenarios or data update request are possible.
Specification	The system should be able to take into account time-sensitive data updates or different configuration scenarios.
Additional Notes	-

7.6.32 T6.5_UC5.4_FRQ05

Requirement ID	T6.5_UC5.4_ FRQ05
Requirement Name	The system must be able to analyse and process the collected demand data.
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	MUST
Main goal	The system must be able to analyse and process the collected passenger flow data from the database and use it for the analysis.
Assumptions	Collected and stored demand data.
Specification	The system must be able to analyse and process the collected passenger flow data from the database and use it for the optimization first, then for the performance analysis.
Additional Notes	-

7.6.33 T6.5_UC5.4_FRQ06

Requirement ID	T6.5_UC5.4_ FRQ06
Requirement Name	The system must be able to analyse and process the timetable data.
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	MUST
Main goal	The system must be able to analyse and process the collected timetable data from the database and use it for the analysis.
Assumptions	Collected and stored timetable data.
Specification	The system must be able to analyse and process the collected timetable data from the database and use it for the optimization first, then for the performance analysis.
Additional Notes	-

7.6.34 T6.5_UC5.4_FRQ07

Requirement ID	T6.5_UC5.4_ FRQ07
Requirement Name	The system must be able to optimize the allocation of trains to platforms to allow maximum connection time for passengers
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	MUST
Main goal	Train platform allocation is optimized for maximizing the connection time for passengers
Assumptions	Relevant data is available
Specification	The system must be able to process the input data, run the optimization algorithm and

	provide the best platform configuration as result
Additional Notes	-

7.6.35 T6.5_UC5.4_FRQ08

Requirement ID	T6.5_UC5.4_ FRQ08
Requirement Name	The system must be able to evaluate congestion of passenger based on the optimized platform configuration.
Use Case ID	UC-FP6-WP6-5.04
Category	Functional
Priority	MUST
Main goal	The system must be able to evaluate congestion of passengers according to optimized platform configuration
Assumptions	Collected and stored timetable data, demand and infrastructure data are available
Specification	The system must be able to evaluate congestion of passengers according to optimized platform configuration by visualization and performance measurement tools.
Additional Notes	-

7.6.36 T6.5_UC5.4_NFRQ02

Requirement ID	T6.5_UC5.4_ NFRQ02
Requirement Name	The system should be able to rerun the process upon every change of the scenario or input data.
Use Case ID	UC-FP6-WP6-5.04
Category	Non- Functional
Priority	Nice-to-have with high priority
Main goal	The system should be able to efficiently rerun the process upon every update to obtain an optimized configuration every time.
Assumptions	The scenario or input data is changed.
Specification	The system should be able to efficiently rerun the process upon every update, in an automated way.
Additional Notes	-

7.7 Requirements task 6.6

7.7.1 T6.6_UC6.1_FRQ01

Requirement ID	T6.6_UC6.1_FRQ01
Requirement Name	A flag in timetable data must indicate if a train service can transport parcels or not
Use Case ID	UC-FP6-WP6-6.1
Category	Functional
Priority	MUST
Main goal	The system must know which passenger train services can transport parcels so that trip options can be calculated that allow the shipment of parcels.
Assumptions	Static timetable data are available. It is known which trains/train services can transport parcels (or parcel lockers or swap bodies).
Specification	The static timetable data are extended by a flag for those services that can transport parcel(s).
Additional Notes	-

7.7.2 T6.6_UC6.1_FRQ02

Requirement ID	T6.6_UC6.1_FRQ02
Requirement Name	Option in frontend to search for trips for parcel(s)
Use Case ID	UC-FP6-WP6-6.1
Category	Functional
Priority	MUST
Main goal	The frontend of the journey planning application must enable the user to select the option that a trip search is done for a parcel or a container of parcels.
Assumptions	-
Specification	The journey planning application offers a dedicated cluster for suggested parcel trips in the overview of trip options. The cluster button can be clicked by the user to trigger a trip search for a parcel.
Additional Notes	-

7.7.3 T6.6_UC6.1_FRQ03

Requirement ID	T6.6_UC6.1_FRQ03
Requirement Name	Computation of trips that permit the transport of parcels
Use Case ID	UC-FP6-WP6-6.6
Category	Functional
Priority	MUST
Main goal	The journey planning application can offer trip options for the transport of a parcel.
Assumptions	Static timetable data have been extended by a flag indicating whether a train can transport parcels or not.

Specification	The journey planning application must be able to compute trip options between stations which are connected by a service without transfer that facilitates the transport of parcels. In addition, a first and last mile walk shall be calculated if addresses were chosen as start location and destination location, respectively, for the trip request.
Additional Notes	-

7.7.4 T6.6_UC6.1_FRQ04

Requirement ID	T6.6_UC6.1_FRQ04
Requirement Name	Display of prices for the transport of a parcel
Use Case ID	UC-FP6-WP6-6.1
Category	Functional
Priority	Nice-to-have with high priority
Main goal	The user shall be informed about prices for a parcel shipment by a passenger train.
Assumptions	The parcel is transported within a region, i.e. within a country and not across a border. The prices depend only on the size and the weight of the parcel but not on the distance between origin and destination.
Specification	The journey planning application provides for a trip option for a parcel shipment a list of prices. The list comprises prices for parcels of different size and weight and will be available in the trip details view.
Additional Notes	-

7.7.5 T6.6_UC6.1_NFRQ01

Requirement ID	T6.6_UC6.1_NFRQ01
Requirement Name	Performance requirement
Use Case ID	UC-FP6-WP6-6.1
Category	Performance
Priority	Nice-to-have with high priority
Main goal	Trip options for parcels between stations shall be computed in an acceptable amount of time which is not significantly larger than the time needed for a similar trip search for a traveller.
Assumptions	-
Specification	The journey planning application takes at most 150% of the time that is needed for calculating a comparable trip for a traveller.
Additional Notes	A comparable trip for a traveller would be a trip from a station to another station. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

7.7.6 T6.6_UC6.2_FRQ01

Requirement ID	T6.6_UC6.2_FRQ01
Requirement Name	Capacity of trains for transporting containers with parcels must be modelled in the timetable data
Use Case ID	UC-FP6-WP6-6.2

Category	Functional
Priority	MUST
Main goal	The service for planning parcel transport must consider the capacity of a train for transporting containers of parcels.
Assumptions	If a regional train travels from a rural area to a city centre (or in the opposite direction) and has x intermediate stops with containers with parcels to be loaded but only storage place for y containers with parcels with y < x, the timetable must foresee which train can load/unload a container at which station.
Specification	The timetable data must specify for each train service that can transport parcels at which stop(s) a container can be loaded and at which stop(s) a container can be unloaded if the capacity of the train is not sufficient to load/unload a container at each stop.
Additional Notes	The modelling in the timetable data could be done by prohibiting boarding/alighting for containers at specific stops.

7.7.7 T6.6_UC6.2_FRQ02

Requirement ID	T6.6_UC6.2_FRQ02
Requirement Name	The time needed for sorting of parcels and consolidating of shipments at hubs, i.e., at bigger stations where containers “transfer” from one train to another, must be reflected in the timetable data.
Use Case ID	UC-FP6-WP6-6.2
Category	Functional
Priority	MUST
Main goal	The system must provide a realistic duration for trips.
Assumptions	Parcels in a container that is loaded at a rural station are sent to different destinations (different cities, different regions). At bigger stations where unloading of containers and a transfer to other trains is possible, time is needed for sorting and consolidating parcels so that the parcels in a container loaded into a train head in the right direction.
Specification	The journey planning application must foresee sufficient time for transfers of containers with parcels (at hub stations).
Additional Notes	The modelling in the timetable data could be done by sufficiently large transfer times.

7.7.8 T6.6_UC6.2_FRQ03

Requirement ID	T6.6_UC6.2_FRQ03
Requirement Name	Containers that were loaded not at hubs but at normal stations must always be unloaded at a hub.
Use Case ID	UC-FP6-WP6-6.2
Category	Functional
Priority	MUST
Main goal	Parcels shall reach their destination and container that were loaded at a normal station and hence contain parcels with different destination

	must not be unloaded at another normal station but only at a hub.
Assumptions	-
Specification	The timetable data must ensure that containers which were loaded at a normal station must be unloaded at a hub. This is especially relevant for train services between hubs that also serve normal stations as intermediate stops.
Additional Notes	It is easy to model this requirement for services that run between a regional/rural station (normal station) and a city centre (hub station) in both directions: A train service to the city centre is only allowed to load containers and another service in opposite direction is only allowed to unload containers. But for train services between hubs that serve also normal stations in between, this is more difficult to model. The modelling in the timetable data could be done by sections in which loading and unloading is possible in general but not both for the same container.

7.7.9 T6.6_UC6.2_FRQ04

Requirement ID	T6.6_UC6.2_FRQ04
Requirement Name	Computation of trips for parcels from address to address via parcel lockers including walk/car legs for first/last mile.
Use Case ID	UC-FP6-WP6-6.2
Category	Functional
Priority	MUST
Main goal	The journey planning application must calculate trips for parcels including (1) a first mile leg from the start address to a parcel locker at a station, (2) transfers and (3) a last mile leg from a parcel locker to the destination address so that a user can check how fast a parcel can be send in passenger trains from address to address.
Assumptions	-
Specification	When requested for address-to-address trip options for a parcel, the journey planning application must calculate trip options considering • the flag that indicates whether a train service transports containers with parcels or not, • the capacity of trains for containers (modelled by entry/exit bans) • the transfer times for container/parcels at hubs, • the sections between hubs where loading and unloading is not allowed for the same container.
Additional Notes	-

7.7.10 T6.6_UC6.2_NFRQ01

Requirement ID	T6.6_UC6.2_NFRQ01
Requirement Name	Performance requirement
Use Case ID	UC-FP6-WP6-6.2

Category	Performance
Priority	Nice-to-have with high priority
Main goal	Trip options for parcels between addresses sent via parcel lockers shall be computed in an acceptable amount of time which is not significantly larger than the time needed for a similar trip search for a traveller.
Assumptions	-
Specification	The journey planning application takes at most 150% of the time that is needed for calculating a comparable trip for a traveller.
Additional Notes	A comparable trip for a traveller would be a trip from an address to another address. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

7.7.11 T6.6_UC6.3_FRQ01

Requirement ID	T6.6_UC6.3_FRQ01
Requirement Name	Extended options in frontend to search for trips for parcel(s)
Use Case ID	UC-FP6-WP6-6.3
Category	Functional
Priority	MUST
Main goal	The frontend of the journey planning application must enable the user to additionally input the type and the number of swap bodies or mobile parcel lockers that shall be transported.
Assumptions	-
Specification	When defining a trip search request for parcels in the frontend, the user from a CEP company can select from different types of swap bodies/mobile parcel lockers and input the number of swap bodies/mobile parcel lockers that shall be transported.
Additional Notes	-

7.7.12 T6.6_UC6.3_FRQ02

Requirement ID	T6.6_UC6.3_FRQ02
Requirement Name	Detailed and up-to-date information about capacity offer in trains
Use Case ID	UC-FP6-WP6-6.3
Category	Functional
Priority	MUST
Main goal	The trip options that are calculated for requests from CEP companies shall consider the available capacity for swap bodies/mobile parcel lockers, i.e., previous bookings that reduce the remaining capacity must be considered.
Assumptions	It is assumed that data about the available capacity for swap bodies/mobile parcel lockers is available

Specification	The PIS backend must be equipped with up-to-date data about the remaining capacity in all trains and for all sections of a service, i.e., the capacity information must be available for each partial trip between subsequent stops. From the data about remaining capacity the PIS backend must be able to derive the remaining capacity for the different types of swap bodies and mobile parcel lockers.
Additional Notes	-

7.7.13 T6.6_UC6.3_FRQ03

Requirement ID	T6.6_UC6.3_FRQ03
Requirement Name	Computation of trips for swap bodies/mobile parcel lockers considering capacity constraints
Use Case ID	UC-FP6-WP6-6.2
Category	Functional
Priority	MUST
Main goal	The journey planning application must calculate trips for swap bodies/mobile parcel lockers that are feasible regarding capacity constraints for each leg of the trip.
Assumptions	It is assumed that data about the available capacity for swap bodies/mobile parcel lockers is available.
Specification	Given the type and number of swap bodies/mobile parcel lockers defined for a trip request by a CEP company, the journey planning application must consider the remaining capacity in all trains associated with a computed trip option and ensure that only trip options are returned that have sufficient capacity left on all legs.
Additional Notes	-

7.7.14 T6.6_UC6.3_NFRQ01

Requirement ID	T6.6_UC6.3_NFRQ01
Requirement Name	Performance requirement
Use Case ID	UC-FP6-WP6-6.3
Category	Performance
Priority	Nice-to-have with high priority
Main goal	Trip options for parcels sent by CEP companies via swap bodies/mobile parcel lockers shall be computed in an acceptable amount of time which is not significantly larger than the time needed for a similar trip search for a traveller.
Assumptions	-
Specification	The journey planning application takes at most 150% of the time that is needed for calculating a comparable trip for a traveller.
Additional Notes	A comparable trip for a traveller would be a trip from a station to another station. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

7.8 Requirements task 6.8

7.8.1 T6.8_UC8.1_FRQ01

Requirement ID	T6.8_UC8.1_FRQ01
Requirement Name	Business intelligence analysis for operational insights
Use Case ID	UC-FP6-WP6-8.1, UC-FP6-WP6-8.2
Category	Functional
Priority	MUST
Main goal	The BIA can generate bespoke reports using the analytics platform to provide insights to other departments
Assumptions	An analytics platform is provided with the software
Specification	The analytics platform allows to generate bespoke reports via drag and drop functionality, accessing data from sources and visualising results
Additional Notes	-

7.8.2 T6.8_UC8.2_FRQ01

Requirement ID	T6.8_UC8.2_FRQ01
Requirement Name	Demand based adjustment to train schedules
Use Case ID	UC-FP6-WP6-8.2
Category	Functional
Priority	MUST
Main goal	From the additional information available on a multimodal travel platform, demand forecasts are improved allowing traffic managers to adjust timetables accordingly.
Assumptions	The analytics platform provided can derive demand for trains and journey legs
Specification	Traffic managers approach BIAs for demand forecasts on trains and line sections. Based on these demand forecasts the traffic manager adjusts timetables
Additional Notes	-

7.8.3 T6.8_UC8.3_FRQ01

Requirement ID	T6.8_UC8.3_FRQ01
Requirement Name	Service feedback from customers
Use Case ID	UC-FP6-WP6-8.3
Category	Functional
Priority	High
Main goal	To guarantee the quality of service on the train, the train operation manager relies on customer feedback. Customer feedback shall be

	available as report.
Assumptions	Feedback can be provided by customers via the solution
Specification	The train operation manager approaches the BIA to set up a recurring report with customer feedback for their lines The BIA can use a designated analytics tool in the backend of the system to realize this request
Additional Notes	-

7.8.4 T6.8_UC8.3_NFRQ01

Requirement ID	T6.8_UC8.3_NFRQ01
Requirement Name	Availability of service feedback data from customers
Use Case ID	UC-FP6-WP6-8.3
Category	Functional
Priority	High
Main goal	The received customer feedback data should be made available to the backend analytics tool
Assumptions	Feedback can be provided by customers via the solution
Specification	Customer feedback data is stored in a database on which the backend analytics tool has access Thus, the BIA can use this data for visualization in requested dashboards
Additional Notes	-

7.8.5 T6.8_UC8.4_DTRQ01

Requirement ID	T6.8_UC8.4_DTRQ01
Requirement Name	Documentation of software configurations, procedures, and changes
Use Case ID	UC-FP6-WP6-8.4
Category	Documentation and training requirements
Priority	MUST
Main goal	To provide reference to new team members, the administrator provides and maintains a documentation on configurations, procedures, and changes
Assumptions	-
Specification	The initial software configuration and procedures must be documented. Whenever a change occurs, it is tracked in the documentation
Additional Notes	-

7.8.6 T6.8_UC8.5_ORQ01

Requirement ID	T6.8_UC8.5_ORQ01
Requirement Name	Data backup
Use Case ID	UC-FP6-WP6-8.5
Category	Operational
Priority	MUST
Main goal	To prevent data loss, data needs to be backed up

Assumptions	-
Specification	The administrator backs up data according to their company's data retention policy, depending also on the type of data
Additional Notes	-

7.8.7 T6.8_UC8.6_ORQ01

Requirement ID	T6.8_UC8.6_ORQ01
Requirement Name	Retrieval from backup
Use Case ID	UC-FP6-WP6-8.6
Category	Operational
Priority	MUST
Main goal	Ensuring that backed up data is retrievable, so that the system can be restored to the state of the most recent backup
Assumptions	Data was backed up
Specification	There must be a data retrieval method in place which enables the restoring of the system to the state of the most recent backup in case the system fails and data is lost due to this system fail.
Additional Notes	Regulation No. 782/2021 on rail passengers' rights and obligations should be taken in consideration

7.8.8 T6.8_UC8.7_RCRQ01

Requirement ID	T6.8_UC8.7_RCRQ01
Requirement Name	Logging, Auditing and Compliance
Use Case ID	UC-FP6-WP6-8.7
Category	Regulatory and Compliance requirements
Priority	MUST
Main goal	Critical information and behaviour must be logged and can be audited when necessary
Assumptions	-
Specification	To guarantee compliance with standards, rules and laws, the system needs to log critical information and behaviour
Additional Notes	Regulation No. 782/2021 on rail passengers' rights and obligations should be taken in consideration

7.8.9 T6.8_UC8.8_FRQ01

Requirement ID	T6.8_UC8.8_FRQ01
Requirement Name	Cross-border journey planning
Use Case ID	UC-FP6-WP6-8.8
Category	Functional
Priority	MUST
Main goal	Provision of a feasible route for given starting and end point, regardless of country borders
Assumptions	The border is between two states cooperating on mobility services
Specification	On-demand and train services are considered for route planning regardless of origin, considering only the service area
Additional Notes	-

7.8.10 T6.8_UC8.9_PRQ01

Requirement ID	T6.8_UC8.9_PRQ01
Requirement Name	Performance requirements and concurrency
Related Use Case ID	UC-FP6-WP6-8.9
Category	Performance
Priority	MUST
Main goal	End users need to be able to use the software concurrently and without noticeable reduction in user experience during peaks
Assumptions	-
Specification	The system architecture is chosen so that multiple end users (depending on region/country/size) can query trips concurrently
Additional Notes	-

7.8.11 T6.8_UC8.10_PRQ01

Requirement ID	T6.8_UC8.10_PRQ01
Requirement Name	Software availability
Related Use Case ID	UC-FP6-WP6-8.10
Category	Performance
Priority	MUST
Main goal	To ensure that the system meets the level of availability required for use in operations
Assumptions	-
Specification	The system needs to achieve an availability rate of 99,9% where planned maintenance downtimes are not included
Additional Notes	A year comprises 8760 hours. The system would thus have to be available 8751 hours for 99,9% availability. This allows for 31536 secs or 8,76 hrs downtime. Assuming downtime of 15 seconds a total of 2.102 instances per year would be possible.

7.8.12 T6.8_UC8.11_PRQ01

Requirement ID	T6.8_UC8.11_PRQ01
Requirement Name	Redundancy
Related Use Case ID	UC-FP6-WP6-8.11
Category	Performance
Priority	Nice-to-have with high priority
Main goal	To ensure that operations are not interrupted by system failure.
Assumptions	-
Specification	The system must be set-up in a redundant architecture.
Additional Notes	Covered by UC-FP6-WP6-8.10

7.8.13 T6.8_UC8.12_FRQ01, T6.8_UC8.13_FRQ01

Requirement ID	T6.8_UC8.12_FRQ01, T6.8_UC8.13_FRQ01
Requirement Name	Creation of dashboard for low code data visualisation
Use Case ID	UC-FP6-WP6-8.12, UC-FP6-WP6-8.13
Category	Functional

Priority	MUST
Main goal	As a functionality for data visualisation within the analytics tool, the creation of customizable dashboards shall be possible, so that BIAs are able to derive business insights from data and provide a low code interface to managers for reports.
Assumptions	A dashboard function is integrated within the backend of the system; the data in question (e.g., demand, service acceptance, etc.) is available to the analytics tool
Specification	The dashboard shall be customizable by the BIA, so that it meets the demands of the requested business insights from users (e.g., marketing manager, network planner, etc.).
Additional Notes	-

7.8.14 T6.8_UC8.12_FRQ02, T6.8_UC8.13_FRQ02

Requirement ID	T6.8_UC8.12_FRQ02, T6.8_UC8.13_FRQ02
Requirement Name	Visualisation of business insights via dashboards
Use Case ID	UC-FP6-WP6-8.12, UC-FP6-WP6-8.13
Category	Functional
Priority	MUST
Main goal	Dashboards shall be available as a low code functionality for data visualisation within the analytics tool, so that BIAs are able to provide business insights from a range of visualisations to users (e.g., marketing manager, network planner, etc.). For these users it shall only be necessary to choose the data, time period and graph type for the data to be visualised.
Assumptions	Within the analytics tool a dashboard function is integrated within the backend of the system; the data in question (e.g., demand, service acceptance, etc.) is available to the analytics tool
Specification	The dashboard function shall not require any or only minimal coding skills. The dashboards need an interface on which the user can choose the visualisation type and access to data which shall be visualised.
Additional Notes	Settings regarding formatting, colouring, which data is displayed on what axis and so on could be a valuable extension of dashboards.

7.8.15 T6.8_UC8.14_FRQ01, T6.8_UC8.15_FRQ01

Requirement ID	T6.8_UC8.14_FRQ01, T6.8_UC8.15_FRQ01
Requirement Name	Demand forecast via analytics tool
Use Case ID	UC-FP6-WP6-8.14, UC-FP6-WP6-8.15
Category	Functional
Priority	MUST
Main goal	Users like a train operation manager or a rolling stock engineer need demand forecasts as basis for their decision making. A BIA should be able to create such demand forecasts with the integrated analytics tool within the backend of the software without deep coding knowledge. The forecasted demand shall be visualised in a graph.

Assumptions	Historical demand data is available, a connection to the PIS is established, an analytics tool is integrated in the backend of the software, the analytics tool has an integrated forecasting model with a low code user interface.
Specification	The analytics tool within the software shall enable the BIA to forecast demand, by choosing the journey leg (From station A to station B), data sets (e.g., ticket sales, journey planning requests, actual usage, etc.), other constraints (e.g., time usage time, departure time, etc.) and setting the forecasting period. The forecasted demand shall be visualised in a graph.
Additional Notes	-

7.8.16 T6.8_UC8.16_FRQ01

Requirement ID	T6.8_UC8.16_FRQ01
Requirement Name	Travel service notifications
Use Case ID	UC-FP6-WP6-8.16
Category	Functional
Priority	MUST
Main goal	Keep end user informed of travel status if changes occur and enable changes or adaptations to journey plan if needed
Assumptions	Email address for notifications is provided or notifications inside a mobile application on end users device are enabled
Specification	When changes to a planned journey occur, end users are notified. The end user may choose to continue with the new conditions or re-arrange his/her travel. The notification may already address alternatives based on the user preferences recorded or set when the travel was organized.
Additional Notes	-

7.8.17 T6.8_UC8.17_FRQ01

Requirement ID	T6.8_UC8.17_FRQ01
Requirement Name	Enable DRT service providers to register services on the platform
Use Case ID	UC-FP6-WP6-8.17
Category	Functional
Priority	Nice-to-have with high priority
Main goal	Enable service providers to demonstrate interest in joining platform and start the insertion process
Assumptions	-
Specification	Service providers submit the information necessary to initiate the process enabling his registration in the platform and start the process of making their services available to end users. The administrator receives a notification with the provided information.
Additional Notes	-

8 Acceptance Criteria

Acceptance criteria are developed to ensure that the implemented solution fulfils the requirement specification. To this end, the results of the test cases in Chapter 9 below are held against the expected results of the acceptance criteria. Here we resort to the use of a standardized template for capturing the different acceptance criteria. The template looks as follows:

Field	Description
Acceptance criterion ID	A unique identifier for the acceptance criterion It is of the form "<requirement ID>_AC<number>"
Acceptance criterion description	A brief description of the acceptance criterion
Verification method	How the acceptance criterion will be verified
Expected result	The expected outcome of the verification

Note that the "Acceptance criterion ID" is based on the requirement ID. Hence, it can be interpreted in the same way and gives insights about the requirement and use case it was derived from. For example, the ID "T6.1_UC1.1.3_FRQ02_AC01", means that this is the first acceptance criteria of the second functional requirement of the third use case from task 6.1.1.

The structure of the acceptance criterion description is based on a scenario-focused approach which illustrates each criterion in a Given/When/Then sequence as follows[5]

1. Scenario – the name for the behaviour that will be described.
2. Given – the beginning state of the scenario.
3. When – specific action that the user makes.
4. Then – the outcome of the action in "When".
5. And – used to continue any of three previous statements.

8.1 Acceptance criteria task 6.1.1

8.1.1 T6.1_UC1.1.1_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.1.1_FRQ01_AC01
Acceptance criterion description	**Given** a timetable and DRT data in form of files need to be stored for multimodal route planning **when** from a source system provided, **then** the system can receive/gather data from public TSP systems and DRT service provider systems in a suitable format which can be used by the trip search engine.
Verification method	T6.1_UC1.1.1_FRQ01_AC01_TC01
Expected result	System can gather and receive data from TSP and DRT services (e.g., timetable data, service area, operating hours, …)

8.1.2 T6.1_UC1.1.1_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.1.1_FRQ02_AC01

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[5] https://www.altexsoft.com/blog/acceptance-criteria-purposes-formats-and-best-practices/, accessed:06.12.23.

Acceptance criterion description	**Given** a user wants to plan a multimodal journey considering DRT services in the route planning, **when** the user queries the journey planning application, **then** the system can compute and display trips that combine public transport legs with DRT legs for first and/or last mile.
Verification method	T6.1_UC1.1.1_FRQ02_AC01_TC01
Expected result	The journey planning application can compute and display trips that combine public transport legs with DRT legs for first and/or last mile.

8.1.3 T6.1_UC1.1.1_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.1.1_FRQ03_AC01
Acceptance criterion description	**Given** the system has a trip planning interface with a location suggestion feature **when** the user enters inputs in the arrival or destination field, **then** the system will show suggestions of matching locations (POI, stops, addresses, …) based on the user's input.
Verification method	T6.1_UC1.1.1_FRQ03_AC01_TC01
Expected result	The system suggests locations (POI, train/bus stops, addresses, …) based on the user's input.

8.1.4 T6.1_UC1.1.1_FRQ04_AC01

Acceptance criterion ID	T6.1_UC1.1.1_FRQ04_AC01
Acceptance criterion description	**Given** DRT service availability data is needed **when** the user requests a route which should consider DRT services, **then** the system sends a request to the API of the DRT system that specifies a start and end location for the DRT trip and a desired departure or arrival time to get the necessary information.
Verification method	T6.1_UC1.1.1_FRQ04_AC01_TC01
Expected result	The system can interface with the DRT system's API to check the availability of a DRT vehicle for a specified trip leg.

8.1.5 T6.1_UC1.1.1_PRQ01_AC01

Acceptance criterion ID	T6.1_UC1.1.1_PRQ01_AC01
Acceptance criterion description	**Given** a user queries the trip planning application and the system is on realistic load and performance condition, **when** the user requests a route with or without DRT option, **then** the system responds on average within 5 respectively 3 seconds.
Verification method	T6.1_UC1.1.1_PRQ01_AC01_TC01, T6.1_UC1.1.1_PRQ01_AC01_TC02
Expected result	The system can provide a quick response to a user's route planning request.

8.1.6 T6.1_UC1.1.2_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.1.2_FRQ01_AC01
Acceptance criterion description	**Given** rules of competition for DRT service provider are available in a suitable format, **when** the system needs to consider these rules of competition during a route planning calculation, **then** the system gathers the rules of competition data from the manual input of data in a structured data format from DRT and PT providers.
Verification method	T6.1_UC1.1.2_FRQ01_AC01_TC01
Expected result	The system shall be able to gather and store data, which defines the rules of competition.

8.1.7 T6.1_UC1.1.2_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.1.2_FRQ02_AC01
Acceptance criterion description	**Given** the rules of competition are available in the system, **when** the user requests a route with DRT options, **then** the rules of competition are considered in the trip search algorithm.
Verification method	T6.1_UC1.1.2_FRQ02_AC01_TC01
Expected result	The system shall only suggest routes which take the current rules of competition into account (e.g., no DRT offer parallel to a public transit service).

8.1.8 T6.1_UC1.1.2_PRQ01_AC01

Acceptance criterion ID	T6.1_UC1.1.2_PRQ01_AC01
Acceptance criterion description	**Given** rules of competition are available in the system, **when** the user requests a route with or without DRT service, **then** the system implements these rules within a reasonable amount of time.
Verification method	T6.1_UC1.1.2_PRQ01_AC01_TC01**Error! Reference source not found.**
Expected result	The system should not take more than 150% longer considering the rules of competition. If DRT services legs validation must also be included the system shall not take longer than (2sec + 3sec) * (100% + 150%) on average

8.1.9 T6.1_UC1.1.3_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.1.3_FRQ01_AC01
Acceptance criterion description	**Given** the DRT service provider wants to set up a new area or optimize an existing one, **when** DRT service providers need a simulation to allocate resources efficiently, **then** a simulation system is in place to support data driven decision making
Verification method	T6.1_UC1.1.3_FRQ01_AC01_TC01
Expected result	There is a simulation system in place which is specifically designed to support the allocation of resources for DRT service providers. The simulation system must consider demand (i.e., DRT trip requests), supply (vehicles), compute how a DRT production system would likely react with the given demand/supply and calculate resulting metrics.

8.1.10 T6.1_UC1.1.3_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.1.3_FRQ02_AC01
Acceptance criterion description	**Given** the DRT service provider wants to set up a new area or optimize an existing one, **when** DRT service providers need a simulation to forecast capacity needs to allocate resources efficiently, **then** the simulation system processes travel demand data and assign a given set of vehicles to DRT trip requests derived from the travel demand data.
Verification method	T6.1_UC1.1.3_FRQ02_AC01_TC01
Expected result	The simulation system should derive a list of DRT trip requests specified by origin, destination, departure time from travel demand data and assign vehicles of a given fleet to trip requests considering the availability of vehicles.

