X2Rail-2

Project Title:	Enhancing railway signalling systems based on train satellite positioning, on-board safe train integrity, formal methods approach and standard interfaces, enhancing traffic management system functions
Starting date:	01/09/2017
Duration in months:	36
Call (part) identifier:	H2020-S2RJU-CFM-IP2-01-2017
Grant agreement no:	777465

Deliverable D6.6
System Requirement Specification (SRS) for WEB-IF

Due date of deliverable	Month 18
Actual submission date	01-02-2019
Organization name of lead contractor for this deliverable	Beneficiary Short Name
Dissemination level	PU/CO
Revision	Final

Authors

Author(s)	**HaCon Ingenieurgesellschaft mbH (HC)** Mahnam Saeednia, Overall author and editor Rolf Gooßmann, Overall author and editor
Contributor(s)	**Ansaldo (ASTS)** Gian Luigi Zanella – Review and contribution to sections 7.5, 8.2 Fabrizio Cosso – Review and contribution to sections 7.5, 8.2
	Bombardier (BTSE) Roland Kuhn, Review
	SIEMENS (SIE) Stefan Wegele, Review
	Network Rail (NR) Imtithal Aziz, Review
	Trafik Verket (TRV) Anna-Maria Östlund, Review Peter Olsson, Review
	Thales Christoph Bücker, Review and update of UC8 Allan Young, Review and update of UC8
	AZD Michal Zemlicka, Review Martin Bojda, Review

1 Executive Summary

In order to manage railway traffic in real time and provide accurate and timely responses to the traffic changes, there is the need to support automated and seamless exchange of dynamic information with external systems such as weather information systems, freight third parties, etc.. This will contribute to various objectives of the Shift2Rail project such as capacity increase, cost reduction and reliability increase, as well as the interoperability among railway services.

Dynamic exchange of information has been facilitated by a common communication platform, the so-called integration layer (IL), developed in the In2Rail [In2Rail] project. This platform will be enhanced in the follow-up Shift2Rail projects such as X2Rail2 [X2Rail2] and IMPACT2 [IMPACT2]. In this framework, D6.6 focuses on the specification of a web interface to manage the provision of updated traffic status information and to receive changes in the transportation demand. This inbound information may be integrated into the Traffic Management Processes and the outbound information enhances the internal operations of external systems. The requirements for connecting freight operation services to the integration layer (IL) are specifically taken into consideration.

2 Table of Contents

3 Abbreviations and acronyms

Abbreviation / Acronyms	Description
CDM	Canonical Data Model
CDR	Conflict Detection and Resolution
DG	Dangerous Goods
ETA	Estimated Time of Arrival
ETI	Estimated Time of Interchange
FRU	Freight Railway Undertaking
IL	Integration Layer
IM	(Railway) Infrastructure Manager
PIS	Passenger Information System
RSRD	Rolling Stock Reference Database
RU	Railway Undertaking
SRS	System Requirement Specification
TAF/TAP TSI	Technical Specification for Interoperability relating to Telematics Applications for Freight/Passenger Services
TMS	Traffic Management System
TOC	Train Operating Company
TSR	Temporary Speed Restriction
Web IF	Web Interface
WIMO	Wagon & Intermodal Operating Unit Data
WIS	Weather Information Services

4 Background

Currently, there are no defined standard data structures and interfaces for communication between existing TMS services, except in certain cases such as TAF/TAP TSI. In order to reduce the related efforts and costs emanating from this issue, a key target of the In2Rail project [In2Rail] was to design a communication platform, the integration layer (IL), with standardized interfaces to connect internal and external services to the TMS. In In2Rail, the following requirement was defined for the Integration Layer:'' The system should be able to provide all internal information to external systems via controlled interfaces'' (REQ ID 1.5.1.0.5) [In2Rail Deliverable 8.3]. In the In2Rail project [In2Rail Deliverable 8.4], the exchanged topics for internal Interfaces of the Integration Layer as well as External Web Services for Dynamic Demand management were specified. The scope of the In2Rail data modelling was limited to the data needed for the main processes of traffic management, i.e. infrastructure, timetable, traffic control, energy, and external services (i.e. weather services, resource planning for rolling stock and crew, RUs (track availability and alternative time table) and passenger information systems). The carried out activities of X2Rail2, resulting in deliverable 6.6, complement and detail the requirements defined in the In2Rail project. The data topics defined in In2Rail have been extended to further include dynamic demand management for freight services (i.e. path request and offer, freight trains delay management, dangerous goods, etc.) and possession request management. Moreover, the data topics required for connection to the PIS as well as rolling stock and crew have been extended. Additionally, requirements for connecting TAF TSI compliant services have been addressed.

5 Objective / Aim

The present document constitutes deliverable D6.6 “System Requirement Specification (SRS) for WEB-IF” in the framework of the Project titled “Enhancing railway signaling systems based on train satellite positioning, on-board safe train integrity, formal methods approach and standard interfaces, enhancing traffic management system functions” (Project Acronym: X2Rail-2; Grant Agreement No. 777465).

The goal of this deliverable is to specify the requirements for enabling and structuring the dynamic exchange of information between TMS and external systems. As specified in In2rail [In2Rail D8.4] external systems are those outside TMS/dispatching, and with a plug-and-play framework for TMS/Dispatching applications. Examples of such systems include services and systems such as weather information services, passenger information systems (PIS), third party freight management systems of third parties such as FRUs, shippers and freight forwarders, etc.

The main objective of the carried out activities within X2Rail2, leading to the current deliverable, is to facilitate dynamic exchange of information between these external systems and the TMS via the Integration layer (IL). Figure 1 shows different TMS related systems that exchange data with the TMS using the IL.

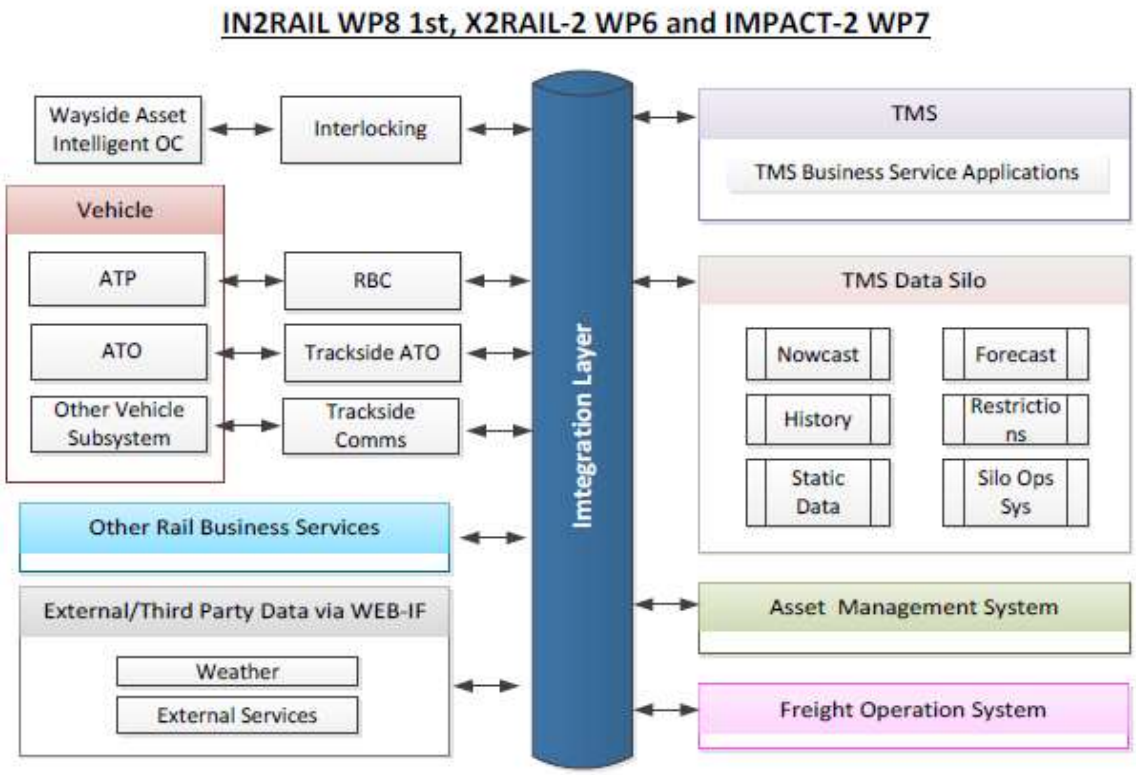

Figure 5.1 - Overview of Integration Layer as a communication platform

The activities of X2Rail2 in this regards, complement those of the In2Rail project by focusing on describing the interfaces between the IL and external systems. The carried out activities within this task complement and extend the results of the In2Rail project, available mainly in [In2Rail D8.4] to a full System Requirement Specification (SRS) for such interfaces. As mentioned in the previous section, the data topics defined in In2Rail have been extended to further include dynamic demand management for freight services (i.e. path request and offer, freight trains delay management, dangerous goods, etc.) and possession request management. Moreover, the data topics required for connection to the PIS as well as rolling stock and crew have been extended. Additionally, requirements for connecting TAF TSI compliant services have been addressed. The specification works further include the functional requirements for the interface to connect freight operation services to the Integration Layer. The necessary information required to effectively define the interface between TMS and external systems including both, functional and non-functional requirements, are provided in this document.

