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IMPACT-2

# Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modal Transport chains – Phase 2

# Deliverable D 7.1

# Requirements Specification for Freight related Topics integrated in Integration Layer

| | |
|---|---|
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# 1 Executive summary

One of the overall aims of the Impact-2 project is to develop a common platform for the intelligent mobility management by taking advantage of the Integration Layer (IL) developed in the In2Rail project [4] and the Conceptual Data Model (CDM) to support the standardisation of data being exchanged between applications. This Integration Layer is being further developed within In2Smart [5] and X2Rail2 [3] and this work will feed into this deliverable.

This integration of data is a step towards the seamless and fully-automated process integration of railway related services and other modes of transport. The focus of this deliverable, Impact-2 D7.1 “Requirements Specification for Freight”, is to enhance the already developed requirements for Integration Layer Topics (groups of data to be exchanged over the IL) with a focus on the necessary constituents needed to link Freight Operations to the overall process.

To this end, this deliverable contains the Data structures and requirements of data exchanges over the IL needed to facilitate the Use Cases developed in Impact-2 D7.2 “Use-Cases for advanced Freight operation” [1]. This can be used to inform the development of the overall CDM, by providing the required data, and requirements to define different Topics for the CDM, and for prototypes developed by partners for Impact-2. This can then be refined and developed further in the FINE-2 project (“Furthering Improvements in Integrated Mobility Management (I2M), Noise and Vibration, and Energy in Shift2Rail”).

# 2 Abbreviations and acronyms

| Abbreviation / acronym | Description |
|---|---|
| AOS | Automated Onboard Systems (ATP+ATO) |
| CA | Collaboration Agreement |
| CPS | Customer Production and Follow up system |
| DG | Dangerous Goods |
| DMP | Data Management Plan |
| DoA | Description of Action |
| FRU | Freight Railway Undertaking |
| GA | Grant Agreement |
| IM | Infrastructure Manager |
| IMPACT-2 | Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modal Transport chains – Phase 2 |
| JU | Joint Undertaking |
| MCU | Master Control Unit |
| OPCS | Interface to DCS for train control. |
| PM | Project Manager (coordinator) |
| RS | Request System |
| S2R | Shift2Rail |
| SPD | System Platform Demonstrator |
| TCC | Train Control Centre |
| TMS | Traffic Management System |
| TMT | Technical Management Team |
| TOM | Timetable Optimization Module |
| TPS | Timetable Planning System |
| WP | Work Package |

# 3 Background

The work within the Shift2Rail project is structured around five Innovation Programs (IPs) interconnected by cross cutting activities (CCAs). The CCAs ensure the interactions between the IPs and different subsystems and thus their connectivity. The work within the CCAs is organized in six Work Areas (WAs). The IMPACT2 project collects all available inputs from different IPs and analyses the synergies between them, taking the societal and economical needs of the future railway system into account.

WP7 of the IMPACT2 project contributes to WA4.2, focussing on the inclusion and linking of freight operations in the overall TMS framework designed in X2Rail2-WP6. The present document constitutes the Deliverable D7.1 “Requirements Specification for Freight” as part of WP7. The objective of this task is to specify and implement the data structures and necessary subroutines into the specific sub-layer foreseen for the data exchange between TMS and Freight Management Systems.

This deliverable identifies the data required for the interfaces between the TMS and Freight management systems within the use cases described in IMPACT2 D7.2 “Use cases for advanced freight operations”. It uses the X2Rail2 D6.1 “System Requirement Specification (SRS) for the Integration Layer” [3] as an input to ensure the data structures described are informed by those delivered as part of IP2.

# 4 Objectives/aims

## 4.1 Aim

This document has been prepared to provide functional and non-functional requirements for Freight related Topics integrated into the Integration Layer. This includes interfaces to Freight Management Systems, Field systems and TMS.

For the purpose of this document “Topics” are considered as follows: “Topics are a group of data used for the exchange of data between the different systems” [2].

This document will provide functional requirements for the interfaces that these topics are exchanged over by analysing the data that needs to be exchanged between applications over the Integration Layer. It will also identify non-functional requirements based on the properties of this exchange.

The interfaces analysed and presented in the deliverable are based on the interfaces to the applications and use cases in Impact 2 D7.2 [1] that enable improved freight operations.

The scope of the requirements in this document is to feed into Prototypes created in Impact-2 and into further work during FINE-2.

## 4.2 Document Structure

This document will contain a chapter for applications used within use cases in D7.2 [1]. For each application, the interfaces related to the use cases in D7.2 will be assessed to understand the data that will be exchanged, and the properties of the exchange.

Each chapter will include the following:

- A summary of the use case(s) with a diagram of the interfaces
- A summary of the interfaces being defined.
- The properties of each interface.
- The data being exchanged for each interface.

The following properties will be described.

| Interface Properties | |
|---|---|
| Interface ID | Interface ID |
| Interface Title | Interface Title |
| Publisher | REQ<br>System publishing the Data |
| Publish Trigger | REQ(s)<br>Events that cause the system to publish/re-publish the data (as required by the use case) |

| | |
|---|---|
| Expected Frequency | Static/Dynamic + Approx. publishing frequency |
| Subscriber | List of systems subscribing to the Data |
| Filter | REQ(s)<br>How should the data be able to be filter for a reader/subscriber. |
| Persistence | REQ<br>How long should the data be persisted on the IL |
| Length of Validity | REQ<br>When should the data be identified as no longer valid by the IL. |
| Historical Depth | REQ<br>How many historical values must be maintained in the IL. |
| Safety Related | REQ<br>Are there safety related requirements for this data. |

**Table 4-1 Example Properties Table**

These properties will be from the perspective of the specific use case. Therefore a publisher may have more triggers than those listed in this document, as use cases outside the scope of this document may need data to be published in different situations.

# 5 Interfaces for Freight related Topics

The table below shows the relationship between use cases in Impact-2 D7.2 [1] and the applications within those use cases that are included in this document. Each application makes up a following section of the document.

| Use Case vs Application (D7.2 Section Reference) | ETA Module | Traffic-Node Coordination Module | Dynamic Crossing Analysis Module | Freight Wagon on board monitoring system | Optimal time slot and itinerary for DG | Timetable Optimization Module | Freight Transport Review | Conflict Detection and Resolution | Container management system | Automated Mining Train Operation |
|---|---|---|---|---|---|---|---|---|---|---|
| Terminal slot planning (HC) (5.3.1) | X | | | | | | | | | |
| Planning a train request (HC) (5.3.2) | X | | | | | | | | | |
| Update information to Traffic Management System (IND) (5.3.3) | | X | | | | | | | | |
| Update information to Node Management System (IND) (5.3.4) | | X | | | | | | | | |
| Node Plan Optimization (IND) (5.3.5) | | X | | | | | | | | |
| Freight Train without Crossing (IND) (5.3.6) | | | X | | | | | | | |
| Crossing between two | | | X | | | | | | | |

| Use Case vs Application (D7.2 Section Reference) | ETA Module | Traffic-Node Coordination Module | Dynamic Crossing Analysis Module | Freight Wagon on board monitoring system | Optimal time slot and itinerary for DG | Timetable Optimization Module | Freight Transport Review | Conflict Detection and Resolution | Container management system | Automated Mining Train Operation |
|---|---|---|---|---|---|---|---|---|---|---|
| Freight Trains (IND) (5.3.7) | | | | | | | | | | |
| Crossing between a Passenger Train and a Freight Train (IND) (5.3.8) | | | X | | | | | | | |
| Freight Train entry to High-Speed line (IND) (5.3.9) | | | X | | | | | | | |
| Wagon Axle box Temperature (STS) (5.3.10) | | | | X | | | | | | |
| Optimal Time slot and Itinerary (STS) (5.3.11) | | | | | X | | | | | |
| Wagon Bogie Vibration (STS) (5.3.12) | | | | X | | | | | | |
| Wagon tank pressure (STS) (5.3.13) | | | | X | | | | | | |
| Optimize timetable region (TRV/RISE) (5.3.14) | | | | | | X | | | | |

| Use Case vs Application (D7.2 Section Reference) | ETA Module | Traffic-Node Coordination Module | Dynamic Crossing Analysis Module | Freight Wagon on board monitoring system | Optimal time slot and itinerary for DG | Timetable Optimization Module | Freight Transport Review | Conflict Detection and Resolution | Container management system | Automated Mining Train Operation |
|---|---|---|---|---|---|---|---|---|---|---|
| Add train to timetable (TRV/RISE) (5.3.15) | | | | | | X | | | | |
| Monitoring of staff, locomotive and wagon transport status (TRV/RISE) (5.3.16) | | | | | | | NA* | | | |
| Conflict detection (SIE) (5.3.17) | | | | | | | | X | | |
| Conflict resolution (SIE) (5.3.18) | | | | | | | | X | | |
| Optimizing container delivery to ports (THA) (5.3.19) | | | | | | | | | X | |
| Automated dispatch of an Available Train (BT) | | | | | | | | | | X ** |
| Remote Controlled Train Loading (BT) (5.3.20) | | | | | | | | | | X *** |
| Automated Train Unloading (BT) (5.3.21) | | | | | | | | | | X *** |

**Figure 5-1 Use Cases vs Applications**

* NOTE: The “Monitoring of staff, locomotive and wagon transport status” use case is not being progressed beyond D7.2 and is therefore not included in this document.

** NOTE: The “Automated dispatch of and Available Train” has been added in this deliverable (found in section 18.1) to extend the related use cases (5.3.20 and 5.3.21).

*** NOTE: The “Remote Controlled Train Loading” Use case has been renamed from “Movement Control in Train Dispatch Area” in D7.2 (updated use case in section 18.2 of this deliverable), and “Automated Train Unloading” has been renamed from “Movement control in unloading area (Car Dumper)” in D7.2 (updated use case in section 18.3 in this deliverable).

# 6 ETA monitoring and calculation

## 6.1 Use Case summary

**Use Case (D7.2 5.3.1): Terminal Slot Planning**

Assignment of loading and unloading slots at the terminals is usually planned at the tactical planning level according to the requests of Freight Railway Undertakings (FRU). This plan may be modified if a freight train cannot fulfil its schedule or in case of a newly planned train trip at short notice.

If a freight train is delayed, it loses its right to use the unloading slot at the arrival terminal. In this case, the terminal operator plans, a new slot for the loading/unloading process and looks for other options to use the capacity being released by the non-used slot. Therefore, the involved terminal actors (e.g. terminal IM, RU, …) receive the updated ETA (an interface to the ETA module will facilitate exchanging the updated ETA in real time). The locomotive and the wagons will be late for their next planned trips and therefore should be rescheduled (in most cases, by the FRU).

Depending on the organization of the terminal operations, some or all of the mentioned actors will be involved. 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 duration of terminal operations, such as loading/unloading and shunting operations represents the main component of the overall freight train travel time. Therefore, real-time and efficient management of terminal operations considering delayed trains minimizes their negative effect on the overall ETA of freight trains, thereby enhancing the overall performance of rail freight operations.

**Use Case (D7.2 5.3.2): Planning a train request**

Freight train operator may request modifications to the currently planned train path or may request a path for a new service. Note that, depending on the case, multiple connected paths may be suggested for fulfilling the planned train request. The connection here may involve handling or cross border operations. 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 freight train operator will ask for a new train path for the delayed train. In such cases, special considerations should be given to the specifications and constraints of the freight train (e.g. weight, etc.).