8.1.11 T6.1_UC1.1.3_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.1.3_FRQ03_AC01
Acceptance criterion description	**Given** DRT service provider wants to simulate how a fleet can be assigned to trip requests to efficiently cover travel demand, **when** the DRT service provider runs a simulation, **then** the simulation system provides certain metrics that allow to assess the service quality reached for a given scenario.
Verification method	T6.1_UC1.1.3_FRQ03_AC01_TC01
Expected result	The simulation system calculated and provided metrics that indicate the quality of service regarding different dimensions, e.g. **user experience indicators:** share of demand covered, average waiting time for pick up after requested departure time **deviation indicators:** detour rate by time and by distance **operational indicators:** total distance covered by each vehicle, including commercial and non-commercial distances; maximum number of passengers on board (to determine vehicle size) **performance indicators:** pooling rate; number of passengers per vehicle hour

8.1.12 T6.1_UC1.1.4_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.1.4_FRQ01_AC01
Acceptance criterion description	**Given** the system shall be able to interact with external trip search systems, **when** the system receives a trip search request form an external system via the OJP protocol, **then** the system receives and processes this request.
Verification method	T6.1_UC1.1.4_FRQ01_AC01_TC01
Expected result	The system provides an endpoint for receiving OJP trip search requests form external systems. The receiving component (passive server adapter) must convert the request into the (proprietary) format of the underlying journey planning application and forward it to this application.

8.1.13 T6.1_UC1.1.4_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.1.4_FRQ02_AC01
Acceptance criterion description	**Given** the system shall be able to interact with external trip search systems, **when** the system receives a trip search request form an external system via the OJP protocol which was processed in the internal journey planning application, **then** the system sends the calculated trip options back to the requesting system.
Verification method	T6.1_UC1.1.4_FRQ02_AC01_TC01
Expected result	The system must be able to send a response for a trip search request containing trip options to an external system via the OJP protocol.

8.1.14 T6.1_UC1.1.4_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.1.4_FRQ03_AC01
Acceptance criterion description	**Given** the system shall be able to support OJP protocol for public transit and DRT, **when** the system receives requests from and sends answers to an external trip planning system, **then** the system must support OJP 2.0 protocol since former versions do not support DRT.
Verification method	T6.1_UC1.1.4_FRQ03_AC01_TC01
Expected result	The system must be able to receive, process and answer requests via the OJP 2.0 protocol to be able to include DRT services in trip planning.

8.1.15 T6.1_UC1.1.4_PRQ01_AC01

Acceptance criterion ID	T6.1_UC1.1.4_PRQ01_AC01
Acceptance criterion description	**Given** the system shall be able to support OJP protocol, **when** the system receives requests and sends answers, **then** it can process 100 incoming requests and 100 outgoing responses within 1 minute.
Verification method	T6.1_UC1.1.4_PRQ01_AC01_TC01
Expected result	The OJP component of the journey planning application shall be able to process 100 incoming requests per minute (receive from external system, convert into proprietary format for internal journey planning application and send to journey planning application) and 100 outgoing responses per minute (receive from internal journey planning application, convert into OJP format, and send to external journey planning application).

8.2 Acceptance criteria task 6.1.2

8.2.1 T6.1_UC1.2.1_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.1_FRQ01_AC01
Acceptance criterion description	**Given** real-time data feeds from rail operators are available, **when** the system fetches real-time data, **then** it converts the relevant data into the internal data structure in the backend of the journey planning system.
Verification method	T6.1_UC1.2.1_FRQ01_AC01_TC01
Expected result	The journey planning system can interface with real-time data feeds from rail operators.

8.2.2 T6.1_UC1.2.1_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.1_FRQ02_AC01
Acceptance criterion description	**Given** real-time data feeds from rail operators are available, **when** the system constructs an ad-hoc timetable, **then** it modifies the static timetable, marks all delayed vehicles, and retrieves their expected arrival time.
Verification method	T6.1_UC1.2.1_FRQ02_AC01_TC01
Expected result	An ad-hoc timetable is created which contains real-time information on delays and expected arrival times

8.2.3 T6.1_UC1.2.1_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.2.1_FRQ03_AC01
Acceptance criterion description	**Given** that static timetable exists and real time feeds from rail operators can be processed, **when** updated real time data arrives in the journey planning system and the ad-hoc timetable is constructed or updated, **then** the ETA of the next and all subsequent stations is determined
Verification method	T6.1_UC1.2.1_FRQ03_AC01_TC01
Expected result	ETAs are incorporated in the ad-hoc timetable

8.2.4 T6.1_UC1.2.1_NFRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.1_NFRQ01_AC01
Acceptance criterion description	**Given** that static timetable exists and regular real time feeds from rail operators can be processed, **when** updated real time data arrives in the journey planning system and the ad-hoc timetable is constructed or updated, **then** the system matches the real-time data to update the static timetable to quickly create an ad-hoc timetable.
Verification method	T6.1_UC1.2.1_NFRQ01_AC01_TC01
Expected result	Real-time information can be matched quickly (within several seconds) with the static timetable to update it and create an ad-hoc timetable.

8.2.5 T6.1_UC1.2.2_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.2_FRQ01_AC01
Acceptance criterion description	**Given** real-time data feeds from rail and bus operators are available, **when** the system fetches real-time data, **then** the system converts the incoming data into the internal data structure and constructs or updates the ad-hoc timetable, so it can be considered for route planning.
Verification method	T6.1_UC1.2.2_FRQ01_AC01_TC01
Expected result	Real-time data from train and bus operators is received and processed by the journey planner application and can be considered for route planning.

8.2.6 T6.1_UC1.2.2_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.2_FRQ02_AC01
Acceptance criterion description	**Given** that an API from a DRT service provider is available, **when** the journey planning system fetches data from the DRT service provider, **then** the system receives and converts the data in a suitable format so that it can be linked and used for route planning.
Verification method	T6.1_UC1.2.2_FRQ02_AC01_TC01
Expected result	Data from DRT services can be fetched and processed in a way that the data can be used for route planning.

8.2.7 T6.1_UC1.2.3_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.3_FRQ01_AC01
Acceptance criterion description	**Given** a user requests a route for which the journey planning system has both kind of information for trip searches, static and real-time timetable data available, **when** a user queries the journey planner for a route for which at least part of the real-time data is not available, **then** the system will inform the user about the non-availability of real-time data along the route.
Verification method	T6.1_UC1.2.3_FRQ01_AC01_TC01
Expected result	The system shows the user for which parts of the journey real-time data is available and for which not.

8.2.8 T6.1_UC1.2.3_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.3_FRQ02_AC01
Acceptance criterion description	**Given** a user requests a route for which the journey planning system has both kind of information for trip searches, static and real-time timetable data available, **when** a user queries the journey planner for a route for which real-time data is available for only some parts of the route, **then** the system still provides route suggestions based on the static and real-time data.
Verification method	T6.1_UC1.2.3_FRQ02_AC01_TC01
Expected result	The journey planner works with real-time information, with partly available real-time information and without real-time information available and will suggest a route based on the available data (preferably real-time data)-

8.2.9 T6.1_UC1.2.3_PRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.3_PRQ01_AC01
Acceptance criterion description	**Given** real-time data is available, **when** a user queries the journey planner for a route, **then** the system provides a route in a timely and accurate manner.
Verification method	T6.1_UC1.2.3_PRQ01_AC01_TC01
Expected result	The performance and accuracy of querying a route with real-time data available versus not available should not differ significantly.

8.2.10 T6.1_UC1.2.4_FRQ01_AC01

<table>
<tr><td>Acceptance criterion ID</td><td>T6.1_UC1.2.4_FRQ01_AC01</td></tr>
<tr><td>Acceptance criterion description</td><td>Given that a user has opened the journey planning application, then the jour
application provides a well-designed frontend, which enables the user to spe
information as well as individual user settings such as preferred modes of tra
walking speed, maximum walking distance to/from stop and an (optional) PR</td></tr>
<tr><td>Verification method</td><td>
<h2>8.2.11 T6.1_UC1.2.4_FRQ01_AC01_TC01</h2>
<table>
<tr><td>Test case ID</td><td>T6.1_UC1.2.4_FRQ01_AC01_TC01</td></tr>
<tr><td>Test case description</td><td>The system must have a well-designed frontend v
user to input origin, destination, and preferred ti</td></tr>
<tr><td>Preconditions</td><td>-</td></tr>
<tr><td>Trigger</td><td>User opens journey planning application</td></tr>
<tr><td>Test steps</td><td>1. User opens journey planning application
2. User inputs origin, destination, and preferred t
journey planning application.</td></tr>
<tr><td>Expected results</td><td>User was provided a frontend for inputting: origir
arrival time, departure time</td></tr>
</table>
T6.1_UC1.2.4_FRQ01_AC01_TC02</td></tr>
<tr><td>Expected result</td><td>The journey planning application has a well-designed frontend, which enable
trip related information as well as individual user settings such as preferred r
individual walking speed, maximum walking distance to/from stop and an (op</td></tr>
</table>

8.2.12 T6.1_UC1.2.4_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.4_FRQ02_AC01
Acceptance criterion description	**Given** that a user wants to plan a trip using the journey planning system, **when** the user queries a route search by providing start and end point as well as other input data like time or travel preferences, **then** the journey planning application generates relevant trip options based on the interpreted user input, presenting them clearly to the user with essential details such as departure times, travel durations, and transportation modes.
Verification method	T6.1_UC1.2.4_FRQ02_AC01_TC01
Expected result	The system accurately understands and interprets the user's requests and provides relevant trip suggestions accordingly.

8.2.13 T6.1_UC1.2.4_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.2.4_FRQ03_AC01
Acceptance criterion description	**Given** data about station facilities is not available, **when** a user queries a trip search, **then** the system performs the trip search even without available facility data.

Verification method	T6.1_UC1.2.4_FRQ03_AC01_TC01
Expected result	The trip search functionality works even when no data about facilities is available

8.2.14 T6.1_UC1.2.4_FRQ04_AC01

Acceptance criterion ID	T6.1_UC1.2.4_FRQ04_AC01
Acceptance criterion description	**Given** that a user wants to consider the properties of station facilities in the trip search, **when** the user queries a trip search with personal preferences defined in PRM profile, **then** the system takes the PRM profile into account by only considering appropriate stations in accordance with this profile and provides the user appropriate route suggestions.
Verification method	T6.1_UC1.2.4_FRQ04_AC01_TC01
Expected result	The system takes station facility properties into consideration and provides the user appropriate route suggestions.

8.2.15 T6.1_UC1.2.4_FRQ05_AC01

Acceptance criterion ID	T6.1_UC1.2.4_FRQ05_AC01
Acceptance criterion description	**Given** that PRM users need information about existing transfer solutions at stations, **when** a PRM user queries the journey planning application, **then** the system will provide journey suggestions including information on existing transfer solutions at stations.
Verification method	T6.1_UC1.2.4_FRQ05_AC01_TC01
Expected result	A PRM should get notified if there are existing transfer solutions on the suggested journeys available.

8.2.16 T6.1_UC1.2.4_FRQ06_AC01

Acceptance criterion ID	T6.1_UC1.2.4_FRQ06_AC01
Acceptance criterion description	**Given** that a user wants to customize their trip profile, **when** a user excludes certain stations or transport modes when querying the journey planning application, **then** the system takes these settings into account and doesn't incorporate excluded stops or transportation modes into the search results.
Verification method	T6.1_UC1.2.4_FRQ06_AC01_TC01
Expected result	The journey planning system provides routes which take the user settings into consideration.

8.2.17 T6.1_UC1.2.5_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.5_FRQ01_AC01
Acceptance criterion description	**Given** that the system can show POI on a map, **when** a user wants to search for a POI, **then** the system has a map view where users can identify POI.
Verification method	T6.1_UC1.2.5_FRQ01_AC01_TC01
Expected result	The system has a map view on which POI are displayed and information of at least their address is provided.

8.2.18 T6.1_UC1.2.5_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.5_FRQ02_AC01
Acceptance criterion description	**Given** that the system can show POI on a map, **when** a user wants to search for a specific category of POI, **then** the system has a map view where users can filter POI based on functional categories (e.g., hotel, museum, restaurant, etc.).
Verification method	T6.1_UC1.2.5_FRQ02_AC01_TC01
Expected result	The user can filter POIs based on their functional category (e.g., hotel, restaurant, museum, etc.). The POIs should appear/disappear based on the chosen category.

8.2.19 T6.1_UC1.2.5_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.2.5_FRQ03_AC01
Acceptance criterion description	**Given** that the system can show POI on a map, **when** a user wants to use a POI as a start point or destination for route planning, **then** the system has the option to tab on a POI marker to select it as either start or destination point.
Verification method	T6.1_UC1.2.5_FRQ03_AC01_TC01
Expected result	POI can be tabbed to select them as either start or end point and the system will switch to the route planning interface as soon as a POI was selected for route planning.

8.2.20 T6.1_UC1.2.5_NFRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.5_NFRQ01_AC01
Acceptance criterion description	**Given** that the system can show POI on a map, **when** a user wants to search for a POI, **then** the map is not cluttered by icons representing POI.
Verification method	T6.1_UC1.2.5_NFRQ01_AC01_TC01
Expected result	To prevent map clutter, the system should load and display POI icons only when the zoom level is appropriate, i.e., when user has zoomed in.

8.2.21 T6.1_UC1.2.6_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.6_FRQ01_AC01
Acceptance criterion description	**Given** that several PRM profiles are predefined, **when** the user receives trip results, **then** the user should be able to choose from a list of predefined profiles.
Verification method	T6.1_UC1.2.6_FRQ01_AC01_TC01
Expected result	A complete list of predefined PRM profiles is provided to the user so that the profile which best fits the user's mobility needs can be selected.

8.2.22 T6.1_UC1.2.6_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.6_FRQ02_AC01
Acceptance criterion description	**Given a** user has special needs regarding trip planning (e.g., a PRM user), **when** the user queries the trip planning system and selects a PRM profile, **then** the system takes those special needs (based on a selected PRM profile) into consideration and includes parameters like walking speed and others in the trip search.
Verification method	T6.1_UC1.2.6_FRQ02_AC01_TC01
Expected result	The user of the journey planning system should be able to get route choices which take special needs and preferences into consideration.

8.2.23 T6.1_UC1.2.6_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.2.6_FRQ03_AC01
Acceptance criterion description	**Given** that a user has selected a PRM profile, **when** the resulting trip options are displayed, **then** the user is made aware that he/she has selected a PRM profile which is considered in the suggested trips.
Verification method	T6.1_UC1.2.6_FRQ03_AC01_TC01
Expected result	The user is reminded that a PRM profile is selected and gets a notification which enables the user to easily change this setting.

8.2.24 T6.1_UC1.2.7_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.7_FRQ01_AC01
Acceptance criterion description	**Given** that user needs differ from those defined in default PRM profiles, **when** a user selects a PRM profile, **then** the user can modify default setting that are registered in the PRM profile by activating or deactivating certain traveller needs (e.g., elevator, no stairs, etc.).
Verification method	T6.1_UC1.2.7_FRQ01_AC01_TC01
Expected result	There should be an option (e.g., a clickable button) which enables the user to modify default setting of traveller needs.

8.2.25 T6.1_UC1.2.7_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.7_FRQ02_AC01
Acceptance criterion description	**Given** that user needs differ from those defined in default PRM profiles, **when** a user changed default PRM settings according to personalized traveller needs, **then** the system considers those changes during route planning and suggests the user routes accordingly.
Verification method	T6.1_UC1.2.7_FRQ02_AC01_TC01
Expected result	The system considers all modifications for planning and suggesting appropriate travel routes.

8.2.26 T6.1_UC1.2.7_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.2.7_FRQ03_AC01
Acceptance criterion description	**Given** that user needs differ from those defined in default PRM profiles, **when** a user changed default PRM settings according to personalized traveller needs, **then** the system provides the possibility to restore default PRM profile settings.
Verification method	T6.1_UC1.2.7_FRQ03_AC01_TC01
Expected result	For each PRM profile there will be a button that enables the user to reset the settings for this profile to the default settings.

8.2.27 T6.1_UC1.2.7_FRQ04_AC01

Acceptance criterion ID	T6.1_UC1.2.7_FRQ04_AC01
Acceptance criterion description	**Given** that users select an PRM profile for trip searching, **when** parameter values of the selected profile deviate from their default values, **then** users are made aware of this deviation.
Verification method	T6.1_UC1.2.7_FRQ04_AC01_TC01
Expected result	Whenever parameter values of the selected profile deviate from their default values, the system should clearly indicate which parameters have been adjusted. The indication should be clear, concise, and prominently displayed to ensure that users easily notice and understand the deviations from default parameter values.

8.2.28 T6.1_UC1.2.7_NFRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.7_NFRQ01_AC01
Acceptance criterion description	**Given** a user requested a travel plan, **when** the results are displayed, **then** the route suggestions are displayed in a clear and easy to understand way.
Verification method	T6.1_UC1.2.7_NFRQ01_AC01_TC01
Expected result	The visualization of journey search results should highlight key information in the journey, e.g., station transfer accessibility level, which reflect the fulfilled traveller needs.

8.2.29 T6.1_UC1.2.8_FRQ01_AC01

Acceptance criterion ID	T6.1_UC1.2.8_FRQ01_AC01

Acceptance criterion description	**Given** a user wants to search for a route with a minimal total walking distance, **when** the user requests a trip search, **then** a route is calculated optimizing for a minimal total walking distance.
Verification method	T6.1_UC1.2.8_FRQ01_AC01_TC01
Expected result	The routing algorithm will consider the walking distance as one goal amongst others and determine pareto-optimal solutions where the total walking distance is minimized.

8.2.30 T6.1_UC1.2.8_FRQ02_AC01

Acceptance criterion ID	T6.1_UC1.2.8_FRQ02_AC01
Acceptance criterion description	**Given** the journey planner can calculate routes which are optimized considering the minimization of the total walking distance, **when** the user wants to request a route, **then** there are two modes in place which let the user choose between classic route optimization (fastest and most comfortable) and a new mode with the additional goal of minimizing the total walking distance.
Verification method	T6.1_UC1.2.8_FRQ02_AC01_TC01
Expected result	The routing algorithm shall be capable to be called in two different modes so that the goal of minimizing walking distance is an optional additional goal.

8.2.31 T6.1_UC1.2.8_FRQ03_AC01

Acceptance criterion ID	T6.1_UC1.2.8_FRQ03_AC01
Acceptance criterion description	**Given** there are profiles for different users like PRM users available in the journey planner, **when** a user requests a route which considers the minimization of the total walking distance, **then** the journey planner offers the user a profile with which the minimization is considered.
Verification method	T6.1_UC1.2.8_FRQ03_AC01_TC01
Expected result	A user can select a profile that leads to trip options with minimum walking distance.

8.3 Acceptance criteria task 6.2

8.3.1 T6.2_UC2.1_FRQ01_AC01

Acceptance criterion ID	T6.2_UC2.1_FRQ01_AC01
Acceptance criterion description	**Given** that TMS can provide data to the PIS via an interface, **when** the TMS updates the operational plan and the calculated delay forecast, **then** the TMS sends specific relevant information to the PIS.
Verification method	T6.2_UC2.1_FRQ01_AC01_TC01
Expected result	Specific relevant information shall be derived and sent to the PIS: Expected delay in arrival and departure times of the trains; Platform track changes; Full or partial cancellations; Incident information in relation to trains; As far as possible, the existing SIRI standard shall be used for the data transmission.

8.3.2 T6.2_UC2.1_FRQ02_AC01

Acceptance criterion ID	T6.2_UC2.1_FRQ02_AC01
Acceptance criterion description	**Given** the TMS updates the operational plan and calculates delay forecasts, **when** the TMS sends the updated information to PIS, **then** the PIS receives and processes the sent information.
Verification method	T6.2_UC2.1_FRQ02_AC01_TC01
Expected result	PIS shall be able to receive and process the following information: Expected delay in arrival and departure times of the trains; Platform track changes; Full or partial cancellations; Incident information in relation to trains; As far as possible, the existing SIRI standard shall be used for the data transmission.

8.3.3 T6.2_UC2.1_NFRQ01_AC01

Acceptance criterion ID	T6.2_UC2.1_NFRQ01_AC01
Acceptance criterion description	**Given** the TMS frequently provides specific up-to-date information to the PIS, **when** the TMS sends this up-to-date information to the PIS, **then** the minimum frequency at which information is sent from the TMS to the PIS is once every 30 seconds.
Verification method	T6.2_UC2.1_NFRQ01_AC01_TC01
Expected result	The transfer frequency of updated information to be sent from TMS to PIS is higher or equal once every 30 seconds.

8.3.4 T6.2_UC2.2_FRQ01_AC01

Acceptance criterion ID	T6.2_UC2.2_FRQ01_AC01
Acceptance criterion description	**Given** the CMS/TMS need up to date data for planning future capacities, **when** new demand forecasting data is available from the forecasting module, **then** the demand forecasting module sends this information to the CMS and TMS.
Verification method	T6.2_UC2.2_FRQ01_AC01_TC01 T6.2_UC2.2_FRQ01_AC01_TC02
Expected result	The PIS demand forecast sends the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the actual time to the TMS and CMS.

8.3.5 T6.2_UC2.2_FRQ02_AC01

Acceptance criterion ID	T6.2_UC2.2_FRQ02_AC01
Acceptance criterion description	**Given** the CMS/TMS need up to date data for planning future capacities, **when** the forecasting module of the PIS sends new information to the CMS and TMS, **then** the CMS and TMS receives this information.
Verification method	T6.2_UC2.2_FRQ02_AC01_TC01
Expected result	The TMS/CMS can receive the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the actual time from the PIS demand forecast module.

8.3.6 T6.2_UC2.2_NFRQ01_AC01

Acceptance criterion ID	T6.2_UC2.2_NFRQ01_AC01
Acceptance criterion description	**Given** the CMS/TMS frequently receives up-to-date data from the forecasting module for planning future capacities, **when** new demand forecasting data is sent from the forecasting module, **then** the minimum frequency at which information is sent from the TMS to the PIS is once every 15 minutes providing that new data updates are available.
Verification method	T6.2_UC2.2_NFRQ01_AC01_TC01
Expected result	The transfer frequency of updated information to be sent from PIS to TMS/CMS shall be higher or equal to once every 15 minutes providing that new data updates are available.

8.3.7 T6.2_UC2.2_NFRQ02_AC01

Acceptance criterion ID	T6.2_UC2.2_NFRQ02_AC01
Acceptance criterion description	**Given** the CMS and TMS frequently receive up-to-date data from the forecasting module for planning future capacities, **when** the data is prepared in the PIS for sending, **then** the PIS anonymises all data before it will be sent to the CMS/TMS.
Verification method	T6.2_UC2.2_NFRQ02_AC01_TC01
Expected result	The updated demand forecast information is anonymized before it is sent from PIS to TMS/CMS

8.3.8 T6.2_UC2.3_FRQ01_AC01

Acceptance criterion ID	T6.2_UC2.3_FRQ01_AC01
Acceptance criterion description	**Given** the CMS/TMS need up to date data for planning future capacities, **when** new information regarding the number of expected travellers in between stops is available, **then** the PIS demand forecasting module sends this information to the CMS/TMS.
Verification method	T6.2_UC2.3_FRQ01_AC01_TC01 T6.2_UC2.3_FRQ01_AC01_TC02
Expected result	The PIS demand forecast module sends the number of expected travellers in the trains between subsequent stops in a timeframe of at least two hours ahead of the actual time to the TMS/CMS.

8.3.9 T6.2_UC2.3_FRQ02_AC01

Acceptance criterion ID	T6.2_UC2.3_FRQ02_AC01
Acceptance criterion description	**Given** the CMS/TMS need up to date data for planning future capacities, **when** the forecasting module of the PIS sends new information about the number of expected travellers in the trains between subsequent stops to the CMS/TMS, **then** the CMS/TMS receives this information.
Verification method	T6.2_UC2.3_FRQ02_AC01_TC01
Expected result	The TMS/CMS can receive the number of expected travellers in the trains between subsequent stops in a timeframe of at least two hours ahead of the actual time from the PIS demand forecast module.

8.3.10 T6.2_UC2.3_NFRQ01_AC01

Acceptance criterion ID	T6.2_UC2.3_NFRQ01_AC01
Acceptance criterion description	**Given** the CMS/TMS frequently receives up to date data from the PIS for planning future capacities, **when** new information regarding the number of expected travellers in between stops is sent, **then** the PIS demand forecasting module sends this information to the CMS/TMS at least once every 5 minutes providing that new data updates are available.
Verification method	T6.2_UC2.3_NFRQ01_AC01_TC01
Expected result	The transfer frequency of updated information about expected numbers of travellers in between stops which are sent from PIS to CMS/TMS is higher or equal to once every 5 minutes providing that new data updates are available.

8.3.11 T6.2_UC2.3_NFRQ02_AC01

Acceptance criterion ID	T6.2_UC2.3_NFRQ02_AC01
Acceptance criterion description	**Given** the CMS/TMS frequently receives up to date data from the PIS for planning future capacities, **when** the data is prepared in the PIS for sending, **then** the PIS anonymises all data before it will be sent to the CMS/TMS.
Verification method	T6.2_UC2.3_NFRQ02_AC01_TC01
Expected result	The updated demand forecast information is anonymized before it is sent from PIS to CMS/TMS

8.3.12 T6.2_UC2.4_FRQ01_AC01

Acceptance criterion ID	T6.2_UC2.4_FRQ01_AC01
Acceptance criterion description	**Given** TMS/CMS uses forecasting data to provide a basis for decision makers, **when** the forecasting module calculates new data including expected travellers embarking/disembarking at stations, **then** the forecasting module sends the freshly forecasted data to TMS/CMS.
Verification method	T6.2_UC2.4_FRQ01_AC01_TC01 T6.2_UC2.4_FRQ01_AC01_TC02
Expected result	The PIS demand forecast module sends the number of expected travellers embarking/disembarking a train at the stations in a timeframe of two weeks ahead of the actual time to the TMS/CMS.

8.3.13 T6.2_UC2.4_FRQ02_AC01

Acceptance criterion ID	T6.2_UC2.4_FRQ02_AC01
Acceptance criterion description	**Given** TMS/CMS uses forecasting data to provide a basis for decision makers, **when** the demand forecasting module sends new data including expected travellers embarking/disembarking at stations to the TMS/CMS, **then** the TMS/CMS receives this information.
Verification method	T6.2_UC2.4_FRQ02_AC01_TC01
Expected result	The TMS/CMS can receive the number of expected travellers embarking/disembarking a train at the stations in a timeframe of two weeks ahead of the actual time from the PIS demand forecast module.

8.3.14 T6.2_UC2.4_NFRQ01_AC01

Acceptance criterion ID	T6.2_UC2.4_NFRQ01_AC01
Acceptance criterion description	**Given** the CMS/TMS frequently receives up to date data from the PIS for planning future capacities, **when** new information regarding the number of expected travellers embarking/disembarking the train at stations is sent to the CMS/TMS, **then** the PIS demand forecasting module sends this information to the CMS/TMS at least once every 5 minutes providing that new data updates are available.
Verification method	T6.2_UC2.4_NFRQ01_AC01_TC01
Expected result	The transfer frequency of updated information about expected numbers of travellers embarking/disembarking the train at stations which is sent from PIS to CMS/TMS is higher or equal to once every 5 minutes providing that new data updates are available.

8.3.15 T6.2_UC2.4_NFRQ02_AC01

Acceptance criterion ID	T6.2_UC2.4_NFRQ02_AC01
Acceptance criterion description	**Given** the CMS/TMS receives up to date data from the PIS for planning future capacities, **when** the PIS prepares the new information regarding the number of expected travellers embarking/disembarking the train at stations before sending it to the CMS/TMS, **then** the PIS anonymises any data before sending it to the CMS/TMS.
Verification method	T6.2_UC2.4_NFRQ02_AC01_TC01
Expected result	Data regarding the number of expected travellers embarking/disembarking the train at stations is anonymized before it is sent from PIS to TMS/CMS

8.4 Acceptance criteria task 6.4

8.4.1 T6.4_UC4.1_FRQ01_AC01

Acceptance criterion ID	T6.4_UC4.1_FRQ01_AC01
Acceptance criterion description	**Given** a forecasting module for forecasting occupancy of vehicles is set up, **when** journey planning request data from the journey planning application or vehicle occupancy sensor data is available, **then** the system should be able to receive and process this data.
Verification method	T6.4_UC4.1_FRQ01_AC01_TC01, T6.4_UC4.1_FRQ01_AC01_TC02
Expected result	Journey planning request data, as well as vehicle occupancy sensor data can be received and processed.

8.4.2 T6.4_UC4.1_NFRQ01_AC01

Acceptance criterion ID	T6.4_UC4.1_NFRQ01_AC01
Acceptance criterion description	**Given** the forecasting module can receive and process journey planning request data and vehicle occupancy data, **when** the module receives this data, **then** it processes the data within a reasonable time.
Verification method	T6.4_UC4.1_NFRQ01_AC01_TC01
Expected result	The relevant data is received and processed within a reasonable time (a couple of hours).

8.4.3 T6.4_UC4.1_FRQ02_AC01

Acceptance criterion ID	T6.4_UC4.1_FRQ02_AC01
Acceptance criterion description	**Given** enough data for training a machine learning model to predict vehicle occupancy is available, **when** a respective model was chosen and the necessary training data collected, **then** the system should be able to train the machine learning model to reach on average values of 50% precision in the forecast for one week in advance and achieve 65% precision in the forecast at one hour in advance based on new journey planning requests and vehicle occupancy data.
Verification method	T6.4_UC4.1_FRQ02_AC01_TC01
Expected result	A trained machine learning model should be stored and able to predict vehicle occupancy based on the mentioned input data.

8.4.4 T6.4_UC4.1_FRQ03_AC01

Acceptance criterion ID	T6.4_UC4.1_FRQ03_AC01
Acceptance criterion description	**Given** new data for retraining the vehicle occupancy forecasting model is available, **when** the vehicle occupancy forecasting model is not up to date anymore, **then** it should be automatically retrained with newly available data.
Verification method	T6.4_UC4.1_FRQ03_AC01_TC01
Expected result	The vehicle occupancy forecasting model is retrained with newly available data.

8.4.5 T6.4_UC4.1_FRQ04_AC01

Acceptance criterion ID	T6.4_UC4.1_FRQ04_AC01
Acceptance criterion description	**Given** the vehicle occupancy forecasting module is set up, **when** a newly available journey planning requests can be received, **then** it should be used to predict vehicle occupancy for the corresponding journey.
Verification method	T6.4_UC4.1_FRQ04_AC01_TC01
Expected result	Journey planning requests can be received and use for forecasting vehicle occupancy.

8.4.6 T6.4_UC4.1_FRQ05_AC01

Acceptance criterion ID	T6.4_UC4.1_FRQ05_AC01
Acceptance criterion description	**Given** vehicle occupancy is forecasted daily, **when** a new forecast is available, **then** the forecast should be extracted and sent to the journey planner.
Verification method	T6.4_UC4.1_FRQ05_AC01_TC01
Expected result	Newly forecasted vehicle occupancy data is sent to the journey planner.

8.4.7 T6.4_UC4.1_NFRQ02_AC01

Acceptance criterion ID	T6.4_UC4.1_NFRQ02_AC01
Acceptance criterion description	**Given** new data for retraining the vehicle occupancy forecasting model is available, **when** a certain retrain time interval is exceeded, **then** the vehicle occupancy forecasting model should be retrained.
Verification method	T6.4_UC4.1_NFRQ02_AC01_TC01
Expected result	The vehicle occupancy model is retrained on a frequent basis.