6 Introduction

6.1 Scope and definition of web interfaces

The IL provides data in accordance with a standardized data model (CDM) for communication between railway services, applications, and external services (via interfaces, Figure 6.1). The development of the IL and the data model are continued in different tasks of X2Rail2 and a designated CDM work group. The information included in the CDM, covers different topics such as the traffic and train status, weather-related information, resource restrictions (new and changes), etc. In the In2Rail project (deliverable D8.2), the data model and interfaces of the Integration Layer were specified to ensure the availability of the current and forecasted status information of various assets on the IL, as a unique communication platform. The goal of these activities was to improve the efficiency of the decision making processes of the relevant rail business services to increase their capacity, improve their reliability and decrease their costs. The same goal is pursued in WP6 activities, leading to deliverable 6.6, with a focus on the dynamic, i.e., very short term exchange of information between the TMS and external systems, facilitated using web interfaces. This will allow seamless and dynamic exchange of information and integration of this information in traffic management processes, such as freight-related processes, as well as any relevant internal processes of external systems. Using web technology also facilitates fast and efficient implementation of web and mobile applications at IMs, RUs, stakeholders or other consumers.

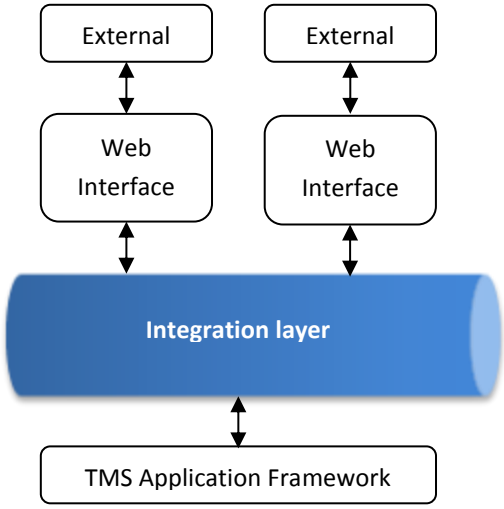

Figure 6.1 – Integration layer's communication with external systems via the Web-IF

7 Requirements for the Web Interface

7.1 General approach

The requirements specified in this document (Annex B) are collected from several sources. The base sources are the In2Rail deliverables D8.1 [In2Rail D8.1] and D8.4 [In2Rail D8.4]. In addition, the requirements related to the partners' internal documents as well as those specified by the customers have been included. For freight related requirements, the TAF TSI master plan [TAF TSI Master Plan] and specifications [TAF TSI Appendices] have been taken into consideration.

In addition, in order to complement the requirements gathered from above-mentioned sources, several use cases related to the dynamic demand information exchange are collected. The requirements of each use case, if not already covered by the previously mentioned requirements, have been added to the requirements matrix.

7.1.1 Criteria for gathering the requirements

The following criteria were considered when specifying the requirements of a Web IF for dynamic demand management:

- High performance web-based communication
- External web-based interfacing including mobile
- Business requirements characterizing dynamic demand such as resource status (e.g. rolling stock, staff, infrastructure, etc.) and constraints, production plan options, etc.

7.2 Description of the requirements matrix

7.2.1 Components of the requirements matrix

The document of Annex B, specifying the requirements for the web interface, is composed of the following sections:

Section 1 (criteria): main criteria used for gathering the requirements;

Section 2 (topics): list of topics covered by the list of requirements;

Section 3 (requirements matrix): list of functional and non-functional requirements for the Web IF;

Section 4 (list of documents): list of documents used to collect the requirements; the requirements related to different sources are differentiated using colours, the description of which is included in this section.

For each collected requirement, the following information fields have been provided:

Req. ID (Requirement identification): a unique number specifying the position of the requirement in the matrix;

Category: a brief term introducing the content of the requirement;

Requirement description: detailed description of the requirement;

Freight: filled in with Y/N, Y specifies if the requirement is specifically related to the freight dynamic demand management;

Reference document: The number refers to the reference number mentioned in section 4 of the document, this number is associated with a colour for facilitating the tracking;

Status of the requirement: any requirement is specified to be either compulsory, or recommended (i.e. optional).

7.2.2 Topics covered by the requirements matrix

The requirements matrix covers major topics of interest in both functional (i.e. business operation requirements) and non-functional (i.e. technical requirements). For each topic several requirements have been gathered based on the sources mentioned above.

The topics covered by the requirements include the following.

- **Functional requirements**
  - Path allocation and request
  - Train information exchange
  - Train preparation for departure
  - Crew and Train resource management
  - Train connections and journey
  - Maintenance and possessions
  - Infrastructure restrictions
  - Disruptions
- **Non-functional requirements**
  - Users' profiles and associated authorization functions
  - Traceability and classification of messages
  - Exchange of information between computers and mobile phones with different modes (charts, forums, emails, SMS, …)
  - Technologies (architecture, external connections, etc.)
  - Architecture
  - Security of information

7.3 Use cases of Dynamic demand management

The capabilities of the specified Web IF are demonstrated via representative use cases, gathered based on partners' prototypes and interests, and therefore not all-inclusive. In the following, the list of use cases of the Web IF for connecting external systems to the TMS is mentioned. It is worth noting that the process of an external system registering for a connection (subscription) to send and receive data are covered in the detailed requirements register and not explicitly identified in the use cases.

- UC1 (HC): Real-time communication of delays and priorities for freight traffic

- UC2 (HC): Possession request management
- UC3 (HC): Connecting passenger information services and applications (mobile and web apps) to the IL to communicate delay and disruption information
- UC4 (HC): Update of the resource plan for rolling stock and crew
- UC5 (HC)**:** Train path slot ordering and modification
- UC6 (HC): Train preparation for departure
- UC7 (HC): Managing unloading in case of delayed freight trains
- UC8 (HC): Communication of weather related information
- UC9 (ASTS): Safest train route for dangerous goods
- UC10 (ASTS): Optimal time slot for safest route
- UC11 (ASTS Realtime communication of sensor alarms
- UC12(HC): Updated rolling stock and wagon operational information

7.4 Use case actors

Below, is the list of actors involved in above-specified use cases. Note that this list is not all-inclusive as some use cases involving additional actors may not have been considered by partners.

7.4.1 Actor infrastructure manager (IM)

The IMs are entities responsible for establishing, maintaining and managing the railway infrastructure.

7.4.1.1 Actor IM Train Dispatcher

The IM train dispatcher is responsible for the real time traffic regulation within the scope of the TMS. The IM train dispatcher is also responsible for making operational decisions to respond to perturbations, minor or major, to meet the daily timetable.

7.4.1.2 Actor IM possession management

The IM possession management is responsible for planning maintenance activities, managing dynamic requests for adapting the possessions according to ongoing events and planning new possessions according to requests and to recover the optimal infrastructure capacity. In addition, the IM possession management is responsible for updating the actual work status and running possessions, including forecasting the validity period (e.g. end times).

7.4.2 Actor Freight Railway Undertaking (FRU)

The actor Freight Railway Undertaking is responsible for organizing and managing the freight transport line. It is the main contact point for the customers. This actor is in charge of the operation and management of the rolling stock and train crew.