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) instead of individual (re-) planning of the path. The scheduling module will receive updated ETA calculation results via interfaces regarding the available resources required for planning a new train. Any none-valid paths/slots are cancelled and the capacity /slot is released accordingly.

Note that all communications in the above mentioned process are carried out via the web interface attached to the TMS Integration Layer. Therefore, the involved parties are able to communicate their needs in real time and the negotiation processes can be carried out effectively. The digitalized path request process allows for web-based ad-hoc train path requests via a web browser, using for instance, a web application. TAF TSI is expected to be used as a basic element of path request integrated into the web app. In addition, tight integration of process status of terminal operations into ETA calculation functions will enhance the accuracy of ETA calculation.

Below, the different interfaces allowing for the required data exchange are described.

## 6.2 Interface summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with ".P" are the publish side and interfaces with ".S" are the subscribe side.

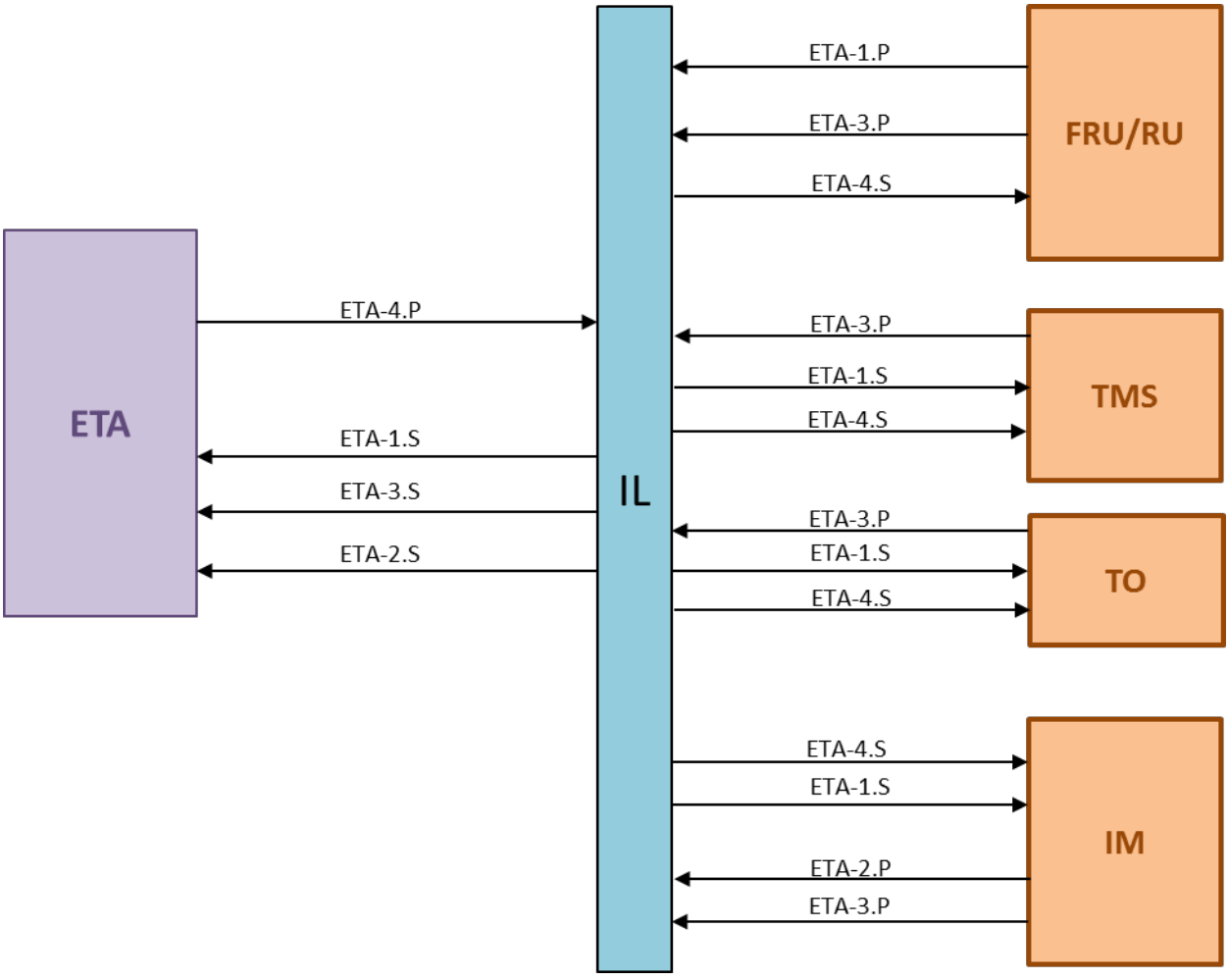


**Figure 6-1 Interface Summary ETA monitoring and calculation**

The table below shows a summary of the interfaces related to the data exchange during the different processes of use cases.

Note that, where there are more than one publisher of the data (fields marked with *), the publishers are expected to provide data according to Table 6.6 only as far as being available from each of these parties/systems. However, the same data structure might be used for all actors leaving certain data attributes empty if data is not available. For each sending party/system an identifier will be used and assigned to the attribute data being published. This will also allow the ETA module to apply certain logic for consolidation of redundant attribute being data published for one train by more than one actor.

| Interface ID | Publisher | Subscriber | Topic | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| ETA function Subscribing | | | | | | | |
| ETA-1 | FRU/RU | ETA module,TMS/IM | Train data | Data related to train characteristics, wagons, containers, blocks and locomotive. | 6.2.1 | UC 5.3.1steps 3,4,5,6, UC5.3.2steps 2,3,5 | Y |
| ETA-2 | IM | ETA module | Proposed path data | Data published by the IM to be used by the ETA module for calculating/Updating the ETA/ETI of a requested/changed path for containers, wagons and blocks on the train. | 6.2.2 | UC5.3.2 steps 2,3 | Y |
| ETA-3 | TMS, IM, FRU/RU, TO | ETA module | Train-run data | Data required by the ETA module to calculate/upgrade/monitor the estimated arrival times of trains and wagons | 6.3.1 | UC5.3.1 step 1 UC5.3.2 steps 2,3 | Y |
| ETA function Publishing | | | | | | | |
| ETA-4 | ETA module | TMS, IM, FRU/RU/TO | ETA/ETI data | Data published by the ETA module regarding the arrival time of trains/wagons at final or intermediate stations | 6.3.2 | UC5.3.1 steps 1,2,5, and 6 UC5.3.2 step 2 | Y |

**Table 6-1 ETA monitoring and calculation Interface Summary**

## 6.3 Data published by external systems to Integration Layer

This is the data published by freight external systems for TMS, ETA module and other systems to use. The data is related to train specifications and other information required for carrying out the different steps of the two use cases mentioned above (details available in D7.2, IMPACT2 [1]). Note that for all the described interfaces, the access rights need to be checked and it has not been considered as part of the interface description.

### 6.3.1 ETA-1 Train Data

The data includes the information related to train specifications, as well as containers, wagons, blocks and locomotives including their physical characteristics.

#### 6.3.1.1 *Properties of the interface for train related data exchange*

| Interface ETA-1 Properties | |
|---|---|
| Interface ID | ETA-1 |
| Interface Title | Train Data |
| Publisher | The FRU/RU shall be able to publish the data related to their train for TMS and ETA module. They publish the data within section 13.3.1.2 to the integration layer. |
| Publish Trigger | When a freight train operator requests a path for a new service.<br>When train attributes such as wagons, locomotive characteristics, etc. change requiring any special considerations that should be given to the specifications and constraints of the freight train (e.g. weight, etc.).<br>When there is a request e.g. by the ETA module for updating the ETA/ETI. |
| Expected Frequency | One time occurrence at every update/request. |
| Subscribers | TO, IM, TMS, ETA |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Train data” data related to a specified “Train ID” |
| Persistence | The Integration Layer shall persist “Train data” at least until the “train journey” concluded. |
| Length of Validity | The Integration Layer shall identify the Train Data as valid until it is deleted. |
| Historical Depth | The Integration Layer shall provide the “Train Data” when a read request is made. |

**Table 6-2 ETA-1 Properties**

#### 6.3.1.2 *Train Data*

| Data Grouping Heading | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Data type** | **Related Use Case** |
| 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<br><br>Note: Usually this ID is a composition of<br>- Operation Train ID<br><br>-Operating day<br>- Start time of the train (sometimes required in larger networks) | String | 1,2 |
| 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 | Numeric (business key reference for shared train composition master data) | 1,2 |
| WagonNumber | Unique identifier for Wagon | 12 character EVN | WagonNumber |
| WagonTrainPosition | Identifies position of wagon within train formation. Sequential numbers. Front of train is 1. | Numeric | 1,2 |
| WagonLoadingGaugeType | Code to define Loading Gauge Type of Vehicle | Alphanumeric | 1,2 |
| WagonTrackGaugeType | Code to define Track Gauge Type of | Alphanumeric | 1,2 |

| | | | |
|---|---|---|---|
| | Vehicle | | |
| WagonLength | Length of the Wagon in [cm] | Numeric | 1,2 |
| WagonMaximumSpeed | Maximum speed of wagon [km/h] | Numeric | 1,2 |
| WagonGrossWeight | Total Weight of goods in wagon or transportation unit. (booked weight of goods included packing) in [kg] | Numeric | 1,2 |
| WagonLoadStatus | Code to indicate load status | Alphanumeric Code e.g. E = Empty | 1,2 |
| WagonType | Code to define Wagon Type | Alphanumeric | 1,2 |
| UltimateDestination | Final Location of the Wagon | {Location} | 2 |
| CommodityCode | Code indicating type of material the wagon is carrying | Alphanumeric | 1,2 |
| CrippleCode | Code to indicate a problem with the wagon if one exists. | Alphanumeric | 1,2 |
| WagonBrakeForce | Brake force of Wagon | Numeric (0-99) | 1,2 |
| WagonBrakeType | Code to indicate the brake type | Alphanumeric | 1,2 |
| WagonBrakeSetting | Code to indicate the setting of the wagon's brake | Alphanumeric | 1,2 |
| WagonDangerousGoods | Details of dangerous goods carried by wagon | {DangerGoods} | 1,2 |
| SpecialHandlingCode | If wagon has special handling requirements. | Code | 1,2 |
| SpecialCharacteristics | Special | Code | 1,2 |

| | | | |
|---|---|---|---|
| | characteristics Code | | |
| WagonContainers | Wagons carrying more than one container | N x {Containers} | 1,2 |
| ContainerNumber | Container number | Numeric | 1,2 |
| ContainerPosition | Distance of Container from front of Wagon. | UnitOfMeasurement: Alphanumeric | 1,2 |
| ContainerType | Code to identify container type | Alphanumeric Code | 1,2 |
| ContainerDangerousGoods | Information if container is carrying dangerous goods. | {DangerousGoods} | 1,2 |
| SpecialHandlingCode | Code if special handling is required | Alphanumeric Code | 1,2 |
| ContainerLength | Length of container | UnitOfMeasurement: Alphanumeric | 1,2 |
| | | Value: Numeric | |
| ContainerHeight | Container Height | UnitOfMeasurement: Alphanumeric | 1,2 |
| | | Value: Numeric | |
| ContainerWidth | Container Width | UnitOfMeasurement: Alphanumeric | 1,2 |
| | | Value: Numeric | |
| TrainCommunication | Train communication method and contact details (radio type etc) | Alphanumeric | 1,2 |
| Locomotive Identifier (s) | Identifier of the locomotive (s) in sequence from train's top | N x String | 1,2 |
| Block ID | Informartion on the block specifications such as number, ID and types of wagons included in the block, | N x {BlockNumber} | 1,2 |

| | | | |
|---|---|---|---|
| | etc. | | |
| RestrictedMaximumSpeed | Restricted maximum speed of the Locomotive in [km/h] | Numeric | 2 |
| LocomotiveBrakeForce | Brake force of Locomotive in [kN] | Numeric (0-99) | 1,2 |

**Table 6-3 ETA-1 Data**

### 6.3.2 ETA-2 Proposed Path data

The data that is exchanged though this interface includes the information required to calculate/update the ETA of a newly-planned train service or an updated path for an already planned train published by the IM. The ETA module will access this information to estimate the arrival time of a train at its final/intermediate stations. The ETA module obtains the Train Data through the ETA-1 interface.