8.4.8 T6.4_UC4.2_FRQ01_AC01

Acceptance criterion ID	T6.4_UC4.2_FRQ01_AC01

Acceptance criterion description	**Given** a user plans a trip with the journey planning system and provides input like origin, destination, and arrival/departure time, **when** the user queries the journey planning application, **then** the system will store this input for later usage in the vehicle occupancy forecasts.
Verification method	T6.4_UC4.2_FRQ01_AC01_TC01
Expected result	The journey planning application can store the user input for later use for the vehicle occupancy forecasts.

8.4.9 T6.4_UC4.2_FRQ02_AC01

Acceptance criterion ID	T6.4_UC4.2_FRQ02_AC01
Acceptance criterion description	**Given** forecasted vehicle occupancy data is available, **when** a user requests a journey via the journey planning application, **then** the journey planning application fetches forecasted vehicle occupancy data to display it to the user.
Verification method	T6.4_UC4.2_FRQ02_AC01_TC01
Expected result	The journey planning system can fetch forecasted vehicle occupancy data to provide it to the user

8.4.10 T6.4_UC4.2_NFRQ01_AC01

Acceptance criterion ID	T6.4_UC4.2_NFRQ01_AC01
Acceptance criterion description	**Given** a trip planning interface where users can input information exists, **when** a user inputs something, **then** the trip planning interface will give feedback whether the input is correct or not.
Verification method	T6.4_UC4.2_NFRQ01_AC01_TC01
Expected result	The user gets a visual indication from the trip planning interface on their entered input. For example, „A stop nearby could not be found“, or „Requested date of travel outside the period covered by the timetable data“.

8.4.11 T6.4_UC4.2_FRQ03_AC01

Acceptance criterion ID	T6.4_UC4.2_FRQ03_AC01
Acceptance criterion description	**Given** the journey planner can access the forecasted vehicle occupancy information, **when** a user requests a journey, **then** the journey planning application generates several trip options considering the forecasted occupancy information as well as other factors like travel time and the number of transfers.
Verification method	T6.4_UC4.2_FRQ03_AC01_TC01
Expected result	The user receives several trip options based on the given input, which consider vehicle occupancy information as well as travel time and the number of transfers.

8.4.12 T6.4_UC4.2_FRQ04_AC01

Acceptance criterion ID	T6.4_UC4.2_FRQ04_AC01
Acceptance criterion description	**Given** the journey planner can access the forecasted vehicle occupancy information, **when** a user requests a journey, **then** the journey planning application displays the forecasted vehicle occupancy information in a clear and organized way.
Verification method	T6.4_UC4.2_FRQ04_AC01_TC01
Expected result	Forecasted vehicle occupancy information is presented to the user in a clear and organized way highlighting key information such as estimated travel time, cost, and forecasted occupancy levels.

8.4.13 T6.4_UC4.2_NFRQ02_AC01

Acceptance criterion ID	T6.4_UC4.2_NFRQ02_AC01
Acceptance criterion description	**Given** a trip planning interface where users can input information exists, **when** a user requests a trip, **then** the trip planning interface will display all relevant information for the trip including the forecasted vehicle occupancy information in a clear and intuitive way.
Verification method	T6.4_UC4.2_NFRQ02_AC01_TC01
Expected result	Trips are displayed containing all relevant information including the forecasted vehicle occupancy.

8.4.14 T6.4_UC4.3_FRQ01_AC01

Acceptance criterion ID	T6.4_UC4.3_FRQ01_AC01
Acceptance criterion description	**Given** data for training the machine learning model is available, **when** historic travel demand data, combining rail and other modes (such as bus, trams, DRT, or walking) are available, **then** the system trains a preselected machine learning model for estimating mobility demand beyond rail, e.g., demand for first/last mile transport.
Verification method	T6.4_UC4.3_FRQ01_AC01_TC01
Expected result	The machine learning model is trained

8.4.15 T6.4_UC4.3_FRQ02_AC01

Acceptance criterion ID	T6.4_UC4.3_FRQ02_AC01
Acceptance criterion description	**Given** the system has access to relevant data such as rail station locations, surrounding locations, and journey planning requests, **when** the system operator wants to determine the mobility demand for a certain region, **then** the system estimates the expected mobility demand and provides insights into the expected volume of travellers requiring first/last mile transportation options.
Verification method	T6.4_UC4.3_FRQ02_AC01_TC01
Expected result	The expected mobility demand is calculated based on historic data

8.4.16 T6.4_UC4.3_FRQ03_AC01

Acceptance criterion ID	T6.4_UC4.3_FRQ03_AC01
Acceptance criterion description	**Given** the system has already derived a first/last mile demand forecast **when** the TSP starts to request an export of the derived data, **then** there is an export function which allows the user to filter the export data (e.g., by date) and exports the data in a machine-readable format, e.g., JSON or csv.
Verification method	T6.4_UC4.3_FRQ03_AC01_TC01
Expected result	The first/last mile demand forecast is exported in a machine-readable file format.

8.4.17 T6.4_UC4.3_NFRQ01_AC01

Acceptance criterion ID	T6.4_UC4.3_NFRQ01_AC01
Acceptance criterion description	**Given** the TSP needs mobility demand estimation data, **when** the TSP requests this data, **then** the system reliably and timely provides this data to the TSP.
Verification method	T6.4_UC4.3_NFRQ01_AC01_TC01, T6.4_UC4.3_NFRQ01_AC01_TC02
Expected result	Data about the mobility demand estimations beyond rail for first and last mile connections is provided reliably.

8.4.18 T6.4_UC4.3_FRQ04_AC01

Acceptance criterion ID	T6.4_UC4.3_FRQ04_AC01
Acceptance criterion description	**Given** the system has access to the mobility demand estimation results, **when** the results are analysed, **then** the system identifies areas with a mismatch between transportation demand and offering, taking factors such as travel demand, population density and other relevant variables into account.
Verification method	T6.4_UC4.3_FRQ04_AC01_TC01
Expected result	Significant mismatches between transportation demand and offerings are identified

8.4.19 T6.4_UC4.3_FRQ05_AC01

Acceptance criterion ID	T6.4_UC4.3_FRQ05_AC01
Acceptance criterion description	**Given** the system has access to the mobility demand estimation results, **when** the TSP wants to have to access to the data, **then** an interactive analytics dashboard is provided by the system.
Verification method	T6.4_UC4.3_FRQ05_AC01_TC01
Expected result	An interactive analytics dashboard for visualization of the estimation of mobility demand data exists

8.4.20 T6.4_UC4.3_NFRQ02_AC01

Acceptance criterion ID	T6.4_UC4.3_NFRQ02_AC01
Acceptance criterion description	**Given** the system has mechanisms to ensure the accuracy and reliability of the available data used for demand estimation, **when** the data which was used for the calculations of the demand is tested, **then** all data should meet certain quality standards.
Verification method	T6.4_UC4.3_NFRQ02_AC01_TC01
Expected result	All data which was used for demand estimation meet certain quality standards

8.4.21 T6.4_UC4.4_FRQ01_AC01

Acceptance criterion ID	T6.4_UC4.4_FRQ01_AC01

Acceptance criterion description	**Given** that the system is set to receive data such as train occupancy, weather conditions, public/disruptive events, train schedule, and other relevant data, **when** these data sets are received and processed, **then** they are successfully stored in the system for anomaly detection and prediction.
Verification method	T6.4_UC4.4_FRQ01_AC01_TC01
Expected result	The system successfully receives, processes, and stores all provided input data, utilizing it for accurate anomaly detection and prediction.

8.4.22 T6.4_UC4.4_NFRQ01_AC01

Acceptance criterion ID	T6.4_UC4.4_NFRQ01_AC01
Acceptance criterion description	**Given** that the system is prepared and compatible to receive and process the data covering delay predictions and occupancy forecasts, **when** the data is received, processed, and subsequently stored, **then** the aggregation, processing and storage of the data is completed within a reasonable time.
Verification method	T6.4_UC4.4_NFRQ01_AC01_TC01
Expected result	The system effectively completes the aggregation, processing, and storage of data within a reasonable, pre-defined timeframe.

8.4.23 T6.4_UC4.4_FRQ02_AC01

Acceptance criterion ID	T6.4_UC4.4_FRQ02_AC01
Acceptance criterion description	**Given** that the system has access to necessary data such as train occupancy and schedule data for training the anomaly detection model, **when** data preprocessing is executed, including data cleaning, data transformation and feature engineering, **then** appropriate machine learning algorithms are used to train the model to detect anomalies.
Verification method	T6.4_UC4.4_FRQ02_AC01_TC01, T6.4_UC4.4_FRQ02_AC01_TC02
Expected result	The system successfully preprocesses the data and utilizes the machine learning algorithms to train a model that can accurately detect anomalies and update a labelled dataset accordingly.

8.4.24 T6.4_UC4.4_FRQ03_AC01

Acceptance criterion ID	T6.4_UC4.4_FRQ03_AC01
Acceptance criterion description	**Given** that a functioning anomaly detection model exists in the system, and new processed data is being fed into the system, **when** this data is inputted into the existing model for retraining, **then** the model effectively incorporates the new data, validates successfully, and passes the performance evaluation.
Verification method	T6.4_UC4.4_FRQ03_AC01_TC01
Expected result	The anomaly detection model effectively integrates the new data, successfully updates its parameters during retraining, validates properly, and the test data confirms that the updated model is functioning effectively.

8.4.25 T6.4_UC4.4_NFRQ02_AC01

Acceptance criterion ID	T6.4_UC4.4_NFRQ02_AC01
Acceptance criterion description	**Given** that the system can be updated with new data and sufficient new data is available after a certain time interval, **when** the retraining intervals and the quality of vehicle anomaly detection accuracy are checked, **then** the system's retraining intervals and quality of detection accuracy are both at sufficient levels, maintaining a high update frequency alongside high-quality detection.
Verification method	T6.4_UC4.4_NFRQ02_AC01_TC01
Expected result	Both the retraining intervals of the system and the quality of its vehicle anomaly detection accuracy prove to be at satisfactory levels, indicating that the system maintains frequent updates without compromising on the quality of its detections.

8.4.26 T6.4_UC4.4_NFRQ03_AC01

Acceptance criterion ID	T6.4_UC4.4_NFRQ03_AC01
Acceptance criterion description	**Given** that mechanisms for evaluating the performance of the anomaly detection model are in place and sufficient new data is available, **when** accuracy metrics and validation test results are checked, **then** the anomaly detection model is documented with accuracy metrics and validation tests, and the post-fine-tuning model delivers improved results over the pre-fine-tuned model.
Verification method	T6.4_UC4.4_NFRQ03_AC01_TC01
Expected result	The anomaly detection model has its accuracy metrics and validation tests meticulously documented. The fine-tuning process results in an enhanced model with better performance metrics, achieving high accuracy while minimizing false positives and negatives.

8.4.27 T6.4_UC4.4_NFRQ03_AC02

Acceptance criterion ID	T6.4_UC4.4_NFRQ03_AC02
Acceptance criterion description	**Given** that mechanisms for fine-tuning the anomaly detection model are in place and sufficient new data is available, **when** the anomaly detection models parameters are fine-tuned, **then** the post-fine-tuning model delivers improved results over the pre-fine-tuned model.
Verification method	T6.4_UC4.4_NFRQ03_AC02_TC01
Expected result	The fine-tuning process results in an enhanced model with better performance metrics, achieving high accuracy while minimizing false positives and negatives.

8.4.28 T6.4_UC4.4_FRQ04_AC01

Acceptance criterion ID	T6.4_UC4.4_FRQ04_AC01
Acceptance criterion description	**Given** that the system has pre-processed data, including weather conditions, public/disruptive events, anomaly labelled data, train schedule, and other relevant optional data, **when** machine learning algorithms are used to train the model with this dataset and the model training is completed, **then** the test results of the trained model exceed the set threshold.
Verification method	T6.4_UC4.4_FRQ04_AC01_TC01, T6.4_UC4.4_FRQ04_AC01_TC02
Expected result	The test results of the trained anomaly prediction model successfully exceed the set performance threshold.

8.4.29 T6.4_UC4.4_FRQ05_AC01

Acceptance criterion ID	T6.4_UC4.4_FRQ05_AC01

Acceptance criterion description	**Given** that a functioning anomaly prediction model exists in the system and new data comprising weather conditions, public/disruptive events, anomaly labelled data, train schedule, and other relevant optional data is available, **when** this updated database is used to retrain the model, the updated model is validated, and its performance is evaluated using a test dataset, **then** the anomaly prediction model incorporates the new data effectively, updates its parameters, validates successfully, and performs effectively according to the evaluated test data.
Verification method	T6.4_UC4.4_FRQ05_AC01_TC01, T6.4_UC4.4_FRQ05_AC01_TC02
Expected result	The anomaly prediction model integrates the new data, updates its parameters during retraining, validates properly, and performs effectively based on the results of the test data evaluation.

8.4.30 T6.4_UC4.4_FRQ06_AC01

Acceptance criterion ID	T6.4_UC4.4_FRQ06_AC01
Acceptance criterion description	**Given** that a trained model for predicting anomalies based on weather conditions, public/disruptive events data and historical data is available, **when** the model is applied on new data, **then** new anomalies for a specified timeframe are predicted based on the new input data.
Verification method	T6.4_UC4.4_FRQ06_AC01_TC01
Expected result	The model successfully predicts new anomalies for the specified timeframe based on the newly received and processed data.

8.4.31 T6.4_UC4.4_NFRQ04_AC01

Acceptance criterion ID	T6.4_UC4.4_NFRQ04_AC01
Acceptance criterion description	**Given** that the system has capability to be updated with new data and sufficient new data is available after surpassing a certain time interval since the last update, **when** the retraining intervals are checked and the quality of anomaly prediction model accuracy is recorded and examined, **then** the system's retraining intervals and quality of prediction accuracy are both maintained at satisfactory levels, ensuring frequent updates and high-quality predictions.
Verification method	T6.4_UC4.4_NFRQ04_AC01_TC01
Expected result	The system effectively maintains its retraining intervals and the quality of prediction accuracy at satisfactory levels, achieving frequent updates and maintaining high-quality anomaly predictions.

8.4.32 T6.4_UC4.4_NFRQ05_AC01

Acceptance criterion ID	T6.4_UC4.4_NFRQ05_AC01
Acceptance criterion description	**Given** that the system has mechanisms for evaluating the training process of the model, including accuracy metrics and validations, **when** the system conducts accuracy metric tests, performs validation tests and fine-tunes the model parameters to improve performance, **then** the anomaly prediction model achieves high accuracy and minimizes false positives and negatives.
Verification method	T6.4_UC4.4_NFRQ05_AC01_TC01
Expected result	The system successfully performs the accuracy metric and validation tests, fine-tunes model parameters, and achieves high accuracy with minimized false positives and negatives in the anomaly prediction model.

8.4.33 T6.4_UC4.4_FRQ07_AC01

Acceptance criterion ID	T6.4_UC4.4_FRQ07_AC01
Acceptance criterion description	**Given** that the system assumes the availability of contextual information for predicted anomalies and that the information is in an easily integrated format, **when** the system receives the predicted anomalies, compiles the information into a structured message format and delivers it to the TMS, **then** it covers the weather conditions, public/disruptive events, and temporal features and if available, integrates more contextual information such as historical comparisons regarding similar conditions.
Verification method	T6.4_UC4.4_FRQ07_AC01_TC01, T6.4_UC4.4_FRQ07_AC01_TC02
Expected result	The system successfully compiles and delivers the structured message of predicted anomalies to the TMS, covering all required contextual information. If additional historical comparison data is available, the system incorporates it for enriched context.

8.4.34 T6.4_UC4.4_NFRQ06_AC01

Acceptance criterion ID	T6.4_UC4.4_NFRQ06_AC01
Acceptance criterion description	**Given** that the system assumes the availability of contextual information for predicted anomalies, **when** the system implements mechanisms for efficient structured message generation, automatic generation based on the predicted anomalies, and ensures that the contextual information is interpretable, **then** the system generates structured messages for predicted anomalies within a reasonable time.
Verification method	T6.4_UC4.4_NFRQ06_AC01_TC01
Expected result	The system successfully implements necessary mechanisms and generates interpretable structured messages for predicted anomalies within a reasonable timeframe.

8.4.35 T6.4_UC4.4_NFRQ07_AC01

Acceptance criterion ID	T6.4_UC4.4_NFRQ07_AC01
Acceptance criterion description	**Given** that the system assumes a configuration-driven design, allowing the utilization of configuration files to change/update message templates, **when** new message templates are integrated into the system, **then** the system ensures their interpretability and the main structure.
Verification method	T6.4_UC4.4_NFRQ07_AC01_TC01, T6.4_UC4.4_NFRQ07_AC01_TC02
Expected result	The system successfully integrates and stores new message templates, ensuring their interpretability and maintaining the format and main structure across various versions, proving easy maintenance and updates of the system.

8.5 Acceptance criteria task 6.5

8.5.1 T6.5_UC5.1_FRQ01_AC01

Acceptance criterion ID	T6.5_UC5.1_FRQ01_AC01
Acceptance criterion description	**Given** that the system has access to available data sources, **when** it needs data to train and apply the trained Machine Learning Model to predict delays **then** it gathers relevant data, including weather data (both forecast and observed conditions), train schedule and observed data, as well as train composition data.
Verification method	T6.5_UC5.1_FRQ01_AC01_TC01
Expected result	The system successfully gathers and processes all relevant data to train the Machine Learning Model and effectively predict delays in Regional Train services.

8.5.2 T6.5_UC5.1_FRQ02_AC01

Acceptance criterion ID	T6.5_UC5.1_FRQ02_AC01
Acceptance criterion description	**Given** the system has access to the forecasted occupancy data source, **when** this additional data relevant to predict schedule delays is gathered, **then** the system successfully utilizes it to enhance the training of the Machine Learning Model for delay prediction in Regional Train services.
Verification method	T6.5_UC5.1_FRQ02_AC01_TC01
Expected result	The system effectively incorporates the additional forecasted occupancy data to refine the training of the Machine Learning Model and consequently improve the accuracy of delay predictions in Regional Train services.

8.5.3 T6.5_UC5.1_PRQ01_AC01

Acceptance criterion ID	T6.5_UC5.1_PRQ01_AC01

Acceptance criterion description	**Given** the availability of reasonable processing hardware, **when** the system collects and processes data, **then** it successfully operates within the stipulated time frame of less than an hour, optimizing resource utilization and minimizing processing time.
Verification method	T6.5_UC5.1_PRQ01_AC01_TC01
Expected result	The system processes the collected data within a time frame of less than an hour, effectively optimizing resource utilization and ensuring the relevance and usability of the output (predicted delays) by the TSP.

8.5.4 T6.5_UC5.1_FRQ03_AC01

Acceptance criterion ID	T6.5_UC5.1_FRQ03_AC01
Acceptance criterion description	**Given** the availability of relevant data for training, **when** the system processes and transforms data into a suitable format, utilizes appropriate machine learning algorithms and techniques to train the model, **then** a trained model capable of making accurate predictions is successfully established, stored, and made available for necessary predictions.
Verification method	T6.5_UC5.1_FRQ03_AC01_TC01
Expected result	The system has successfully processed and transformed the data, trained the model using the appropriate machine learning algorithms and techniques, and successfully stored the trained model, making it available for accurate predictions as needed.

8.5.5 T6.5_UC5.1_FRQ04_AC01

Acceptance criterion ID	T6.5_UC5.1_FRQ04_AC01
Acceptance criterion description	**Given** the availability of newly collected observed data and previously collected data, **when** the system receives, processes, and integrates new data with historical data to update the dataset, and appropriate techniques and algorithms are used to update the model **then** an updated model that considers historical patterns and new data for accurate predictions is established.
Verification method	T6.5_UC5.1_FRQ04_AC01_TC01
Expected result	The system effectively collects and processes new data, integrates it with historical data, updates the model, and makes the updated model available for future use, thereby improving the accuracy of the predictions.

8.5.6 T6.5_UC5.1_FRQ05_AC01

Acceptance criterion ID	T6.5_UC5.1_FRQ05_AC01

Acceptance criterion description	**Given** the system has a trained Machine Learning model and new relevant data, **when** this trained model is applied to the newly collected data, **then** it successfully predicts delays.
Verification method	T6.5_UC5.1_FRQ05_AC01_TC01
Expected result	The system applies the trained Machine Learning model to newly collected data and accurately predicts delays.

8.5.7 T6.5_UC5.1_FRQ06_AC01

Acceptance criterion ID	T6.5_UC5.1_FRQ06_AC01
Acceptance criterion description	**Given** that the system has sufficient storage capacity to store the predicted delays for a year, **when** a continuous storage mechanism is implemented to store the predicted delays, **then** the system successfully stores all predicted delays, and deletes old ones if necessary.
Verification method	T6.5_UC5.1_FRQ06_AC01_TC01
Expected result	The system effectively stores all predicted delays using the implemented continuous storage mechanism, making stored data accessible for future reference, and deleting outdated data.

8.5.8 T6.5_UC5.1_FRQ07_AC01

Acceptance criterion ID	T6.5_UC5.1_FRQ07_AC01
Acceptance criterion description	**Given** the system has predicted delays stored and available to be accessed, **when** the TSP fetches the predicted delays, **then** the system successfully provides all requested predicted delays.
Verification method	T6.5_UC5.1_FRQ07_AC01_TC01
Expected result	The system successfully provides all requested predicted delays.

8.5.9 T6.5_UC5.1_NRFQ01_AC01

Acceptance criterion ID	T6.5_UC5.1_NFRQ01_AC01
Acceptance criterion description	**Given** that the system has a trained Machine Learning model and new relevant data, **when** the system periodically retrains the delay prediction model with the most recent data available, **then** the model remains up-to-date and provides the best predictions possible.
Verification method	T6.5_UC5.1_NFRQ01_AC01_TC01
Expected result	The system successfully retrains and updates the delay prediction model periodically with the most recent data, ensuring the model remains current and provides highly accurate predictions.

8.5.10 T6.5_UC5.2_FRQ01_AC01

Acceptance criterion ID	T6.5_UC5.2_FRQ01_AC01
Acceptance criterion description	**Given** that the data sources for Train's TMS and Bus Services are available, **when** the system gathers timetable data for both Train and Bus services, **then** it can effectively perform the identification of possible synchronization issues between timetables.
Verification method	T6.5_UC5.2_FRQ01_AC01_TC01, T6.5_UC5.2_FRQ01_AC01_TC02
Expected result	The system successfully collects relevant timetable data for Train and Bus services, thus enabling it to identify potential synchronization issues between the timetables.

8.5.11 T6.5_UC5.2_PRQ01_AC01

Acceptance criterion ID	T6.5_UC5.2_PRQ01_AC01
Acceptance criterion description	**Given** that reasonable processing hardware is available, **when** the system receives and processes new data efficiently to optimize resource utilization and minimize processing time, **then** the system successfully produces relevant output within an hour of receiving new input data.
Verification method	T6.5_UC5.2_PRQ01_AC01_TC01
Expected result	The system successfully processes the received data within an hour, demonstrating optimal resource utilization and efficient processing, resulting in timely and relevant output.

8.5.12 T6.5_UC5.2_FRQ02_AC01

Acceptance criterion ID	T6.5_UC5.2_FRQ02_AC01
Acceptance criterion description	**Given** that the relevant data has been collected, **when** the system analyses and processes the collected data, **then** it successfully identifies possible synchronization issues automatically.
Verification method	T6.5_UC5.2_FRQ02_AC01_TC01
Expected result	The system successfully analyses and processes the collected data, enabling the automatic identification of possible synchronization issues.

8.5.13 T6.5_UC5.2_FRQ03_AC01

Acceptance criterion ID	T6.5_UC5.2_FRQ03_AC01
Acceptance criterion description	**Given** that the system has enough storage capacity to store the output for at least 2 years, **when** a continuous storage mechanism is implemented to store the output, **then** the system successfully stores the identified synchronization issues for future access.
Verification method	T6.5_UC5.2_FRQ03_AC01_TC01
Expected result	The system effectively stores the synchronization issues identified using the implemented continuous storage mechanism, making the data accessible for at least two full annual cycles.

8.5.14 T6.5_UC5.2_FRQ04_AC01

Acceptance criterion ID	T6.5_UC5.2_FRQ04_AC01
Acceptance criterion description	**Given** that an external interface is implemented to facilitate access to the output of this module, **when** a TMS requests access to the data, **then** the identified synchronization issues are provided to the TMS.
Verification method	T6.5_UC5.2_FRQ04_AC01_TC01
Expected result	The system successfully implements an external interface leading to the TMS being able to fetch the identified synchronization issues.

8.5.15 T6.5_UC5.2_PRQ02_AC01

Acceptance criterion ID	T6.5_UC5.2_PRQ02_AC01
Acceptance criterion description	**Given** that reasonable processing hardware is available and relevant data present, **when** the system processes that data, **then** it identifies possible synchronization issues within an hour.
Verification method	T6.5_UC5.2_PRQ02_AC01_TC01
Expected result	The system effectively identifies possible synchronization issues within an hour, providing timely and relevant data to the TMS.

8.5.16 T6.5_UC5.3_FRQ01_AC01

Acceptance criterion ID	T6.5_UC5.3_FRQ01_AC01
Acceptance criterion description	**Given** that an interface with the traveller exists and is capable of receiving feedback, **when** a traveller provides feedback via the WebApp, **then** the system successfully collects and is ready to analyse and process this feedback.
Verification method	T6.5_UC5.3_FRQ01_AC01_TC01
Expected result	The system effectively gathers traveller feedback for further analysis and processing.

8.5.17 T6.5_UC5.3_FRQ02_AC01

Acceptance criterion ID	T6.5_UC5.3_FRQ02_AC01
Acceptance criterion description	**Given** that the WebApp is available to collect traveller feedback at any point in time, **when** a traveller sends feedback at different times of the day, **then** the system successfully receives and stores this feedback for further analysis and improvement with as minimal downtime as possible
Verification method	T6.5_UC5.3_FRQ02_AC01_TC01,
Expected result	The system effectively enables travellers to send feedback at any time via the WebApp, with as little downtime as possible

8.5.18 T6.5_UC5.3_FRQ03_AC01

Acceptance criterion ID	T6.5_UC5.3_FRQ03_AC01
Acceptance criterion description	**Given** that a TSP wants to interact with the system, **when** the TSP interacts with the system, **then** the Reporting Backoffice provides an interface that allows the TSP to visualize the reporting output and to request feedback from travellers based on a defined region.
Verification method	T6.5_UC5.3_FRQ03_AC01_TC01
Expected result	The Reporting Backoffice successfully provides an interface for the TSP to interact with the system, allowing the TSP to visualize the reporting output and request feedback from travellers based on a defined region.

8.5.19 T6.5_UC5.3_FRQ04_AC01

Acceptance criterion ID	T6.5_UC5.3_FRQ04_AC01
Acceptance criterion description	**Given** an interface with the traveller exists and can receive traveller feedback and that the traveller allows web browser notifications and location sharing for the WebApp, **when** the TSP defines regions in a map via an interface triggering notifications in the webapp for user feedback, **then** the system notifies all users which are within the specified area.
Verification method	T6.5_UC5.3_FRQ04_AC01_TC01
Expected result	The system effectively allows the TSP to request feedback from travellers in defined regions, enhancing the completeness of the network status information.

8.5.20 T6.5_UC5.3_NFRQ01_AC01

Acceptance criterion ID	T6.5_UC5.3_NFRQ01_AC01
Acceptance criterion description	**Given** that the WebApp is available to collect traveller feedback, **when** the user interface of the feedback collector is user-friendly and intuitive, **then** the system successfully enables users to understand the interface easily and e.g., adapt its layout to the screen size of the device it is used from.
Verification method	T6.5_UC5.3_NFRQ01_AC01_TC01, T6.5_UC5.3_NFRQ01_AC01_TC02
Expected result	The system provides a user-friendly and intuitive interface for the feedback collector, enabling users to easily understand the interface, provides meaningful feedback and adapts its layout to the respective screen size.

8.5.21 T6.5_UC5.3_NFRQ02_AC01

Acceptance criterion ID	T6.5_UC5.3_NFRQ02_AC01
Acceptance criterion description	**Given** that the WebApp is available to collect traveller feedback, **when** the WebApp is implemented to be compatible with most mobile devices, **then** the system successfully ensures a higher feedback rate by facilitating access for a wide range of mobile Operating Systems.
Verification method	T6.5_UC5.3_NFRQ02_AC01_TC01
Expected result	The WebApp is effectively compatible with most mobile devices, ensuring a high feedback rate by reaching travellers across a wide range of mobile Operating Systems.

8.5.22 T6.5_UC5.3_NFRQ03_AC01

Acceptance criterion ID	T6.5_UC5.3_NFRQ03_AC01
Acceptance criterion description	**Given** that the WebApp is available to collect traveller feedback, **when** the scope of the interface is focused on congestion (high amounts of passenger at trains and/or stations) and travellers provide information in a stepwise form, **then** the system successfully captures feedback specific to congestion.
Verification method	T6.5_UC5.3_NFRQ03_AC01_TC01
Expected result	The system successfully captures traveller feedback specifically focused on congestion (trains and/or station) via a stepwise form in the WebApp, enhancing its value in addressing congestion-related concerns.

8.5.23 T6.5_UC5.3_FRQ05_AC01

Acceptance criterion ID	T6.5_UC5.3_FRQ05_AC01
Acceptance criterion description	**Given** that the traveller feedback has been collected, **when** the system stores, analyses, and processes this collected feedback, **then** it successfully improves the knowledge about the network status, taking into account specific parameters and aggregating feedback from multiple travellers to increase confidence in the resulting information.
Verification method	T6.5_UC5.3_FRQ05_AC01_TC01
Expected result	The system successfully stores, analyses, and processes the collected traveller feedback, thereby enhancing understanding of the network status and increasing confidence in the results based on aggregated feedback from multiple travellers.

8.5.24 T6.5_UC5.3_FRQ06_AC01

Acceptance criterion ID	T6.5_UC5.3_FRQ06_AC01
Acceptance criterion description	**Given** that the system has enough storage capacity to store the output, **when** a continuous storage mechanism is implemented to store the output, **then** the system successfully stores the processed traveller feedback information via a continuous storage mechanism, making it accessible for future reference.
Verification method	T6.5_UC5.3_FRQ06_AC01_TC01, T6.5_UC5.3_FRQ06_AC01_TC02
Expected result	The system successfully implements a continuous storage mechanism and stores the processed traveller feedback information effectively, ensuring its availability for future access.

8.5.25 T6.5_UC5.3_FRQ07_AC01

Acceptance criterion ID	T6.5_UC5.3_FRQ07_AC01
Acceptance criterion description	**Given** that the processed traveller feedback information has been stored and is available to be accessed with each TSP having access to info for the area/stations they operate, raw data as well as the conducted analysis, **when** a TSP requests the processed information, **then** the TSP successfully receives the processed information, enhancing their understanding of the network status.
Verification method	T6.5_UC5.3_FRQ07_AC01_TC01
Expected result	Implementation of an external interface provides the TSP with successful access to both the raw data and conducted analysis related to their operational area/stations, allowing them to gather a more comprehensive understanding of the network status.