7.4.3 Actor Railway Undertaking (RU)

The actor Railway Undertaking provides transport services for goods and/or passengers. This actor is in charge of operation and management of the rolling stock and train crew.

7.4.4 Actor Terminal Operator

The operators of terminals (or transshipment points in intermodal terminals) are responsible for handling cargo inside the terminal. The handling of infrastructure, and the rolling stock and crew within the terminal are the responsibilities of terminal infrastructure manager and terminal railway undertaking, respectively. Shunting operations are carried out either by the terminal railway undertaking or separate entities (such as the FRUs).

7.4.5 Actor Freight Forwarder

This actor is responsible for organizing transport for customers. The basic activities include booking space on a ship, train or other modes of transport, route planning, documentation, insurance, warehousing, etc.

7.4.6 Actor Passenger Information System (PIS)

This actor is responsible for informing the passengers of the long term plan, the current status of the running trains and the compliance with the planning (delays, disruptions, etc.) through information systems available across different platforms such as information displays at stations, mobile devices and the internet.

7.5 Detailed description of use cases

The use cases listed in section 7.3 are elaborated in this section, including a base-line description describing the scope and the operational situation of the use case, the high-level information exchange among the involved parties, and the expected outcome.

The main functionality of the web-interface is to exchange information between the TMS and external systems. Every exchanged data refers to data types defined inside the Canonical Data Model, CDM (for more information, see [In2Rail D8.1] and [In2Rail D8.4]). The relation among the data types is also included in the CDM definition. Therefore and for the sake of completion, the high level data exchange between the TMS and the involved actors connected via the web-interface is included in the description of the use case. A more elaborative explanation of relevant data topics follows in Section 8. Note that, the collected set of topics and information to be exchanged may be extended as needed and what is included is the minimum set of required information.

7.5.1 UC1: Real-time communication of delays and priorities for freight traffic

Title	Real-time communication of delays and priorities for freight traffic

Actors	RU/FRU/IM/Freight forwarder
Compiled by	HC

Base-line Description

As part of the forecast time table, as delivered by the TMS, some conflict resolution may already be considered in the arrival times at locations of interest for freight transport. These are commonly in relation to an n-hour time horizon starting from zero (the actual time). Freight users are interested in ETA which most often needs reflection of conflicts outside this horizon, especially when an intermediate handling operation at a terminal is involved.

Most often, a conflict involving a freight train is resolved by assigning the lowest priority to the freight train. However, in such cases, it is efficient to decide on the freight train's priority based on its load type, special customer requests, penalties for delays, etc. A typical example would be the case of a conflicting passenger train with few passengers on board and a high priority freight train.

Deciding on the priorities of the conflicting trains, when involving a freight train, requires a knowledge about the current situation regarding all conflicting trains. Required information on the freight train's side, i.e. the amount of delay of the conflicting train (based on a common strategy, e.g. if the freight train is given the least priority), load restrictions, shipper's and freight forwarder's demands, etc., may be exchanged via the web-interface.

In case of a conflict involving freight trains, external users of the system and the corresponding owners of goods and wagons may be informed of delays via the web interface. The specific information, owned by external freight systems and required by the IMs for managing the conflict, may be requested via the web interface for the involved freight train. The exchange of such information is required for adapting the appropriate CDR strategy. This information may be sent by the FRU (after making the appropriate enquiries from the freight forwarders), or directly by the freight forwarder via the web interface. The necessary information exchange between TMS and the conflicting passenger trains can either be directly done through the IL or via a Web IF, depending on the source.

Information Exchange (Register)

IM → FRU → Freight forwarder

Conflicting train ID

Conflict delay

Conflict location

Suggested planned time when the freight train is able to use the route

Suggested planned arrival times

Connecting services including minimum handling and maximum waiting times Freight forwarder → FRU → IM Load type Train lead time Timewise classification of the delay penalty of the freight train The tolerance between the earliest and latest arrival times Alternative handling point/arrival station Connecting services including minimum handling and maximum waiting times
Result
Communication of delays updated forecasted arrival times (ETA/ETD) and priorities of the conflicting trains.

7.5.2 UC2: possession request management

Title	Possession request management
Actors	IM/IM possession management
Compiled by	HC
Base-line Description	
Today, technologies such as PICOP mobile applications enable real time collaboration and communication via smart phones and tablets. Using such technologies, field staff connect to the traffic management system to exchange information in real-time. They exchange possession related information, such as the correct geographical area, working times, time buffers, etc., with the TMS using their applications. They may request changes to a planned possession. This communication may be carried out via web-interfaces. It allows connection of mobile and portal applications to the TMS via IP based mobile and Web IF. On the TMS side, the workflow of possession management follows status transitions, e.g. the release of a possession. Possession release is the last step before the planned possession (including e.g. track/line blockages or temporary speed restrictions) is granted by the IM to the possession management party. The response may involve changes to the planned possession including required transitions of possession status information. In summary, the following actions may be taken: 1. The IM receives a command for a TSR or possession modification via the interface (e.g. the IM possession management applies for such possessions via an external	

application). 2. The related access rights are verified for this command. 3. The relevant decision is communicated (or fetched by the interface) and presented (e.g. via the GUI) to the IM possession management.
Information Exchange (Register)
IM Possession management → IM Track information (ID) Working time Time buffers Modified geographical area Possession request *TSR specifications IM → IM Possession management Possession release Changes to the planned possession (working time) *TSR specifications put in effect *: When applicable.
Result
Request of a new/modified possession (IM possession management), Release of a planned possession, Communication of a modified possession (IM)

7.5.3 UC3: Connecting passenger information services (PIS) and applications (mobile and web apps) to the IL to communicate delay and disruption information

Title	Connecting passenger information services and applications (mobile and web apps) to the IL to communicate delay and disruption information.
Actors	IM/PIS
Compiled by	HC

Base-line Description
The focus of this use case is on the distribution of information to passenger information systems and other applications that are authorized (e.g. via subscription) to receive the related information in real-time. Each of these systems may subscribe to receive information according to their individual interests. The information will be provided to them, continuously or upon request, via the web interface. This information may follow the TAP format. Examples of such information topics include updated real time traffic plan, updated forecasted time of arrival, updated delays, etc. The receipt of this information via the web interface is subject to the subscription of the PIS and other external systems to each specific information topic. The exchange of information between the TMS services and the PIS and other external systems via the web interface is bi-directional. For instance, the information required by the TMS services on the operational status of trains such as the passenger count, is sent via the interface to the IL and TMS.
Information Exchange (Register)
IM → PIS Train ID Delay (actual train departure time) Updated forecasted arrival time Updated forecasted departure time *Alternative connections Location of disruption Cause of disruption *Time frame of the disruption Disruption type *Replacement services *Connection information (status of the connection, etc.) PIS → IM Train ID Unit ID *Number of booked passengers per unit, per class and per destination

*: When applicable.
Result
Communication of delays and delay management information, updated forecasted arrival times (ETA/ETD)

7.5.4 UC4: Update of the resource plan for rolling stock and crew

Title	Update of the resource plan for rolling stock and crew
Actors	(FRU) RU/IM
Compiled by	HC
Base-line Description	
The assignment of rolling stock and crew resources to train runs is carried out at the planning level and is usually communicated using off-line timetables. In case of disruptions, such plans may be updated and the updated plans are communicated by the RU's resource planning system to the relevant parties. The same procedure applies to the updated crew plans. In the process of delay and disruption management, there may be restrictions limiting the usability of a slot in terms of crew and rolling stock. The RUs may request additional requirements for the alternative time table based on the specifications and time table availability of the rolling stock and crew. Exchange of information in both cases may be managed via the Web IF..	
Information Exchange (Register)	
<u>Rolling stock update</u> <u>RU → IM</u> Train ID Locomotive/wagon ID Locomotive/wagon specifications (weight, length, gauge, type, maximum speed, etc.) Amenity features (number of seats, restaurants, Wi-Fi availability, etc.)	