#### 6.3.2.1 *Properties of the interface for proposed path data exchange*

| Interface ETA-1 Properties | |
|---|---|
| Interface ID | ETA-2 |
| Interface Title | Proposed Path Data |
| Publisher | The IM publishes the data related to their suggestion for a new/modified train path, in response to a request received from the FRU/RU. The ETA module accesses this information for calculating/updating a train's ETA/ETI. |
| Publish Trigger | When a freight train operator requests modifications to the currently planned train path (for example due to delays along a line or at a terminal).<br>When a freight train operator requests a path for a new service.<br>When train attributes such as wagons, locomotive characteristics, etc. change requiring any special considerations that should be given to the specifications and constraints of the freight train (e.g. weight, etc.). As a result, the train path should be re-calculated. |
| Expected Frequency | One time occurrence at every update |
| Subscribers | ETA |
| Filter | The Integration Layer shall provide the publisher with the ability to publish "Proposed Path Data" related to a particular Path ID.<br>The Integration Layer shall provide the subscriber with the ability to receive "Proposed Path Data" i.e. the data specifying the path for a train service. |

| | |
|---|---|
| | The Integration Layer shall provide the subscriber with the ability to receive "Train Data" related to a particular Train ID. |
| Persistence | The Integration Layer shall persist "Proposed Path" data until the status of a path changes to ''confirmed/denied''. |
| Length of Validity | The Integration Layer shall identify the proposed path data as Valid until a path is confirmed/denied for a request. |
| Historical Depth | The Integration Layer shall provide the "proposed path" data when a read request is made. |

**Table 6-4 ETA-2 Properties**

### 6.3.2.2 *Proposed Path Data*

| Data Grouping Heading | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Data type** | **Related Use Case** |
| 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<br><br>Note: Usually this ID is a composition of<br>- Operation Train ID<br><br>-Operating day<br>- Start time of the train (sometimes required in larger networks) | String | 1,2 |
| Proposed Path Identifier | 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) | string | 1,2 |
| WagonNumber | Unique identifier for Wagon | 12 character EVN | 1,2 |
| 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 | Numeric (business key reference for shared train composition master | 1,2 |

| | | | |
|---|---|---|---|
| | element of TAF TSI | data) | |
| Locomotive Identifier | Identifier of the locomotive | String | 1,2 |
| Proposed Path Departure Time and Date | Suggested planned time when the freight train is able to use the route | DateTime | 2 |
| Proposed Path Handling | List of references to handling points of the freight train and required minimum handling / maximum waiting times for departing path. First handling point = departing location, last handling point = destination location. | N x (location ID, minimum handling time in [datetime], maximum waiting time in [datetime]) | 2 |

**Table 6-5 ETA-2 Data**

### 6.3.3 ETA-3 Train Run data

The data includes the information related a train run required by the ETA module to upgrade/monitor the estimated arrival times of running trains and wagons at their final or intermediate stations. The ETA module has access to the Train Data related a particular Train ID through ETA-1 interface.

#### 6.3.3.1 *Properties of the interface for Train Run data exchange*

| Interface ETA-1 Properties | |
|---|---|
| Interface ID | ETA-3 |
| Interface Title | Train-Run Data |
| Publisher | The information concerning a running train is published by different parties (IM, TMS, FRU, TO) for the ETA module to update or monitor a train's ETA/ETI. The data within section 13.3.1.2 is published to the integration layer. |
| Publish Trigger | When there is an update regarding the status of a running train such as delays (at lines/stations), change in composition, etc.<br><br>When there is an update in the infrastructure status (TSR put in place, etc.)<br><br>When there is an update in terminal operations related to one of a running train's intermediate handling points. |
| Expected Frequency | Dynamic every 5 to 30 seconds (the interval depends on the network status such as size, traffic frequency, etc.) |

| | |
|---|---|
| Subscribers | ETA |
| Filter | The Integration Layer shall provide the subscriber with the ability to read data related to a particular “Path ID”<br><br>The Integration Layer shall provide the subscriber with the ability to read “Train Run” data related to a particular “Train ID” |
| Persistence | The Integration Layer shall persist “Train Run” data until a new update is available/the train service is concluded/cancelled. |
| Length of Validity | The Integration Layer shall identify the “Train Run” data as Valid until an update is published. |
| Historical Depth | The Integration Layer shall provide the subscriber with the latest update of “Train Run” data. |

**Table 6-6 ETA-3 Properties**

#### 6.3.3.2 *Train Run Data*

| Data Grouping Heading | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Data type** | **Related Use Case** |
| 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<br><br>Note: Usually this ID is a composition of<br>- Operation Train ID<br><br>-Operating day<br>- Start time of the train (sometimes required in larger networks) | String | 1,2 |
| WagonNumber | Unique identifier for Wagon | 12 character EVN | 1,2 |
| Train composition | This information is sent from the RU to the IM informing the composition of the proposed train. This | Numeric (business key reference for shared train composition master data) | 1,2 |

| | | | |
|---|---|---|---|
| | information is covered by the TrainComposition element of TAF TSI | | |
| Location DateTime | DateTime at the location when the train is located at the location. | Timestamp | ETA module |
| Location Source | Provider of the location data. | Listed [GPS, UTM, RBC, Occupancies] | ETA module |
| Location GPS Coordinates | Global Positioning System coordinates where the train is located at location DateTime. | Complex [GPS Coordinates] | ETA module |
| Location UTM Coordinates | Universal Transverse Mercator coordinates where the train is located at location DateTime. | Complex [UTM Coordinates] | ETA module |
| Location Current Speed | Current speed of train at location in [km/h] | Numeric | ETA module |
| Location KP – Line Section | Kilometric Point at Line Section the train is located on. | Complex [Numeric, String] | ETA module |
| Path Temporary Speed Restriction identifier | Identifier of the path TSRs included in the system by the TSR management system. | N x {TSR} | 2, ETA module |
| TSR Maximum Speed | Maximum Speed of the TSR. | Numeric | ETA module |
| TSR Start Point | Location element where the TSR starts to affect the running of the train. | Complex [Location] | ETA module |
| TSR Start DateTime | DateTime when the TSR starts to affect the running of the train. | Timestamp | ETA module |
| TSR End Point | Location element where the TSR leaves to affect the running of the train. | Complex [Location] | ETA module |
| TSR End DateTime | DateTime when the TSR leaves to affect the | Timestamp | ETA module |

| | | | |
|---|---|---|---|
| | running of the train. | | |
| Train's speed profile | Code identifying shared speed profile data | Alphanumeric | ETA module |
| Remaining distance to the destination | Distance to the destination [cm] | Numeric | ETA module |
| Speed limit | Permanent speed limits on train path [km/h] | Numeric | ETA module |
| Locomotive ID | to feed runtime calculation and route compliance checks | String | ETA module |
| Temporary Speed Restriction Identifier | Identifier of a TSR included in the system by the TSR management system. | String | 2, ETA module |
| Estimated Terminal Handling Time | Estimation of the time required to handle a train at each intermediate terminal | N x {NumberofTerminals} Numeric | 2, ETA module |

**Table 6-7ETA-3 Data**

## 6.4 Data published by ETA to Integration Layer

### 6.4.1 ETA-4 ETA/ETI data

The data includes the information published by the ETA module regarding the calculation/upgrading/monitoring the estimated arrival times of trains and wagons at their final or intermediate stations.

#### 6.4.1.1 *Properties of the interface for ETA/ETI data exchange*

| Interface ETA-1 Properties | |
|---|---|
| Interface ID | ETA-4 |
| Interface Title | ETA/ETI Data |
| Publisher | The information concerning a running train/a newly planned service published by the ETA module regarding an update or calculation of the estimated arrival time of a train/wagons at intermediate stations or their final destinations. They publish the data within section 13.3.1.2 to the integration layer. |
| Publish Trigger | The ETA module calculates a train run at specific intervals including the following instances:<br><br>When there is an update regarding the status of a running train such as delays |

| | |
|---|---|
| | (line, station, etc.), change in composition, etc.<br>When there is an update in the infrastructure status (TSR put in place, etc.)<br>When there is a path proposal in place in response to a path request. |
| Expected Frequency | Dynamic every 5 to 30 second (the interval depends on the network status such as size, traffic frequency, etc.) |
| Subscribers | FRU/RU, IM, TO |
| Filter | The Integration Layer shall provide the subscriber with the ability to read data related to a particular "Train ID"<br>The Integration Layer shall provide the subscriber with the ability to read data related to a particular "Wagon ID"<br>The Integration Layer shall provide the subscriber with the ability to read data related to a particular "Block ID" |
| Persistence | The Integration Layer shall persist "ETA/ETI" data until there is an update published by the ETA module. |
| Length of Validity | The Integration Layer shall identify the "ETA/ETI" data as Valid until an update is published. |
| Historical Depth | The Integration Layer shall provide the subscriber with the latest update of train arrival times. |

**Table 6-8 ETA-4 Properties**

### 6.4.1.2 *ETA/ETI Data*

| Data Grouping Heading | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Data type** | **Related Use Case** |
| Path Identifier | 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) | string | 1,2 |
| Train Identifier | Identification of a train, this ID (Number/character) is used as a reference for further | String | 1,2 |

| | | | |
|---|---|---|---|
| | information related to the train on the IL<br>Note: Usually this ID is a composition of<br>- Operation Train ID<br>-Operating day<br>- Start time of the train (sometimes required in larger networks) | | |
| Estimated time of arrival of the train (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)<br>The related information includes those stored under attributes such as 'Forecasted Arrival Time'' ''Forecasted Departure Time'', and ''Train Location ID'' on the IL. | DateTime | 1,2 |
| Wagon ETA/ETI | Information of the Estimated time of arrival and handling of the wagon | N x {wagonNumber}<br>DateTime | 2 |
| Block ETA/ETI | Information of the Estimated time of arrival and handling of the wagon | N x {BlockNumber}<br>DateTime | 2 |
| Path Confirmation Status | Path confirmed, refused | Binary (0 if not) | 2 |
| Wagon Order (Optional) | Information indicating the order of the wagons by sequenced wagon IDs | N x {wagonNumber} | 1 |

**Table 6-9 ETA-4 Data**

# 7 Traffic-Node Coordination Module

## 7.1 Use Case summary

**Use Case ID (D7.2 5.3.3): Update information to Traffic Management System**

The use case describes an innovative scenario for interaction between the Mainline and Nodes, which are managed by different systems sharing information between them. The new Traffic-Node Coordination Module (TNCM) uses information provided by the Traffic management System (TMS) and the Node Management System (NMS) and is able to provide the TMS with the updated data related to the border between the Node and the Mainline. This information is accurately provided by TNCM according to complete knowledge of the current situation within the Node.