8.5.26 T6.5_UC5.3_NFRQ04_AC01

Acceptance criterion ID	T6.5_UC5.3_NFRQ04_AC01
Acceptance criterion description	**Given** that Traveller feedback has been collected, **when** the system processes the feedback, **then** the system successfully processes the congestion information within thirty minutes.
Verification method	T6.5_UC5.3_NFRQ04_AC01_TC01
Expected result	The system successfully processes the received traveller feedback within thirty minutes, keeping the processed congestion information up-to-date.

8.5.27 T6.5_UC5.4_FRQ01_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ01_AC01

Acceptance criterion description	**Given** demand data is available, **when** real-time or modelled passenger flow data (demand data) is needed, **then** the system should be able to collect this data from identified sources and store them in a database.
Verification method	T6.5_UC5.4_FRQ01_AC01_TC01
Expected result	Real-time or modelled passenger flow data (demand data) is collected from identified sources and stored in a database for further analysis.

8.5.28 T6.5_UC5.4_FRQ02_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ02_AC01
Acceptance criterion description	**Given** the availability of timetable data, **when** the system requires to collect timetable data, **then** the system collects the timetable and train platforming data from the specified Trenitalia internal sources and stores it in a database for subsequent analysis.
Verification method	T6.5_UC5.4_FRQ02_AC01_TC01
Expected result	The timetable and train platforming data is successfully collected from the specified Trenitalia internal sources and is stored in the database, confirming the system's capability to make it available for subsequent analysis.

8.5.29 T6.5_UC5.4_FRQ03_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ03_AC01
Acceptance criterion description	**Given** the availability of train punctuality data, **when** the system analyses a station, **then** the system considers train punctuality at the analysed station and stores it in a database for subsequent analysis.
Verification method	T6.5_UC5.4_FRQ03_AC01_TC01
Expected result	Train punctuality data for the analysed station is successfully considered by the system and is stored in the database, validating the system's ability to make it available for subsequent analysis.

8.5.30 T6.5_UC5.4_FRQ04_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ04_AC01
Acceptance criterion description	**Given** the availability of infrastructure data, **when** the system analyses a station, **then** the system considers the station geometry and the platform configuration at the analysed station and stores it in a database for subsequent analysis.
Verification method	T6.5_UC5.4_FRQ04_AC01_TC01
Expected result	The station geometry and platform configuration for the analysed station are successfully considered by the system and stored in the database.

8.5.31 T6.5_UC5.4_NFRQ01_AC01

Acceptance criterion ID	T6.5_UC5.4_NFRQ01_AC01
Acceptance criterion description	**Given** the ability to generate different scenarios or data update requests, **when** time-sensitive data updates or different configuration scenarios are available, **then** the system simulates the various scenarios and conducts a gap analysis.
Verification method	T6.5_UC5.4_NFRQ01_AC01_TC01
Expected result	The system successfully simulates different scenarios and conducts a gap analysis, demonstrating its ability to adapt to time-sensitive data updates or different configuration scenarios.

8.5.32 T6.5_UC5.4_FRQ05_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ05_AC01
Acceptance criterion description	**Given** that demand data has been collected and stored, **when** the system goes through the analysis process, **then** it analyses and processes the collected passenger flow data from the database initially for optimization and then for performance analysis.
Verification method	T6.5_UC5.4_FRQ05_AC01_TC01
Expected result	The system successfully analyses and processes the collected passenger flow data for optimization and performance analysis, demonstrating its ability to utilize the stored demand data effectively.

8.5.33 T6.5_UC5.4_FRQ06_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ06_AC01
Acceptance criterion description	**Given** that timetable data has been collected and stored, **when** the system goes through the analysis process, **then** it analyses and processes the collected timetable data from the database, initially for optimization and then for performance analysis.
Verification method	T6.5_UC5.4_FRQ06_AC01_TC01
Expected result	The system successfully analyses and processes the collected timetable data for optimization and performance analysis, demonstrating its ability to utilize the stored timetable data effectively.

8.5.34 T6.5_UC5.4_FRQ07_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ07_AC01
Acceptance criterion description	**Given** the availability of relevant data, **when** the system processes the input data and runs the optimization algorithm, **then** the system optimizes the allocation of trains to platforms in a way that allows maximum connection time for passengers and provides the best platform configuration as a result.
Verification method	T6.5_UC5.4_FRQ07_AC01_TC01
Expected result	The system successfully processes input data, runs the optimization algorithm, and optimizes the allocation of trains to platforms, allowing maximum connection time for passengers, and provides the best platform configuration.

8.5.35 T6.5_UC5.4_FRQ08_AC01

Acceptance criterion ID	T6.5_UC5.4_FRQ08_AC01
Acceptance criterion description	**Given** collected and stored timetable data, demand and infrastructure data are available, **when** the system has the optimized platform configuration completed, **then** the system evaluates congestion of passengers according to this optimized platform configuration using visualization and performance measurement tools.
Verification method	T6.5_UC5.4_FRQ08_AC01_TC01
Expected result	The system successfully evaluates congestion of passengers based on the optimized platform configuration, demonstrating its ability to use visualization and performance measurement tools effectively.

8.5.36 T6.5_UC5.4_NFRQ02_AC01

Acceptance criterion ID	T6.5_UC5.4_NFRQ02_AC01
Acceptance criterion description	**Given** that the scenario or input data is changed, **when** the system is updated accordingly, **then** the system reruns the analysis and optimization process efficiently and automatically to obtain an optimized configuration every time.
Verification method	T6.5_UC5.4_NFRQ02_AC01_TC01
Expected result	The system successfully reruns the process upon every update, demonstrating its ability to adapt and provide an optimized configuration efficiently and automatically whenever the scenario or input data is changed.

8.6 Acceptance criteria task 6.6

8.6.1 T6.6_UC6.1_FRQ01_AC01

Acceptance criterion ID	T6.6_UC6.1_FRQ01_AC01
Acceptance criterion description	**Given** the availability of static timetable data, **when** the system checks a train service's capacity for parcel transport, **then** the timetable data provides a flag in the data which lets the system identify whether a specific train service can transport parcels or not.
Verification method	T6.6_UC6.1_FRQ01_AC01_TC01
Expected result	The system correctly identifies which passenger train services can transport parcels, enabling it to calculate trip options that allow parcel shipment.

8.6.2 T6.6_UC6.1_FRQ02_AC01

Acceptance criterion ID	T6.6_UC6.1_FRQ02_AC01
Acceptance criterion description	**Given** a user searches a trip for a parcel or container of parcels, **when** a user interacts with the journey planning application, **then** the frontend provides an option for the user to see trip searches for a parcel or a container of parcels.
Verification method	T6.6_UC6.1_FRQ02_AC01_TC01
Expected result	The journey planning application successfully offers the user a dedicated cluster for suggested parcel trips in the overview of trip options.

8.6.3 T6.6_UC6.1_FRQ03_AC01

Acceptance criterion ID	T6.6_UC6.1_FRQ03_AC01
Acceptance criterion description	**Given** the availability of static timetable data with flags indicating whether a train can transport parcels or not, **when** the journey planning application computes trip options, **then** the journey planner computes trips for the transport of parcels including the first and last mile walks to the stations.
Verification method	T6.6_UC6.1_FRQ03_AC01_TC01, T6.6_UC6.1_FRQ03_AC01_TC02
Expected result	The journey planning application successfully computes trip options for the transport of a parcel, taking into consideration whether the train services facilitate parcel transport and if necessary, calculates a first and last mile walk for trip requests based on specific start and destination locations.

8.6.4 T6.6_UC6.1_FRQ04_AC01

Acceptance criterion ID	T6.6_UC6.1_FRQ04_AC01
Acceptance criterion description	**Given** that the parcel is transported within a region, with prices depending only on its size and weight, **when** the journey planning application prepares a trip option for a parcel shipment, **then** it provides a list of prices, which includes prices for parcels of different sizes and weights.
Verification method	T6.6_UC6.1_FRQ04_AC01_TC01
Expected result	The journey planning application successfully provides a list of prices for a trip option for a parcel shipment. The list accurately includes prices for parcels of different sizes and weights.

8.6.5 T6.6_UC6.1_NFRQ01_AC01

Acceptance criterion ID	T6.6_UC6.1_NFRQ01_AC01
Acceptance criterion description	**Given** the need to compute trip options for parcels between stations, **when** the journey planning application performs this calculation, **then** it must take at most 150% of the time that is needed for calculating a comparable trip for a traveller, disregarding the time required for data transfer between the server (backend) and a frontend.
Verification method	T6.6_UC6.1_NFRQ01_AC01_TC01
Expected result	The journey planning application successfully computes trip options for parcels between stations in a time duration that is at most 150% of the time taken to calculate a comparable trip for a traveller, thereby meeting the performance requirement.

8.6.6 T6.6_UC6.2_FRQ01_AC01

Acceptance criterion ID	T6.6_UC6.2_FRQ01_AC01
Acceptance criterion description	**Given** a regional train travels from a rural area to a city centre (or vice versa) and has *x* intermediate stops with containers with parcels to be loaded but only storage place for *y* containers with parcels with $y < x$, **when** capacity constraints for transporting containers with parcels are considered, **then** the timetable data must specify for each train service that can transport parcels at which stops a container can be loaded and unloaded, particularly if the train's capacity is insufficient to load/unload a container at each stop.
Verification method	T6.6_UC6.2_FRQ01_AC01_TC01
Expected result	The timetable data is successful in specifying for each train service that can transport parcels exactly at which stops a container can be loaded/unloaded, considering the capacity constraints related to transporting containers of parcels.

8.6.7 T6.6_UC6.2_FRQ02_AC01

Acceptance criterion ID	T6.6_UC6.2_FRQ02_AC01
Acceptance criterion description	**Given** that the journey planning application foresees a trip, **when**, parcels in a container are sent to different destinations and require sorting and consolidating at hubs, **then** sufficient time for the transfer of containers with parcels at hub stations is factored in.
Verification method	T6.6_UC6.2_FRQ02_AC01_TC01
Expected result	The journey planning application successfully factors in sufficient time for the transfer of containers with parcels at hub stations in its trip forecasts, thus providing realistic duration for trips.

8.6.8 T6.6_UC6.2_FRQ03_AC01

Acceptance criterion ID	T6.6_UC6.2_FRQ03_AC01
Acceptance criterion description	**Given** the system processes the timetable data correctly, **when** parcels are loaded at a normal station, **then** it ensures that these containers are unloaded only at a hub, which is especially relevant for train services between hubs that also have normal stations as intermediate stops.
Verification method	T6.6_UC6.2_FRQ03_AC01_TC01
Expected result	The system successfully processes the timetable data and ensures that containers loaded at a normal station are unloaded only at a hub, thus upholding the requirement that parcels reach their designated destinations correctly.

8.6.9 T6.6_UC6.2_FRQ04_AC01

Acceptance criterion ID	T6.6_UC6.2_FRQ04_AC01
Acceptance criterion description	**Given** a parcel is sent from address-to-address, **when** the user requests trip options for a parcel from address-to-address including first and last mile journey legs, **then** the journey planner must calculate trip options which include a first mile leg from the start address to a parcel locker, transfers, and a last mile leg from a parcel locker to the destination address.
Verification method	T6.6_UC6.2_FRQ04_AC01_TC01
Expected result	The journey planning application accurately calculates trip options for a parcel considering all necessary constraints and factors, and provides options that include a first mile leg, transfers, and a last mile leg, thus allowing a user to check how fast a parcel can be sent in passenger trains from address to address.

8.6.10 T6.6_UC6.2_NFRQ01_AC01

Acceptance criterion ID	T6.6_UC6.2_NFRQ01_AC01
Acceptance criterion description	**Given** the need to compute trip options for parcels between addresses sent via parcel lockers, **when** the journey planning application performs this calculation, **then** it must take at most 150% of the time that is needed for calculating a comparable trip for a traveller, disregarding the time required for data transfer between the server (backend) and a frontend.
Verification method	T6.6_UC6.2_NFRQ01_AC01_TC01
Expected result	The journey planning application successfully computes trip options for parcels between addresses sent via parcel lockers in a time duration that is at most 150% of the time taken to calculate a comparable trip for a traveller, thereby meeting the performance requirement.

8.6.11 T6.6_UC6.3_FRQ01_AC01

Acceptance criterion ID	T6.6_UC6.3_FRQ01_AC01
Acceptance criterion description	**Given** there is a frontend for users from a CEP company**, when** a user from a CEP company engages with the frontend of the journey planning application to search for trips for parcels, **then** the frontend offers extended options that allow the user to specify the type and the number of swap bodies or mobile parcel lockers that are to be transported.
Verification method	T6.6_UC6.3_FRQ01_AC01_TC01
Expected result	The frontend of the journey planning application successfully allows users from CEP companies to make specifications about the type and quantity of swap bodies or mobile parcel lockers that should be transported whenever a search request for trips for parcels is made.

8.6.12 T6.6_UC6.3_FRQ02_AC01

Acceptance criterion ID	T6.6_UC6.3_FRQ02_AC01
Acceptance criterion description	**Given** the availability of up-to-date data about the remaining capacity for swap bodies/mobile parcel lockers in all trains and for all sections of a service, **when** the PIS backend calculates trip options for requests from CEP companies, **then** it considers the current available capacity, which includes accounting for any previous bookings that reduces remaining capacity.
Verification method	T6.6_UC6.3_FRQ02_AC01_TC01
Expected result	The PIS backend successfully utilizes the available capacity data for different types of swap bodies and mobile parcel lockers in its calculations of trip options for CEP companies, effectively considering the available capacity and any impacts from previous bookings.

8.6.13 T6.6_UC6.3_FRQ03_AC01

Acceptance criterion ID	T6.6_UC6.3_FRQ03_AC01
Acceptance criterion description	**Given** the availability of data about the available capacity for swap bodies/mobile parcel lockers, **when** the journey planning application calculates trips for these items, **then** it considers capacity constraints for each leg of the trip, ensuring that only trip options with sufficient remaining capacity across all legs are returned.
Verification method	T6.6_UC6.3_FRQ03_AC01_TC01
Expected result	The journey planning application successfully calculates trips for swap bodies/mobile parcel lockers, considering capacity constraints for each trip leg. It only returns trip options with sufficient remaining capacity across all legs, ensuring the feasibility of suggested trips in relation to capacity constraints.

8.6.14 T6.6_UC6.3_NFRQ01_AC01

Acceptance criterion ID	T6.6_UC6.3_NFRQ01_AC01
Acceptance criterion description	**Given** the need to compute trip options for parcels sent by CEP companies via swap bodies/mobile parcel lockers, **when** the journey planning application performs this calculation, **then** it must take at most 150% of the time that is needed for calculating a comparable trip for a traveller, disregarding the time required for data transfer between the server (backend) and a frontend.
Verification method	T6.6_UC6.3_NFRQ01_AC01_TC01
Expected result	The journey planning application successfully computes trip options for parcels sent by CEP companies via swap bodies/mobile parcel lockers in a time duration that is at most 150% of the time taken to calculate a comparable trip for a traveller.

8.7 Acceptance criteria task 6.8

8.7.1 T6.8_UC8.1_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.1_FRQ01_AC01
Acceptance criterion description	**Given** the BIA is approached by another department for insights, **when** the BI analyst uses drag and drop functionality to select data sources and visualisation methods, **then** the analytics platform generates a report based on the selection.
Verification method	T6.8_UC8.1_FRQ01_AC01_TC01
Expected result	The system generates a report based on the selected data and visualisation method

8.7.2 T6.8_UC8.2_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.2_FRQ01_AC01
Acceptance criterion description	**Given** a traffic manager wants to adjust the train schedule based on upcoming demand, **when** they approach the BIA, **then** the BI analyst can generate the demand forecast on trains and line sections.
Verification method	T6.8_UC8.2_FRQ01_AC01_TC01 T6.8_UC8.2_FRQ01_AC01_TC02
Expected result	The traffic manager receives the report on demand forecast for trains and line sections so they can adjust the train schedule accordingly

8.7.3 T6.8_UC8.3_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.3_FRQ01_AC01
Acceptance criterion description	**Given** a train operation manager wants to use customer feedback to guarantee service quality, **when** they approach the BIA, **then** the BI analyst can generate a report with the relevant customer feedback with the analytics tool.
Verification method	T6.8_UC8.3_FRQ01_AC01_TC01
Expected result	The train operation manager receives the report on customer feedback for their lines and can use it to guarantee service quality

8.7.4 T6.8_UC8.3_NFRQ01_AC01

Acceptance criterion ID	T6.8_UC8.3_NFRQ01_AC01
Acceptance criterion description	**Given** a customer provides feedback on the service quality of the application, **when** the feedback data is submitted, **then** the data is stored in a database which is accessible by the analytics tool in the backend of the system.
Verification method	T6.8_UC8.3_NFRQ01_AC01_TC01
Expected result	The BIA can access customer feedback data from the analytics tool.

8.7.5 T6.8_UC8.4_DTRQ01_AC01

Acceptance criterion ID	T6.8_UC8.4_DTRQ01_AC01
Acceptance criterion description	**Given** the necessity of changes to the software configurations or procedures these changes are performed, **then** the administrator lists these changes in t respective document.
Verification method	

<table>
<tr><td></td><td><h3>8.7.6 T6.8_UC8.3_NFRQ01_AC01_TC01</h3>
<table>
<tr><td>Test case ID</td><td>T6.8_UC8.3_NFRQ01_AC01_TC01</td></tr>
<tr><td>Test case description</td><td>Access to customer feedback data</td></tr>
<tr><td>Preconditions</td><td>1. Customers provided feedback data
2. Customer feedback data is accessible</td></tr>
<tr><td>Trigger</td><td>The Train Operation Manager (TOM) requests the BIA to an customer feedback</td></tr>
<tr><td>Test steps</td><td>1. BIA starts to generate the report on customer feedback i analytics tool
2. The analytics tool accesses customer feedback data</td></tr>
<tr><td>Expected results</td><td>Customer feedback data can be accesses and used to gener report with the backend analytics tool</td></tr>
</table>
T6.8_UC8.4_DTRQ01_AC01_TC01</td></tr>
<tr><td>Expected result</td><td>The software is documented to provide reference for new team members ab configurations, procedures, and changes</td></tr>
</table>

8.7.7 T6.8_UC8.5_ORQ01_AC01

Acceptance criterion ID	T6.8_UC8.5_ORQ01_AC01
Acceptance criterion description	**Given** a loss of data, **when** the administrator accesses the data backup, **then** the lost data can be restored.
Verification method	T6.8_UC8.5_ORQ01_AC01_TC01
Expected result	Lost data can be restored under the conditions of the data retention policy

8.7.8 T6.8_UC8.6_ORQ01_AC01

Acceptance criterion ID	T6.8_UC8.6_ORQ01_AC01
Acceptance criterion description	**Given** a loss of data, **when** the administrator accesses the data backup, **then** the lost data can be restored by retrieving the backed-up data.
Verification method	T6.8_UC8.6_ORQ01_AC01_TC01
Expected result	Lost data can be restored under the conditions of the data retention policy

8.7.9 T6.8_UC8.7_RCRQ01_AC01

Acceptance criterion ID	T6.8_UC8.7_RCRQ01_AC01
Acceptance criterion description	**Given** that a standard, rule, or law requires certain behaviour, **when** the situation occurs, **then** the critical information (or behaviour) is protocolled in the respective log file.
Verification method	T6.8_UC8.7_RCRQ01_AC01_TC01
Expected result	The logs can be used to prove compliance with standards, rules, and laws or to highlight shortcomings

8.7.10 T6.8_UC8.8_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.8_FRQ01_AC01
Acceptance criterion description	**Given** an end user query for routes from a starting to an end point, **when** the starting and end point are in different countries or feasible routes lead through another country, **then** these routes are considered during trip planning.
Verification method	T6.8_UC8.8_FRQ01_AC01_TC01
Expected result	The software takes routes through other countries into account when planning a journey

8.7.11 T6.8_UC8.9_PRQ01_AC01

Acceptance criterion ID	T6.8_UC8.9_PRQ01_AC01
Acceptance criterion description	**Given** a peak in the usage of the solution, **when** the number of end users simultaneously using the solution remains below the estimated number characteristics for the region/country, **then** no reduction in performance is observable.
Verification method	T6.8_UC8.9_PRQ01_AC01_TC01
Expected result	There is no noticeable reduction in performance, as long as there are no more than multiple end users depending on the region/country simultaneously using the software

8.7.12 T6.8_UC8.10_PRQ01_AC01

Acceptance criterion ID	T6.8_UC8.10_PRQ01_AC01
Acceptance criterion description	**Given** end users' expectation that the solution is always available, **when** an issue occurs, **then** there are failover mechanisms in place that guarantee that the system is back online immediately guaranteeing annual availability of at least 99.9%.
Verification method	T6.8_UC8.10_PRQ01_AC01_TC01
Expected result	The annual availability of the system, excluding maintenance downtimes, exceeds 99.9%

8.7.13 T6.8_UC8.11_PRQ01_AC01

Acceptance criterion ID	T6.8_UC8.11_PRQ01_AC01
Acceptance criterion description	**Given** annual system availability of at least 99.9%, **when** an issue occurs, **then** the redundant infrastructure minimises downtime.
Verification method	T6.8_UC8.11_PRQ01_AC01_TC01
Expected result	The downtime of the solution is minimised, allowing for annual availability of at least 99.9%

8.7.14 T6.8_UC8.12_FRQ01_AC01, T6.8_UC8.13_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.12_FRQ01_AC01, T6.8_UC8.13_FRQ01_AC01
Acceptance criterion description	**Given** a user requests the creation of a dashboard to derive business insight from a BIA, **when** the BIA creates the dashboard as visualisation interface within the analytics tool and implements the requested features, **then** a dashboard provides a low code interface with which the requesting user can visualise data in graphs which were predetermined by the BIA.
Verification method	T6.8_UC8.12_FRQ01_AC01_TC01, T6.8_UC8.13_FRQ01_AC01_TC01
Expected result	A dashboard which provides a low code interface for visualising the requested data for the derivation of business insights

8.7.15 T6.8_UC8.12_FRQ02_AC01, T6.8_UC8.13_FRQ02_AC01

Acceptance criterion ID	T6.8_UC8.12_FRQ02_AC01, T6.8_UC8.13_FRQ02_AC01
Acceptance criterion description	**Given** a user want to derive business insights from system data, **when** the user selects the desired data sets, time period and graph type in the visualisation interface within the analytics tool, **then** the previously selected data is visualised in a graph in the dashboard.
Verification method	T6.8_UC8.12_FRQ02_AC01_TC01, T6.8_UC8.13_FRQ02_AC01_TC01
Expected result	A graph visualising the selected data to enable the derivation of business insights

8.7.16 T6.8_UC8.14_FRQ01_AC01, T6.8_UC8.15_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.14_FRQ01_AC01, T6.8_UC8.15_FRQ01_AC01
Acceptance criterion description	**Given** a user needs demand forecasts which are derived from historic data for data driven decision making, **when** a BIA uses the forecasting interface within the analytics tool and chooses the journey leg, data sets, other constraints, and the forecasting time period, **then** the analytics tool forecasts demand for the chosen inputs and visualise the forecast.
Verification method	T6.8_UC8.14_FRQ02_AC02_TC02, T6.8_UC8.15_FRQ02_AC02_TC02
Expected result	The analytics tool shall forecast and visualise demand, with regards to the input provided by the user.

8.7.17 T6.8_UC8.16_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.16_FRQ01_AC01
Acceptance criterion description	**Given** that a travel plan exists, **when** changes to the travel occur, **then** the user gets notified.
Verification method	T6.8_UC8.16_FRQ01_AC01_TC01

Expected result	A new travel is planned to cover the traveller needs

8.7.18 T6.8_UC8.17_FRQ01_AC01

Acceptance criterion ID	T6.8_UC8.17_FRQ01_AC01
Acceptance criterion description	**Given** a new DRT service provider **when** waiting to join in the "ecosystem", **then** the on-demand service provider is given the possibility to express his interest and register the relevant information in available form(s).
Verification method	T6.8_UC8.17_FRQ01_AC01_TC01
Expected result	Demonstration of interest form is uploaded

9 Testing Strategy

An effective software testing strategy is essential to ensure the delivery of a high-quality product. For this purpose, the testing strategy addresses the following components:

1. Scope and objectives,
2. Test levels and techniques,
3. Test environment and infrastructure,
4. Test data,
5. Roles and Responsibilities,
6. Documentation and reporting.

9.1 Scope and Objectives

The primary objective of software testing is to ensure that the software meets all the specified requirements and performs as expected in the intended environment. This includes the validation of requirements, ensuring performance standards (such as load time, response time, and handling of concurrent users) and checking conformity with industry standards and regulations. Tests are executed to maximize usability and stability to ensure ease of use and accessibility. Additionally, the strategy aims to identify and resolve defects, enhance software quality, and provide confidence and assurance to stakeholders.

The testing covers all aspects of the application. It encompasses a range of user roles and scenarios to thoroughly test the application in real-world conditions. Because different users interact with different parts of the software, the testing areas are structured in the following manner:

1. User interface,
2. Backend service,
3. Demand-responsive and routing algorithms,
4. Analytics tool,
5. External systems.

The user interface is of particular interest for the end-user. Functional tests involve checking the correct insertion and recognition of train/bus stops as well as insertion of the own location for first/last mile services into an origin and destination field. The testing involves checking the functionality of different preference settings and the filtering of routes and route suggestions. For persons with reduced mobility, it must be ensured that the operational readiness of escalators etc. is correctly displayed.

Other user groups, like the administrator are responsible for the backend services. Here, tests of the redundant architecture, the creation of log-files for failed actions and the recovery of data must be proofed.

Both, backend services and user interface are accompanied by various algorithms such as the demand-based and routing algorithms which must be verified. In this stage, the duration as well as the validity of the algorithms calculating the routing requests is checked.

Further affected users are experts from the subject area who rely indirectly on the analytics tool for e.g., timetable planning. Relevant functionalities are the graph generation from databases as well as the connection to databases for the retrieval of processed data/offers. This leads to a combination of offers available for the experts in the field.

For first/last mile services it is essential that external systems from third-party providers are incorporated. Consequently, checks of visibility of the offers and a sanity check regarding the interplay with regional rail services must be conducted.

9.2 Test-levels and techniques

The test suite applied is comprised of

- L1 Unit tests,
- L2 Integration tests,
- L3 User Acceptance tests,
- L4 Regression tests,
- L5 Stress tests,

where the tests are sorted by their level (L) in ascending order, indicating when the tests are to be carried out.

Unit testing is a crucial practice in software development that helps maintain high-quality standards, facilitates agile methodologies, reduces costs, and boosts developer confidence by allowing them to make changes without fear of unintended consequences.

Integration testing is essential for verifying the interactions between different parts of a software application, ensuring that they work together correctly and efficiently. This process helps in identifying issues that are not apparent at the unit level, thereby improving the quality, reliability, and performance of the final product.

User Acceptance Testing is important for ensuring that the software meets business requirements, is user-friendly, and operates effectively in its intended environment. It plays a key role in achieving user satisfaction, reducing post-launch issues, and ensuring a successful implementation. For user acceptance testing, the current version of the application is released to a limited user base for feedback.

Regression testing is needed after a code update to ensure that the update introduced no new bugs. Regression testing can be automated, to allow a fast repetition of tests.

Stress testing is essential for assessing a system's ability to maintain performance, reliability, and stability under extreme or unexpected conditions. It helps identify potential weaknesses and guides optimizations to ensure the system remains robust and efficient, even when pushed beyond its typical operational limits.

Disaster Recovery and Failover Testing is typically done to validate backup procedures and the application's ability to seamlessly failover to backup systems. However, these shall not be part of the testing strategy as they are too complex for a demonstrator.

Moreover, the tests must be distinguished by the respective testing technique used. At first it is tested how individual units interact (white box) and later if the overall functionality works (black box). Unit tests are to be carried out as white box tests, as the internal structure, design, and implementation of the item being tested are known to the tester. Both user acceptance tests based on the use cases and stress tests are carried out as black box tests. The integration tests are to combine white and black box testing techniques. Depending on the purpose of the regression test these tests are either white or black box tests.

In addition, we recommend using a code coverage monitoring tool that allows to keep track of the (un)tested parts of code during testing.

9.3 Test Data and Test environment

Ideally, the system is to be divided into a development, a test, and a production environment so that further development and testing can be performed without affecting production. The developers shall work on the development environment and push completed code for testing to the test environment. Since the demonstration of the system will be on a rather small scale comprising a small group of participants who use the system, test and demonstration environment will coincide into one stage for the FP6 FutuRe project.

For data preparation, representative test data that mimics real-world scenarios for comprehensive testing must be created. It is paramount that the data used during the test phase is either based on real-world data or mimics this data sufficiently well. The adherence to data security standards and General Data Protection Regulation (GDPR) must be considered.

Simultaneously it is adhered to data security. It is of major importance to ensure that any sensitive or personal data used in testing is protected or anonymized.

9.4 Roles and Responsibilities

The testing team will be comprised of the following roles:

1. Test lead/manager: The Test lead/manager is responsible for the selection of the right test tools, quality assurance and adherence to timelines.
2. Test engineers: The Test engineers design test scenarios, execute tests and report bugs.
3. Test Automator: Due to the high number of tests, it is necessary to introduce the role of a software test Automator. The software test Automator designs automated test scripts that are reusable. Additionally, it is ensured that all automated testing related activities are carried out as per the standards and regulatory framework dependent on the country.
4. Software development team: The software development team remediates the reported bugs.
5. Release Management: The Release Management plans the releases for testing and is responsible for development of software development procedures.
6. Business Analyst: Accompanied by the more software-related responsibilities the Business Analyst aligns the testing procedure with business requirements and assists in User Acceptance Test (UAT).
7. Quality Assurance Team: A dedicated Quality Assurance team ensures that the product meets quality standards and that the testing is thorough.

9.5 Documentation, reporting, and metrics

Comprehensive documentation of all test scenarios, plans, and cases will be maintained, with regular updates provided on testing progress, issues, and quality metrics.

Test cases are to be described and tracked in a coherent form. The template is shown below.

Test Case ID	A unique identifier for the test case
Test Case Description	A brief description of the test case
Preconditions	The conditions that must be met before the test case can be executed
Trigger	Opening action of an involved actor
Test steps	The steps that are taken to execute the test case
Expected results	The expected outcome of the test case

Remark: m-n relation with acceptance criteria

The “Test Case ID” is number which is very similar to the “Acceptance Criteria ID” and can be interpreted in the same way. Exemplarily, the ID “T6.1_UC1.1.3_FRQ02_AC01_TC01“ says that this test case was derived from the first acceptance criteria of the second functional requirement of the third use case from task 6.1.1.

For conducting and documenting the tests the table below can function as a documentation template.