On board equipment availability Rolling stock availability time frame IM→ RU *Path specification requirements in terms of rolling stock specification: Maximum speed Maximum weight Maximum axle load Maximum gaudge Energy restrictions Signalling restrictions Braking restrictions Staff update RU → IM Train ID Staff name Staff contact details Staff type Staff availability time frame IM→ RU *Path specification requirements in terms of crew qualification *Location of the staff update *When applicable
Result
Communication of the updated staff and crew resource planning

7.5.5 UC5: Train path slot ordering and management

Title	Train Path Slot ordering and management

Actors	FRU/IM
Compiled by	HC

Base-line Description

FRUs generate path requests during the planning phase to reserve capacity for their services. During operations, the FRUs may request modifications to a currently planned train path (e.g. partial cancellation of a train path, change of a train route, change of the schedule of a train route, change of the planned connection between trains, etc.). They may request an ad-hoc path for a new and unplanned service. For instance, if the start of a freight train is delayed more than a certain threshold, it may not be able to use its planned path and in this case, the FRU will request a new train path for the delayed train. In such cases, specifications and constraints of the freight train (e.g. weight, load type, etc.) should be taken into consideration.
Since a requested new or changed path may comply with the definition of an existing non-allocated pre-arranged path (slot), this can be offered (allocated) in response to an ad-hoc path request. Any non-relevant paths/slots are cancelled and the capacity /slot is released accordingly. The Web IF provides a communication channel between the FRU and the IM, i.e. all negotiations between the FRU and the IM may be carried out via the web interface.

In summary, the following actions will be taken:

1. The modification/new train path request will be communicated by the FRU to IM train dispatcher, via the Web IF.
2. The changes/new path's specifications are communicated to the FRU.
3. The negotiations will continue until an agreement is reached.
4. Non relevant previously allocated paths/slots are cancelled and the corresponding capacity is released.
5. The assigned rolling stock or staff are (re-)planned by FRU if required.

Information exchange (register)

IM → FRU

Suggested planned time when the freight train is able to use the path

Suggested planned arrival times

Connecting services including minimum handling and maximum waiting times

FRU → IM

Train specifications (train number, wagons' specifications and number, operating locomotive (type, traction engine, equipment concerning security), braking regime, train and wagon weight, load type, train length, origin, destination, desired time of departure, desired time of

arrival, driver's working hours and required qualifications) Train lead time Timewise classification of the delay penalty of the freight train The tolerance between the earliest and latest arrival time Alternative handling point/arrival station Connecting services including minimum handling and maximum waiting times
Result
An offered (allocated) slot / changed or newly planned / activated train path for a requested train.

7.5.6 UC6: Train preparation for departure

Title	Train preparation for departure
Actors	FRU/IM
Compiled by	HC
Base-line Description	
The train preparation for departure requires the data exchange between IMs and FRUs to grant/receive permission to access the network. FRUs prepare a train for departure using: • the infrastructure restriction notices • the technical wagon data (e.g. from the TAF TSI Rolling Stock Reference Databases) • the dangerous goods reference file • the current, updated information regarding the wagons' status The process of accessing the network, is as follows: 1. The FRU sends the following data to the IM • Train composition • The ready status of the train indicating when it is ready to access the network • Trains' entrance point defining where the train shall enter the network 2. The IM sends the following data to the FRU • Train acceptance or rejection according to the train composition's compliance with the path • Time and location to access the network When the train is ready and at the start point, the related status updates (e.g. train ready at	

the start point and train departure from the position) can be sent by the RU via the web interface.
Information exchange (register)
FRU → IM Train ID Train composition Planned departure time Train entrance position modification (if requesting one) IM → FRU Train accepted/rejected Train position to access the network (or the modified position, if requested by the FRU)
Result
Confirmation of the train's access to the network, including where and when

7.5.7 UC7: Managing unloading slots in case of delayed freight trains

Title	Terminal slot planning, managing unloading slots
Actors	FRU/IM/Terminal operator
Compiled by	HC
Base-line Description	
If a loaded freight train is delayed, the IM updates the estimated time of train's arrival at the terminal. As a consequence the train loses its right to use the unloading slot at the arrival terminal. In this case, the terminal operator plans a new slot for the unloading process and looks for a replacement for the free slot. This use case may be related to the UC4, resource planning for rolling stock and crew, in that, the locomotive and the wagons will be late for their next planned trips and the related plans should be updated. This use case is valid also for cross border and cross network situations. In such cases, the train waits ahead of the border where the space allows.	

The delay management process at the terminal is as follows: 1. The new ETA is communicated to the FRU by IM, depending on the case. 2. The new arrival time is communicated to the terminal by FRU. 3. If the time slot for the unloading is lost, a new slot is scheduled (slot planning/allocation) and is communicated to the FRU by the terminal operator. 4. The related parties such as freight forwarders and customers are informed of the incurred delays (e.g. via the web interface). Note: the related tasks within the terminal may be handled by terminal IM and terminal RU, depending on the layout and organization of the terminal activities. The trips associated with the wagons and the locomotives are re-planned (if necessary).
Information exchange (register)
IM → FRU Updated ETA FRU → Terminal Operator Updated ETA Terminal Operator → FRU planned time slot for unloading
Result
Planned slot for a delayed train arriving at the terminal.

7.5.8 UC8: Communication of weather related information

Title	Communication of weather related information
Actors	IM/RU/ Other affected actors (PIS, etc.)
Compiled by	HC
Base-line Description	
The weather information is updated and supplied via web (as open data sources such as *opendata.dwd.de* (provided by Deutscher Wetterdienst, Germany or *https://www.yr.no/* provided by Norwegian Meteorological Institute together with the Norwegian Broadcasting Corporation, to name a few)). The web interface provides a communication channel between the TMS and the	

corresponding external weather-related services. This information will be available on the IL and different actors can access the available information based on their access rights and subscribed topics. They may publish the topics of their interest using relevant platforms.

TMS processes make use of available data in order to carry out their internal operations such as forecast calculation, disruption management, conflict prediction, etc. Besides, it may be necessary to distribute information regarding further actions to be taken by different entities such as bridge closure, TSR specification, and communication of delays and cancellations to the PIS. Other systems such as Asset Management System may also make use of weather data to, for example, compensate for degradation due to weather effects.

Information Exchange (Register)

Note: The updated weather information is not targeted at a specific actor and is available on the IL. All interested actors can access the data (with proper subscription).

WIS → IL

Location (e.g. Geo referencing) and attributes (areas, railway lines and nodes, track sections and switches, etc.)

Time

Type of weather condition (wind, snow, storm, etc.) and the related attributes (e.g. wind speed, humidity, temperature, etc.)

IL → PIS

Affected connections

Delay amount

Alternative routes

Alternative transport services

Duration of disruption

Warnings

The IM train dispatcher collects the necessary information and

IL→ RU

Affected train's ID

Location (e.g. Geo referencing) and attributes (areas, railway lines and nodes, track sections and switches)

*Delay amount (provided by the IM train dispatcher)

Type of weather condition (wind, snow, storm, etc.) and the related attributes (e.g. wind speed, humidity, temperature, etc.) *Alternative connections (provided by the IM train dispatcher) *When applicable
Result
Receipt and distribution of weather related information from/to external parties.

7.5.9 UC9: Safest Train Route for Dangerous Goods

Title	Safest Train Route for Dangerous Goods
Actors	FRU/IM/ FO
Compiled by	ASTS
Base-line Description	
A freight train that carries dangerous goods must go from point A to unloading point B. Several routes are possible from point A to point B. The optimal route to carry the dangerous goods from A to B is determined by the IM, using algorithms that minimize the risks for people, environments, buildings and infrastructure, due to accidents along the railway during the trip. For example, the optimal path avoids train with dangerous goods passing close to crowded places, schools, hospitals, areas with high density traffic, and so forth. The risk is evaluated based on the types of dangerous goods carried, urban and non-urban areas crossed by the path, human settlements, and possible hazards for people and environment. FO and FRU can request the Safest path to plan the safest route, load and unload points, and places for change the consist of the train.	
Information Exchange (Register)	
FRU → IM Number of wagons Type of wagons Type and classification of dangerous goods carried per wagon Operating locomotive Braking regime Train and wagon weight	

Train length Origin(s) A and destination B(s) IM → FRU Safest path
Result
The safest train path is determined.