In this way, this module allows:

- To provide improved information to TMS based on the knowledge of the current situation within the Node.
- To isolate the TMS of the specific operation mode of the Node:
  - The internal movements and activities within the Node.
  - The behaviour and integration capabilities of the systems of the Node.

**Use Case ID (D7.2. 5.3.4): Update information to Node Management System**

The use case describes an innovative scenario for interaction between the Mainline and the information and movements within a Node. The Mainline is managed by the TMS, and each Node is individually managed by specific systems deployed for each Node. The new TNCM is able to provide to NMS updated data related to the border between the Node and the Mainline using information provided by the TMS and the NMS. This information is accurately provided by TNCM according to complete knowledge of the current situation of the traffic in the Mainline.

In this way, this module allows:

- To provide improved information to NSM based on the knowledge of the current traffic situation into the Mainline.
- To possibly isolate the NMS of:
  - The specific operation mode of the TMS.
  - The behaviour and integration capabilities of the TMS.

**Use Case ID (D7.2 5.3.5): Node Plan Optimization**

The use case describes an innovative scenario for interaction between the synchronization of both areas of management (Mainline and node), which is based on the scheduled and expected timetable of the trains arriving to the node and departing from the node. Taking into account that the management of both sides is performed by different actors, it is a key element that both sides remain informed about the updated information regarding the

timetable of the trains in the borders. During the operation, several circumstances on the mainline or nodes could imply disturbances on the scheduled timetables. In these cases the tasks in the Node should be internally organized in order to comply at maximum with the current departure timetables scheduled to the Node.

These modifications required over the Node Plan must be carried out by the NMS, in charge of the operation within the Node. For supporting these actions, the TNCM is able to provide modification proposals for the current Node Plan, according to the updated information received from the TMS and from the NMS.

## 7.2 Interface Summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with ".P" are the publish side and interfaces with ".S" are the subscribe side.

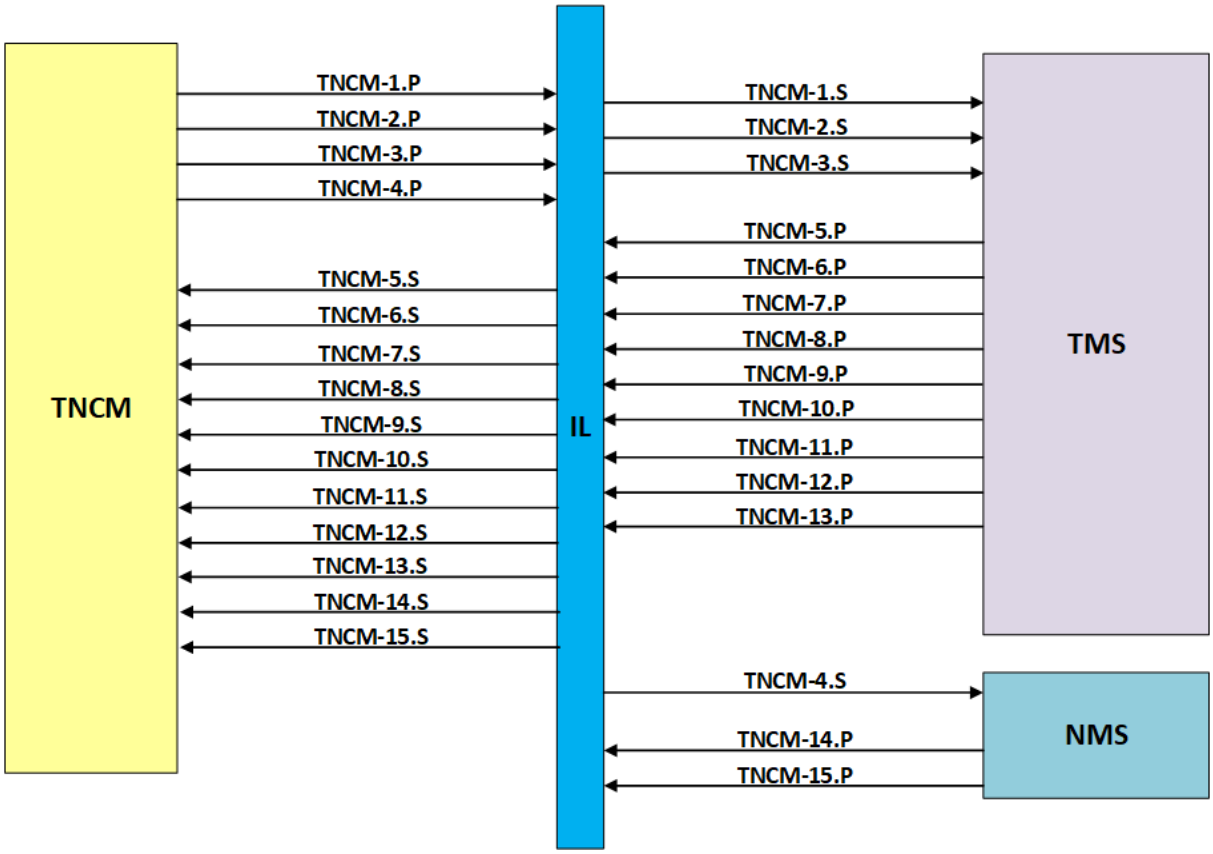


**Figure 7-1 Traffic-Node Coordination Module Interface Summary**

The table below shows a summary of the interfaces related to the Traffic-Node Coordination Module.

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| TNCM Publishing | | | | | | | |
| TNCM-1 | TNCM | TMS | Train Scheduled Timetable | Data related to Train Timetable: Scheduled Timetable | X2R2 D6.1 8.2.1.2.2 "Scheduled Timetable" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-2 | TNCM | TMS | Rolling Stock Scheduled Formation | Data related to Rolling Stock: Scheduled Formation | X2R2 D6.1 8.2.1.3.2 "Scheduled Formation" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-3 | TNCM | TMS | Train Staff Scheduled Crew | Data related to Train Staff: Scheduled Crew | X2R2 D6.1 8.2.1.4.2 "Scheduled Crew" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-4 | TNCM | NMS | Proposed Node Plan | Proposed modifications on the expected node operations | 7.3.4.2 | D7.2 5.3.5 | Y |
| TNCM Subscribing | | | | | | | |
| TNCM-5 | TMS | TNCM | Train Identification | Data related to Train Identification | X2R2 D6.1 8.2.1.1 "Data related to Train Identification" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-6 | TMS | TNCM | Train Target Timetable | Data related to Train Timetable: Target Timetable | X2R2 D6.1 8.2.1.2.3 "Target Timetable" | D7.2 5.3.3 D7.2 5.3.4 | Y |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TNCM-7 | TMS | TNCM | Train Audited Timetable | Data related to Train Timetable: Audited Timetable | X2R2 D6.1 8.2.1.2.5 "Audited Timetable" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-8 | TMS | TNCM | Train Forecasted Timetable | Data related to Train Timetable: Forecasted Timetable | X2R2 D6.1 8.2.1.2.7 "Forecasted Timetable" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-9 | TMS | TNCM | Rolling Stock Target Formation | Data related to Rolling Stock: Target Formation | X2R2 D6.1 8.2.1.3.4 "Target Formation" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-10 | TMS | TNCM | Rolling Stock Audited Formation | Data related to Rolling Stock: Audited Formation | X2R2 D6.1 8.2.1.3.6 "Audited Formation" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-11 | TMS | TNCM | Train Staff Target Crew | Data related to Train Staff: Target Crew | X2R2 D6.1 8.2.1.4.4 "Target Crew" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-12 | TMS | TNCM | Train Staff Audited Crew | Data related to Train Staff: Audited Crew | X2R2 D6.1 8.2.1.4.6 "Audited Crew" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-13 | TMS | TNCM | Train Path Audited Location | Data related to Train Path: 8.2.1.5.2 Audited Train Path | X2R2 D6.1 8.2.1.5.2 "Audited Train Path" | D7.2 5.3.3 D7.2 5.3.4 | Y |
| TNCM-14 | NMS | TNCM | Expected Node Plan | Data related to expected timetable of the operations inside the Node | 7.4.10.2 | D7.2 5.3.5 | Y |
| TNCM-15 | NMS | TNCM | Audited Node Plan | Data related to real data timetable of the operations inside the Node | 7.4.11.2 | D7.2 5.3.5 | Y |

**Table 7-1 Traffic-Node Coordination Module Interface Summary**

## 7.3 Data Published by Traffic-Node Coordination Module (TNCM)

Data published by the Traffic-Node Coordination Module to the Integration Layer available for TMS or NMS.

### 7.3.1 TNCM-1 Train Target Timetable

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.3.1.1 *Target Timetable Properties*

| Interface TCNM-1 Properties | |
|---|---|
| Interface ID | TNCM-1 |
| Interface Title | Target Timetable |
| Publisher | The TNCM shall be able to publish the data to the integration layer. |
| Publish Trigger | TNCM provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line |
| Expected Frequency | Dynamic<br><br>Approximately once per minute. |
| Subscribers | TMS (Others) |
| Filter | The Integration Layer shall modify data to systems with the ability to write "Target Timetable" referred to Train. |
| Persistence | The Integration Layer shall persist "Target Timetable" enough time for allowing the NMS or TMS process and actualise the new data for a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the "Target Timetable" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Target Timetable" data received when a read request is made. |

**Table 7-2 TCNM-1 Properties**

#### 7.3.1.2 *Target Timetable Data*

The data for this interface can be found in Chapter 8.2.1.2.3 "Target Timetable" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.3.2 TNCM-2 Rolling Stock Target Formation

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.3.2.1 *Rolling Stock Target Formation Properties*

| Interface TCNM-2 Properties | |
|---|---|
| Interface ID | TNCM-2 |
| Interface Title | Rolling Stock Target Formation |
| Publisher | The TNCM shall be able to publish the data to the integration layer. |
| Publish Trigger | TNCM provides new information to Integration Layer either when the traffic situation changes in the Node or the Main Line affecting the rolling stock assignment. |
| Expected Frequency | Dynamic<br><br>Approximately once per minute. |
| Subscribers | TMS (Others) |
| Filter | The Integration Layer shall modify data to systems with the ability to write "Rolling Stock Target Formation" referred to Train. |
| Persistence | The Integration Layer shall persist "Rolling Stock Target Formation" enough time for allowing the NMS or TMS process and actualise the new data, a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the "Rolling Stock Target Formation" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Rolling Stock Target Formation" data received when a read request is made. |

**Table 7-3 TCNM-2 Properties**

#### 7.3.2.2 *Rolling Stock Target Formation Data*

The data for this interface can be found in Chapter 8.2.1.3.4 "Target Formation" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.3.3 TNCM-3 Train Staff Target Crew

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.3.3.1 *Train Staff Target Crew Properties*

| Interface TCNM-3 Properties | |
|---|---|
| Interface ID | TNCM-3 |
| Interface Title | Train Staff Target Crew |
| Publisher | The TNCM shall be able to publish the data to the integration layer. |
| Publish Trigger | TNCM provides new information to Integration Layer when the traffic situation |

| | |
|---|---|
| | changes either in the Node or the Main Line affecting the current train crew assignment. |
| Expected Frequency | Dynamic<br>When it is the result of the analysis. |
| Subscribers | TMS (Others) |
| Filter | The Integration Layer shall modify data to systems with the ability to write "Train Staff Target Crew" referred to Train. |
| Persistence | The Integration Layer shall persist "Train Staff Target Crew" enough time for allowing the NMS or TMS process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the "Train Staff Target Crew" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Train Staff Target Crew" data received when a read request is made. |

**Table 7-4TCNM-3 Properties**

#### 7.3.3.2 *Train Staff Target Crew Data*

The data for this interface can be found in Chapter 8.2.1.4.4 "Target Crew" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.3.4 TNCM-4 Proposed Node Plan

This is the data published by the Traffic-Node Coordination Module to the Integration Layer available for NMS, "Proposed modifications on the expected node operations". The proposed node operations can be suggestions of modifications or deletion of expected node operations, and addition of new node operations.