Test Case ID	A unique identifier for the test case
Tester	Name and Company
Time and date	Time: XX:YY; Date: DDMMYYY
Feature	Short descriptive name
Hardware	What hardware was used for testing
Software version	Version of the tested software
Tools used for testing	What tools were used for testing
Testing steps	Step 1 Step 2 …
Actual Results	Outcome of the test
Status	The status of the test case (pass, fail, or pending)

10 Test Cases

10.1Methodology of Test Case definition

The test cases are derived from the requirements. They are linked via the use-cases ID, connecting use cases, requirements and acceptance criteria defined above. Within the test case template, a short description of the case is provided. Thereafter the preconditions are outlined followed by the presentation of the test steps. At the end of the template the expected results are shown.

The test sequences are to be applied to the system in the respective test environment and the results to be recorded. The recorded results are compared to the expected outcome from the test case template. The possible results are:

- Pass: The actual outcome is identical or sufficiently close to the expected outcome.
- Fail: The actual outcome diverges from the expected outcome.
- Pending: The test has not been completed e.g., because an earlier test step failed.

10.2Test cases task 6.1.1

10.2.1 T6.1_UC1.1.1_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.1.1_FRQ01_AC01_TC01
Test case description	The system shall be able to gather data from the TSP and DRT service providers
Preconditions	TSP and DRT data is provided and made accessible
Trigger	The TSP and DRT source systems provide files (timetable and availability information)
Test steps	1. The TSP and DRT source systems provide files (timetable and availability information) 2. The travel planning system can gather the provided files from the TSP and DRT service providers
Expected results	The system has gathered the necessary data in a suitable format so that the trip search engine can provide the user multimodal route suggestions

10.2.2 T6.1_UC1.1.1_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.1.1_FRQ02_AC01_TC01
Test case description	The system can calculate and display multimodal route suggestions
Preconditions	TSP and DRT data is provided, made accessible and the system can access this data in a suitable format for the search engine
Trigger	A user requests a multimodal travel route
Test steps	1. A user requests a multimodal travel route 2. The system processes the request and calculates a multimodal travel route based on the user's input
Expected results	The journey planning application can compute and display trips that combine public transport legs with DRT legs for first and/or last mile.

10.2.3 T6.1_UC1.1.1_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.1.1_FRQ03_AC01_TC01
Test case description	Trip planning user interface with location suggestions
Preconditions	The system has a suggestion feature implemented and has access to relevant POI data
Trigger	A user types something in the destination or origin interface
Test steps	1. A user types something in the destination or origin interface 2. The system processes each input and makes suggestions based on it
Expected results	The user gets location suggestions which match the user's input so that the address, POI, station/stop, etc. do not need to be fully written out

10.2.4 T6.1_UC1.1.1_FRQ04_AC01_TC01

Test case ID	T6.1_UC1.1.1_FRQ04_AC01_TC01
Test case description	Verify the integration of the system with the API of the DRT (Demand Responsive Transport) system.
Preconditions	A documented API is provided by the DRT service provider
Trigger	Information from a DRT service provider is requested
Test steps	1. Initiate a routing request specifying the use of a DRT service provider. 2. The system utilizes user-provided input data (e.g., origin, destination, departure/arrival time) to generate a request to the API of the designated DRT service provider.
Expected results	The API responds with the requested information, including details relevant to the routing request. The journey planning system incorporates the available DRT data from the response into the trip planning suggestions.

10.2.5 T6.1_UC1.1.1_PRQ01_AC01_TC01

Test case ID	T6.1_UC1.1.1_PRQ01_AC01_TC01

Test case description	Performance of the journey planning system without DRT services included
Preconditions	A journey planning system is ready for operation; there is no need to validate DRT services for the routing request; system shall be under realistic load and performance
Trigger	A user queries a route in the journey planning system
Test steps	1. A user queries the journey planner to provide a travel route 2. Time measuring is started with the query 3. Route is calculated and sent to the requesting user device 4. Time measuring is stopped as soon as feasible routes sent to the requesting user device
Expected results	The routes are calculated and sent back within 3 seconds on average. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

10.2.6 T6.1_UC1.1.1_PRQ01_AC01_TC02

Test case ID	T6.1_UC1.1.1_PRQ01_AC01_TC02
Test case description	Performance of the journey planning system with the validation of DRT legs included
Preconditions	A journey planning system is ready for operation; system shall be under realistic load and performance
Trigger	A user queries a route with the journey planning system
Test steps	1. A user queries the journey planner to provide a travel route which includes a DRT leg 2. Time measuring is started with the query 3. Route is calculated and sent to the requesting user device 4. Time measuring is stopped as soon as feasible routes sent to the requesting user device
Expected results	The routes are on average displayed within 5 seconds. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

10.2.7 T6.1_UC1.1.2_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.1.2_FRQ01_AC01_TC01
Test case description	Collection of data regarding rules of competition by the system
Preconditions	Rules of competition exist, and data is available
Trigger	Rules of competition data needs to be inserted or updated for later usage
Test steps	1. Rules of competition data needs to be inserted or updated for later usage 2. System gathers the rules of competition data in a suitable data format
Expected results	The rules of competition data are gathered in a suitable data format so that it can be used for the search engine

10.2.8 T6.1_UC1.1.2_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.1.2_FRQ02_AC01_TC01
Test case description	Computation of trips in accordance with the rules of competition
Preconditions	Data from rules of competition is gathered and available in a format which is useable by the search engine.
Trigger	A user queries a trip planning request on which rules of competition must be considered
Test steps	1. A user queries a trip planning request for a route on which rules of competition must be considered 2. System considers user input and rules of competition to calculate and suggest routes
Expected results	Routes considering and following the rules of competition are suggested

10.2.9 T6.1_UC1.1.2_PRQ01_AC01_TC01

Test case ID	T6.1_UC1.1.2_PRQ01_AC01_TC01
Test case description	Performance of the journey planning system under consideration of rules of competition but without DRT services included
Preconditions	A journey planning system is ready for operation; system shall be under realistic load and performance; rules of competition must be considered
Trigger	A user queries a route with the journey planning system
Test steps	1. A user queries the journey planner to provide a travel route 2. Time measuring is started with the query 3. Route is calculated and sent to the requesting user device 4. Time measuring is stopped as soon as feasible routes sent to the requesting user device
Expected results	The routes are on average displayed within (2sec + 3sec) * (100% + 150%) on average. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

10.2.10 T6.1_UC1.1.3_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.1.3_FRQ01_AC01_TC01
Test case description	A simulation system specifically designed for DRT service providers shall be set up
Preconditions	A simulation system specifically designed for DRT service providers is set up
Trigger	A DRT service provider starts to set up a new area or optimize an existing one
Test steps	1. A user sets up a scenario for a given timeframe with supply configurations for a DRT service and starts the simulation 2. The simulation calculates given metrics based on the supply input
Expected results	There is a simulation system in place which is specifically designed to support resource allocation for DRT service providers. The simulation system must consider demand (i.e., DRT trip requests), supply (vehicles), compute how a DRT production system would likely react with the given demand/supply and calculate resulting metrics.

10.2.11 T6.1_UC1.1.3_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.1.3_FRQ02_AC01_TC01
Test case description	Simulation of a DRT fleet serving trip requests
Preconditions	A simulation system specifically designed for DRT service providers is set up

Trigger	A DRT service provider runs a simulation to assess service quality
Test steps	1. A DRT service provider runs a simulation to assess service quality 2. The simulation software uses demand forecast data to simulate how capacity offers will meet the forecasted demand
Expected results	The simulation system should derive a list of DRT trip requests specified by origin, destination, departure time from travel demand data and assign vehicles of a given fleet to trip requests considering the availability of vehicles.

10.2.12 T6.1_UC1.1.3_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.1.3_FRQ03_AC01_TC01
Test case description	The simulation system must provide metrics after a simulation run that allows to assess the service quality reached for a given scenario.
Preconditions	A simulation system specifically designed for DRT service providers is set up
Trigger	A DRT service provider runs a simulation to assess service quality
Test steps	1. A DRT service provider runs a simulation to assess service quality 2. The simulation system calculates and displays metrics for assessing service quality
Expected results	Based on demand forecast (derived from DRT trip requests) and supply assignments to the demand forecast the simulation system calculated and provided metrics that indicate the quality of service regarding different dimensions, e.g. **user experience indicators:** share of demand covered, average waiting time for pick up after requested departure time **deviation indicators:** detour rate by time and by distance **operational indicators:** total distance covered by each vehicle, including commercial and non-commercial distances; maximum number of passengers on board (to determine vehicle size) **performance indicators:** pooling rate; number of passengers per vehicle hour

10.2.13 T6.1_UC1.1.4_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.1.4_FRQ01_AC01_TC01
Test case description	Receiving external trip search requests via OJP 2.0
Preconditions	The trip planning system can receive requests via OJP 2.0 protocol
Trigger	The trip planning system receives a request from an external trip planning system via an OJP 2.0 protocol
Test steps	1. The trip planning system receives a request from an external trip planning system via an OJP 2.0 protocol 2. The system's receiving component (passive server adapter) must convert the request into the (proprietary) format of the underlying journey planning application 3. The system's receiving component forwards it to the application
Expected results	The system converted and forwarded the external request to the internal journey planner to calculate a journey based on the input provided by the external request

10.2.14 T6.1_UC1.1.4_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.1.4_FRQ02_AC01_TC01
Test case description	Answering OJP trip search requests with trip options
Preconditions	The trip planning system can receive and process requests via OJP 2.0 protocol
Trigger	The trip planning system receives a request from an external trip planning system via an OJP 2.0 protocol
Test steps	1. The trip planning system receives a request from an external trip planning system via an OJP 2.0 protocol 2. The system processes the received request and calculates trip options in the internal journey planning application 3. The Passive Server Adapter converts the response of the internal journey planning application into the OJP 2.0 format 4. After conversion the Passive Server Adapter sends the response to the Active Server Adapter of the calling system
Expected results	The system sends an answer to the external call via the OJP 2.0 protocol which provides the requested trip options

10.2.15 T6.1_UC1.1.4_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.1.4_FRQ03_AC01_TC01
Test case description	DRT options can also be requested by external sources using the OJP 2.0 protocol
Preconditions	The trip planning system can receive, process and answer requests via OJP 2.0 protocol
Trigger	The trip planning system receives a request from an external trip planning system which includes DRT options via an OJP 2.0 protocol
Test steps	1. The trip planning system receives a request from an external trip planning system which includes DRT options via an OJP 2.0 protocol 2. The system processes the received request and calculates trip options in the internal journey planning application taking DRT options into consideration 3. The Passive Server Adapter must convert the response of the journey planning application which includes DRT options into the OJP 2.0 format 4. After conversion the Passive Server Adapter sends the response to the Active Server Adapter of the calling system
Expected results	The system received, processed, and answered an external request via OJP 2.0 protocol which included DRT services

10.2.16 T6.1_UC1.1.4_PRQ01_AC01_TC01

Test case ID	T6.1_UC1.1.4_PRQ01_AC01_TC01
Test case description	Performance of the OJP component
Preconditions	The trip planning system can receive and answer requests via OJP 2.0 protocol
Trigger	The trip planning system receives 100 requests (almost) simultaneously from an external trip planning system via OJP 2.0 protocol
Test steps	1. The trip planning system receives 100 requests from an external trip planning system via an OJP 2.0 protocol 2. Time measurement starts with the first received request 3. Time measurement stops when the 100th request was processed, and the respective response was sent to the external journey planning application
Expected results	The system can receive and answer all 100 requests via OJP 2.0 protocol within 1 minute.

10.3Test cases task 6.1.2

10.3.1 T6.1_UC1.2.1_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.1_FRQ01_AC01_TC01
Test case description	System can interface with real-time data feeds of rail operators
Preconditions	Real-time information from rail operators is available (either position data or estimated time of arrival (ETA)) Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 Train delays from the second order effect, i.e., a train delay caused by another train delay will be addressed through operator 1 and 2's internal coordination and thus the delay information will be available directly from operator 1 and 2.
Trigger	The trip planning system fetches real-time data regarding the arrival times from relevant sources form rail operator 1 and 2
Test steps	1. The trip planning system fetches real-time data regarding the arrival times from relevant sources form rail operator 1 and 2 2. The system converts the data to a suitable format which enables the integration into the internal data structure so that it can be processed to construct ad-hoc timetables at a later stage 3. The system links data from operator 1 and operator 2 into the same backend database so that route search can be performed based on both.
Expected results	The data was successfully integrated into the internal data structure so that an ad-hoc timetable can be constructed based on real-time data from both train operators

10.3.2 T6.1_UC1.2.1_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.1_FRQ02_AC01_TC01
Test case description	The system can construct an ad-hoc timetable based on real-time data feeds of rail operators
Preconditions	Real-time information from rail operators is available Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 Train delays from the second order effect will be addressed through operator 1 and 2’s internal coordination and thus the delay information will be available directly from operator 1 and 2.
Trigger	The trip planning system fetches real-time from rail operator 1 and 2
Test steps	1. The trip planning system fetches real-time from rail operator 1 and 2 2. The system modifies the static timetable to implement the real-time information 3. All delayed vehicles are marked, and arrival times are retrieved 4. A new timetable - the ad-hoc timetable - is created by the system
Expected results	The journey planning system constructed an ad-hoc timetable by modifying the static timetable, mark the vehicles that are delayed and retrieve the arrival time for all subsequent stations of a given line.

10.3.3 T6.1_UC1.2.1_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.2.1_FRQ03_AC01_TC01
Test case description	The constructed ad-hoc timetable must correctly capture delay at subsequent stations
Preconditions	Real-time information from Rail operators is available (either position data or ETA) Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 Train delays from the second order effect will be addressed through operator 1 and 2's internal coordination and thus the delay information will be available directly from operator 1 and 2.
Trigger	The trip planning system fetches real-time data regarding the arrival times from relevant sources from rail operator 1 and 2
Test steps	1. The trip planning system fetches real-time data regarding the arrival times from relevant sources form rail operator 1 and 2 2. The system converts the data to a format that can be used to construct ad-hoc timetables 3. The system constructs an ad-hoc timetable based on real-time and static timetable data 4. The system updates ad-hoc timetable with new information
Expected results	An ad-hoc timetable which includes real-time estimation of arrival times for all subsequent stations is created

10.3.4 T6.1_UC1.2.1_NFRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.1_NFRQ01_AC01_TC01
Test case description	The system must be able to update real-time data quickly and with high frequency
Preconditions	Real-time information from Rail operator 1 and 2 (e.g., delay information, cancellations, platform changes) are available Availability of journey planning system Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 Train delays from the second order effect will be addressed through operator 1 and 2's internal coordination and thus the delay information will be available directly from operator 1 and 2. The journey planning system will not calculate second order effect.
Trigger	The trip planning system fetches real-time data from rail operator 1 and 2
Test steps	1. The trip planning system fetches real-time data from rail operator 1 and 2 2. The system converts the data to a format that can be used to construct ad-hoc timetables 3. The system starts to match the data with the static timetable 4. Time measuring is started with the matching process 5. The system updates ad-hoc timetable with the newly received information 6. Time measuring stops when all data points are updated
Expected results	An ad-hoc timetable which includes real-time information can be updated within several seconds

10.3.5 T6.1_UC1.2.2_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.2_FRQ01_AC01_TC01
Test case description	The system must be able to interface with real-time data feeds of bus operators.
Preconditions	Real-time information from Rail operator 1 and 2 are available Bus operator provides real-time information for its buses Journey planning system is equipped with static timetable data of rail operator 1, rail operator 2, bus operator, and some necessary data from DRT service provider (e.g., service area, operating hours)
Trigger	The trip planning system fetches real-time data from train and bus operators
Test steps	1. The trip planning system fetches real-time data from train and bus operators 2. The system converts the data to a suitable format which enables the integration into the internal data structure in the backend of the journey planning system 3. The system links data from operator 1 and operator 2 into the same backend database so that route search can be performed based on both 4. The data is provided to the journey planning application in a suitable data format
Expected results	The journey planning application can consider real-time data from bus and train operators for the requested route and provides appropriate route suggestions to the user

10.3.6 T6.1_UC1.2.2_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.2_FRQ02_AC01_TC01
Test case description	The system must be able to interface with the system of a DRT service provider for checking latest availability of data.
Preconditions	Real-time information from Rail operator 1 and 2 are available API from DRT service providers are available Journey planning system is equipped with static timetable data of rail operator 1, rail operator 2, bus operator, and some necessary data from DRT service provider (e.g., service area, operating hours)
Trigger	The trip planning system fetches real-time data from a DRT service provider
Test steps	1. The trip planning system fetches real-time data from DRT services API 2. The system converts the data to a suitable format which enables the integration into the internal data structure in the backend of the journey planning system 3. The system links data from operator 1 and operator 2 into the same backend database so that route search can be performed based on both 4. The data is provided to the journey planning application in a suitable data format
Expected results	The journey planning application can consider real-time data from a DRT operator for the requested route and provides appropriate route suggestions to the user

10.3.7 T6.1_UC1.2.3_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.3_FRQ01_AC01_TC01
Test case description	The system must be able to inform users when there is no real-time information available.
Preconditions	Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 and of other service providers such as a bus operator or a DRT service provider. Ad-hoc timetable may not be available on certain lines due to lack of real-time data.
Trigger	A user requests a route for which there is no real-time data available
Test steps	1. A user inputs origin, destination, and arrival/departure time for which there is no real-time data available 2. The user requests route suggestions
Expected results	When the resulting route suggestions are displayed, the system will inform the user what parts of the suggested routes are not based on real-time data

10.3.8 T6.1_UC1.2.3_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.3_FRQ02_AC01_TC01
Test case description	The system must also be able to calculate trip options when real-time data is not or only partly available
Preconditions	Journey planning system is equipped with static timetable data of rail operator 1 and rail operator 2 and of other service providers such as a bus operator or a DRT service provider. Ad-hoc timetable may not be available on certain lines due to lack of real-time data.
Trigger	A user requests a route for which there is no or only partly real-time data available
Test steps	1. A user inputs origin, destination, and arrival/departure time for which there is no or only partly real-time data available 2. The user requests route suggestions
Expected results	The system provides route suggestions based on static timetable data and thus can supplement real-time data with static timetable data

10.3.9 T6.1_UC1.2.3_PRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.3_PRQ01_AC01_TC01
Test case description	The system responds to trip requests considering real-time data nearly as fast as to trip requests which are only based on static timetable data.
Preconditions	System has access to real-time and static data
Trigger	A user requests a route for which real-time data is considered
Test steps	1. A user requests routes for which real-time data is considered 2. Time measurement starts with the route query 3. A route is calculated considering real-time data and sent to the requesting user device 4. Time measuring is stopped as soon as feasible routes sent to the requesting user device
Expected results	The system provided routes based on real-time data on average nearly as fast as routes only based on static timetable data

10.3.10 T6.1_UC1.2.4_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.4_FRQ01_AC01_TC01
Test case description	The system must have a well-designed frontend which enables the user to input origin, destination, and preferred time of travel
Preconditions	-
Trigger	User opens journey planning application
Test steps	1. User opens journey planning application 2. User inputs origin, destination, and preferred time of travel in the journey planning application.
Expected results	User was provided a frontend for inputting: origin, destination, arrival time, departure time

10.3.11 T6.1_UC1.2.4_FRQ01_AC01_TC02

Test case ID	T6.1_UC1.2.4_FRQ01_AC01_TC02
Test case description	The system must have a well-designed frontend which enables the user to specify trip related information as well as individual user settings such as preferred modes of transport, individual walking speed, maximum walking distance to/from stop and an (optional) PRM profile.
Preconditions	-
Trigger	User starts journey planning application
Test steps	1. User starts journey planning application 2. User sets individual settings such as preferred modes of transport, individual walking speed, maximum walking distance to/from stop and an (optional) PRM profile.
Expected results	The user can specify trip related information as well as individual user settings such as preferred modes of transport, individual walking speed, maximum walking distance to/from stop and PRM profiles

10.3.12 T6.1_UC1.2.4_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.4_FRQ02_AC01_TC01
Test case description	The system must be able to process user input, including origin, destination, and preferred time of travel and additional individual settings.
Preconditions	-
Trigger	User enters origin, destination, and desired departure/arrival time on the journey planning application.
Test steps	1. User enters origin, destination, and desired departure/arrival time on the journey planning application. 2. User triggers trip search 3. The journey planning algorithm seeks trips taking the individual settings into account
Expected results	Traveller receives trip options based on the provided input

10.3.13 T6.1_UC1.2.4_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.2.4_FRQ03_AC01_TC01
Test case description	The system must be able provide route suggestions even when facility data is not available.
Preconditions	Station facility data is already collected for certain stations and data can be converted into a structured data format that can be imported into the journey planning system.
Trigger	User enters origin, destination and desired departure/arrival time and specific station facility property needs in the journey planning application
Test steps	1. User enters origin, destination and desired departure/arrival time and specific station facility property needs in the journey planning application 2. User triggers trip search 3. The journey planning algorithm seeks trips taking the individual settings into account
Expected results	Traveller receives trip options based on the provided input even when no relevant facility data is available

10.3.14 T6.1_UC1.2.4_FRQ04_AC01_TC01

Test case ID	T6.1_UC1.2.4_FRQ04_AC01_TC01
Test case description	The system must be able to consider station facilities properties in route suggestions
Preconditions	The list of station facilities is already stored at backend of the journey planning system.
Trigger	User enters origin, destination and desired departure/arrival time and specific station facility property needs in the journey planning application
Test steps	1. User enters origin, destination and desired departure/arrival time and specific station facility property needs on the journey planning application 2. User triggers trip search 3. The journey planning algorithm seeks trips taking the individual settings into account
Expected results	User receives trip options considering station facility properties

10.3.15 T6.1_UC1.2.4_FRQ05_AC01_TC01

Test case ID	T6.1_UC1.2.4_FRQ05_AC01_TC01
Test case description	PRM get notified about existing transfer solutions at stations
Preconditions	Existing solutions at different stations are already collected through field survey or browsing relevant data from local statistics.
Trigger	User enters origin, destination, desired departure/arrival time and individual PRM settings which require transfer solutions at stations
Test steps	1. User enters origin, destination, desired departure/arrival time and individual PRM settings which require transfer solutions at stations 2. User triggers trip search 3. The journey planning algorithm seeks trips taking the individual settings into account
Expected results	PRM user receives notifications if there are any existing transfer solutions available at transfer stations along the route (e.g., “Staff available")

10.3.16 T6.1_UC1.2.4_FRQ06_AC01_TC01

Test case ID	T6.1_UC1.2.4_FRQ06_AC01_TC01
Test case description	System’s ability to exclude certain stations or transport modes
Preconditions	-
Trigger	User enters origin, destination and desired departure/arrival time and individual settings excluding a station and certain transport mode
Test steps	1. User enters origin, destination and desired departure/arrival time and individual settings excluding a station and certain transport mode 2. User triggers trip search 3. The journey planning algorithm seeks trips taking the individual settings into account
Expected results	User receives trip options considering the excluded station and transport mode

10.3.17 T6.1_UC1.2.5_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.5_FRQ01_AC01_TC01
Test case description	The system must feature a map view that presents Points of Interest to the user
Preconditions	-
Trigger	User opens travel planning application
Test steps	1. User opens travel planning application 2. User opens the map view within the travel planning application 3. An address or location is inputted in the search field of the map view
Expected results	The system's map view displays Points of Interest in close proximity to the provided location/address, including at least the POI address, denoting their locations

10.3.18 T6.1_UC1.2.5_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.5_FRQ02_AC01_TC01
Test case description	The system must be able to show/hide POIs depending on their category when the user activates/deactivates the display for the respective category of POIs.
Preconditions	-
Trigger	Map view is opened within the travel planning application
Test steps	1. Map view is opened within the travel planning application 2. An address or location is inputted 3. A user filters POI for a certain category like hotels, restaurants, museums, others
Expected results	Only POI which match the filtered category are displayed on the screen and all others disappear

10.3.19 T6.1_UC1.2.5_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.2.5_FRQ03_AC01_TC01
Test case description	The system must offer the option to select a POI in the map view as start or destination for the next trip search.
Preconditions	-
Trigger	Map view is opened within the travel planning application
Test steps	1. Map view is opened within the travel planning application 2. An address or location is inputted 3. Select a POI from the map view 4. Select POI as start/end point of your journey
Expected results	The system will use the POI as start/end point and transition to the trip search interface

10.3.20 T6.1_UC1.2.5_NFRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.5_NFRQ01_AC01_TC01
Test case description	The map must not be cluttered by icons representing POIs.
Preconditions	-
Trigger	Map view is selected
Test steps	1. Map view is selected
Expected results	To prevent map clutter, the system should load and display POI icons only when the zoom level is appropriate, i.e., when user has zoomed in..

10.3.21 T6.1_UC1.2.6_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.6_FRQ01_AC01_TC01
Test case description	The system must provide a view that provides profiles for different types of PRM from which a profile can be selected by the user.
Preconditions	PRM profiles are predefined
Trigger	A PRM initiates a trip search with default settings and finds the results not suitable, and he/she activates a PRM profile before starting a new search.
Test steps	1. The user indicates the trip results with default settings are not suitable 2. A list of predefined PRM profiles is provided to the user 3. The user chooses best fitting PRM profile
Expected results	A user can choose the PRM profile which best fits the user's mobility needs from a complete list of PRM profiles w

10.3.22 T6.1_UC1.2.6_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.6_FRQ02_AC01_TC01
Test case description	Depending upon the selected profile, the system must apply corresponding parameter values to the trip search request.
Preconditions	PRM profiles exists

	A PRM profile is selected
Trigger	A user which has a PRM profile selected enters origin, destination, arrival/departure time into the journey planner
Test steps	1. A user which has a PRM profile selected enters origin, destination, arrival/departure time into the journey planner 2. A user triggers the journey planner to suggest routes based on the provided input
Expected results	The journey planner suggested routes which take the specific needs of the selected PRM profiles into consideration (e.g., no stairs, …)

10.3.23 T6.1_UC1.2.6_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.2.6_FRQ03_AC01_TC01
Test case description	The user must be made aware that a certain profile is active for his/her trip searches.
Preconditions	PRM profiles exists PRM profile is selected
Trigger	A user which has a PRM profile selected enters origin, destination, arrival/departure time into the journey planner
Test steps	1. A user which has a PRM profile selected enters origin, destination, arrival/departure time into the journey planner 2. A user triggers the journey planner to suggest routes based on the provided input 3. User gets results based on entered inputs and PRM profile specific needs
Expected results	When the user gets to enter origin, destination, and departure/arrival time (step 1) and when the trip results are presented (step 3), the user is made aware that a PRM profile is selected and affecting the suggested routes

10.3.24 T6.1_UC1.2.7_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.7_FRQ01_AC01_TC01
Test case description	System must enable a user to change default parameter values that are associated with a PRM profile.
Preconditions	A PRM profile is selected
Trigger	Journey results from a query which considered a PRM profile are presented
Test steps	1. A user which has a PRM profile selected enters origin, destination, arrival/departure time into the journey planner 2. A user triggers the journey planner to suggest routes based on the provided input 3. Journey results from a query which considered the selected PRM profile are presented 4. The option to change default traveller needs is selected 5. A new window pops up where the user can change default settings of traveller needs 6. Change at least one traveller need 7. Save changes
Expected results	A user can change the default settings and changes are saved

10.3.25 T6.1_UC1.2.7_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.7_FRQ02_AC01_TC01
Test case description	If a user profile was selected and parameter values have been adjusted, the system must apply the parameter values of the selected profile considering the adjusted values for the trip search request.
Preconditions	A PRM profile is selected and at least one value has been adjusted
Trigger	At least one default value of a PRM profile has been adjusted
Test steps	1. A user which has an adjusted PRM profile selected enters origin, destination, arrival/departure time into the journey planner 2. A user triggers the journey planner to suggest routes based on the provided input
Expected results	Route suggestions which consider the adjusted PRM profile with its adjusted parameters are displayed

10.3.26 T6.1_UC1.2.7_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.2.7_FRQ03_AC01_TC01
Test case description	The system must offer the option to reset changed parameter values of a profile to their default value.
Preconditions	At least one default value of a PRM profile has been adjusted
Trigger	A user goes to the individual setting page
Test steps	1. A user goes to the individual setting page 2. The user selects “PRM profiles”
Expected results	In this window the system should provide an option which restores the PRM profiles to default settings

10.3.27 T6.1_UC1.2.7_FRQ04_AC01_TC01

Test case ID	T6.1_UC1.2.7_FRQ04_AC01_TC01
Test case description	The user must be made aware when parameter values of the selected profile deviate from their default value.
Preconditions	User uses a PRM profile for which parameter values have been adjusted and thus deviate from their default values (e.g., walking speed)
Trigger	A user checks the values which are set in the selected PRM profile
Test steps	1. A user navigated to the individual settings page 2. User selects PRM profile settings 3. User checks the values which are set in the selected PRM profile
Expected results	In the settings interface it is clearly indicated which of the values deviate from their default values

10.3.28 T6.1_UC1.2.7_NFRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.7_NFRQ01_AC01_TC01
Test case description	System’s visualization of journey search results to the end user should be clear and easy to understand
Preconditions	-
Trigger	A user which has a PRM profile selected enters origin, destination, arrival/departure time into the journey planner
Test steps	1. A user which has a PRM profile selected enters origin, destination, arrival/departure time into the journey planner 2. The user triggers the journey planner
Expected results	Journey search results are visualised. The visualisation of journey search results should highlight key information in the journey which reflect the fulfilled traveller needs, e.g., station transfer accessibility level. It is important to strike a balance between displaying helpful information and not displaying too much information to avoid overwhelming the user.

10.3.1 T6.1_UC1.2.8_FRQ01_AC01_TC01

Test case ID	T6.1_UC1.2.8_FRQ01_AC01_TC01

Test case description	The routing algorithm must support the goal of minimizing total walking distance
Preconditions	A multi-criteria pareto-optimal search method is implemented in the search algorithm in the journey planner application
Trigger	A user requests a route with the additional goal of optimizing the total walking distance
Test steps	1. A user enters origin, destination, and arrival/departure time 2. User receives trip options 3. User chooses a profile with which the journey planner will calculate a trip option considering the minimization of the total walking distance 3. user receives adjusted trip options
Expected results	The backend of the journey planner considers not only the fastest and most comfortable way but additionally searches for a route where the total walking distance is minimized. The trip options are presented

10.3.1 T6.1_UC1.2.8_FRQ02_AC01_TC01

Test case ID	T6.1_UC1.2.8_FRQ02_AC01_TC01
Test case description	The routing algorithm must offer two options for the trip search calculation
Preconditions	A multi-criteria pareto-optimal search method is implemented in the search algorithm in the journey planner application There is a list of profiles available which are associated with predefined parameters. If such a profile is activated, the parameters will be applied to the following trip searches.
Trigger	User has requested a trip
Test steps	1. User receives trip options 2. User choses profile with which a trip calculation considering the minimization of the total walking distance
Expected results	The user receives trip options which do consider the fastest routes, the most comfortable routes, and the routes with minimal walking distance. Thus, in the backend of the journey planner there are two alternative modes to calculate optimal routes.