7.5.10 UC10: Optimal Time Slot for Safest Route

Title	Optimal Time Slot for Safest Route
Actors	FRU / IM
Compiled by	ASTS
Base-line Description	
A freight train that carries dangerous goods must go from point A to unloading point B. The safest route has been chosen as described in UC *Safest Train Route for Dangerous Goods*. To go from point A to point B there are several time windows available on the chosen route. The optimal time window to carry the dangerous goods from A to B is determined by the IM, using algorithms that minimize the risk of accidents along the railway and the probability of damage to infrastructures, buildings and people. Factors used for the evaluation of risks are, for example, weather condition, planned works near the ballast, strikes, riots. Related use case: *Safest Train Route for Dangerous Goods*.	
Information Exchange (Register)	
WIS → TMS Location (e.g. Geo referencing) and attributes (areas, railway lines and nodes, track sections and switches) Time Type of weather condition (wind, snow, storm, etc.) and the related attributes (e.g. wind speed, humidity, temperature, etc.) FRU→IM (or FO→IM)	

Train number (FRU) Number of wagons (FRU, FO) Type of wagons (FRU, FO) Type and classification of dangerous goods carried per wagon (FRU, FO) Operating locomotive (FRU) Braking regime (FRU) Train and wagon weight (FRU) Train length (FRU) Origin A and destination B, or Safest path as per UC (FRU, FO) List of possible time windows for trip from point A to point B (FRU, FO) IM→FRU (or IM→FO) Time of departure Time of arrival (ETA)
Result
The optimal time slot for the safest (i.e. to minimize the risk of accidents) route is determined.

7.5.11 UC11: Realtime Communication of Sensor Alarms

Title	Realtime communication of Sensor Alarms from wagon with dangerous goods.
Actors	RU/IM/IM Train Dispatcher
Compiled by	ASTS

Base-line Description

A freight train is composed by tank wagons filled with dangerous liquid. Any wagon is equipped with a MCU (master Control Unit) communicating with a network of wireless sensors installed at sensible points of the wagon. The MCU is able to communicate with the TMS Control Center.

The train is traveling from station A to station B.

During the travel, the MCU detects an out of limits measurement from sensors and forwards the alarm(s) to the TMS Control Center (IM), the IM Train Dispatcher and the RU. A message to the train driver is sent by the IM to advise her/him about the anomaly: actions like train stop or slowing down could be taken by the IM.

The FRU and FO can continuously monitor their goods during the trip.

Information Exchange (Register)

Wagon's MCU → IM

Train number
Wagon number
Wagon specifications
Train operator (FRU)
Operating locomotive
List of sensors information
- type (e.g. axle-box vibration, axle-box temperature, tank pressure)
- measurement
- alarm detected
- date and time of detection

IM → Train driver

Alarm related to detected anomaly
Suggested action

IM → RU

Train number
Wagon number
Wagon specifications
List of sensors information
- type (e.g. axle-box vibration, axle-box temperature, tank pressure)
- measurement
- alarm detected

- date and time of detection
Result
The optimal procedure will be taken which could be the slowing down or the immediate stop of the train.

7.5.12 UC12: Connection to WIMO and other data bases for updated wagon and rolling operational information

Title	Updated rolling stock and wagon information
Actors	RU/ External applications (e.g. customers, freight forwarders, etc.)
Compiled by	HC
Base-line Description	
According to TAF TSI requirements, an operational database for wagon and intermodal units (WIMO) should be maintained either locally (e.g. at each RU) or centrally. The WIMO includes updated wagon related information, such as wagon and rolling stock movements. This data is processed and the resulting information is provided to the internal and external parties according to the TAF TSI format. With this messaging communication, the WIMO tracks the movement of a wagon from its origin to destination (e.g. the recipient's siding) with the forecasted handling time (ETI) at mid-way stations and the forecasted arrival time (ETA) at the final delivery point. Another available database is the Rolling Stock Reference Database (RSRD) which gathers the rolling stock operational data [TAF TSI Master Plan]. For each wagon, a record is created when the customer transfers the release time of the wagon. The WIMO dataset stores the wagon related information under a unique wagon ID. In case of various IDs for one wagon (e.g. due to different track gauges), the WIMO integrates this information with a unique wagon ID. It sends out this information to the enquiring actors such as RUs (e.g. the location of the consignment). Note: TAF TSI requirements are considered in the specification in terms of data requirements. However, provision of TAF TSI compliant interfaces depends of the progression and implementation of TAF TSI at any specific system.	
Information Exchange (Register)	
IL → RU →Freight forwarder Wagon/Rolling stock tracking information • position • order	

• Updated ETA • Updated ETI • Consignment position (in case several consignments are within one wagon, such as intermodal units)
Result
External systems (e.g. apps) get updated information regarding the changes in the status of wagons and rolling stock from WIMO.

8 Data topic requirements

8.1 External connection to IL via web-interface

The standard data structure provided by the IL data model, also called Canonical Data Model (CDM), enables sharing data among different services and facilitates the integration of this data in their relevant processes.

In this section, a set of preliminary data topics required for dynamic demand management is collected. This data has partially been specified in the In2Rail project. Where relevant, the proper reference to the In2Rail document has been made. Where such specification is not available, we create it based on the In2Rail CDM data format. Note that, the data is specified at the topic level (according to the In2Rail data model definitions, a topic specifies a group of data) or where relevant, down to the data element level. The connecting services can access the available data on the IL based on their subscription.

There are several standardized data models already defined for different processes in the railway sector, such as TAF TSI for freight. As one of the main external users of the data provided by the IL, is the freight sector, the specific requirements for TAF TSI compliance are considered in defining the requirements of this web-interface.

The TAF TSI is not integrated in the IL, however, it is made sure that there is all the information to cover the TAF TSI data requirements (TAF TSI compliance).

In a nutshell, the following functionalities are presumed for the WEB-IF:

- Connecting external mobile and web applications such as PIS, freight monitoring apps, etc.
- Enabling dynamic, i.e., very short term exchange of information between TMS and external systems.
- Facilitating fast and efficient implementation of web and mobile applications at IMs, RUs, stakeholders or other consumers.
- Facilitating integration of freight processes.

Based on the use cases defined in section 7.3, the following areas are explored for specification of data requirements for information exchange between external systems and the IL.

Area 1: Freight train dispatching

1. Communication of delays, disruptions and priorities
2. Train preparation for departure
    a. Optimal time slot for safest route for dangerous goods
3. Train path ordering and management
    a. General
    b. Dangerous goods

4. Connection to external databases for wagon and Rolling stock

Area 2: Possessions

1. Possession request management
2. Possession release

Area 3: Communication with external systems for information distribution

1. PIS
2. Weather systems

Area 4: Resource planning

1. Rolling stock
2. Crew

Area 5: Freight terminal operations

1. Unloading operations slot management

Each use case may cover one or multiple areas as shown in table 8.1.

	UC 1	UC 2	UC 3	UC 4	UC 5	UC 6	UC 7	UC 8	UC 9	UC 10	UC 11	UC 12
Area 1	X				X	X					X	X
Area 2		X										
Area 3			X					X		X		
Area 4				X					X	X		
Area 5							X		X	X		

Table 8.1- Relation of use cases to the TMS areas for dynamic demand management

For each area, the relevant IL data topics and the involved data structures are described in the following sections.