#### 7.3.4.1 *Proposed Node Plan Properties*

| Interface TCNM-4 Properties | |
|---|---|
| Interface ID | TNCM-4 |
| Interface Title | Proposed Node Plan |
| Publisher | The TNCM shall be able to publish the data to the integration layer. |
| Publish Trigger | TNCM analyses the information received from TMS and NMS and generates an improved plan recommendation to be provided to TMS. |
| Expected Frequency | Dynamic<br>Approximately once per 10 minutes. |
| Subscribers | NMS |

| | |
|---|---|
| Filter | The Integration Layer shall modify data to systems with the ability to write "Proposed Node Plan". |
| Persistence | The Integration Layer shall persist "Proposed Node Plan" as valid a maximum time of 24 hours or until the train has completed its journey. Then, it will be deleted.. |
| Length of Validity | The Integration Layer shall identify the "Proposed Node Plan" data as valid until new modifications are received. |
| Historical Depth | The Integration Layer shall provide the last "Proposed Node Plan" data received when a read request is made. |

**Table 7-5 TCNM-4 Properties**

#### 7.3.4.2 *Proposed Node Plan Data*

| Proposed Node Operation | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** | **Related Use Case** |
| Node | Identifier of the Node where the operation is proposed. | String | D7.2 5.3.5 |
| Expected Node Operation Reference | Order of the modified Expected Node Operation in Expected Node Plan. | Numeric | D7.2 5.3.5 |
| Proposed Action | Action proposed regarding the node operation. | Listed [Modification, Deletion, Addition] | D7.2 5.3.5 |
| Activity | Activity in the Node. | Listed [Loading, Unloading, Coupling, Reception, Arrival…] | D7.2 5.3.5 |
| Node Internal Control Point | Location where the activity is expected. | String | D7.2 5.3.5 |
| Affected Train | Identifier of the Train affected by the activity. | String | D7.2 5.3.5 |
| Affected Wagons | Identifiers of the Wagons affected by the activity. | Array [String] | D7.2 5.3.5 |
| Affected Containers | Identifiers of the Containers affected by the activity. | Array [String] | D7.2 5.3.5 |
| Proposed Activity Start | Audited DateTime of start of the activity. | Timestamp | D7.2 5.3.5 |
| Proposed Activity | Audited DateTime of end of the | Timestamp | D7.2 5.3.5 |

| | | | |
|---|---|---|---|
| End | activity. | | |

**Table 7-6 TCNM-4 Data**

Table 7-7 Proposed Node Operation

## 7.4 Data read or subscribed by Traffic-Node Coordination Module (TNCM)

### 7.4.1 TNCM-5 Train Identification

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.1.1 *Train Identification Properties*

| Interface TCNM-5 Properties | |
|---|---|
| Interface ID | TNCM-5 |
| Interface Title | Train Identification |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | The TMS provides new information to Integration Layer each time a train property is modified. |
| Expected Frequency | Dynamic<br>When it is the result of the analysis. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Train Identification” referred to Train. |
| Persistence | Data will be available until the TNCM has processed the information or for a maximum time of 24 hours. |
| Length of Validity | The Integration Layer shall identify the “Train Identification” data as valid until new data is received. |
| Historical Depth | The Integration Layer shall provide the last “Train Identification” data received when a read request is made. |

**Table 7-8 TCNM-5 Properties**

#### 7.4.1.2 *Train Identification Data*

The data for this interface can be found in Chapter 8.2.1.1 “Data related to Train Identification” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 7.4.2 TNCM-6 Train Target Timetable

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.2.1 *Target Timetable Properties*

| Interface TCNM-6 Properties | |
|---|---|
| Interface ID | TNCM-6 |
| Interface Title | Target Timetable |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line. |
| Expected Frequency | Dynamic<br>Approximately once per minute. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Target Timetable" referred to Train. |
| Persistence | The Integration Layer shall persist "Target Timetable" referred to Train until the TNCM has processed the information or for a maximum time of 24 hours. |
| Length of Validity | The Integration Layer shall identify the "Target Timetable" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Target Timetable" data received when a read request is made. |

**Table 7-9TCNM-6 Properties**

#### 7.4.2.2 *Target Timetable Data*

The data for this interface can be found in Chapter 8.2.1.2.3 "Target Timetable" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.4.3 TNCM-7 Train Audited Timetable

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.3.1 *Audited Timetable Properties*

| Interface TCNM-7 Properties | |
|---|---|
| Interface ID | TNCM-7 |
| Interface Title | Audited Timetable |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line. |

| | |
|---|---|
| Expected Frequency | Dynamic<br><br>Approximately once per minute. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Audited Timetable" referred to Train. |
| Persistence | The Integration Layer shall persist "Audited Timetable" referred to Train until the TNCM has processed the information or for a maximum time of 24 hours. . |
| Length of Validity | The Integration Layer shall identify the "Audited Timetable" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Audited Timetable" data received when a read request is made. |

**Table 7-10TCNM-7 Properties**

#### 7.4.3.2 *Audited Timetable Data*

The data for this interface can be found in Chapter 8.2.1.2.5 "Audited Timetable" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.4.4 TNCM-8 Train Forecasted Timetable

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.4.1 *Forecasted Timetable Properties*

| Interface TCNM-8 Properties | |
|---|---|
| Interface ID | TNCM-8 |
| Interface Title | Forecasted Timetable |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line. |
| Expected Frequency | Dynamic<br><br>Approximately once per minute. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Forecasted Timetable" referred to Train |
| Persistence | The Integration Layer shall persist "Forecasted Timetable" referred to Train until the TNCM has processed the information or for a maximum time of 24 hours. |

| | |
|---|---|
| Length of Validity | The Integration Layer shall identify the "Forecasted Timetable" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Forecasted Timetable" data received when a read request is made. |

**Table 7-11 TCNM-8 Properties**

#### 7.4.4.2 *Audited Timetable Data*

The data for this interface can be found in Chapter 8.2.1.2.7 "Forecasted Timetable" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.4.5 TNCM-9 Rolling Stock Target Formation

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.5.1 *Rolling Stock Target Formation Properties*

| Interface TCNM-9 Properties | |
|---|---|
| Interface ID | TNCM-9 |
| Interface Title | Rolling Stock Target Formation |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line affecting the rolling stock assignment. |
| Expected Frequency | Dynamic<br><br>Once per minute |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Rolling Stock Target Formation" enough time for allowing the NMS or TMS process and actualise the new data, a maximum time of 24 hours. After this time limit, it will be deleted |
| Persistence | The Integration Layer shall persist "Rolling Stock Target Formation" referred to Train. |
| Length of Validity | The Integration Layer shall identify the "Rolling Stock Target Formation" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Rolling Stock Target Formation" data received when a read request is made. |

**Table 7-12 TCNM-9 Rolling Stock Target Formation Properties**

#### 7.4.5.2 *Rolling Stock Target Formation Data*

The data for this interface can be found in Chapter 8.2.1.3.4 “Target Formation” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 7.4.6 TNCM-10 Rolling Stock Audited Formation

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.6.1 *Rolling Stock Audited Formation Properties*

| Interface TCNM-10 Properties | |
|---|---|
| Interface ID | TNCM-10 |
| Interface Title | Rolling Stock Audited Formation |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer either when the traffic situation changes in the Node or the Main Line affecting the rolling stock assignment. |
| Expected Frequency | Dynamic<br>Once per minute |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Rolling Stock Audited Formation” referred to Train. |
| Persistence | The Integration Layer shall persist “Rolling Stock Audited Formation” referred to Train enough time for allowing the NMS or TMS process and actualise the new data, a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the “Rolling Stock Audited Formation” data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last “Rolling Stock Audited Formation” data received when a read request is made. |

**Table 7-13 TCNM-10 Rolling Stock Audited Formation Properties**

#### 7.4.6.2 *Rolling Stock Audited Formation Data*

The data for this interface can be found in Chapter 8.2.1.3.6 “Audited Formation” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 7.4.7 TNCM-11 Train Staff Target Crew

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.7.1 *Train Staff Target Crew Properties*

| Interface TCNM-11 Properties | |
|---|---|
| Interface ID | TNCM-11 |
| Interface Title | Train Staff Target Crew |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line affecting the current train crew assignment. |
| Expected Frequency | Dynamic<br>When it is the result of the analysis. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Train Staff Target Crew" referred to Train. |
| Persistence | The Integration Layer shall persist "Train Staff Target Crew" referred to Train enough time for allowing the NMS or TMS process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the "Train Staff Target Crew" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Train Staff Target Crew" data received when a read request is made. |

**Table 7-14 TCNM-11 Train Staff Target Crew Properties**

#### 7.4.7.2 *Train Staff Target Crew Data*

The data for this interface can be found in Chapter 8.2.1.4.4 "Target Crew" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.4.8 TNCM-12 Train Staff Audited Crew

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.8.1 *Train Staff Audited Crew Properties*

| Interface TCNM-12 Properties | |
|---|---|
| Interface ID | TNCM-12 |
| Interface Title | Train Staff Audited Crew |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation |

| | |
|---|---|
| | changes either in the Node or the Main Line affecting the current train crew assignment. |
| Expected Frequency | Dynamic<br>When it is the result of the analysis. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Train Staff Audited Crew" referred to Train. |
| Persistence | The Integration Layer shall persist "Train Staff Audited Crew" referred to Train enough time for allowing the NMS or TMS process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the "Train Staff Audited Crew" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Train Staff Audited Crew" data received when a read request is made. |

**Table 7-15 TCNM-12 Train Staff Audited Crew Properties**

#### 7.4.8.2 *Train Staff Audited Crew Data*

The data for this interface can be found in Chapter 8.2.1.4.6 "Audited Crew" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 7.4.9 TNCM-13 Train Path Audited Location

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 7.4.9.1 *Train Path Audited Location Properties*

| Interface TCNM-13 Properties | |
|---|---|
| Interface ID | TNCM-13 |
| Interface Title | Train Path Audited Location |
| Publisher | TMS provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line affecting the current train crew assignment |
| Publish Trigger | Train Position is generated for TMS and it publish the "Train Path Audited Location" data to the integration layer. The subscriber receive data. |
| Expected Frequency | Dynamic<br>When it is the result of the analysis/change in TMS. |
| Subscribers | TNCM (Others) |

| | |
|---|---|
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Train Path Audited Location” referred to Train. |
| Persistence | The Integration Layer shall persist “Train Path Audited Location” referred to Train enough time for allowing the NMS or TMS process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the “Train Path Audited Location” data as valid until the train has completed its journey.. |
| Historical Depth | The Integration Layer shall provide the last “Train Path Audited Location” data received when a read request is made. |