10.3.1 T6.1_UC1.2.8_FRQ03_AC01_TC01

Test case ID	T6.1_UC1.2.8_FRQ03_AC01_TC01
Test case description	There must be at least one profile offered with which the journey planner considers to minimization of the total walking distance
Preconditions	A multi-criteria pareto-optimal search method is implemented in the search algorithm in the journey planner application There is a list of profiles available which are associated with predefined parameters. If such a profile is activated, the parameters will be applied to the following trip searches
Trigger	User selects a profile for which the minimization of the total walking distance is considered
Test steps	1. A user receives trip options 2. The user chooses a profile to get new trip options which consider to minimization of the total walking distance 3. The user receives new trip options
Expected results	At least one profile for which the minimization of the total walking distance was considered in the calculation of the trip option exists. The newly received trip options include at least one option where the total walking distance was minimized.

10.4Test cases task 6.2

10.4.1 T6.2_UC2.1_FRQ01_AC01_TC01

Test case ID	T6.2_UC2.1_FRQ01_AC01_TC01
Test case description	TMS data can be provisioned to PIS
Preconditions	TMS and PIS are available; Available operational plan including trains and operational restrictions (planned or incident based) impacting trains; Availability of integrated PIS / end customer application for the area covered by the TMS.
Trigger	The TMS updates the operational plan and the calculated delay forecast
Test steps	1. The TMS updates the operational plan and the calculated delay forecast 2. TMS sends updated relevant information to PIS
Expected results	Specific relevant information was derived and sent to the PIS: Expected delay in arrival and departure times of the trains; Platform track changes; Full or partial cancellations; Incident information in relation to trains;

10.4.2 T6.2_UC2.1_FRQ02_AC01_TC01

Test case ID	T6.2_UC2.1_FRQ02_AC01_TC01
Test case description	PIS data can be received from TMS
Preconditions	PIS and TMS are available;

	TMS has sent information to PIS; Availability of integrated PIS / end customer application for the area covered by the TMS;
Trigger	Information is sent from the TMS to the PIS
Test steps	1. Information is sent from the TMS to the PIS 2. PIS receives information from TMS and processes the data
Expected results	PIS received and processed the following information: Expected delay in arrival and departure times of the trains; Platform track changes; Full or partial cancellations; Incident information in relation to trains;

10.4.3 T6.2_UC2.1_NFRQ01_AC01_TC01

Test case ID	T6.2_UC2.1_NFRQ01_AC01_TC01
Test case description	Frequency of TMS data provision to PIS
Preconditions	TMS and PIS are available; Available operational plan including trains and operational restrictions (planned or incident based) impacting trains; Availability of integrated PIS / end customer application for the area covered by the TMS;
Trigger	Information is sent from the TMS to the PIS
Test steps	1. Information is sent from the TMS to the PIS 2. Time measurement is started with the start of the sending process 3. New information e.g., new delay data from vehicles is processed within the TMS 4. New information is prepared for sending it to the PIS 5. New information is sent out to the PIS 6. Time measurement is stopped with the start of the new sending process
Expected results	The transfer frequency of updated information which is sent from TMS to PIS is higher or equal to once every 30 seconds

10.4.4 T6.2_UC2.2_FRQ01_AC01_TC01

Test case ID	T6.2_UC2.2_FRQ01_AC01_TC01
Test case description	PIS can provision traveller demand data to TMS
Preconditions	TMS and PIS demand forecast module is available; Travel demand forecast is available in PIS for two weeks ahead of actual daytime;
Trigger	New demand forecasting data is available from the forecasting module of the PIS
Test steps	1. New demand forecasting data is available from the forecasting module of the PIS 2. Demand forecasting module sends new data to the TMS
Expected results	The PIS demand forecast sent the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the actual time to the TMS

10.4.5 T6.2_UC2.2_FRQ01_AC01_TC02

Test case ID	T6.2_UC2.2_FRQ01_AC01_TC02
Test case description	PIS can provision traveller demand data to CMS
Preconditions	CMS and PIS demand forecast module is available; Travel demand forecast is available in PIS for two weeks ahead of actual daytime;
Trigger	New demand forecasting data is available from the forecasting module of the PIS
Test steps	1. New demand forecasting data is available from the forecasting module of the PIS 2. Demand forecasting module sends new data to the CMS
Expected results	The PIS demand forecast sent the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the actual time to the CMS

10.4.6 T6.2_UC2.2_FRQ02_AC01_TC01

Test case ID	T6.2_UC2.2_FRQ02_AC01_TC01
Test case description	TMS can receive traveller demand data from PIS demand forecast module
Preconditions	TMS and PIS demand forecast module are available; PIS demand forecast module has send information. Travel demand forecast is available in PIS for two weeks ahead of actual daytime;
Trigger	PIS sends new data to the TMS
Test steps	1. PIS sends new data to the TMS 2. TMS can receive the sent data
Expected results	The TMS received the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the actual time from the PIS demand forecast module.

10.4.7 T6.2_UC2.2_FRQ02_AC01_TC02

Test case ID	T6.2_UC2.2_FRQ02_AC01_TC02
Test case description	CMS can receive traveller demand data from PIS demand forecast module
Preconditions	CMS and PIS demand forecast module are available; PIS demand forecast module has send information. Travel demand forecast is available in PIS for two weeks ahead of actual daytime;
Trigger	PIS sends new data to the CMS
Test steps	1. PIS sends new data to the CMS 2. CMS can receive the sent data
Expected results	The CMS received the number of expected travellers for A-to-B station relations and pre-defined daytime intervals in a timeframe of two weeks ahead of the actual time from the PIS demand forecast module.

10.4.8 T6.2_UC2.2_NFRQ01_AC01_TC01

Test case ID	T6.2_UC2.2_NFRQ01_AC01_TC01
Test case description	Frequency for provision of traveller demand data to CMS/TMS
Preconditions	CMS/TMS and PIS demand forecast module are available; PIS demand forecast module has send information. Travel demand forecast is available in PIS for two weeks ahead of actual daytime;
Trigger	Traveller demand data is sent from the PIS to the CMS/TMS
Test steps	1. Traveller demand data is sent from the PIS to the CMS/TMS 2. Time measurement is started with the start of the sending process 3. New demand data is derived within the PIS 4. Newly derived demand forecasts are prepared for sending them

	to the CMS/TMS 5. New information is sent out to the CMS/TMS 6. Time measurement is stopped with the start of the new sending process
Expected results	The transfer frequency of updated information which is sent from PIS to CMS/TMS is higher or equal to once every 15 minutes providing that new data updates are available.

10.4.9 T6.2_UC2.2_NFRQ02_AC01_TC01

Test case ID	T6.2_UC2.2_NFRQ02_AC01_TC01
Test case description	Provision of anonymised information about traveller demand to CMS/TMS
Preconditions	CMS/TMS and PIS demand forecast module are available; PIS demand forecast module has send information. Travel demand forecast is available in PIS for two weeks ahead of actual daytime;
Trigger	Data preparation of traveller demand data for sending it from the PIS to the CMS/TMS starts
Test steps	1. Data preparation of traveller demand data for sending it from the PIS to the CMS/TMS starts 2. Outgoing data is anonymised
Expected results	All data is anonymised before it gets send from the PIS to the CMS/TMS so that no personal information can be derived from the data

10.4.10 T6.2_UC2.3_FRQ01_AC01_TC01

Test case ID	T6.2_UC2.3_FRQ01_AC01_TC01
Test case description	PIS can provision numbers of expected travellers in trains to TMS
Preconditions	TMS and PIS demand forecast module are available; Numbers of expected travellers in the trains are available in PIS demand forecast module for at least two hours ahead of actual daytime;
Trigger	The PIS demand forecasting module derives the number of expected travellers in between stops
Test steps	1. The PIS demand forecasting module derives the number of expected travellers in between stops 2. Then the demand forecasting module prepares the newly available information to be sent to the TMS 3. The PIS demand forecasting tool sends the newly available information to the TMS
Expected results	The PIS demand forecast module sent the number of expected travellers in the trains between subsequent stops in a timeframe of at least two hours ahead of the actual time to the TMS

10.4.11 T6.2_UC2.3_FRQ01_AC01_TC02

Test case ID	T6.2_UC2.3_FRQ01_AC01_TC02
Test case description	PIS can provision numbers of expected travellers in trains to CMS
Preconditions	CMS and PIS demand forecast module is available; Numbers of expected travellers in the trains are available in PIS demand forecast module for at least two hours ahead of actual daytime;
Trigger	The PIS demand forecasting module derives the number of expected travellers in between stops
Test steps	1. The PIS demand forecasting module derives the number of expected travellers in between stops 2. Then the demand forecasting module prepares the newly available information to be sent to the CMS 3. The PIS demand forecasting tool sends the newly available information to the CMS
Expected results	The PIS demand forecast module sent the number of expected travellers in the trains between subsequent stops in a timeframe of at least two hours ahead of the actual time to the CMS

10.4.12 T6.2_UC2.3_FRQ02_AC01_TC01

Test case ID	T6.2_UC2.3_FRQ02_AC01_TC01
Test case description	TMS can receive the numbers of expected travellers in trains from PIS demand forecast module
Preconditions	TMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers in the trains are available in PIS demand forecast module for at least two hours ahead of actual daytime;
Trigger	The forecasting module of the PIS sends new information about the number of expected travellers in the trains between subsequent stops to the TMS
Test steps	1. The forecasting module of the PIS sends new information about the number of expected travellers in trains between subsequent stops to the TMS 2. The TMS processes the new information and updates existing ones
Expected results	The TMS received the number of expected travellers in the trains between subsequent stops in a timeframe of at least two hours ahead of the actual time from the PIS demand forecast module.

10.4.13 T6.2_UC2.3_FRQ02_AC01_TC02

Test case ID	T6.2_UC2.3_FRQ02_AC01_TC02
Test case description	CMS can receive the numbers of expected travellers in trains from PIS demand forecast module
Preconditions	CMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers in the trains are available in PIS demand forecast module for at least two hours ahead of actual daytime;
Trigger	The forecasting module of the PIS sends new information about the number of expected travellers in the trains between subsequent stops to the CMS
Test steps	1. The forecasting module of the PIS sends new information about the number of expected travellers in trains between subsequent stops to the CMS 2. The CMS processes the new information and updates existing ones
Expected results	The CMS received the number of expected travellers in the trains between subsequent stops in a timeframe of at least two hours ahead of the actual time from the PIS demand forecast module.

10.4.14 T6.2_UC2.3_NFRQ01_AC01_TC01

Test case ID	T6.2_UC2.3_NFRQ01_AC01_TC01
Test case description	Frequency for provision of numbers of expected travellers in trains to TMS/CMS
Preconditions	CMS/TMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers in the trains are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	Number of expected travellers in trains is sent from the PIS to the CMS/TMS
Test steps	1. Number of expected travellers in trains is sent from the PIS to the CMS/TMS 2. Time measurement is started with the start of the sending process 3. New data of expected travellers is derived within the PIS 4. Newly derived information is prepared for sending it to the CMS/TMS 5. New information is sent out to the CMS/TMS 6. Time measurement is stopped with the start of the new sending process
Expected results	The transfer frequency of updated information which is sent from PIS to CMS/TMS is higher or equal to once every 5 minutes providing that new data updates are available.

10.4.15 T6.2_UC2.3_NFRQ02_AC01_TC01

Test case ID	T6.2_UC2.3_NFRQ02_AC01_TC01
Test case description	Provision of anonymised information about expected travellers in trains to CMS/TMS
Preconditions	CMS/TMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers in the trains are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	Data preparation for sending expected travellers in trains data from the PIS to the CMS/TMS starts
Test steps	1. Data preparation for sending expected travellers in trains data from the PIS to the CMS/TMS starts 2. Outgoing data is anonymised
Expected results	All data is anonymised before it gets send from the PIS to the CMS/TMS so that no personal information can be derived from the data

10.4.16 T6.2_UC2.4_FRQ01_AC01_TC01

Test case ID	T6.2_UC2.4_FRQ01_AC01_TC01
Test case description	PIS can provision the numbers of expected travellers embarking/disembarking a train at the stations to TMS
Preconditions	TMS and PIS demand forecast module is available; Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	The PIS demand forecasting module derives the number of expected travellers embarking/disembarking a train at stations
Test steps	1. The PIS demand forecasting module derives the number of expected travellers embarking/disembarking a train at stations 2. Then the demand forecasting module prepares the newly available information to be sent to the TMS 3. The PIS demand forecasting tool sends the newly available information to the TMS
Expected results	The PIS demand forecast module sent the number of expected travellers embarking/disembarking a train at the stations in a timeframe of two weeks ahead of the actual time to the TMS.

10.4.17 T6.2_UC2.4_FRQ01_AC01_TC02

Test case ID	T6.2_UC2.4_FRQ01_AC01_TC02
Test case description	PIS can provision the numbers of expected travellers embarking/disembarking a train at the stations to CMS
Preconditions	CMS and PIS demand forecast module is available; Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	The PIS demand forecasting module derives the number of expected travellers embarking/disembarking a train at stations
Test steps	1. The PIS demand forecasting module derives the number of expected travellers embarking/disembarking a train at stations 2. Then the demand forecasting module prepares the newly available information to be sent to the CMS 3. The PIS demand forecasting tool sends the newly available information to the CMS
Expected results	The PIS demand forecast module sent the number of expected travellers embarking/disembarking a train at the stations in a timeframe of two weeks ahead of the actual time to the CMS.

10.4.18 T6.2_UC2.4_FRQ02_AC01_TC01

Test case ID	T6.2_UC2.4_FRQ02_AC01_TC01
Test case description	TMS can receive numbers of expected travellers embarking/disembarking a train at the stations from PIS demand forecast module
Preconditions	TMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	PIS sends new information about the number of expected travellers embarking/disembarking a train at the stations to the TMS
Test steps	1. PIS sends new information about the number of expected travellers embarking/disembarking a train at the stations to the TMS 2. The TMS processes the new information and updates existing ones
Expected results	The TMS received the number of expected travellers embarking/disembarking a train at the stations in a timeframe of two weeks ahead of the actual time from the PIS demand forecast module.

10.4.19 T6.2_UC2.4_FRQ02_AC01_TC02

Test case ID	T6.2_UC2.4_FRQ02_AC01_TC02
Test case description	CMS can receive numbers of expected travellers embarking/disembarking a train at the stations from PIS demand forecast module
Preconditions	CMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	PIS sends new information about the number of expected travellers embarking/disembarking a train at the stations to the CMS
Test steps	1. PIS sends new information about the number of expected travellers embarking/disembarking a train at the stations to the CMS 2. The CMS processes the new information and updates existing ones
Expected results	The CMS received the number of expected travellers embarking/disembarking a train at the stations in a timeframe of two weeks ahead of the actual time from the PIS demand forecast module.

10.4.20 T6.2_UC2.4_NFRQ01_AC01_TC01

Test case ID	T6.2_UC2.4_NFRQ01_AC01_TC01
Test case description	Frequency for provision of numbers of expected travellers embarking/disembarking a train at the stations to CMS/TMS
Preconditions	CMS/TMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	Number of expected travellers embarking/disembarking a train at the stations is sent from the PIS to the CMS/TMS
Test steps	1. Number of expected travellers embarking/disembarking a train at the stations is sent from the PIS to the CMS/TMS 2. Time measurement is started with the start of the sending process 3. New data of expected travellers is derived within the PIS 4. Newly derived information is prepared for sending it to the CMS/TMS 5. New information is sent out to the CMS/TMS 6. Time measurement is stopped with the start of the new sending process
Expected results	The transfer frequency of updated information which is sent from PIS to CMS/TMS is higher or equal to once every 5 minutes providing that new data updates are available.

10.4.21 T6.2_UC2.4_NFRQ02_AC01_TC01

Test case ID	T6.2_UC2.4_NFRQ02_AC01_TC01
Test case description	Provision of anonymised information about expected travellers embarking/disembarking a train at the stations to CMS/TMS
Preconditions	CMS/TMS and PIS demand forecast module is available; PIS demand forecasting module has sent information; Numbers of expected travellers embarking/disembarking a train at the stations are available in PIS demand forecast module for two weeks ahead of actual daytime;
Trigger	Data preparation for sending expected travellers embarking/disembarking a train at the stations data from the PIS to the CMS/TMS starts
Test steps	1. Data preparation for sending expected travellers embarking/disembarking a train at the stations data from the PIS to the CMS/TMS starts 2. Outgoing data is anonymised
Expected results	All data is anonymised before it gets send from the PIS to the CMS/TMS so that no personal information can be derived from the data

10.5Test cases task 6.4

10.5.1 T6.4_UC4.1_FRQ01_AC01_TC01

Test case ID	T6.4_UC4.1_FRQ01_AC01_TC01
Test case description	Ability to receive and process journey planning request data
Preconditions	Journey planning system is available Journey planning requests will be made by users and provide information such as origin, destination, and preferred time of travel The data received will be sufficient and accurate for demand forecasting purposes
Trigger	Data from the journey planning system is sent to the forecasting module
Test steps	1. Journey planning request data is received 2. Journey planning request data is processed
Expected results	Journey planning request data is received and processed and thus can be used for forecasting purposes

10.5.2 T6.4_UC4.1_FRQ01_AC01_TC02

Test case ID	T6.4_UC4.1_FRQ01_AC01_TC02
Test case description	Ability to receive and process vehicle occupancy sensor data
Preconditions	Vehicle occupancy sensor data is available The data received will be sufficient and accurate for demand

	forecasting purposes
Trigger	Data from vehicle occupancy sensors is sent to the forecasting module
Test steps	1. Vehicle occupancy sensor data is received 2. Vehicle occupancy sensor data is processed
Expected results	Vehicle occupancy sensor data is received and processed and thus can be used for forecasting purposes

10.5.3 T6.4_UC4.1_NFRQ01_AC01_TC01

Test case ID	T6.4_UC4.1_NFRQ01_AC01_TC01
Test case description	The demand forecasting module must be able to receive and process the collected data within a reasonable time
Preconditions	The system assumes that data will be received from a journey planning system or other systems The availability and format of the received data will be compatible with the system's processing capabilities The definition of "reasonable time" may vary depending on the specific requirements and expectations of the final application Other data may be available (like disruptions or delays information, occupancy sensors on the train)
Trigger	New data is sent to the demand forecasting module
Test steps	1. The time measurement starts with the receival of the journey planning request or vehicle occupancy data 2. The data is automatically processed and put into the right data format 3. The formatted data is ingested by the system – time measurement is stopped when all data was ingested
Expected results	The measured time is reasonable (on average not more than a couple of hours). This will be more precisely specified in WP11.

10.5.4 T6.4_UC4.1_FRQ02_AC01_TC01

Test case ID	T6.4_UC4.1_FRQ02_AC01_TC01
Test case description	Ability to train a machine learning model
Preconditions	Journey planning request data and historical vehicle occupancy data are available for training the machine learning model
Trigger	A new machine learning model is needed to be set up for forecasting purposes
Test steps	1. Pre-processed and transformed data is selected 2. Algorithms and techniques are applied to train the model based on the provided data 3. The trained machine learning model is tested and stored
Expected results	A machine learning model for forecasting vehicle occupancy is trained, stored and ready for deployment.

10.5.5 T6.4_UC4.1_FRQ03_AC01_TC01

Test case ID	T6.4_UC4.1_FRQ03_AC01_TC01
Test case description	Ability to retrain the vehicle occupancy forecasting model
Preconditions	New journey planning request data and historical vehicle occupancy data are available for retraining the machine learning model
Trigger	Enough new data for vehicle occupancy forecasting model is available
Test steps	1. Received new data is pre-processed and integrated with existing historical data to create an updated dataset 2. Algorithms and techniques are applied to retrain the model based on the newly provided data 3. The capabilities of the retrained machine learning model are tested and stored 4. The old model is overwritten by the newly trained model
Expected results	The vehicle occupancy forecasting model is retrained with newly available data and the old model is overwritten.

10.5.6 T6.4_UC4.1_FRQ04_AC01_TC01

Test case ID	T6.4_UC4.1_FRQ04_AC01_TC01
Test case description	Receive journey planning request
Preconditions	The system assumes that a trained model for predicting vehicle occupancy based on journey planning requests and historical data is available. The accuracy of the trained model will impact the accuracy of the occupancy prediction for the requested journey. The system assumes that the journey planning request will provide the necessary information for predicting vehicle occupancy, such as origin, destination, and preferred time of travel.
Trigger	A journey planning request is received
Test steps	1. The system receives a journey planning request 2. The trained forecasting module uses the journey planning request to forecast the occupancy for the respective journey
Expected results	The journey planning request was received, processed, and used for forecasting the vehicle occupancy of the respective journey

10.5.7 T6.4_UC4.1_FRQ05_AC01_TC01

Test case ID	T6.4_UC4.1_FRQ05_AC01_TC01
Test case description	The system must be able to inform the journey planning system about a new occupancy model
Preconditions	The system assumes that a trained occupancy model is available and regularly updated with new data The journey planning system can receive and process the forecasted occupancy information provided by the system
Trigger	The process is triggered in regular time intervals
Test steps	1. The vehicle occupancy forecast is sent to the journey planner 2. The journey planner receives and processes the forecasted vehicle occupancy information
Expected results	The journey planner has up to date forecasted vehicle occupancy information available and can enrich its responses to journey planning requests with it

10.5.8 T6.4_UC4.1_NFRQ02_AC01_TC01

Test case ID	T6.4_UC4.1_NFRQ02_AC01_TC01
Test case description	Ability to keep the vehicle occupancy forecasting model updated
Preconditions	Vehicle occupancy forecasting model can be retrained with new data
Trigger	Sufficient new data is available, and a certain time interval since the last update is exceeded
Test steps	1. The retraining intervals of the system are checked 2. The quality of vehicle occupancy forecast accuracy is recorded 3. Both metrics are checked
Expected results	The system's retraining intervals and quality of forecasting accuracy are both at a sufficient level. Thus, the system keeps a high update frequency while maintaining high quality forecasts

10.5.9 T6.4_UC4.2_FRQ01_AC01_TC01

Test case ID	T6.4_UC4.2_FRQ01_AC01_TC01
Test case description	Storage of input from Journey Planning Requests
Preconditions	The system assumes that users will provide input in the form of origin, destination, and preferred time of travel. The provided user input will be used for journey planning and demand forecasting purposes.
Trigger	User makes a journey planning request
Test steps	1. A user provides input such as origin, destination, and arrival/departure time in the journey planner 2. The user requests a route 3. The input data is stored for forecasting vehicle occupancy
Expected results	The user's input data can be used for forecasting vehicle occupancy

10.5.10 T6.4_UC4.2_FRQ02_AC01_TC01

Test case ID	T6.4_UC4.2_FRQ02_AC01_TC01
Test case description	Fetching forecasted vehicle occupancy data
Preconditions	A forecasted vehicle occupancy information is available.
Trigger	A user requests a journey via the journey planning application
Test steps	1. A user enters information on departure/arrival time, origin and destination and requests a journey 2. The journey planner fetches the relevant forecasted vehicle occupancy information based on the user's input
Expected results	The system returns relevant forecasted vehicle occupancy information to the journey planner based on the user's request

10.5.11 T6.4_UC4.2_NFRQ01_AC01_TC01

Test case ID	T6.4_UC4.2_NFRQ01_AC01_TC01

Test case description	The trip planning interface should be user-friendly and intuitive
Preconditions	There is a trip planning interface through which users can enter their information
Trigger	A user inputs information through the trip planning interface
Test steps	1. A user inputs incorrect information through the trip planning interface 2. The trip planning application gives feedback that the entered input is not correct 3. The user corrects the input
Expected results	After the user corrects the input some sort of visual validation is given from the trip planning interface

10.5.12 T6.4_UC4.2_FRQ03_AC01_TC01

Test case ID	T6.4_UC4.2_FRQ03_AC01_TC01
Test case description	Journey planner generates several trip options based on forecasted vehicle occupancy information, travel time and the number of transfers
Preconditions	Access to the available forecasted occupancy information for the relevant vehicles or modes of transportation.
Trigger	User requests a journey
Test steps	1. A user enters information on departure/arrival time, origin and destination and request a journey 2. The journey planner accesses necessary information 3. Based on the available information, the journey planner generates several trip options which consider the forecasted vehicle occupancy information as well as travel time and the number of transfers
Expected results	Based on the user’s input several trip options considering forecasted vehicle occupancy information as well as travel time and the number of transfers are generated

10.5.13 T6.4_UC4.2_FRQ04_AC01_TC01

Test case ID	T6.4_UC4.2_FRQ04_AC01_TC01
Test case description	Journey planner displays forecasted vehicle occupancy information to the user
Preconditions	Access to the available forecasted occupancy information for the relevant vehicles or modes of transportation. The forecasted vehicle occupancy information will be relevant to the user's proposed journey based on their input.
Trigger	User requests a journey
Test steps	1. A user enters information on departure/arrival time, origin and destination and request a journey 2. The journey planner generates trip options 3. For each trip option, information about the forecasted vehicle occupancy is displayed to the user in a clear and organized way.
Expected results	Forecasted vehicle occupancy information is presented to the user in a clear and organized way.

10.5.14 T6.4_UC4.2_NFRQ02_AC01_TC01

Test case ID	T6.4_UC4.2_NFRQ02_AC01_TC01
Test case description	The trip planning interface should display the forecasted vehicle occupancy in a clear and intuitive way
Preconditions	There is a trip planning interface through which users can enter their information
Trigger	A user inputs information through the trip planning interface
Test steps	1. A user requests a trip 2. Several trip options are displayed to the user
Expected results	For each trip the forecasted vehicle occupancy information is displayed in a clear and intuitive way

10.5.15 T6.4_UC4.3_FRQ01_AC01_TC01

Test case ID	T6.4_UC4.3_FRQ01_AC01_TC01
Test case description	The system can train a machine learning model
Preconditions	Historical travel demand data is available for the relevant areas, including rail and other modes of transportation (such as bus, trams, DRT, or walking) The machine learning model will be trained using this historical data to estimate the mobility demand beyond rail, specifically for first/last mile analysis
Trigger	Historic travel demand training data is available
Test steps	1. Historic travel demand training data is available 2. A preselected machine learning model is trained with the available training data 3. The trained model is tested
Expected results	The trained machine learning model is able to estimate the mobility demand beyond rail, providing insights and predictions for first/last mile analysis.

10.5.16 T6.4_UC4.3_FRQ02_AC01_TC01

Test case ID	T6.4_UC4.3_FRQ02_AC01_TC01
Test case description	Mobility demand beyond rail is estimated considering multiple factors
Preconditions	The system has access to relevant data such as rail station locations, surrounding locations, and journey planning requests. The estimation of mobility demand will be based on this data to determine the level of demand for transportation options connecting rail stations and surrounding areas
Trigger	A model to estimated mobility demand beyond rail is set up
Test steps	1. The estimation model is fed with the available data on rail station locations and surrounding areas 2. The system calculates the mobility demand beyond rail for first/last mile connections
Expected results	The estimated mobility demand beyond rail for first/last mile connections is derived and provides insights into the expected volume of travellers requiring first/last mile transportation options

10.5.17 T6.4_UC4.3_FRQ02_AC01_TC02

Test case ID	T6.4_UC4.3_FRQ02_AC01_TC02
Test case description	Mobility demand beyond rail can be estimated
Preconditions	The system has access to relevant data such as rail station locations, surrounding locations, and journey planning requests. The estimation of mobility demand will be based on this data to determine the level of demand for transportation options connecting rail stations and surrounding areas
Trigger	A model to estimate mobility demand beyond rail is set up
Test steps	1. The estimation model is fed with the available data on rail station locations and surrounding areas 2. Estimation of the mobility demand beyond rail for first/last mile connections for different dates, times, days of the week and special events are initiated
Expected results	The estimated mobility demand beyond rail for first/last mile connections is derived considering time of day, day of the week, and special events.

10.5.18 T6.4_UC4.3_FRQ03_AC01_TC01

Test case ID	T6.4_UC4.3_FRQ03_AC01_TC01
Test case description	Export of first/last mile demand forecast data
Preconditions	The system has already derived first/last mile demand forecast data.
Trigger	TSP starts to request first/last mile demand forecast data
Test steps	1. The TSP uses the export option in the system 2. The TSP specifies the export (e.g., sets the date range) 3. The TSP exports the selected data
Expected results	Data on the first/last mile demand forecast within the chosen date range is exported in a machine-readable file format like csv or JSON.