8.2 Freight train dispatching

8.2.1 Communication of delays

Name	Description
Train Identifier	Identification of a train, this ID (Number/character) is used as a reference for further information related to the train on the IL Note: Usually this ID is a composition of - Operation Train ID

	-Operating day - Start time of the train (sometimes required in larger networks)
Train Delay ID	Information provided by the IM to RU (FRU) including the delay event related information such as the delay cause
Train Running Interrupted	Information provided by the IM to the RU (FRU) in case its train run has been interrupted
Train Running Forecast (ETA/ETI)	Forecast of further train run for the interrupted trains, the requested forecasts for train arrival at a specific location may be stored under this topic (including the minimum handling and maximum waiting times) The related information includes those stored under attributes such as 'Forecasted Arrival Time'' ''Forecasted Departure Time'', and ''Train Location ID'' on the IL.
(TAF TSI) Train Delay Performance	Information containing the actual delay values
Delay Penalty	Classification of the delay penalty of the freight train (e.g. timewise)

8.2.2 Train preparation for departure

Name	Description
Train Identifier	Identification of a train, this ID (Number/character) is used as a reference for further information related to the train on the IL Note: Usually this ID is a composition of - Operation Train ID -Operating day - Start time of the train (sometimes required in larger networks)
Train Composition	This information is sent from the RU to the IM informing the composition of the proposed train. This information is covered by the TrainComposition element of TAF TSI and on the IL includes information regarding the

	Loco / Wagon position in train composition
Train Accepted	This information is sent from the IM back to the RU indicating, that the train composition is acceptable for the booked path. This information is covered by the TAF TSI message TrainAccepted
Train Ready for Departure	This information is sent from the RU to the IM indicating that the train is ready for accessing the network. It is covered by the TrainReady message of TAF TSI
Train Entrance Position	Information provided by the IM to the RU defining exactly the date and time of the presence of the train for accessing the network. Information is covered by the TrainPosition message of TAF TSI
Train Entrance Position Modification	Information provided by the IM to the RU communicating the modification of train's access point to the network
Train at Start	Information provided by the RU to IM to inform that the train is at the start of its journey. Information is covered by the **Train** ready at start message of TAF TSI

8.2.3 Optimal Time Slot for Safest Route (for dangerous goods) (ASTS)

Name	Description
Train Identifier	Identification of a train, this ID (Number/character) is used as a reference for further information related to the train on the IL Note: Usually this ID is a composition of - Operation Train ID - -Operating day

	- Start time of the train (sometimes required in larger networks)
Train Composition	This information is sent from the RU to the IM informing the composition of the proposed train. This information is covered by the TrainComposition element of TAF TSI
Dangerous Goods Details	This information is sent from the RU to the IM informing the presence and type of dangerous goods. This information is covered by the WagonOperationalData/DangerousGoodsDetails element of TAF TSI
Path Request	This information is sent from the RU to each IM involved to request a train path. This information is covered by the PathRequestMessage element of TAF TSI
Time Slots	This information is sent from RU to IMs to specify the requested time slot for the train service. Possibly covered by one of the following TAF TSI elements - DepartureTimeAtLocation - RequestTimeFrame
Path Departure Time and Date.	- This information is returned by the IM to the RU to provide the safest departure and arrival time.

8.2.4 Train path ordering and management

8.2.4.1 Train path ordering

One of the main use cases of the Web IF for connecting external services, is train path ordering and management (e.g. for ad-hoc path request). The necessity of such availability is made clearer considering that today a high share of freight paths are determined ad-hoc.

Name	Description
Train Identifier	Identification of a train, this ID (Number/character) is used as a reference for further information related to the train on the IL Note: Usually this ID is a composition of - Operation Train ID -Operating day

	- Start time of the train (sometimes required in larger networks)
Path Request	This information is sent from the RU to each IM involved to request a train path. This information is covered by the PathRequestMessage element of TAF TSI
Time Slots (Optional)	This information is sent from RU to IMs to specify the requested time slot for the train service. Possibly covered by one of the following TAF TSI elements - DepartureTimeAtLocation - RequestTimeFrame
Requested Path Departure Time and Date (Optional)	Suggested planned time when the freight train is able to use the route
Requested Path Earliest Arrival Time and Date (Optional)	Optional earliest arrival time at destination
Suggested Path Latest Arrival Time and Date (Optional)	Suggested planned (latest) arrival time at destination
Handling Points and Times	List of references to handling points of the freight train and required handling times. First handling point = departing location, last handling point = destination location.
Path Connecting Services	Connecting services at destination location including minimum handling and maximum waiting times. The information on the IL include 'Min Handling Time' and 'Max Waiting Time'
Train Load Specification	Load type (included in the Goods Code on the IL), weight (included in the Goods Weight on the IL), Seals Number, etc.
Loaded Train Specification	Train length, train weight, train lead time, etc.
Delay Penalty	Time-wise (minutes) penalty value of the delay of a freight train

8.2.4.2 Train path proposal

Name	Description
Path ID	Identification of the suggested train path as being requested earlier, this number is used as a reference of further information related to the train path on the IL (e.g. TrainOperationalIdentification)
Train Identifier	Identification of a train, this ID (Number/character) is used as a reference for further information related to the train on the IL Note: Usually this ID is a composition of - Operation Train ID -Operating day - Start time of the train (sometimes required in larger networks)
Proposed Path Departure Time and Date	planned time when the freight train is able to use the path
Proposed Path Arrival Time and Date	planned arrival time
Path Confirmation Status	Path confirmed, refused, not available
Path Departure Time and Date	planned time when the freight train is able to use the path (agreed between IM and RU)
Path Arrival Time and Date	planned arrival time (agreed between IM and RU)
Path Canceled	Cancelation of a planned path or modification of a planned path.
Path Crew Requirement	Path specification requirements in terms of crew qualification

8.2.5 Safest Train Route for Dangerous Goods (ASTS)

Name	Description
Train ID	Identification of a train, this ID (Number/character) is used as a reference for further information related to the train on the IL Note: Usually this ID is a composition of

	- Operation Train ID - -Operating day - Start time of the train (sometimes required in larger networks)
Train Composition	This information is sent from the RU to the IM informing the composition of the proposed train. This information is covered by the TrainComposition element of TAF TSI.
Dangerous Goods Details	This information is sent from the RU to the IM informing the presence and type of dangerous goods. This information is covered by the WagonOperationalData / DangerousGoodsDetails element of TAF TSI.
Path Request	This information is sent from the RU to each IM involved to request a train path. This information is covered by the PathRequestMessage element of TAF TSI
Safest Path details	This information is returned by the IM to the RU to provide the safest path based on type of goods and available routes. Possibly covered by one of the following TAF TSI elements - PathInformation - PlannedJourneyLocation

8.3 Connection to data bases for updated wagon and rolling stock operational information

Availability of operational information related to wagons and rolling stock is important for tracking of wagons as well as ad-hoc planning of trains for RUs' operations. The web-interface should be able to provide the interested parties and external applications (such as freight forwarders and Freight Railway Undertakings (FRUs)), with dynamic (real-time, upon request) information regarding the position and status of wagons. Such information is available through various sources. For example, according to the TAF TSI requirements, the related wagon and rolling stock information are constantly uploaded to two databases: the WIMO and RSRD, respectively [TAF TSI WIMO], [TAF TSI Master Plan]. The WIMO includes updated information, such as wagon movements, of the RU operations. This database contains data about the movement of a wagon and of an Intermodal unit from departure to final delivery at the customer's siding including the ETIs and actual times at different mid-way locations until the final delivery time (ETA). This information includes the status of the wagons such as loaded/empty and stopped/on journey. The RSRD includes the rolling stock related data comprising both static reference data and dynamic data related to the real-time status of the rolling stock. The latter is

of special importance for dynamic demand management. Additionally, it stores the status of rolling stock such as loading of the rolling stock, loaded wagon on journey, empty wagon on journey, and unloading of rolling stock. The status of a rolling stock is required for the information exchange between RUs and IMs and other railway undertakings involved in freight transport.

Movement of wagons and intermodal units from their point of departure to arrival at the customers' sidings (including ETIs and actual times at various mid-way locations) is registered in the mentioned databases. The purpose of the WIMO is the storage and provision of the data elements needed for operational purposes and for the tracking of wagons / Intermodal units within the geographical scope of the TAF TSI.

Each railway undertaking should be able to send, receive, and store the related information using the defined TAF TSI messaging. External applications can request the updated data provided by the databases via the appropriate Web IF from the IL. Figure 8.1 shows two possible channels for accomplishing this task. The data may be updated on the IL on a regular basis. Alternatively, TMS application framework may fetch the data from the WIMO [TAF TSI WIMO] dynamically and on an event-based basis.