**Table 7-16 TCNM-13 Train Path Audited Location Proprrties**

#### 7.4.9.2 *Train Path Audited Location Data*

The data for this interface can be found in Chapter 8.2.1.5.2 “Audited Train Path” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 7.4.10 TNCM-14 Expected Node Plan

The Node Manager System provide Expected Node Plan to Integration Layer available for TNCM. The Node Plan details the schedule of operations to be performed within the Node

#### 7.4.10.1 *Expected Node Plan Properties*

| Interface TCNM-14 Properties | |
|---|---|
| Interface ID | TNCM-14 |
| Interface Title | Expected Node Plan |
| Publisher | The NMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TNCM analyses the information received from TMS and NMS and generates an improved plan recommendation to be provided to TMS. |
| Expected Frequency | Dynamic<br>Approximately once per 10 minutes. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Expected Node Plan”. |
| Persistence | The Integration Layer shall persist “Expected Node Plan” referred to Train as valid a maximum time of 24 hours or until the train has completed its journey. Then, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the “Expected Node Plan” data as valid until new modifications are received. |
| Historical Depth | The Integration Layer shall provide the last “Expected Node Plan” data received when a read request is made. |

**Table 7-17 TCNM-14 Expected Node Plan Properties**

### 7.4.10.2 *Expected Node Plan Data*

This is the expected timetable of the operations inside the Node, including the arrival and departure train details. The Expected Node Plan if composed by a set of ordered Expected Node Operations.

| Expected Node Operation | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** | **Related Use Case** |
| Node | Identifier of the Node where the operation is expected. | String | D7.2 5.3.5 |
| Activity | Activity in the Node. | Listed [Loading, Unloading, Coupling, Reception, Arrival…] | D7.2 5.3.5 |
| Node Internal Control Point | Location where the activity is expected. | String | D7.2 5.3.5 |
| Affected Train | Identifier of the Train affected by the activity. | String | D7.2 5.3.5 |
| Affected Wagons | Identifiers of the Wagons affected by the activity. | Array [String] | D7.2 5.3.5 |
| Affected Containers | Identifiers of the Containers affected by the activity. | Array [String] | D7.2 5.3.5 |
| Expected Activity Start | Expected DateTime of start of the activity. | Timestamp | D7.2 5.3.5 |
| Expected Activity End | Expected DateTime of end of the activity. | Timestamp | D7.2 5.3.5 |

**Table 7-18 Expected Node Operation**

| Expected Node Plan | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** | **Related Use Case** |
| N x Expected Node Operation | Set of ordered Expected Node Operations composing the complete Node Plan. | Array [Complex [Expected Node Operation]] | D7.2 5.3.5 |

**Table 7-19 Expected Node Plan**

### 7.4.11 TNCM-15 Audited Node Plan

The Node Manager System provides the Expected Node Plan to Integration Layer available for TNCM. The Node Plan details the schedule of operations to be performed within the Node.

#### 7.4.11.1 *Audited Node Plan Properties*

| Interface TCNM-15 Properties | |
|---|---|
| Interface ID | TNCM-15 |
| Interface Title | Audited Node Plan |
| Publisher | The NMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TNCM analyses the information received from TMS and NMS and generates an improved plan recommendation to be provided to TMS. |
| Expected Frequency | Dynamic<br><br>Approximately once per 10 minutes. |
| Subscribers | TNCM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Audited Node Plan”. |
| Persistence | The Integration Layer shall persist “Audited Node Plan” referred to Train as valid a maximum time of 24 hours or until the train has completed its journey. Then, it will be deleted.. |
| Length of Validity | The Integration Layer shall identify the “Audited Node Plan” data as valid until new modifications are received |
| Historical Depth | The Integration Layer shall provide the last “Audited Node Plan” data received when a read request is made. |

**Table 7-20 TCNM-15 Aduited Node Plan Properties**

#### 7.4.11.2 *Audited Node Plan Data*

This is real data of the past events inside the Node. The Audited Node Plan is composed by a set of ordered Audited Node Operations.

| Audited Node Operation | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** | **Related Use Case** |
| Node | Identifier of the Node where the operation is audited. | String | D7.2 5.3.5 |
| Expected Node Operation Reference | Order of the referred Expected Node Operation in Expected | Numeric | D7.2 5.3.5 |

| | | | |
|---|---|---|---|
| | Node Plan. | | |
| Activity | Activity in the Node. | Listed [Loading, Unloading, Coupling, Reception, Arrival…] | D7.2 5.3.5 |
| Node Internal Control Point | Location where the activity is expected. | String | D7.2 5.3.5 |
| Affected Train | Identifier of the Train affected by the activity. | String | D7.2 5.3.5 |
| Affected Wagons | Identifiers of the Wagons affected by the activity. | Array [String] | D7.2 5.3.5 |
| Affected Containers | Identifiers of the Containers affected by the activity. | Array [String] | D7.2 5.3.5 |
| Audited Activity Start | Audited DateTime of start of the activity. | Timestamp | D7.2 5.3.5 |
| Audited Activity End | Audited DateTime of end of the activity. | Timestamp | D7.2 5.3.5 |

**Table 7-21 Audited Node Operation**

| Audited Node Plan | | | |
|---|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** | **Related Use Case** |
| N x Audited Node Operation | Set of ordered Audited Node Operations composing operations performed | Array [Complex [Audited Node Operation]] | D7.2 5.3.5 |

**Table 7-22 Audited Node Plan**

# 8 Dynamic Crossing Analysis Module

## 8.1 Use Case summary

**Use Case ID (D7.2 5.3.6): Freight Train without Crossing**

The use case describes a Freight train running on a track of a high-speed line with two parallel tracks, one for each direction of traffic, without crossing any other Train running in the opposite direction. The running of the freight train is supervised in order to detect possible crossings with high-speed trains. If a possible crossing is not detected, then the system does not take any action. As a result, the traffic regulation is able to know in advance that it does not have to manage any crossing operation between trains, because the traffic is continuously supervised beforehand.

**Use Case ID (D7.2 5.3.7): Crossing between two Freight Trains**

The use case describes a Freight Train is running on a track of a High-Speed line with two parallels tracks, one for each direction of traffic. At same time, other Freight Train is running in the opposite direction on the other track. Both trains cross in a point of the line. The Dynamic Crossing Analysis Module (DCAM) supervises the circulation of the Freight Train, but along is journey it is concluded that it is not necessary any additional action because the Freight Train does not cross any High Speed Train.

The crosses between two Freight Trains do not require any additional action because the speed of both trains is not elevated.

**Use Case ID (D7.2 5.3.8): Crossing between a Passenger Train and a Freight Train**

The use case describes a freight train is running on a track of a high-speed line with two parallels tracks, one for each direction of traffic. At same time, a high-speed passenger train is running in the opposite direction on the other track. The DCAM supervises the circulation of the freight train, detecting the future crossing between the freight train and a high-speed passenger train. The DCAM protects the future crossing.

Both trains cross in a point of the line. The crossing is protected by means of the actions proposed by the DCAM and provided to the Temporal Speed restriction Management System (TSRM) and the Traffic Management System (TMS).

**Use Case ID (D7.2 5.3.9): Freight Train entry to High-Speed line**

The use case describes a Freight Train is running towards a track of the High-Speed Line from a non-High-Speed track. The High-Speed Line has two parallels tracks, one for each direction of traffic. On the other track, a High-Speed Passenger Train is running in the opposite direction.

The DCAM supervises the circulation of the Freight Train, first on the current non-High-Speed track and then on the High-Speed Line track, detecting a future crossing between the Freight Train and a High-Speed Passenger Train. The running of the Freight Train during the

non-High-Speed track requires to be supervised in order to guarantee that if the Freight Train crosses a High-Speed Passenger Train in the High-Speed Line, the cross will be safe, avoiding conflictive situations.

The future crossing is protected by means of the actions proposed by the DCAM and provided to the TSRM and the TMS. Both trains cross.

## 8.2 Interface Summary

Below is a diagram of the interfaces to show the flow of information in the above use cases. The diagram shows functions to publish (P) and subscribe (S).

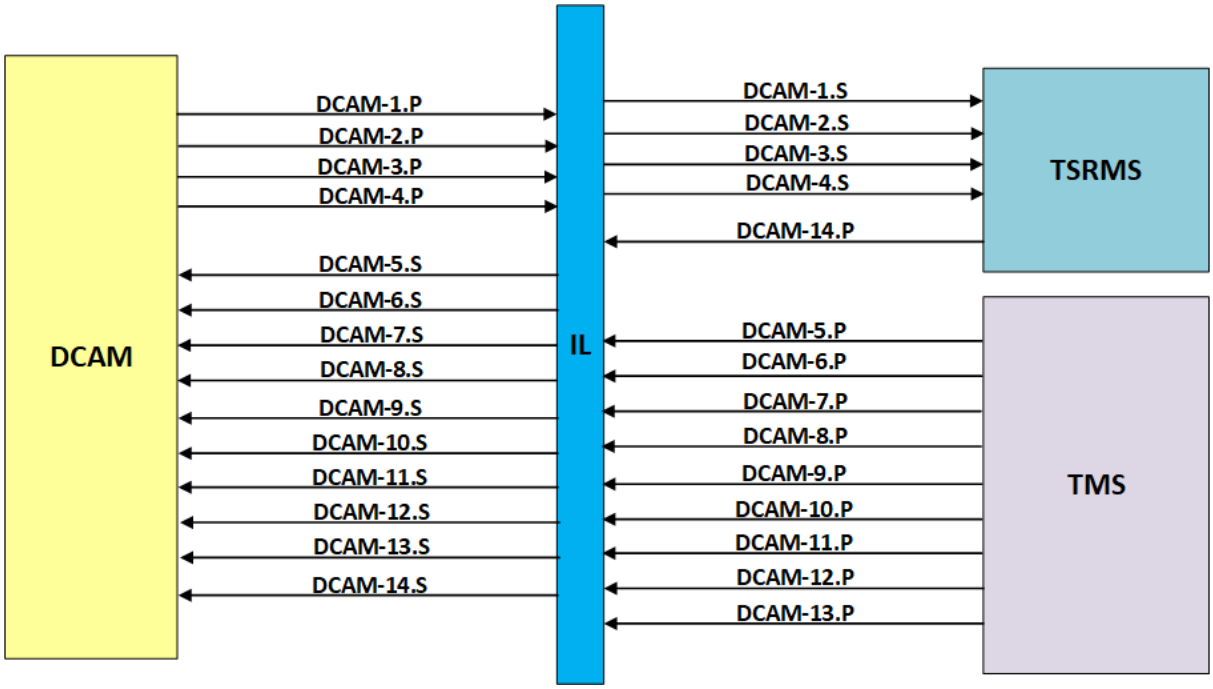


**Figure 8-1 Dynamic Crossing Analysis Module Interface Summary**

The table below shows a summary of the interface related to the Dynamic Crossing Analysis Module.