10.5.19 T6.4_UC4.3_NFRQ01_AC01_TC01

Test case ID	T6.4_UC4.3_NFRQ01_AC01_TC01
Test case description	The system provides the data reliably and timely
Preconditions	There is a Transportation Service Provider (TSP) who requires access to forecasted occupancy information The TSP can request this information from the system whenever needed
Trigger	The TSP requests information
Test steps	1. Several requests for data are made within a certain time period 2. The success rate of sending the data is measured
Expected results	The downtime of the system does not exceed a certain threshold

10.5.20 T6.4_UC4.3_NFRQ01_AC01_TC02

Test case ID	T6.4_UC4.3_NFRQ01_AC01_TC02
Test case description	The system provides the data in a reliable manner

Preconditions	There is a Transportation Service Provider (TSP) who requires access to forecasted occupancy information The TSP can request this information from the system whenever needed
Trigger	The TSP requests information
Test steps	1. Several requests for data are made within a certain time period 2. The time between receiving the request and sending the data is measured for each request
Expected results	The system answers incoming requests on average within a certain time (a few seconds)

10.5.21 T6.4_UC4.3_FRQ04_AC01_TC01

Test case ID	T6.4_UC4.3_FRQ04_AC01_TC01
Test case description	Analysis of estimation results and identifications of high demand and low offering areas
Preconditions	Access to the estimation results, which include information on mobility demand and available transportation services The test data includes areas with a disparity between demand and offerings
Trigger	Analysis of the estimation results
Test steps	1. Mobility demand estimation results are analysed considering factors such as travel demand, population density, and other relevant variables 2. Areas with a high disparity between demand and offerings are identified
Expected results	Areas with significant mismatch between transportation demand and availability are identified, to improve planning and decision-making processes

10.5.22 T6.4_UC4.3_FRQ05_AC01_TC01

Test case ID	T6.4_UC4.3_FRQ05_AC01_TC01
Test case description	Interactive analytics dashboard
Preconditions	Transport service providers require access to data insights for informed decision-making
Trigger	TSP opens interactive analytics dashboard
Test steps	1. Interactive analytics dashboard is started/opened 2. Each interactive visualization is used 3. Return to the original view of the dashboard
Expected results	The dashboard can be manipulated to gather deeper insights and when returning to the original view everything is still displayed in the clear and understandable way as before

10.5.23 T6.4_UC4.3_NFRQ02_AC01_TC01

Test case ID	T6.4_UC4.3_NFRQ02_AC01_TC01
Test case description	Mechanisms for accuracy and completeness of data
Preconditions	Data is available Mechanisms to ensure the accuracy and reliability of the available data used for demand estimation are in place
Trigger	Data is tested
Test steps	1. Data which was used for estimations is collected 2. The collected data is tested for completeness and accuracy
Expected results	Data which was used for the estimation calculations meet certain quality standards

10.5.24 T6.4_UC4.4_FRQ01_AC01_TC01

Test case ID	T6.4_UC4.4_FRQ01_AC01_TC01
Test case description	Data processing and aggregation for anomaly detection and prediction
Preconditions	The system assumes that the following data is available: - Train Occupancy - Weather conditions - Public/disruptive events - Train Schedule - Other relevant data (optional) The system assumes that the data received will be sufficient and accurate for anomaly detection and prediction
Trigger	The anomaly detection system needs data input
Test steps	1. Train occupancy data (forecast or observed if available), weather data and event data is received 2. Other relevant data (e.g., train delays, historical maintenance, disruption logs, etc.) is received 3. All received data is processed
Expected results	The system received, processed, and stored the data for anomaly detection and prediction

10.5.25 T6.4_UC4.4_NFRQ01_AC01_TC01

Test case ID	T6.4_UC4.4_NFRQ01_AC01_TC01
Test case description	Performance of data collection, preprocessing and storage of data for anomaly detection and prediction
Preconditions	Data covering delay predictions and occupancy forecasts is available The format is compatible with the systems capabilities
Trigger	Data is received
Test steps	1. Data is received, and time measurement started 2. Data processing is finished 3. Processed data is stored 3. Time measurement is stopped as soon as the data is processed and stored for further analysis
Expected results	Data aggregation, processing and storing is done within a reasonable time

10.5.26 T6.4_UC4.4_FRQ02_AC01_TC01

Test case ID	T6.4_UC4.4_FRQ02_AC01_TC01
Test case description	Preprocessing for model training for anomaly detection
Preconditions	The system assumes that the following data is available for training the anomaly detection model: - Train Occupancy - Train Schedule
Trigger	Data processing is finished, and data is stored
Test steps	1. A new preprocessing of the data is started, including mechanisms for data transformation (e.g., encoding) and feature engineering 2. Preprocessing is finished, and the data is ready for training the machine learning model
Expected results	Training data was successfully pre-processed

10.5.27 T6.4_UC4.4_FRQ02_AC01_TC02

Test case ID	T6.4_UC4.4_FRQ02_AC01_TC02
Test case description	Testing the trained anomaly detection model
Preconditions	The system assumes that the following data is available for training the anomaly detection model: - Train Occupancy - Train Schedule
Trigger	Model training is finished
Test steps	1. Machine learning training is completed 2. Newly trained model is tested
Expected results	The performance metrics of the trained model are higher than the set threshold

10.5.28 T6.4_UC4.4_FRQ03_AC01_TC01

Test case ID	T6.4_UC4.4_FRQ03_AC01_TC01
Test case description	Model update process for anomaly detection
Preconditions	There is already a functioning anomaly detection model in the system that has been trained and validated Historical data will be used as a reference for updating the anomaly detection model The following data is available for training the anomaly detection model: - Train Occupancy - Train Schedule
Trigger	New processed data is obtained and fed into the system
Test steps	1. Input the new processed data into the existing machine learning model 2. Retrain the model to update its parameters considering the new data 3. Validate the updated model using a validation data set 4. Check the performance of the updated model using a test data set
Expected results	The anomaly detection model should effectively incorporate the new data, update its parameters during retraining, validate successfully, and evaluate its functioning using the test data to ensure the updated model is functioning effectively.

10.5.29 T6.4_UC4.4_NFRQ02_AC01_TC01

Test case ID	T6.4_UC4.4_NFRQ02_AC01_TC01
Test case description	Model update lifecycle for anomaly detection
Preconditions	The system can be updated with new data
Trigger	Sufficient new data is available, and a certain time interval since the last update is exceeded
Test steps	1. The retraining intervals of the system are checked 2. The quality of anomaly detection accuracy is recorded 3. Both metrics are checked
Expected results	The system's retraining intervals and quality of detection accuracy are both at a sufficient level. Thus, the system keeps a high update frequency while maintaining high quality detections

10.5.30 T6.4_UC4.4_NFRQ03_AC01_TC01

Test case ID	T6.4_UC4.4_NFRQ03_AC01_TC01
Test case description	Performance evaluation of anomaly detection model
Preconditions	Mechanisms for evaluating the training process of the model, including accuracy metrics and validations are in place

Trigger	Sufficient new data is available, and a certain time interval since the last update is exceeded
Test steps	1. Check accuracy metrics results (accuracy, precision) for the anomaly detection model. 2. Check validation test results (e.g., Cross-Validation) 3. Start fine-tuning process for model parameters
Expected results	The anomaly detection model has accuracy metrics and validations tests documented. The fine-tuning process of model parameters results in better performance compared to the pre-fine-tuned model. The model achieves high accuracy, minimizes false positives and false negatives

10.5.31 T6.4_UC4.4_NFRQ03_AC02_TC01

Test case ID	T6.4_UC4.4_NFRQ03_AC02_TC01
Test case description	Parameter fine-tuning of the anomaly detection model
Preconditions	A fine-tuning mechanism for improving the model's performance metrics is in place
Trigger	Model is trained
Test steps	1. Model training is initiated 2. Start fine-tuning process for model parameters
Expected results	The fine-tuning process of model parameters is completed and results in better performance compared to the pre-fine-tuned model. The model achieves high accuracy, minimizes false positives and false negatives

10.5.32 T6.4_UC4.4_FRQ04_AC01_TC01

Test case ID	T6.4_UC4.4_FRQ04_AC01_TC01
Test case description	Preprocessing for model training for anomaly prediction
Preconditions	The system assumes that the following data is available for training the anomaly prediction model: - Weather conditions - Public/disruptive events - Anomaly labelled data (dataset generated by the anomaly detection model) - Train Schedule - Other relevant data (optional)
Trigger	Data processing is finished, and data is stored
Test steps	1. A new preprocessing of the data is started, including mechanisms for data transformation (e.g., encoding) and feature engineering 2. Preprocessing is finished, and the data is ready for training the machine learning model
Expected results	Training data was successfully pre-processed

10.5.33 T6.4_UC4.4_FRQ04_AC01_TC02

Test case ID	T6.4_UC4.4_FRQ04_AC01_TC02
Test case description	Model training for anomaly prediction
Preconditions	The system assumes that the following data is available for training the anomaly prediction model: - Weather conditions - Public/disruptive events - Anomaly labelled data (dataset generated by the anomaly detection model) - Train Schedule - Other relevant data (optional)
Trigger	Data preprocessing is finished
Test steps	1. Machine learning algorithms are utilized to train the machine learning model with the pre-processed data 2. Model training and testing was finished
Expected results	The test results of the trained model are higher than the set threshold

10.5.34 T6.4_UC4.4_FRQ05_AC01_TC01

Test case ID	T6.4_UC4.4_FRQ05_AC01_TC01
Test case description	Create an updated dataset
Preconditions	Historical data will be used as a reference for updating the anomaly prediction model The system assumes that the following data is available for training the anomaly prediction model: - Weather conditions - Public/disruptive events - Anomaly labelled data (dataset generated by the anomaly detection model) - Train Schedule - Other relevant data (optional)
Trigger	New processed data is obtained and fed into the system
Test steps	1. Input the new processed data for the existing machine learning model 2. Merge the new data with the old database creating an up-to-date database
Expected results	The database on which the anomaly prediction model is trained was updated

10.5.35 T6.4_UC4.4_FRQ05_AC01_TC02

Test case ID	T6.4_UC4.4_FRQ05_AC01_TC02
Test case description	Model update process for anomaly prediction
Preconditions	There is already a functioning anomaly prediction model in the system that has been trained and validated Historical data will be used as a reference for updating the anomaly prediction model The system assumes that the following data is available for training the anomaly prediction model: - Weather conditions - Public/disruptive events - Anomaly labelled data (dataset generated by the anomaly detection model) - Train Schedule - Other relevant data (optional)
Trigger	New updated database is available
Test steps	1. Updated database is available 2. Retrain the model to update its parameters considering the new database 3. Validate the updated model using a validation data set 4. Check the performance of the updated model using a test data set
Expected results	The anomaly prediction model should effectively incorporate the new data, update its parameters during retraining, validate successfully, and evaluate its functioning using the test data to ensure the updated model is functioning more effectively than the old one.

10.5.36 T6.4_UC4.4_FRQ06_AC01_TC01

Test case ID	T6.4_UC4.4_FRQ06_AC01_TC01
Test case description	Predict new anomalies for upcoming data covering weather conditions and public/disruptive events
Preconditions	A trained model for predicting anomalies based on weather conditions, public/disruptive event data and historical data is available The received data will provide the necessary information for predicting anomalies, such as weather conditions and public/disruptive events data
Trigger	For the prediction process new data is fed into the model
Test steps	1. The model receives new data covering weather conditions and public/disruptive events 2. The model uses the data to make predictions for a specified timeframe
Expected results	New anomalies for the specified timeframe were predicted

10.5.37 T6.4_UC4.4_NFRQ04_AC01_TC01

Test case ID	T6.4_UC4.4_NFRQ04_AC01_TC01
Test case description	Model update lifecycle for anomaly prediction
Preconditions	The system can be updated with new data
Trigger	Sufficient new data is available, and a certain time interval since the last update is exceeded
Test steps	1. The retraining intervals of the system are recorded 2. The quality of the anomaly prediction model accuracy is recorded 3. Both metrics are checked
Expected results	The system's retraining intervals and quality of the prediction accuracy are both at a sufficient level. Thus, the system keeps a high update frequency while maintaining high quality prediction

10.5.38 T6.4_UC4.4_NFRQ05_AC01_TC01

Test case ID	T6.4_UC4.4_NFRQ05_AC01_TC01
Test case description	Performance evaluation of anomaly prediction model
Preconditions	Mechanisms for evaluating the training process of the model, including accuracy metrics and validations are in place
Trigger	Sufficient new data is available, and a certain time interval since the last update is exceeded
Test steps	1. Check accuracy metrics results (accuracy, precision) for the anomaly prediction model. 2. Check validation test results (e.g., Cross-Validation) 3. Start fine-tuning process for model parameters
Expected results	The anomaly prediction model has accuracy metrics and validations tests documented. The fine-tuning process of model parameters results in better results compared to the pre-fine-tuned model. The model achieves high accuracy, minimizes false positives and false negatives

10.5.39 T6.4_UC4.4_FRQ07_AC01_TC01

Test case ID	T6.4_UC4.4_FRQ07_AC01_TC01
Test case description	Generation of structured message with contextual information for predicted anomalies
Preconditions	Contextual information for predicted anomalies is available Contextual information is in a format that can be easily integrated in other systems
Trigger	Contextual information is received from the machine learning model
Test steps	1. The system compiles the contextual information 2. After compiling the system structures the information in a known message delivery format (e.g., JSON) 3. The system sends the data in form of a structured method to the TMS
Expected results	The system gathers contextual information on anomaly predictions covering weather conditions, public/disruptive events, and temporal features, generates a structured messages for each predicted anomaly and delivers the message to the TMS

10.5.40 T6.4_UC4.4_FRQ07_AC01_TC02

Test case ID	T6.4_UC4.4_FRQ07_AC01_TC02
Test case description	Generation of structured message with additional contextual information for predicted anomalies and providing context on its frequencies
Preconditions	Contextual information for predicted anomalies is available Contextual information is in a format that can be easily integrated in other systems More contextual information like historical comparisons regarding similar conditions is available
Trigger	Additional contextual information is received
Test steps	1. The system integrates the additional contextual information 2. After integration the system structures the information in a known message delivery format (e.g., JSON)
Expected results	The system integrates additional contextual information on anomaly predictions covering weather conditions, public/disruptive events, and temporal features to provide context on the frequency and generates a structured messages for each predicted anomaly

10.5.41 T6.4_UC4.4_NFRQ06_AC01_TC01

Test case ID	T6.4_UC4.4_NFRQ06_AC01_TC01
Test case description	Performance of structure message generation regarding contextual information for predicted anomalies
Preconditions	Contextual information for predicted anomalies is available
Trigger	Contextual information for predicted anomalies was received
Test steps	1. Contextual information for predicted anomalies was received and time measurement started 2. The generation of a structured message is started 3. Time measurement is stopped as soon as the message was generated and sent to the TMS
Expected results	A structured message for predicted anomalies is generated within a reasonable time

10.5.42 T6.4_UC4.4_NFRQ07_AC01_TC01

Test case ID	T6.4_UC4.4_NFRQ07_AC01_TC01
Test case description	Integration of new message template
Preconditions	A configuration-driven design, allowing the utilization of configuration files to change/update message templates was developed
Trigger	A new message template is generated
Test steps	1. Generate a new message template 2. Load the new template in the system
Expected results	The new message template is integrated into the system

10.5.43 T6.4_UC4.4_NFRQ07_AC01_TC02

Test case ID	T6.4_UC4.4_NFRQ07_AC01_TC02
Test case description	Ensuring new message template fulfils format and main structure
Preconditions	A configuration-driven design, allowing the utilization of configuration files to change/update message templates was developed
Trigger	A new message template is generated
Test steps	1. Generate two new message templates, each of which violate either the format or main structure of the templates 2. Load the new templates in the system
Expected results	The system should ensure that the format and main structure cannot be violated

10.6Test cases task 6.5

10.6.1 T6.5_UC5.1_FRQ01_AC01_TC01

Test case ID	T6.5_UC5.1_FRQ01_AC01_TC01
Test case description	Fetching train schedule, observed data from TMS and data from weather data sources
Preconditions	Relevant data is available
Trigger	Data is requested
Test steps	1. The system sends a request to TMS for train schedule and observed data. 2. The system sends a request to get forecasted and observed weather data from the respective data source. 3. The received data is processed for usage in a trained Machine Learning Model.
Expected results	Data on train schedules and observed data and weather data is processed and available for training or applying the trained machine learning models.

10.6.2 T6.5_UC5.1_FRQ02_AC01_TC01

Test case ID	T6.5_UC5.1_FRQ02_AC01_TC01
Test case description	Fetching forecasted occupancy data to improve schedule delay predictions
Preconditions	Forecasted occupancy data source is available and accessible
Trigger	Data is requested
Test steps	1. The system sends a request to get forecasted occupancy data from the respective data source. 2. The received data is processed for usage in a trained Machine Learning Model.
Expected results	The system successfully fetches forecasted occupancy data and processes this data for use in the trained Machine Learning Model to enhance delay predictions.

10.6.3 T6.5_UC5.1_PRQ01_AC01_TC01

Test case ID	T6.5_UC5.1_PRQ01_AC01_TC01
Test case description	Processing the collected data within a reasonable time to predict delays
Preconditions	Reasonable processing hardware is available and collected data is ready for processing
Trigger	Initiation of data processing for delay prediction
Test steps	1. The system starts processing the collected data. 2. Time measurement is started with the start of the processing 3. Time measurement is stopped as soon as the processing is finished, and the data is available for predicting delays
Expected results	The system successfully processes the collected data within a reasonable time frame, which is less than an hour.

10.6.4 T6.5_UC5.1_FRQ03_AC01_TC01

Test case ID	T6.5_UC5.1_FRQ03_AC01_TC01
Test case description	Training a Machine Learning Model to predict delays using weather data, training data and, optionally, forecasted occupancy data
Preconditions	The relevant training data is available
Trigger	Data processing is completed
Test steps	1. The received data is processed and transformed into a suitable format for model training. 2. The system applies the appropriate algorithms and techniques to the formatted training data to train the model. 3. The system uses the trained model to make delay predictions.
Expected results	The system successfully applies appropriate machine learning techniques to train the model for future predictions.

10.6.5 T6.5_UC5.1_FRQ04_AC01_TC01

Test case ID	T6.5_UC5.1_FRQ04_AC01_TC01
Test case description	Retraining the machine learning model with newly collected observed data
Preconditions	Newly collected observed data and previously collected data is available
Trigger	A need to update the Machine Learning Model for improved predictions
Test steps	1. The system receives new data updates for model training 2. The system processes and integrates the new data with existing historical data 3. The system applies suitable machine learning techniques and algorithms to update the model 4. The system stores the updated model for further use in delay predictions
Expected results	The updated machine learning model successfully overwrites old models and is available for future forecasting and analysis, offering improved accuracy for delay predictions

10.6.6 T6.5_UC5.1_FRQ05_AC01_TC01

Test case ID	T6.5_UC5.1_FRQ05_AC01_TC01
Test case description	Applying the trained machine learning model to predict schedule delays
Preconditions	A trained Machine Learning Model and new relevant data are available
Trigger	Schedule delay prediction is initiated
Test steps	1. The system receives a request to predict schedule delays 2. The received request is processed and applied to the trained Machine Learning model 3. The system analyses the data and provides an accurate prediction of schedule delays 4. The predicted schedule delay information is formatted for communication to the user or integration with other systems
Expected results	The system successfully applies the trained Machine Learning model to accurately predict schedule delays and presents the information in a format suitable for user communication or system integration.

10.6.7 T6.5_UC5.1_FRQ06_AC01_TC01

Test case ID	T6.5_UC5.1_FRQ06_AC01_TC01
Test case description	Storing the predicted delays for future reference
Preconditions	The system has enough storage capacity to store predicted delays for a year
Trigger	Delays are predicted and need to be stored
Test steps	1. Schedule delays are predicted with the machine learning model 2. The system stores the newest delay predictions
Expected results	The system successfully stores the predicted schedule delays in a continuous storage mechanism, and delays which are older than a certain threshold are deleted

10.6.8 T6.5_UC5.1_FRQ07_AC01_TC01

Test case ID	T6.5_UC5.1_FRQ07_AC01_TC01
Test case description	Fetching predicted delays through a specific interface
Preconditions	Predicted delays have been stored and are ready to be accessed
Trigger	TSP fetches predicted delays
Test steps	1. A stored predicted delay is fetched via an external authenticated interface 2. The fetching request is processed and answered
Expected results	The system successfully offers predicted delays using the external authenticated interface, enabling the TSP to gather improved information about the operation.

10.6.9 T6.5_UC5.1_NFRQ01_AC01_TC01

Test case ID	T6.5_UC5.1_NFRQ01_AC01_TC01
Test case description	Keeping the delay prediction model as updated as possible
Preconditions	The system has a trained Machine Learning Model and new relevant data
Trigger	Sufficient availability of new data and the need to provide up-to-date predictions
Test steps	1. The system documents how many updates are conducted 2. The update protocol is checked for update frequency and quality
Expected results	The system successfully keeps the delay prediction model updated within certain time intervals and a certain quality

10.6.10 T6.5_UC5.2_FRQ01_AC01_TC01

Test case ID	T6.5_UC5.2_FRQ01_AC01_TC01
Test case description	Collecting relevant timetable data from Train's TMS
Preconditions	The Train's TMS data sources are available

Trigger	Need to identify possible synchronization issues between timetables
Test steps	1. The system initiates the collection of timetable data from the Train's TMS 2. The collected data is processed for further identification of potential synchronization issues
Expected results	The system successfully collects and processes the relevant timetable data from the Train's TMS for identifying synchronization issues.

10.6.11 T6.5_UC5.2_FRQ01_AC01_TC02

Test case ID	T6.5_UC5.2_FRQ01_AC01_TC02
Test case description	Collecting relevant timetable data from Bus Services
Preconditions	The Bus Services data sources are available
Trigger	Need to identify possible synchronization issues between timetables
Test steps	1. The system initiates the collection of timetable data from Bus Services 2. The collected data is processed for further identification of potential synchronization issues
Expected results	The system successfully collects and processes the relevant timetable data from Bus Services for identifying synchronization issues.

10.6.12 T6.5_UC5.2_PRQ01_AC01_TC01

Test case ID	T6.5_UC5.2_PRQ01_AC01_TC01
Test case description	Processing the collected timetable data within a reasonable time
Preconditions	Reasonable processing hardware is available and collected data is ready for processing
Trigger	Initiation of data processing for identification of synchronization issues
Test steps	1. The system receives new timetable data 2. The time measurement is started 3. The data is processed 4. The processed output is made available 5. Time measurement is stopped as soon as the output is available
Expected results	The system successfully processes the collected timetable data and makes the output available within one hour

10.6.13 T6.5_UC5.2_FRQ02_AC01_TC01

Test case ID	T6.5_UC5.2_FRQ02_AC01_TC01
Test case description	Analysing collected data and identifying possible synchronization issues
Preconditions	The relevant timetable data has been collected
Trigger	Identify synchronization issues
Test steps	1. Analysis of the collected timetable data is initiated 2. The system identifies potential synchronization issues automatically based on the analysis
Expected results	The system successfully analyses the collected data and automatically identified potential synchronization issues

10.6.14 T6.5_UC5.2_FRQ03_AC01_TC01

Test case ID	T6.5_UC5.2_FRQ03_AC01_TC01
Test case description	Storing the identified synchronization issues for future reference
Preconditions	The system has enough storage capacity to store the output for at least two full annual cycles
Trigger	Identification of synchronization issues
Test steps	1. The system identifies the potential synchronization issues 2. The system stores the identified potential synchronization issues in a continuous storage mechanism 3. If two full annual cycles have already been stored, the oldest entries with identified synchronization issues are replaced by new ones
Expected results	The system successfully stores the identified synchronization issues in a continuous storage mechanism and deletes older versions if necessary while ensuring their availability for at least two full annual cycles.

10.6.15 T6.5_UC5.2_FRQ04_AC01_TC01

Test case ID	T6.5_UC5.2_FRQ04_AC01_TC01
Test case description	Making the identified synchronization issues available for manual collection by the TMS
Preconditions	The identified synchronization issues have been stored and are ready to be accessed
Trigger	The TMS fetches the identified synchronization issues
Test steps	1. The TMS accesses the external interface to fetch the stored synchronization issues 2. The potential synchronization issues are provided to the TMS
Expected results	The system successfully provides the potential synchronization issues to the TMS

10.6.16 T6.5_UC5.2_PRQ02_AC01_TC01

Test case ID	T6.5_UC5.2_PRQ02_AC01_TC01
Test case description	Identifying possible synchronization issues in a reasonable time
Preconditions	Reasonable processing hardware is available, and relevant data is ready for processing
Trigger	Need to identify synchronization issues for consideration by the TMS
Test steps	1. The system begins the process of identifying potential synchronization issues 2. Time measurement is started with the start of the identification process 3. The system completes this process 4. Time measurement is stopped with the completion of the process
Expected results	The system successfully identifies possible synchronization issues in under an hour

10.6.17 T6.5_UC5.3_FRQ01_AC01_TC01

Test case ID	T6.5_UC5.3_FRQ01_AC01_TC01
Test case description	Collecting Traveller feedback via a WebApp
Preconditions	An interface with the traveller exists and is able to receive traveller feedback
Trigger	Traveller provides feedback
Test steps	1. Traveller opens WebApp and provides feedback 2. Feedback is collected
Expected results	The system successfully collects Traveller feedback via the implemented WebApp

10.6.18 T6.5_UC5.3_FRQ02_AC01_TC01

Test case ID	T6.5_UC5.3_FRQ02_AC01_TC01
Test case description	Sending feedback via the WebApp at any time
Preconditions	The WebApp is available any time to collect Traveller feedback
Trigger	Traveller sends feedback
Test steps	1. The Traveller accesses the WebApp 2. The Traveller sends feedback via the WebApp at several different times
Expected results	The system successfully accepts and stores the Traveller's feedback sent via the WebApp at any given time.

10.6.19 T6.5_UC5.3_FRQ02_AC01_TC02

Test case ID	T6.5_UC5.3_FRQ02_AC01_TC02
Test case description	Minimizing downtime

Preconditions	The WebApp is available any time to collect Traveller feedback Downtime is tracked as a metric of the WebApp
Trigger	Downtime is checked
Test steps	1. In regular intervals the metrics downtime of the WebApp is checked 2. The downtime metrics is compared to predefined targets
Expected results	The system successfully meets the targets for the downtime metrics

10.6.20 T6.5_UC5.3_FRQ03_AC01_TC01

Test case ID	T6.5_UC5.3_FRQ03_AC01_TC01
Test case description	Checking the availability and functionality of the interface for the TSP
Preconditions	The interface is available, and the TSP is registered
Trigger	The TSP interacts with the system
Test steps	1. The TSP accesses the interface 2. Verify that the Reporting Backoffice allows the TSP to visualize the reporting output
Expected results	The TSP should be able to successfully access the available interface and visualize the reporting output through the interface provided by the Reporting Backoffice

10.6.21 T6.5_UC5.3_FRQ04_AC01_TC01

Test case ID	T6.5_UC5.3_FRQ04_AC01_TC01
Test case description	Requesting feedback from travellers via the WebApp
Preconditions	An interface with the traveller exists and is able to request and receive traveller feedback The traveller allows web browser notifications from the WebApp The traveller has the WebApp opened in a browser
Trigger	The TSP requests traveller feedback
Test steps	1. The TSP defines regions in a map using a Backoffice portal 2. The TSP requests feedback from the users in this region
Expected results	The system successfully sends a request for feedback to travellers within a specific region as defined by the TSP and the travellers in the defined region get notified and those outside the region are not notified

10.6.22 T6.5_UC5.3_NFRQ01_AC01_TC01

Test case ID	T6.5_UC5.3_NFRQ01_AC01_TC01
Test case description	Assessing user-friendliness and intuitiveness of the feedback collector interface
Preconditions	The WebApp is available to collect Traveller feedback
Trigger	A Traveller uses the WebApp to provide feedback

Test steps	1. A Traveller navigates the WebApp to provide feedback for the first time 2. The Traveller assesses the ease of use and intuitiveness of the interface during the feedback process
Expected results	The Traveller is able to easily navigate the interface and intuitively provide meaningful feedback, confirming the user-friendliness and intuitiveness of the feedback collector interface.

10.6.23 T6.5_UC5.3_NFRQ01_AC01_TC02

Test case ID	T6.5_UC5.3_NFRQ01_AC01_TC02
Test case description	Assessing user-friendliness and intuitiveness of the feedback collector interface
Preconditions	The WebApp is available to collect Traveller feedback
Trigger	A Traveller uses the WebApp to provide feedback
Test steps	1. A Traveller navigates the WebApp to provide feedback from at least three devices with different screen sizes 2. The WebApp adapts its layout to each of the different screen sizes
Expected results	The WebApp successfully adapts its layout to each of the different screen sizes

10.6.24 T6.5_UC5.3_NFRQ02_AC01_TC01

Test case ID	T6.5_UC5.3_NFRQ02_AC01_TC01
Test case description	Assessing the compatibility of the WebApp with most mobile devices
Preconditions	The WebApp is available to collect Traveller feedback
Trigger	Traveller uses a mobile device to access the WebApp
Test steps	1. A variety of Travellers access the WebApp using different mobile devices and operating systems 2. These Travellers evaluate the compatibility and functionality of the WebApp on their respective devices
Expected results	The Travellers successfully use the WebApp to provide feedback using their mobile devices, confirming the wide compatibility of the WebApp with various mobile devices and operating systems.

10.6.25 T6.5_UC5.3_NFRQ03_AC01_TC01

Test case ID	T6.5_UC5.3_NFRQ03_AC01_TC01
Test case description	Checking if the scope of collected traveller feedback is focused on congestion
Preconditions	The WebApp is available to collect traveller feedback
Trigger	A traveller provides feedback on the WebApp
Test steps	1. A traveller navigates the WebApp to provide feedback 2. The system checks if the format of the feedback section is focused on gathering information about congestion, e.g., “Are there

	many seats available?", "Are passengers standing?", etc.
Expected results	The system successfully collects and checks traveller's feedback, ensuring it is focused on collecting information about congestion in trains and/or stations

10.6.26 T6.5_UC5.3_FRQ05_AC01_TC01

Test case ID	T6.5_UC5.3_FRQ05_AC01_TC01
Test case description	Storing, analysing, and processing the collected traveller feedback
Preconditions	The traveller feedback has been collected
Trigger	Using the traveller feedback
Test steps	1. The system stores the collected traveller feedback 2. The system analyses and processes the stored feedback based on specific parameters e.g., time, location, date, etc.
Expected results	The system successfully stores, analyses, and processes the collected traveller feedback, so it can be used to improve knowledge on the current congestion situation. If the same feedback is provided from different sources this feedback is weighted higher in the analysis.

10.6.27 T6.5_UC5.3_FRQ06_AC01_TC01

Test case ID	T6.5_UC5.3_FRQ06_AC01_TC01
Test case description	Storing the processed feedback information for future reference
Preconditions	The system has enough storage capacity to store the output
Trigger	Following the processing of traveller feedback
Test steps	1. The system processes the collected traveller feedback 2. The system stores the processed information additionally to the older information
Expected results	The system successfully stores the processed feedback information

10.6.28 T6.5_UC5.3_FRQ06_AC01_TC02

Test case ID	T6.5_UC5.3_FRQ06_AC01_TC02
Test case description	Storing the processed feedback information for future reference
Preconditions	The system has reached its targeted storage capacity
Trigger	Following the processing of traveller feedback
Test steps	1. The system processes the collected traveller feedback 2. The system stores the processed information following a continuous storage mechanism 3. Old information is replaced by new information
Expected results	The system successfully stores the processed feedback information, following the continuous storage mechanism

10.6.29 T6.5_UC5.3_FRQ07_AC01_TC01

Test case ID	T6.5_UC5.3_FRQ07_AC01_TC01
Test case description	Providing an interface for the TSP to access the processed feedback information
Preconditions	The processed feedback information has been stored and is available to be accessed via an external interface
Trigger	The TSP fetches the processed feedback information
Test steps	1. An external interface is accessed to request the output of this module 2. The TSP accesses the external interface to fetch the stored processed feedback information
Expected results	The system successfully provides the processed feedback information to the TSP for the area /stations/trains the TSP operates via the implemented external interface, enabling the TSP to gather a more complete knowledge about the network status. Information on areas/stations/trains which are not operated by the TSP are not provided to the respective TSP.