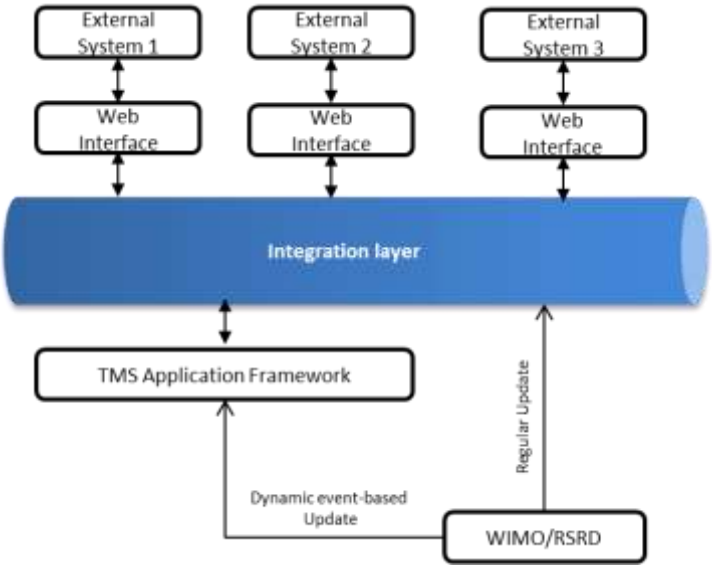

Figure 8.1- External connection to operational databases

The data provided by the data bases is processed and the resulting information will be made available to the requesting parties. In this section, specific data topics have been defined for the IL web-interface to be compatible with the TAF TSI messaging requirements to exchange wagon and rolling stock related information with external databases. This enables RUs and other external parties that already communicate according to the TAF TSI format to make use of the Web IF in order to integrate the IL data highway in their operations.

The wagons' data is available in Canonical Data Model (CDM) on different levels (e.g. wagons, traction units vehicles, etc.).

Name	Description
WagonNumber	The relevant reference number required to trace the wagon. The wagon number is used in the train composition message and in all wagon related messages and even in the consignment note. The WagonNumber is used as a reference to more details of the wagon on the IL (WagonLength, WagonType, etc.).
Wagon Exception	In the TAF TSI, a corresponding message (WagonException) is used by the RU/Service Provider to inform the Lead RU about deviations e.g. bad order. This information includes the Wagon Exception Reason provided by the message (WagonException ReasonETI_ETA_Request) in the TAF TSI.
Wagon Interchange Notice	In the TAF TSI, a corresponding message (WagonInterchangeNotice) is used by the RU/Service Provider to ask the neighboring RU/Service Provider the acceptance of the responsibility for a wagon.
Wagon Refusal at Interchange	In the TAF TSI, a corresponding message (WagonRefusedAtInterchange) is used by the neighbouring RU/Service Provider as answer to the message “WagonInterchangeNotice” to inform the sender of the wagonInterchangeNotice the responsibility for the wagon is refused.
Wagon Acceptance at Interchange	Information regarding the acceptance of the responsibility for the wagon (in response to the message WagonInterchangeNotice) in the TAF TSI.
Wagon Release Date Time	This information is defined to cover a corresponding message (WagonReleaseNotice) in TAF TSI used by the Lead RU to inform the RU in charge, that

	the wagon is ready to be pulled. The related data elements include wagon ID, place, date and time of release, total weight, and DG.
Wagon Departure Date Time	This information is defined to cover a message used by the RU in charge to inform the LRU, that the wagon has been picked-up (pulled) and has reached the RU's Yard of departure. This information includes the actual date and time of the wagon pull from departure point.
Wagon Yard Arrival	This information is defined to cover a message (WagonYardArrival) used by the RU to inform the LRU, that the wagon has arrived at its yard.
Wagon Interchange Sub Notice	This information is defined to cover a message (WagonInterchange SubNotice) in TAF TSI used by the RU/Service Provider to inform the IM, that the responsibility is handled over to the next RU/Service provider.
Wagon Yard Departure	This information is defined to cover a message in TAF TSI (WagonYardDeparture) used by the RU/Service Provider to inform the Lead RU that the wagon has left the yard
Wagon at Interchange	This information is defined to cover a message in TAF TSI (WagonReceived_At Interchange) used by the neighbouring RU/Service Provider to confirm the acceptance of the responsibility for the wagon.
Wagon Delivery	This information is defined to cover a message in TAF TSI (WagonDeliveryNotice) used by the last RU/Service Provider in the transport chain to inform the Lead RU that the

	wagon has been placed at the consignee's siding.
Wagon Trip Plan	Information on the planned trip for wagons
Wagon ETA/ETI	Information of the Estimated time of arrival and handling of the wagon provided by the WagonETA/ETI message of TAF TSI.
Wagon Order	Information indicating the order of the wagons
Wagon Load Status on Journey	Related to the load status of the rolling stock, including DG information, weight information, etc. The information provided by WIMO can be stored under attributes including (Loaded, Goods Code, Goods Wight, Dangerous Goods, Dangerous Goods Code, etc.) on the IL. The status may further specify empty wagons.
Empty Wagon Availability	This status is required to get the information about availability of a wagon of defined characteristics
Consignment Status	This information is exchanged when there are several consignments within one wagon.

8.4 Possession request management

A record of all activated and requested possessions (including TSRs) are stored at the TMS. The data topics related to the TSR are provided in the In2Rail D8.4, Section 7.3.7.1. The relevant extended topics of possession request management are specified in this section.

All the information related to possessions is stored under the following categories (i.e. topics) on the IL: Possession State Topic and Possession Request Topic.

8.4.1 Possession State Topic

The state topics carry the information related to all requested as well as approved possessions. This information may be updated by the TMS. Each possession record should contain the following information:

Name	Description
Possession ID	Identity of the possession
Possession Business Reference	Business reference-key of the possession; multiple possessions may share the same business reference
Possession Type	Type of the possession, e.g. maintenance, complete closure…
Possession Status	State of the possession (activated/deactivated, schedule, fixed, running, etc.)
Metric Possession Start/End Location	The metric location of possession (referring to track section and the metric position values for the start and end points of the possession). The information is updated and communicated by the IM, if there are changes to the planned possession
Geographic Possession Start/End Location	The geographical location of possession (geo-referencing of the start and end points of the possession). The information is updated and communicated by the IM, if there are changes to the planned possession
Possession Direction	The direction where the Possession is valid
Possession Start/End Date Time	The time of beginning and ending a possession
Possession Deactivation Possible	Indicates the possibility of deactivation of the possession by the operator
Possession Approval	Indicates approvals provided for a given possession
Temporary Speed Restriction Identifier (TSR ID)	Identifier of a TSR included in the system by the TSR management system.

TSR Data	This topic will be updated as part of X2Rail2, T6.2. It refers to attributes of the TSR such as Reception Point, Maximum Speed, Start Point, Start Date Time, End Point, End Date Time, available on the IL.

8.4.2 Possession Request Topic

When there is a request for definition of a new possession or modification of an existing possession, the request should, at least, include the following data.

Name	Description
Possession Start Location	Position where the possession starts
Possession End Location	Position where the possession ends
Possession Track List	List of all included tracks (Track IDs)
Possession Start Time	The start Datetime of the possession as proposed by the IM Pos. Management
Possession End Time	The end Datetime of the possession as proposed by the IM Pos. Management
Possession direction	The direction where the Possession is valid
Possession Reason	The reason of the possession
Possession Cancellation	IM Possession Management requests the cancellation of the possession.
Possession Time Buffers	This topic includes the Start Margin and End Margin information related to the possession, referring to the margins to advance/delay the possession start and end.

8.5 Communication with external systems-PIS

One of the main external users of the IL services is the passenger information system. This is a two ways communication, i.e. the TMS sends the information concerning the passengers such as delays and dispatching information to the PIS via the web-interface and the PIS sends the information to the TMS to be integrated in the related TMS processes. The exchanged information includes those specified in the table below.

8.5.1 Updating the PIS- Train run

Name	Description
Train Identifier	Identity of the train
Train Departure DateTime	Date/Time of the train departure
Train Location ID	Location of the train along its journey
Train Run Forecast	The topic includes attributes such as **Train Forecasted Arrival Time**, and **Train Forecasted Departure Time** on the IL

8.5.2 Updating the PIS- Connections

Name	Description
Connection Track	Track ID on which the train is expected at the location (optional, e.g. if the departure/arrival tracks have changed)
Connection type	Type of the train connection, e.g. transfer connections, and operational dependancies such as splitting, coupling, etc.
Connection Status	Status of the train connection
Alternative Connection Location ID	Alternative location of the train connection
Connection Max Waiting Time	Maximum waiting time for the second train
Connection min handling time	Minimum handling time for first train
Train Run Forecast	Arrival and departure time of both first and second trains

8.5.3 Updating the PIS- Disruption

Name	Description
Description Description	A brief description of the incident, including its cause (Optional)
Disruption ID	Identification of the disruption
Disruption Begin Date Time	Begin date and time of the disruption
Disruption End Date Time	Expected end date and time of the disruption

	(optional)
Disruption Type	Type of the disruption
Related Train Run ID	ID of the train run to which the disruption info is related
Related Train Run Forecast	Including attributes such as Related Train Departure Date Time, Related Train Location Begin, Train Delay, and Related train Location End on the IL.
Replacement Services	Optional Information regarding the replacement services available if services are partially or fully cancelled.