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| DCAM Publishing | | | | | | | |
| DCAM-1 | DCAM | TSRMS | Establish Temporary Speed Restriction | Request to establish Temporary Speed Restriction | X2R2 D6.1 8.4.2.1 "Establish a TSR" | D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-2 | DCAM | TSRMS | Activate Temporary Speed Restriction | Request to activate Temporary Speed Restriction | X2R2 D6.1 8.4.2.2 "Activate a TSR" | D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-3 | DCAM | TSRMS | Deactivate Temporary Speed Restriction | Request to deactivate Temporary Speed Restriction | X2R2 D6.1 8.4.2.3 "Deactivate a TSR" | D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-4 | DCAM | TSRMS | Remove Temporary Speed Restriction | Request to remove Temporary Speed Restriction | X2R2 D6.1 8.4.2.4 "Remove a TSR" | D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM Subscribing | | | | | | | |
| DCAM-5 | TMS | DCAM | Train Identification | Data related to Train Identification | X2R2 D6.1 8.2.1.1 "Data related to Train Identification" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-6 | TMS | DCAM | Train Timetable: Target Timetable | Data related to Train Timetable: Target Timetable | X2R2 D6.1 8.2.1.2.3 "Target Timetable" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-7 | TMS | DCAM | Train Timetable: Audited Timetable | Data related to Train Timetable: Audited Timetable | X2R2 D6.1 8.2.1.2.5 "Audited Timetable" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-8 | TMS | DCAM | Train Timetable: Forecasted Timetable | Data related to Train Timetable: Forecasted Timetable | X2R2 D6.1 8.2.1.2.7 "Forecasted Timetable" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DCAM-9 | TMS | DCAM | Data related to Train Path: Audited Location | Data related to Train Path: Audited Location | X2R2 D6.1 8.2.1.5.2 "Audited Train Path" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-10 | TMS | DCAM | Status of the signalling elements: Track | Data related to Status of the signalling elements: Track | X2R2 D6.1 8.7.1.3.1 "Track" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-11 | TMS | DCAM | Status of the signalling elements: Signal | Data related to Status of the signalling elements: Signal | X2R2 D6.1 8.7.1.3.3 "Signal" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-12 | TMS | DCAM | Status of the signalling elements: Axle Counter | Data related to Status of the signalling elements: Axle Counter | X2R2 D6.1 8.7.1.3.6 "Axle Counter" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-13 | TMS | DCAM | Status of the signalling elements: Track Circuit | Data related to Status of the signalling elements: Track Circuit | X2R2 D6.1 8.7.1.3.7 "Track Circuits" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |
| DCAM-14 | TSRMS | DCAM | Temporary Speed Restriction | Data related to Temporary Speed Restriction | X2R2 D6.1 8.4.1.1 "TSR" | D7.2 5.3.6<br>D7.2 5.3.7<br>D7.2 5.3.8<br>D7.2 5.3.9 | Y |

**Table 8-1 Dynamic Crossing Analysis Module Interface Summary**

## 8.3 Data Published by Dynamic Crossing Analysis Module (DCAM)

The Dynamic Crossing Analysis Module does not provide any specific data through the Integration Layer by itself; but interact with other systems by means of invoking requests on the exposed command requests.

The requests that the Dynamic Crossing Analysis Module are provided by:

- The system in charge of the Temporary Speed Restrictions, in order to execute the operations designed for ensuring the crossing between the trains.
- The interlockings in charge of blocking and releasing signals for allowing stopping freight trains if it is necessary.

### 8.3.1 DCAM-1 Establish Temporary Speed Restriction

DCAM provide data to establish Temporary Speed Restrictions to operate.

#### 8.3.1.1 *Establish Temporary Speed Restriction Properties*

| Interface DCAM-1 Properties | |
|---|---|
| Interface ID | DCAM-1 |
| Interface Title | Request - Establish Temporary Speed Restriction |
| Publisher | The DCAM publish Request to the integration layer. |
| Publish Trigger | DCAM requires new Temporary Speed Restrictions each time a traffic situation is modified and needs a TSR, and put data for the request to the integration layer. |
| Expected Frequency | Dynamic<br><br>Approximately, once per 10 minutes and each time a modification in the trains path takes place. |
| Subscribers | TSRMS |
| Filter | The Integration Layer shall create data to systems with the ability to write “Request - Establish Temporary Speed Restriction” referred to Train. |
| Persistence | The Integration Layer shall persist “Request - Establish Temporary Speed Restriction” until the TSRMS process the data or, at least, 24 hours. |
| Length of Validity | The Integration Layer shall identify the “Request - Establish Temporary Speed Restriction” data as valid for 10 minutes or new data is received. |
| Historical Depth | The Integration Layer shall provide the last “Request - Establish Temporary Speed Restriction” data received when a read request is made. |

**Table 8-2 Request - Establish Temporary Speed Restriction Properties**

#### 8.3.1.2 *Establish Temporary Speed Restriction Data*

The data for this interface can be found in Chapter 8.4.2.1 “Establish a TSR” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 8.3.2 DCAM-2 Activate Temporary Speed Restriction

DCAM provide data to modify Temporary Speed Restrictions to operate.

#### 8.3.2.1 *Activate Temporary Speed Restriction Properties*

| Interface DCAM-2 Properties | |
|---|---|
| Interface ID | DCAM-2 |
| Interface Title | Activate - Establish Temporary Speed Restriction |
| Publisher | The DCAM publish Request to the integration layer. |
| Publish Trigger | DCAM requires adding or modifying Temporary Speed Restrictions each time a traffic situation is analysed and needs a TSR, and putting data to the integration layer. |
| Expected Frequency | Dynamic<br>Approximately, once per 10 minutes and each time a modification in the trains path takes place. |
| Subscribers | TSRMS |
| Filter | The Integration Layer shall modify data to systems with the ability to write “Activate - Establish Temporary Speed Restriction” referred to Train. |
| Persistence | The Integration Layer shall persist “Activate - Establish Temporary Speed Restriction” until the TSRMS process the data or, at least, 24 hours. |
| Length of Validity | The Integration Layer shall identify the “Activate - Establish Temporary Speed Restriction” data as valid for 10 minutes or new data is received. Then, it is deleted. |
| Historical Depth | The Integration Layer shall provide the last “Activate - Establish Temporary Speed Restriction” data received when a read request is made. |

**Table 8-3 Activate - Establish Temporary Speed Restriction Properties**

#### 8.3.2.2 *Activate Temporary Speed Restriction Data*

The data for this interface can be found in Chapter 8.4.2.2“Activate a TSR” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 8.3.3 DCAM-3 Deactivate Temporary Speed Restriction

DCAM provide data to modify Temporary Speed Restrictions to operate.

#### 8.3.3.1 *Deactivate Temporary Speed Restriction Properties*

| Interface DCAM-3 Properties | |
|---|---|
| Interface ID | DCAM-3 |
| Interface Title | Deactivate - Establish Temporary Speed Restriction |
| Publisher | The DCAM publish Request to the integration layer. |
| Publish Trigger | DCAM requires to deactivate Temporary Speed Restrictions each time a traffic situation is analysed and the conflict has finished, and put data to the integration layer. |
| Expected Frequency | Dynamic<br>Approximately, once per 10 minutes and each time a conflict in a train path has finished. |
| Subscribers | TSRMS |
| Filter | The Integration Layer shall modify data to systems with the ability to write “Deactivate - Establish Temporary Speed Restriction” referred to Train. |
| Persistence | The Integration Layer shall persist “Deactivate - Establish Temporary Speed Restriction” until the TSRMS process the data or, at least, 24 hours. |
| Length of Validity | The Integration Layer shall identify the “Deactivate - Establish Temporary Speed Restriction” data as valid for 10 minutes or until new data is received. Then, it is deleted. |
| Historical Depth | The Integration Layer shall provide the last “Deactivate - Establish Temporary Speed Restriction” data received when a read request is made. |

**Table 8-4 Deactivate - Establish Temporary Speed Restriction Properties**

#### 8.3.3.2 *Deactivate Temporary Speed Restriction Data*

The data for this interface can be found in Chapter 8.4.2.3 “Deactivate a TSR” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 8.3.4 DCAM-4 Remove Temporary Speed Restriction

DCAM provide data to remove Temporary Speed Restrictions to operate.

#### 8.3.4.1 *Remove Temporary Speed Restriction Properties*

| Interface DCAM-4 Properties | |
|---|---|
| Interface ID | DCAM-4 |
| Interface Title | Remove - Establish Temporary Speed Restriction |
| Publisher | The DCAM publish Request to the integration layer. |

| | |
|---|---|
| Publish Trigger | DCAM requires to remove Temporary Speed Restrictions each time a traffic situation is analysed and the conflict has finished and put data to the integration layer. |
| Expected Frequency | Dynamic<br><br>Approximately, once per 10 minutes and each time a conflict in a train path has finished. |
| Subscribers | TSRMS |
| Filter | The Integration Layer shall delete data to systems with the ability to write "Remove - Establish Temporary Speed Restriction" referred to Train. |
| Persistence | The Integration Layer shall persist "Remove - Establish Temporary Speed Restriction" until the TSRMS process the data or, at least, 24 hours. |
| Length of Validity | The Integration Layer shall identify the "Remove - Establish Temporary Speed Restriction" data as valid for 10 minutes or until new data is received. Then, it is deleted.. |
| Historical Depth | The Integration Layer shall provide the last "Remove - Establish Temporary Speed Restriction" data received when a read request is made. |

**Table 8-5 Remove - Establish Temporary Speed Restriction Properties**

#### 8.3.4.2 *Remove Temporary Speed Restriction Data*

The data for this interface can be found in Chapter 8.4.2.4 "Remove a TSR" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

## 8.4 Data Read or Subscribed to by Dynamic Crossing Analysis Module (DCAM)

### 8.4.1 DCAM-5 Train Identification

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.1.1 *Train Identification Properties*

| Interface DCAM-5 Properties | |
|---|---|
| Interface ID | DCAM-5 |
| Interface Title | Train Identification |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provide new information to Integration Layer when the traffic situation changes either in the Node or the Main Line . |
| Expected Frequency | Dynamic |

| | |
|---|---|
| | Approximately, once per minute and each time a new path is detected. |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Train Identification" referred to Train. |
| Persistence | The Integration Layer shall persist "Train Identification" referred to Train until the DCAM process the data or, at least, 24 hours. |
| Length of Validity | The Integration Layer shall identify the "Train Identification" data as valid for 10 minutes or until new data is received. Then, it is deleted.. |
| Historical Depth | The Integration Layer shall provide the last "Train Identification" data received when a read request is made. |

**Table 8-6 Train Identification Properties**

#### 8.4.1.2 *Train Identification Data*

The data for this interface can be found in Chapter 8.2.1.1 "Data related to Train Identification" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 8.4.2 DCAM-6 Train Target Timetable

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.2.1 *Target Timetable Properties*

| Interface DCAM-6 Properties | |
|---|---|
| Interface ID | DCAM-6 |
| Interface Title | Target Timetable |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes in either the Node or the Main Line. |
| Expected Frequency | Dynamic<br><br>Approximately once per minute |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Target Timetable" referred to Train. |
| Persistence | The Integration Layer shall persist "Target Timetable" referred to Train until the DCAM has processed the information or for a maximum time of 24 hours. |

| | |
|---|---|
| Length of Validity | The Integration Layer shall identify the "Target Timetable" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Target Timetable" data received when a read request is made. |

**Table 8-7 Target Timetable Properties**

#### 8.4.2.2 *Target Timetable Data*

The data for this interface can be found in Chapter 8.2.1.2.3 "Target Timetable" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 8.4.3 DCAM-7 Train Audited Timetable