10.6.30 T6.5_UC5.3_NFRQ04_AC01_TC01

Test case ID	T6.5_UC5.3_NFRQ04_AC01_TC01
Test case description	Keeping the processed congestion information as updated as possible
Preconditions	Traveller feedback has been collected
Trigger	Availability of new traveller feedback data and the need to provide up-to-date congestion information
Test steps	1. The system receives new traveller feedback data 2. Time measurement is started 3. The system processes the feedback data 4. Time measurement is stopped as soon as feedback data is successfully processed
Expected results	The system successfully updates the processed congestion information by processing the new traveller feedback data within thirty minutes

10.6.31 T6.5_UC5.4_FRQ01_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ01_AC01_TC01
Test case description	Collecting and storing passenger demand data
Preconditions	Availability of real-time or modelled passenger flow data
Trigger	Collection process is initiated
Test steps	1. The system initiates the process to collect real-time or modelled passenger flow data 2. The collected demand data is stored in a database
Expected results	The system successfully collects the demand data from the identified sources and stores it in a database, preparing it for further analysis

10.6.32 T6.5_UC5.4_FRQ02_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ02_AC01_TC01
Test case description	Collecting and storing timetable data
Preconditions	Availability of timetable and train platforming data
Trigger	Collection process is initiated
Test steps	1. The system initiates the process to collect timetable and train platforming data from Trenitalia internal sources 2. The collected timetable data is stored in a database
Expected results	The system successfully collects the timetable and train platforming data from Trenitalia internal sources and stores it in a database, preparing it for further analysis

10.6.33 T6.5_UC5.4_FRQ03_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ03_AC01_TC01

Test case description	Considering and storing train punctuality data for analysis
Preconditions	Availability of train punctuality data
Trigger	Need to collect, store, and consider train punctuality data for analysis
Test steps	1. The system initiates the process to collect train punctuality data at the analysed station 2. The train punctuality data is stored in a database for further analysis
Expected results	The system successfully collects, stores, and considers train punctuality data, preparing it for further analysis

10.6.34 T6.5_UC5.4_FRQ04_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ04_AC01_TC01
Test case description	Considering and storing station geometry and platform configuration data for analysis
Preconditions	Availability of timetable and infrastructure data
Trigger	Need to collect, store, and consider station geometry and platform configuration data for analysis
Test steps	1. The system initiates the process to collect station geometry and platform configuration data at the analysed station 2. The considered station geometry and platform configuration data for further analysis
Expected results	The system successfully collects, stores, and considers the station geometry and platform configuration data and stores it in a database, preparing it for further analysis

10.6.35 T6.5_UC5.4_NFRQ01_AC01_TC01

Test case ID	T6.5_UC5.4_NFRQ01_AC01_TC01
Test case description	Performing on different scenarios considering updated input data provided by railway undertakings
Preconditions	Different scenarios or data update requests can be generated
Trigger	The scenario or input data has changed
Test steps	1. The system receives updated input data or different configuration scenarios provided by the railway undertakings 2. The system simulates different scenarios considering these updates or configurations 3. The system conducts a gap analysis based on the results of the simulations
Expected results	The system successfully simulates different scenarios and conducts gap analysis considering the adapted input data updates provided by the railway undertakings. The system takes into account time-sensitive data updates or different configuration scenarios

10.6.36 T6.5_UC5.4_FRQ05_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ05_AC01_TC01
Test case description	Analysing and processing the collected demand data
Preconditions	The passenger flow data has been collected and stored in the database
Trigger	Need to analyse and process the demand data for optimization and performance analysis
Test steps	1. The system retrieves the collected passenger flow data from the database 2. The system analyses and processes this data for optimization purposes 3. The system further analyses the processed data for performance analysis.
Expected results	The system successfully analyses and processes the collected demand data and utilizes it for optimization and performance analysis

10.6.37 T6.5_UC5.4_FRQ06_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ06_AC01_TC01
Test case description	Analysing and processing the collected timetable data
Preconditions	The timetable data has been collected and stored in the database
Trigger	Timetable data is processed for optimization and performance analysis
Test steps	1. The system retrieves the collected timetable data from the database 2. The system analyses and processes this data for optimization purposes 3. The system further analyses the processed data for performance analysis
Expected results	The system successfully analyses and processes the collected timetable data and utilizes it for optimization and performance analysis

10.6.38 T6.5_UC5.4_FRQ07_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ07_AC01_TC01
Test case description	Optimizing the allocation of trains to platforms to optimize connection time for passengers
Preconditions	Relevant data is available, and the system is capable of processing the input data and running the optimization algorithm
Trigger	Need to optimize the allocation of trains to platforms
Test steps	1. The system processes the input data 2. The system runs the optimization algorithm 3. The system provides the best platform configuration as a result
Expected results	The system successfully optimizes the allocation of trains to platforms, maximizing the connection time for passengers, and provides the best platform configuration as a result

10.6.39 T6.5_UC5.4_FRQ08_AC01_TC01

Test case ID	T6.5_UC5.4_FRQ08_AC01_TC01
Test case description	Evaluating passenger congestion based on the optimized platform configuration
Preconditions	Timetable data, demand, and infrastructure data have been collected and stored
Trigger	Evaluation of passenger congestion based on the optimized platform configuration
Test steps	1. The system retrieves the optimized platform configuration 2. The system evaluates passenger congestion based on the optimized platform configuration using visualization and performance measurement tools
Expected results	The system successfully evaluates passenger congestion according

	to the optimized platform and visualises the results

10.6.40 T6.5_UC5.4_NFRQ02_AC01_TC01

Test case ID	T6.5_UC5.4_NFRQ02_AC01_TC01
Test case description	Rerunning the process upon every change of the scenario or input data to obtain an optimized configuration
Preconditions	All relevant data is available
Trigger	The scenario or input data has been changed
Test steps	1. Changes to the scenario or input data have been made 2. The system reruns the entire process in response to these changes
Expected results	The system successfully reruns the whole process efficiently upon every change of the scenario or input data, ensuring an optimized configuration every time

10.7Test cases task 6.6

10.7.1 T6.6_UC6.1_FRQ01_AC01_TC01

Test case ID	T6.6_UC6.1_FRQ01_AC01_TC01
Test case description	The system can identify train services that can transport parcels based on a flag in the timetable data
Preconditions	Static timetable data are available and extended by a flag for services that can transport parcels
Trigger	Trip options for the shipment of parcels are requested
Test steps	1. The system accesses static timetable data to calculate trip options 2. The system identifies those services that can transport parcels based on a flag in the timetable data
Expected results	The system correctly identifies train services that can transport parcels and includes these services in the calculated trip options, thereby enabling accurate shipment planning for parcels

10.7.2 T6.6_UC6.1_FRQ02_AC01_TC01

Test case ID	T6.6_UC6.1_FRQ02_AC01_TC01
Test case description	The system should provide an option in the frontend to search for trips suitable for parcels
Preconditions	The journey planning application is operational, and users can initiate trip searches
Trigger	A user is searching for a trip that will involve transporting a parcel, or a container of parcels
Test steps	1. A user opens the journey planning application and requests a trip search 2. Trip suggestions are calculated and presented 3. The user clicks on the dedicated cluster for suggested parcel trips to see the trip suggestions for parcels or container of parcels
Expected results	The journey planning application correctly initiates a trip search for a parcel upon user request, and provides suitable trip options in response

10.7.3 T6.6_UC6.1_FRQ03_AC01_TC01

Test case ID	T6.6_UC6.1_FRQ03_AC01_TC01
Test case description	The system should be able to compute trip options that permit the transport of parcels
Preconditions	The journey planning application is operational, users are able to initiate trip searches, and timetable data indicating whether a train can transport parcels is available
Trigger	A user is searching for a trip that will involve transporting a parcel
Test steps	1. The user opens the journey planning application to start a trip search for a parcel. 2. The user inputs departure/arrival time, start and end station, and triggers the journey planning application to compute trip options. 3. The journey planning application computes trip options that permit the transport of parcels
Expected results	The journey planning application correctly calculates trip options that can accommodate the transport of parcels

10.7.4 T6.6_UC6.1_FRQ03_AC01_TC02

Test case ID	T6.6_UC6.1_FRQ03_AC01_TC02
Test case description	The system should be able to compute trip options that permit the transport of parcels and include first and last mile routes
Preconditions	The journey planning application is operational, users are able to initiate trip searches, and timetable data indicating whether a train can transport parcels is available
Trigger	A user is searching for a trip that will involve transporting a parcel
Test steps	1. The user opens the journey planning application to start a trip search for a parcel. 2. The user inputs departure/arrival time, start and end address, and triggers the journey planning application to compute trip options. 3. The journey planning application computes trip options that permit the transport of parcels, taking into account first and last mile walks
Expected results	The journey planning application correctly calculates trip options that can accommodate the transport of parcels and includes necessary first and last mile walks

10.7.5 T6.6_UC6.1_FRQ04_AC01_TC01

Test case ID	T6.6_UC6.1_FRQ04_AC01_TC01
Test case description	The system should be able to display the prices for the transport of parcels
Preconditions	The journey planning application is operational, users are able to initiate trip searches, and pricing data is available and only dependent on the size and weight of the parcel
Trigger	A user initiates a search for a trip involving the transportation of a parcel
Test steps	1. The user opens the journey planning application to start a trip search for a parcel 2. The journey planning application computes trip options that permit the transport of parcels. 3. The system displays the list of prices for the transport of the parcel in the trip details view
Expected results	The journey planning application correctly displays the accurate prices for the transport of parcels of different sizes and weights.

10.7.6 T6.6_UC6.1_NFRQ01_AC01_TC01

Test case ID	T6.6_UC6.1_NFRQ01_AC01_TC01
Test case description	The system should be able to compute trip options for parcels within an acceptable time frame
Preconditions	The journey planning application is operational, and users can initiate trip searches
Trigger	A user initiates a search for a trip involving the transportation of a parcel
Test steps	1. A user queries the journey planner to provide a route for a parcel 2. Time measurement is started with the query 3. The journey planning system computes trip options for the parcel 4. Time measurement is stopped once the feasible routes for the parcel are computed
Expected results	The time taken to compute trip options for parcels is at most 150% of the time needed for calculating a comparable trip for a traveller. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

10.7.7 T6.6_UC6.2_FRQ01_AC01_TC01

Test case ID	T6.6_UC6.2_FRQ01_AC01_TC01
Test case description	The system should be able to recognize the capacity of trains for transporting containers with parcels based on the timetable data
Preconditions	Timetable data is available and specifies for each train service that can transport parcels at which stops a container can be loaded or unloaded
Trigger	The system is computing trip options for a parcel
Test steps	1. The user initiates a search for a trip involving the transportation of a parcel 2. The system accesses the timetable data to identify train services that can transport parcels and their loading/unloading capacity at each stop 3. The system computations consider the specified loading/unloading restrictions in the timetable data for each train service
Expected results	The journey planning application correctly computes trip options while accounting for the capacity of each train service to load and unload containers with parcels at each stop. The application should accurately reflect the restrictions provided in the timetable data

10.7.8 T6.6_UC6.2_FRQ02_AC01_TC01

Test case ID	T6.6_UC6.2_FRQ02_AC01_TC01
Test case description	The system should accurately account for the sorting and consolidation time of shipments at hubs in its trip calculations
Preconditions	Timetable data is available and details the necessary sorting and consolidation time at hubs
Trigger	The system is calculating trip options for a parcel
Test steps	1. The user initiates a search for a trip involving the transportation of a parcel 2. The system identifies trips that involve transfers at hubs 3. The system calculations factor in the necessary sorting and consolidation time for those transfers 4. The system provides a realistic duration for the trip considering these factors
Expected results	The journey planning application successfully computes trip options, properly considering the time needed for sorting of parcels and consolidating of shipments at hubs. The provided trip duration should accurately reflect these operations

10.7.9 T6.6_UC6.2_FRQ03_AC01_TC01

Test case ID	T6.6_UC6.2_FRQ03_AC01_TC01
Test case description	The system should ensure that containers loaded at normal stations must always be unloaded at a hub
Preconditions	Timetable data is available and specifies unloading restrictions for containers loaded at normal stations
Trigger	The system is calculating trip options for a parcel
Test steps	1. The user initiates a search for a trip involving the transportation of a parcel 2. The system identifies trips involving containers loaded at normal stations 3. The system ensures that these containers are only scheduled to be unloaded at hub stations 4. The system provides trip options that adhere to this requirement
Expected results	The journey planning application successfully computes trip options, properly considering the requirement that containers loaded at normal stations must always be unloaded at a hub.

10.7.10 T6.6_UC6.2_FRQ04_AC01_TC01

Test case ID	T6.6_UC6.2_FRQ04_AC01_TC01
Test case description	The system should be able to calculate trips for a parcel from address to address, including the first and last mile legs, transfers, and the sections between hubs where loading and unloading is restricted
Preconditions	The journey planning application is operational, users can initiate trip searches, timetable data details relevant restrictions, and addresses are input for both the start and end of the trip
Trigger	A user is searching for an address-to-address trip for a parcel
Test steps	1. The user opens the journey planning application to start an address-to-address trip search for a parcel 2. The system carries out calculations that consider train capacity, transfer times at hubs, and sections where loading and unloading the same container isn't allowed 3. The journey planning application provides trip options that include first and last mile legs (from and to the addresses provided), and necessary transfers
Expected results	The journey planning application correctly calculates trip options that consider all necessary factors. The resulting options should include first and last mile routes, accurate transfer times, and considerations for train capacity and unloading restrictions.

10.7.11 T6.6_UC6.2_NFRQ01_AC01_TC01

Test case ID	T6.6_UC6.2_NFRQ01_AC01_TC01
Test case description	The system should be able to compute trip options for parcels between addresses sent via parcel lockers within an acceptable time frame

Preconditions	The journey planning application is operational, and users can initiate trip searches
Trigger	A user initiates a search for a trip involving the transportation of a parcel from address to address via parcel lockers
Test steps	1. A user queries the journey planner to provide a route for a parcel from address to address via parcel lockers 2. Time measurement is started with the query. 3. The journey planning system computes trip options for the parcel 4. Time measurement is stopped once the feasible routes for the parcel are computed
Expected results	The time taken to compute trip options for parcels from address to address via parcel lockers is at most 150% of the time needed for calculating a comparable trip for a traveller. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

10.7.12 T6.6_UC6.3_FRQ01_AC01_TC01

Test case ID	T6.6_UC6.3_FRQ01_AC01_TC01
Test case description	The front end of the system should provide extended options to search for trips for parcels, allowing for the input of different types and numbers of swap bodies or mobile parcel lockers from CEP companies
Preconditions	The journey planning application is operational, and users can initiate trip searches An additional front end for CEP companies exists
Trigger	A user from a CEP company initiates a search for a trip involving the transportation of a parcel using swap bodies or mobile parcel lockers
Test steps	1. The user opens the journey planning application to start a trip search for a parcel 2. The application provides options to input the type and the number of swap bodies or mobile parcel lockers 3. The user inputs the desired type and number of swap bodies or mobile parcel lockers into the search request
Expected results	The journey planning application correctly provides options to select type and number of swap bodies or mobile parcel lockers, and it incorporates the user’s selection into the computed trip options

10.7.13 T6.6_UC6.3_FRQ02_AC01_TC01

Test case ID	T6.6_UC6.3_FRQ02_AC01_TC01
Test case description	The system should consider currently available capacity for swap bodies or mobile parcel lockers when calculating trip options for CEP company requests
Preconditions	The journey planning application is operational, users can initiate trip searches, and up-to-date capacity data is available for all trains and service sections
Trigger	A user from a CEP company initiates a trip search that involves the transportation of swap bodies or mobile parcel lockers
Test steps	1. The user opens the journey planning application and inputs the type and number of swap bodies or mobile parcel lockers for a trip 2. The journey planning application accesses the backend to retrieve up-to-date data on remaining capacity for all trains and service sections 3. The application calculates trip options considering the available capacity for swap bodies or mobile parcel lockers, taking into account previous bookings 4. The system provides the user with trip options that respect the current capacity limitations
Expected results	The journey planning application successfully incorporates current capacity availability in its trip calculations. The displayed trip options should accurately represent available capacity for swap bodies or mobile parcel lockers at the time of the search.

10.7.14 T6.6_UC6.3_FRQ03_AC01_TC01

Test case ID	T6.6_UC6.3_FRQ03_AC01_TC01
Test case description	The system should calculate trips for swap bodies or mobile parcel lockers that are feasible considering capacity constraints for each leg of the trip
Preconditions	The journey planning application is operational, users can initiate trip searches, and up-to-date capacity data is available for all trains and service sections
Trigger	A user from a CEP company initiates a trip search involving the transportation of swap bodies or mobile parcel lockers
Test steps	1. The user opens the journey planning application and inputs the type and number of swap bodies or mobile parcel lockers for a trip 2. The application accesses up-to-date data about remaining capacity in all trains and for all service sections from the backend 3. The system calculates trip options that consider available capacity for different types of swap bodies or mobile parcel lockers, and ensures that options returned have sufficient capacity for each leg of the trip 4. The system provides the user with feasible trip options
Expected results	The journey planning application successfully computes feasible trip options that consider capacity constraints for each leg of the trip

10.7.15 T6.6_UC6.3_NFRQ01_AC01_TC01

Test case ID	T6.6_UC6.3_NFRQ01_AC01_TC01
Test case description	The system should be able to compute trip options for parcels sent by CEP companies via swap bodies or mobile parcel lockers within an acceptable time frame
Preconditions	The journey planning application is operational
Trigger	A user from a CEP company initiates a search for a trip involving the transportation of a parcel via swap bodies or mobile parcel lockers
Test steps	1. A user from a CEP company queries the journey planner to provide a route for a parcel via swap bodies or mobile parcel lockers 2. Time measurement is started with the query 3. The journey planning system computes trip options for the parcel 4. Time measurement is stopped once the feasible routes for the parcel are computed
Expected results	The time taken to compute trip options for parcels sent by CEP companies via swap bodies or mobile parcel lockers is at most 150% of the time needed for calculating a comparable trip for a traveller. The time required for data transfer between the server (backend) and a frontend must be ignored as it depends on the performance of the network that is not under control of FP6 WP6.

10.8Test cases task 6.8

10.8.1 T6.8_UC8.1_FRQ01_AC01_TC01

Test case ID	T6.8_UC8.1_FRQ01_AC01_TC01
Test case description	A report including a graph type data analytics is generated
Preconditions	The system has stored historic data about the question at hand
Trigger	The BIA starts the report (graph type) function
Test steps	1. BIA starts the report (graph type) function 2. System offers the different types of graphs 3. BIA selects one graph type report 4. System offers stored historic data in time series 5. BIA selects one or more time series and/or region, line, etc. 6. System generates and provides the report
Expected results	Report (graph type) of the relevant analytics of the selected time and region

10.8.2 T6.8_UC8.2_FRQ01_AC01_TC01

Test case ID	T6.8_UC8.2_FRQ01_AC01_TC01
Test case description	Successful adjustment to train schedules based on demand
Preconditions	The system has current schedule, available trains and network stored
Trigger	The Traffic Manager (TraMa) requests the BIA (BIA) to prepare an adopted offer due to demand
Test steps	1. TraMa or BIA starts the function to determine new offers and enters the change e.g., new trains, cut trains, modified times 2. System calculated the proposal for a demand-oriented offer 3. TraMa or BIA change the input data 4. System changes the proposal 5. TraMa or BIA decides to refine the offer => step 3. or accept the offer => step 6. 6. TraMa or BIA forward the offer the TMS for execution
Expected results	New offer due to demand in operation

10.8.3 T6.8_UC8.2_FRQ01_AC01_TC02

Test case ID	T6.8_UC8.2_FRQ01_AC01_TC02
Test case description	Adjustment to train schedules based on demand unsuccessful
Preconditions	The system has current schedule, available trains and network stored
Trigger	The TraMa requests the BIA to prepare an adopted offer due to demand
Test steps	1. TraMa or BIA starts the function to determine new offers and enters the change e.g., new trains, cut trains, modified times 2. System calculated the proposal for a demand-oriented offer 3. TraMa or BIA change the input data 4. System changes the proposal 5. TraMa or BIA decides to refine the offer => step 3. or decide to stop as no offer for the demand is possible => step 6. 6. offer stay unchanged, Function terminated 6. System generates and provides the report
Expected results	Previous offer stays in the TMS in operation

10.8.4 T6.8_UC8.3_FRQ01_AC01_TC01

Test case ID	T6.8_UC8.3_FRQ01_AC01_TC01
Test case description	Reaction to train issues based on customers' feedback
Preconditions	1. The system has current and past schedules, trains, and network stored 2. Customer feedback is available in the system
Trigger	The Train Operation Manager (TOM) requests the BIA to analyse customer feedback by time series or line
Test steps	1. BIA starts the backend analytics tool to create a report on customer feedback 2. The system offers different cluster of issues reported from customers 3. BIA selects one cluster and generates the report 5. BIA forward the report to TOM 6. TOM receives the customer feedback concerning their train lines as a report (on a e.g., monthly basis)
Expected results	(e.g., monthly) report on issues on train lines

10.8.5 T6.8_UC8.3_NFRQ01_AC01_TC01

Test case ID	T6.8_UC8.3_NFRQ01_AC01_TC01
Test case description	Access to customer feedback data
Preconditions	1. Customers provided feedback data 2. Customer feedback data is accessible
Trigger	The Train Operation Manager (TOM) requests the BIA to analyse customer feedback
Test steps	1. BIA starts to generate the report on customer feedback in the analytics tool 2. The analytics tool accesses customer feedback data
Expected results	Customer feedback data can be accesses and used to generate a report with the backend analytics tool

10.8.6 T6.8_UC8.4_DTRQ01_AC01_TC01

Test case ID	T6.8_UC8.4_DTRQ01_AC01_TC01
Test case description	Documentation of software configurations, procedures, and changes
Preconditions	Documentation of software configurations, procedures, and changes was kept
Trigger	Documentation check
Test steps	1. Documentation is available and covers completely configurations and procedures
Expected results	A complete and comprehensible documentation on configurations, procedures and changes exists

10.8.7 T6.8_UC8.5_ORQ01_AC01_TC01

Test case ID	T6.8_UC8.5_ORQ01_AC01_TC01
Test case description	Data is backed up in case of data loss
Preconditions	Available space on the back-up drive OR connectivity to the cloud storage
Trigger	User executes an action and realises data went missing: BI analyst queries the database for customer behaviour data and realises that data was lost
Test steps	1. Data is lost 2. The administrator accesses the data back-up. 3. The administrator restores the lost data
Expected results	The lost data is restored

10.8.8 T6.8_UC8.6_ORQ01_AC01_TC01

Test case ID	T6.8_UC8.6_ORQ01_AC01_TC01
Test case description	Backed up data can be retrieved in case of data loss
Preconditions	Data was backed up
Trigger	User executes an action and realises data went missing: BI analyst queries the database for customer behaviour data and realises that data was lost
Test steps	1. Data is lost 2. The administrator accesses the data back-up. 3. The administrator restores the lost data by retrieving it from the backed-up data
Expected results	The lost data is restored

10.8.9 T6.8_UC8.7_RCRQ01_AC01_TC01

Test case ID	T6.8_UC8.7_RCRQ01_AC01_TC01
Test case description	Log files are produced and reviewed
Preconditions	Critical information is being logged and can be audited. Compliance criteria were defined, and a report template generated
Trigger	Critical behaviour is executed
Test steps	1. Checking of the log files that the behaviour has been tracked 2. Checking of the compliance report that the critical behaviour displays a violation of compliance rules
Expected results	Details about the failed action are saved in a log-file and show up in the compliance report

10.8.10 T6.8_UC8.8_FRQ01_AC01_TC01

Test case ID	T6.8_UC8.8_FRQ01_AC01_TC01
Test case description	Cross-border operation
Preconditions	Information from adjacent countries is available
Trigger	Select "Plan route" option on website
Test steps	1. From landing page select "Plan Route" 2. User selects a travel date 3. Select "Origin" (can comprise stations in adjacent countries) 5. Select "Destination" (can comprise stations in adjacent countries)
Expected results	A list of route options including cross border legs is displayed

10.8.11 T6.8_UC8.9_PRQ01_AC01_TC01

Test case ID	T6.8_UC8.9_PRQ01_AC01_TC01
Test case description	The software can be used concurrently
Preconditions	The system architecture is chosen so that up to Y end users can query trips concurrently. Multiple end-users access the software and perform actions
Trigger	Y users enter a starting and end point for a trip and request a route
Test steps	1. Starting Y queries simultaneously in the system 2. When starting each query, the time measurement starts 2. The system provides routing suggestions for the entered starting and end point for each query 3. The time measurement stops for each query (the moment the suggestions are being provided)
Expected results	The time needed for the generation of routing results for each query is less than 3 seconds

10.8.12 T6.8_UC8.10_PRQ01_AC01_TC01

Test case ID	T6.8_UC8.10_PRQ01_AC01_TC01
Test case description	The system reaches in production an availability of 99,9%.
Preconditions	Failover mechanisms are set in place to guarantee basic features of the software
Trigger	An issue occurs causing the system to shut down
Test steps	1. Time measurement starts the moment the system is offline 2. Failover mechanisms are activated. 3. The system is up and running again 4. Time measurement stops once the system is back online
Expected results	The downtime is < 15 secs (which allows for 2.102 instances forcing system shut down p.a.)

10.8.13 T6.8_UC8.11_PRQ01_AC01_TC01

Test case ID	T6.8_UC8.11_PRQ01_AC01_TC01
Test case description	Architectural redundancy
Preconditions	A redundant architecture is set-up
Trigger	The system/software is not available
Test steps	1. The system/software is not available 2. The redundant components are activated
Expected results	The downtime is minimised, and no user experience degradation is observed with the redundant software solution

10.8.14 T6.8_UC8.12_FRQ01_AC01_TC01, T6.8_UC8.13_FRQ01_AC01_TC01

Test case ID	T6.8_UC8.12_FRQ01_AC01_TC01, T6.8_UC8.13_FRQ01_AC01_TC01
Test case description	Creation of dashboard for low code data visualisation
Preconditions	1. The system has an integrated analytics tool 2. The analytics tool has access to relevant data, e.g., user feedback,

	booking data, train traffic data, etc. 3. The system provides the possibility for a BIA to create custom dashboards for managers or other personas
Trigger	A BIA receives a request from a user (e.g., marketing manager, network planner, etc.) to create a dashboard for them
Test steps	1. A BIA receives a request to create a dashboard 2. Based on the request the BIA chooses and/or creates the data and visualisation types which shall be available in the dashboard 3. The BIA creates the dashboard and makes it available for the requesting user
Expected results	A custom dashboard for the requesting user with a low code functionality to visualise business insights via graphs which were predetermined by the BIA

10.8.15 T6.8_UC8.12_FRQ02_AC01_TC01, T6.8_UC8.13_FRQ02_AC01_TC01

Test case ID	T6.8_UC8.12_FRQ02_AC01_TC01, T6.8_UC8.13_FRQ02_AC01_TC01
Test case description	Visualisation of business insights via dashboards
Preconditions	1. The system has an integrated analytics tool 2. The analytics tool has access to relevant data, e.g., user feedback, booking data, train traffic data, etc. 3. The system provides an intuitive, low code user interface for data visualisation via dashboards
Trigger	A user opens the dashboard interface within the analytics tool
Test steps	1. A user selects the dashboard interface within the analytics tool 2. Options regarding data selection, time period and graph types are displayed 3. A user chooses the data sets 4. A user chooses the time period 5. A user chooses the graph type 6. A user triggers the generation of graph based on the selected data, time period and graph type
Expected results	A graph visualising the selected data and time in form of the selected graph type. This graph was predetermined by the BIA who created the dashboard.

10.8.16 T6.8_UC8.14_FRQ02_AC02_TC02, T6.8_UC8.15_FRQ02_AC02_TC02

Test case ID	T6.8_UC8.14_FRQ02_AC02_TC02, T6.8_UC8.15_FRQ02_AC02_TC02
Test case description	Demand forecast via analytics tool
Preconditions	1. The system has an analytics tool integrated 2. The analytics tool has access to relevant data, e.g., booking data, train traffic data, etc. 3. The system provides an intuitive, low code user interface for demand forecasting
Trigger	A BIA opens the forecasting interface within the analytics tool of the

	software.
Test steps	1. A BIA opens the forecasting interface within the analytics tool 2. Options regarding the journey leg, data sets, other constraints and the forecasting time period are displayed. The BIA chooses the desired options. 3. The BIA triggers the generation of the forecast based on the selected journey legs, data sets, other constraints, and the forecasting time period
Expected results	A forecast based on the chosen inputs was generated and is visualised

10.8.17 T6.8_UC8.16_FRQ01_AC01_TC01

Test case ID	T6.8_UC8.16_FRQ01_AC01_TC01
Test case description	Travel Service Notification if changes occur
Preconditions	1. A travel plan exists 2. The user has notifications for the application enabled or provided an email address
Trigger	A delay occurs in the planned journey
Test steps	1. The TMS sends the PIS an updated operational plan 2. The PIS recognises the delay and sends the user a notification containing information regarding the delay
Expected results	The notification is received by the user and contains information on the change
Actual results	The actual outcome of the test case.
Status	The status of the test case (pass, fail, or pending).

10.8.18 T6.8_UC8.17_FRQ01_AC01_TC01

Test case ID	T6.8_UC8.17_FRQ01_AC01_TC01
Test case description	Enable DRT service providers to register services on the platform
Preconditions	Form for expressing one's interest exists
Trigger	The on-demand service provider expresses the interest by registering via a form
Test steps	1. The on-demand service provider starts the registration process to be onboarded to the ecosystem by opening the registration form 2. The on-demand service provider inputs all necessary details of the service provider 3. The on-demand service provider submits the form
Expected results	The registration of interest form is received by the platform administrator for review

11 Conclusions

In this deliverable a requirement specification for a multimodal travel solution is developed. The software solution focused on the revitalisation of regional railways by incorporating first/last mile services, demand-based and real-time routing algorithms.

The specification was initiated by thinking of different user profiles that are affected by the software solution. In consequence, user-stories were derived incorporating perspectives from commuters, persons with reduced mobility, tourists, and families. Here, demand-responsive and real-time routing techniques are interweaved with the development of recommendations for journey selection and recommendations for rescheduling a trip in case of delays. This is accompanied by extra information about specialized equipment on stations such as lifts, escalators, and wider paths.

Additionally, a software during operation requires a strong alignment among administrators and software operators. Requirements were developed covering data management and backup as well as logging, auditing and compliance which is followed by documentation requirements for both end-users and backend-service providers.

Lastly, the software will also be used by infrastructure managers, railway undertakings, traffic managers and business intelligence analysts who will generate reports to provide insights into their specific questions. This will then lead to an enhancement of operability due to new insights into passenger behaviour, demand, and customer feedback in general. With this new information demand forecasts can be more precise, and the adjustment of train schedules can be executed with valuable insights. The necessary requirements to provide value adding business insights were derived.

The whole specification ranging from use cases to test cases was supported through the valuable input from other European partners which were provided through the developed questionnaire but also drawn from direct collaboration.

The use cases, requirements, acceptance criteria and test cases are prepared in concise templates to make the specific goals of users and relevant preconditions as well as the system interaction traceable and comparable. Thus, different stakeholders can interpret the results fast, and a better comprehensibility is ensured.

The testing strategy featured unit, integration, user acceptance, regression, and stress tests. Unit tests and regression tests are considered as white box tests. User acceptance tests and stress tests are regarded as black box tests. In general, the tests should be grouped to the focus topics of the user interface, backend services, demand-based and routing algorithms, the analytics tool, and the integration with external systems for the first/last mile providers. To conclude, the development of a multimodal travel solution required a holistic approach to incorporate the wide range of user groups and requirement areas. By pursuing this kind of systems, a flexible, high capacity, sustainable railway is aimed to be established.

12 References

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13 List of tables

14 Annexes

[Questionnaire will be added here for final PDF version]