8.5.4 PIS to TMS

Name	Description
Train Identifier	Unique identification number of the train
Booked Passengers per Class	Number of booked passengers within this rolling stock unit (for 1st and 2nd class)
Booked Passengers	Number of passengers within this rolling stock unit
Booked Passengers per Destination	Number of passengers within this rolling stock unit per booked destination station

8.6 Communication with external systems-weather systems

The weather related topics and the involved data structures have been described in [In2Rail D8.4], section 7.5 (Interface control document for integration layer interfaces for external web interfaces, weather forecast/report services).

8.7 Resource planning for rolling stock and crew

Rolling stock and crew planning is carried out during the timetable planning. However, ad-hoc modification of this plan may be requested by both RU and IM as part of the dynamic demand management. The related information that should be exchanged via the interface to and from the IL are specified partly in In2Rail D8.4, section 7.5. Additional information for real time management of rolling stock is mentioned in the table below. In this table, ‘’Rolling Stock’’ refers to wagons, coaches, locomotives, etc.

Name	Description
Rolling Stock Type	Identification of the rolling stock type

	(locomotive, wagon, etc.)
Rolling Stock ID	Rolling stock unit ID
Rolling Stock Ref	Defined in In2Rail, D8.4. It is the reference link to the vehicle information on the IL, identifying the rolling stock resource details (physical and dynamic characteristics, etc.). For coaches this may include features and amenities (Hadicapped-accessibility, wifi, WC, etc.).
Rolling Stock OnBoard Equip	Onboard Equipment availability and specification
Rolling Stock Deployment Plan	The deployment plan of the rolling stock, including the time frame of the rolling stock availability. The related information on the IL include NextAvailableLocation, and NextAvailableDateTime, and allocation plan of the vehicle.
Rolling Stock Position	Real time Geographical position of the rolling stock, available from sources such as WIMO and RSRD
Rolling Stock Restrictions	e.g. revision, damages, vmax restriction, gauge limitations, etc.
Empty Wagon Availability	This status is required to get the information about availability of a vehicle of defined characteristics

8.7.1 Crew

Name	Description
Crew Deployment Plan	Real time and updated deployment plans showing the employees' assignment to schedules
Shift Status	List of the ''Attendance'' status of duties: Spare, attendance, absence, etc.

Crew Ref	Reference to the crew specification, linking to the crew details available on the IL, including name, contact details, paid time, work time, sign-off time, absent time, and day off, driving time, crew qualification, etc.
Crew Shift Time Slot	The start and end times of a shift, identified by the '**CrewShiftDateTimeOn**', referring to the start date and time of duties and '**CrewShiftDateTimeOff**', referring to the end date and time of duties
CrewShiftID	Reference number identifying the specification of the duty such as path, path requirements in terms of staff, etc.
CrewShiftRoleRequired	The crew requirements of a duty (in case of any update of the train path and change of requirements)
CrewShiftAllocationLastUpdateDateTime	Last Date Time at which Shift Allocation was last updated (UTC + Offset)

8.8 Managing freight terminal operations (unloading slots)

The table below specifies the information exchange between the actors involved in the management of freight terminals, i.e. (at least) IM, RU, and terminal operator. Note that, this information is not representative for all types of terminals and may be taken as a basis. The information topics exchanged in each specific situation depend on the type of the terminal, level of automation, and the actors that carry out various activities. In the table below, the information related to planning the unloading slots at the terminal is mentioned. It can be extended to various operations within the terminal.

Name	Description
Train Identifier	The information is needed to get/send an ETA update
Unloading Slot Cancelled	Information sent by the terminal operator regarding the cancellation of an unloading schedule
Unloading Slot Schedule Updated	Information sent by the terminal operator

	regarding the update of an unloading schedule
Train Run Forecast (ETA/ETI)	Information sent by the IM to the RU containing the train run forecast.
Train Yard Arrival	Information sent by the terminal operator to the RU regarding the arrival of the train at the yard.

8.9 TAF TSI requirements

TAF TSI supports railway operations by facilitating data exchange regarding train preparation, train running forecast, and wagon movement [TAF TSI EUR-Lex].

The specific requirements for train preparation, as well as connecting to the TAF TSI data bases WIMO and RSRD have been mentioned in sections 8.2 and 8.3 of this document. Additional topics regarding train running forecast are specified in this section.

8.9.1 Train running details

The following information is exchanged in TAF TSI, regarding a train run forecast:

Name	Description
Train run forecast (ETA/ETI)	Information sent by the IM to the RU containing the train run forecasts.
Train Running Interrupted	
Train Identifier	Used by the IMs and RUs in each message where the train identification is required (Train-Ident in TAF TSI).
Train service number	The operational train number which identifies the train for traffic management purposes and is usually inherited from the Path Number (Optional).

9 Conclusion and additional remarks

The current document gathers a rather detailed set of requirements for the web interface to connect external services to TMS via the IL. The document further includes a collection of data topics (a set of data) that will be exchanged between the IL and external systems to fulfill the needs of both TMS and external systems for managing the dynamic demand. The data topics cover a set of data attributes on the IL.

The requirements specified in Appendix B of the document are based on a review of In2Rail deliverables, experiences obtained from internal customer projects, as well as identified use cases.

Multiple prototypes are being developed within the course of currently running X2Rail2 and IMPACT2 projects, which have a close relation with the interface specification. For instance: train path slot planning and management (a prototype in the IMPACT2 project) requires real-time information exchange and negotiation between the freight railway undertaking and the infrastructure manager, the perturbation management module (PMM) exchanges UC1 information on train order resulting from algorithms that optimize consequences of conflicting trains, weather and asset status data is used by both TMS and an Asset Management Systems, and the container management system receives train ETA data. Therefore, the specified requirements will provide input for the mentioned activities and will continue to be extended and modified until the end of the mentioned projects.

Further development of the IL and the CDM data model are continued in different tasks of X2Rail2 and a designated CDM work group, and the data topics gathered in this document will be considered in the related activities.

10 References

[In2Rail] Innovative Intelligent Rail, grant agreement No: 635900

[X2Rail2] Enhancing railway signalling systems based on train satellite positioning, on-board safe train integrity, formal methods approach and standard interfaces, enhancing Traffic Management System functions, grant agreement No: 777465

[IMPACT2] Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modal Transport chains – Phase 2, grant agreement No: 777513

[In2Rail D8.1] Requirements for the Integration Layer, In2Rail, grant agreement No: 635900

[In2Rail D8.4] Interface Control Document for Integration Layer Interfaces, external/Web interfaces and Dynamic Demand Service, In2Rail, grant agreement No: 635900

[TAF TSI Master Plan] TAF-TSI Master Plan, Version 4, January 2013

[TAF TSI Appendices] Technical appendices related to COMMISSION REGULATION (EU) No 1305/2014 of 11 December 2014, see also ERA website www.era.europa.eu

[TAF TSI EUR-Lex] TAF TSI published on EU Journal, COMMISSION REGULATION (EU) No 1305/2014

[TAF TSI WIMO] ERA-TD-102: TAF TSI – Annex D.2 : Appendix B – Wagon and Intermodal Unit Operating Database (WIMO), Version 2.0

Appendix A: Ownership of results

Ownership of results			
Company	**Percentage**	**Short Description of share/ of delivered input**	**Concrete Result (where applicable)**
HC		Shared Ownership	
ASTS		Shared Ownership	
BTSE		Shared Ownership	
SIE		Shared Ownership	
TTS		Shared Ownership	
NR		Shared Ownership	
TTS		Shared Ownership	

Table 1: Ownership of results

Appendix B: Requirements matrix for defining a web interface for managing dynamic exchange of information and demand

X2R2-D6.6
RequirementsMatrix