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.3.1 *Audited Timetable Properties*

| Interface DCAM-7 Properties | |
|---|---|
| Interface ID | DCAM-7 |
| Interface Title | Audited Timetable |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes in either the Node or the Main Line. |
| Expected Frequency | Dynamic<br>Approximately once per minute |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Audited Timetable" referred to Train. |
| Persistence | The Integration Layer shall persist "Audited Timetable" referred to Train. |
| Length of Validity | The Integration Layer shall identify the "Audited Timetable" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Audited Timetable" data received when a read request is made. |

**Table 8-8 Audited Timetable Properties**

#### 8.4.3.2 *Audited Timetable Data*

The data for this interface can be found in Chapter 8.2.1.2.5 "Audited Timetable" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 8.4.4 DCAM-8 Train Forecasted Timetable

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.4.1 *Forecasted Timetable Properties*

| Interface DCAM-8 Properties | |
|---|---|
| Interface ID | DCAM-8 |
| Interface Title | Forecasted Timetable |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes in either the Node or the Main Line. |
| Expected Frequency | Dynamic<br><br>When it is the result of the analysis. |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Forecasted Timetable" referred to Train. |
| Persistence | The Integration Layer shall persist "Forecasted Timetable" referred to Train until the DCAM has processed the information or for a maximum time of 24 hours. |
| Length of Validity | The Integration Layer shall identify the "Forecasted Timetable" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Forecasted Timetable" data received when a read request is made. |

**Table 8-9 Forecasted Timetable Properties**

#### 8.4.4.2 *Audited Timetable Data*

The data for this interface can be found in Chapter 8.2.1.2.7 "*Forecasted Timetable*" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 8.4.5 DCAM-9 Train Path Audited Location

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.5.1 *Train Path Audited Location Properties*

| Interface DCAM-9 Properties | |
|---|---|
| Interface ID | DCAM-9 |
| Interface Title | Train Path Audited Location |

| | |
|---|---|
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides new information to Integration Layer when the traffic situation changes either in the Node or the Main Line affecting the current train crew assignment |
| Expected Frequency | Dynamic<br>When it is the result of the analysis/change in TMS. |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Train Path Audited Location" referred to Train. |
| Persistence | The Integration Layer shall persist "Train Path Audited Location" referred to Train enough time for allowing the DCAM process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the "Train Path Audited Location" data as valid for 10 minutes or until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Train Path Audited Location" data received when a read request is made. |

**Table 8-10 Train Path Audited Location Properties**

#### 8.4.5.2 *Train Path Audited Location Data*

The data for this interface can be found in Chapter 8.2.1.5.2 "Audited Train Path" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 8.4.6 DCAM-10 Status of the Track elements

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.6.1 *Status of the Track elements Properties*

| Interface DCAM-10 Properties | |
|---|---|
| Interface ID | DCAM-10 |
| Interface Title | Status of the Track elements |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provides the status of Interlocking elements and put data to the integration layer. |
| Expected Frequency | Dynamic<br>When it is the result of the analysis/change in TMS. |

| | |
|---|---|
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Status of the Track elements” referred to Train. |
| Persistence | The Integration Layer shall persist “Status of the Track elements” referred to Train enough time for allowing the DCAM process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the “Status of the Track elements” data as valid for 10 minutes or until the train has completed its journey . |
| Historical Depth | The Integration Layer shall provide the last “Status of the Track elements” data received when a read request is made. |

**Table 8-11 Status of the Track elements Properties**

#### 8.4.6.2 *Status of the Track elements Data*

The data for this interface can be found in Chapter 8.7.1.3.1 “Track” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 8.4.7 DCAM-11 Status of the Signal elements

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.7.1 *Status of the Signal elements Properties*

| Interface DCAM-11 Properties | |
|---|---|
| Interface ID | DCAM-11 |
| Interface Title | Status of the Signal elements |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provide the status of Signal elements and put data to the integration layer.. |
| Expected Frequency | Dynamic<br>Each time signals changes. |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Status of the Signal elements” referred to Train. |
| Persistence | The Integration Layer shall persist “Status of the Signal elements” referred to Train enough time for allowing the DCAM process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the “Status of the Signal elements” data as valid until the train has completed its journey . |

| | |
|---|---|
| Historical Depth | The Integration Layer shall provide the last "Status of the Signal elements" data received when a read request is made. |

**Table 8-12 Status of the Signal elements Properties**

#### 8.4.7.2 *Status of the Signal elements Data*

The data for this interface can be found in Chapter 8.7.1.3.3 "Signal" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 8.4.8 DCAM-12 Status of the Axle Counters elements

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.8.1 *Status of the Axle Counters elements Properties*

| Interface DCAM-12 Properties | |
|---|---|
| Interface ID | DCAM-12 |
| Interface Title | Status of the Axle Counters elements |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provide the status of Axle Counters elements and put data to the integration layer. |
| Expected Frequency | Dynamic<br>When it is the result of the analysis/change in TMS. |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Status of the Axle Counters elements" referred to Train. |
| Persistence | The Integration Layer shall persist "Status of the Axle Counters elements" referred to Train enough time for allowing the DCAM process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted. |
| Length of Validity | The Integration Layer shall identify the "Status of the Axle Counters elements" data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last "Status of the Axle Counters elements" data received when a read request is made. |

**Table 8-13 Status of the Axle Counters elements Properties**

#### 8.4.8.2 *Status of the Axle Counters elements Data*

The data for this interface can be found in Chapter 8.7.1.3.6 "Axle Counter" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

### 8.4.9 DCAM-13 Status of the Track Circuit elements

Train information of trains arriving or departing the Nodes in the border between the Node and the mainline.

#### 8.4.9.1 *Status of the Track Circuit elements Properties*

| Interface DCAM-13 Properties | |
|---|---|
| Interface ID | DCAM-13 |
| Interface Title | Status of the Track Circuit elements |
| Publisher | The TMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TMS provide the status of Track Circuits elements and put data to the integration layer.. |
| Expected Frequency | Dynamic<br><br>When it is the result of the analysis/change in TMS. |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Status of the Track Circuit elements” referred to Train. |
| Persistence | The Integration Layer shall persist “Status of the Track Circuit elements” referred to Train enough time for allowing the DCAM process and actualise the new data, until a maximum time of 24 hours. After this time limit, it will be deleted.. |
| Length of Validity | The Integration Layer shall identify the “Status of the Track Circuit elements” data as valid until the train has completed its journey. |
| Historical Depth | The Integration Layer shall provide the last “Status of the Track Circuit elements” data received when a read request is made. |

**Table 8-14 Status of the Track Circuit elements Properties**

#### 8.4.9.2 *Status of the Track Circuit elements Data*

The data for this interface can be found in Chapter 8.7.1.3.7 “Track Circuits” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

### 8.4.10 DCAM-14 Temporary Speed Restriction

DCAM required the information about the Temporary Speed Restrictions to operate.

#### 8.4.10.1 *Temporary Speed Restriction Properties*

| Interface DCAM-14 Properties | |
|---|---|
| Interface ID | DCAM-14 |
| Interface Title | Temporary Speed Restriction |

| | |
|---|---|
| Publisher | The TSRMS shall be able to publish the data to the integration layer. |
| Publish Trigger | TSRMS provide the status of Temporary Speed Restrictions each time a traffic situation is modified and needs a TSR and put data to the integration layer. |
| Expected Frequency | Dynamic<br>Approximately, once per 10 minutes and each time a modification in the trains path takes place. |
| Subscribers | DCAM (Others) |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Status of the Track Circuit elements" referred to Train. |
| Persistence | The Integration Layer shall persist "Status of the Track Circuit elements" referred to Train until the TSRMS process the data or, at least, 24 hours.. |
| Length of Validity | The Integration Layer shall identify the "Status of the Track Circuit elements" data as valid for 10 minutes or new data is received. |
| Historical Depth | The Integration Layer shall provide the last "Status of the Track Circuit elements" data received when a read request is made. |

**Table 8-15 Temporary Speed Restriction Properties**

#### 8.4.10.2 *Temporary Speed Restriction Data*

The data for this interface can be found in Chapter 8.4.1.1 "TSR" of "X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer"[3]

# 9 Freight Wagon On Board Monitoring System

## 9.1 Use Case summary

**Use Case ID (D7.2 5.3.10) Wagon Axle box Temperature**

**Use Case ID (D7.2 5.3.12) Wagon Bogie Vibration**

**Use Case ID (D7.2 5.3.13) Wagon tank pressure**

These use cases describe an innovative scenario for real time monitoring of health status and geographic position of a freight wagon carrying dangerous goods.

A demonstrator will be developed consisting of a on board diagnostic system composed of a Master Control Unit (MCU) communicating with a network of sensors wireless installed at sensible points of the wagon and with an GPS antenna to receive the position signal. The MCU provides TMS with by LTE communication. The TMS, following the data received, can make safety decisions to manage any dangerous situations and has constantly updated the position of the wagon.

The three use cases differ in the three different types of sensors chosen which consequently imply different safety decision that TMS have to undertake to manage the dangerous situations.

The Figure 9-1 shows the layout of the on board monitoring system with highlighted the data communication (wireless) between the sensor nodes and the MCU (Master Control Unit) and the data communication between the MCU and IL/TMS (GSM)

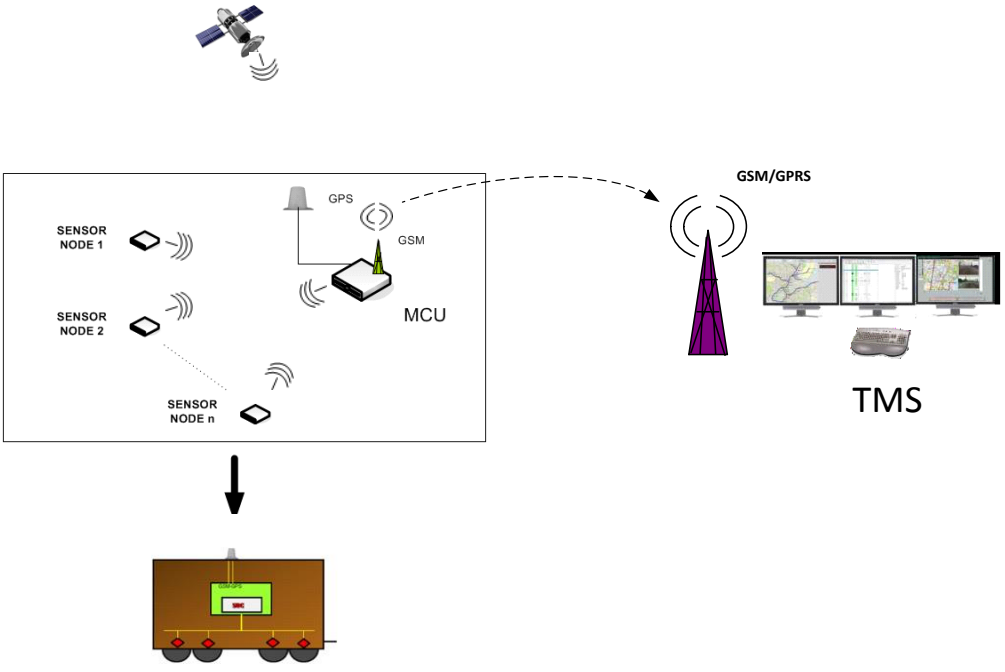


**Figure 9-1 Freight Wagon On Board Monitoring System (BMS)**

## 9.2 Interface Summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with ".P" are the publish side and interfaces with ".S" are the subscribe side. Although some of the interfaces belong to TMS, as these are described from the perspective of this use case, they are all currently identified as "MCU" (Master Control Unit) interfaces.

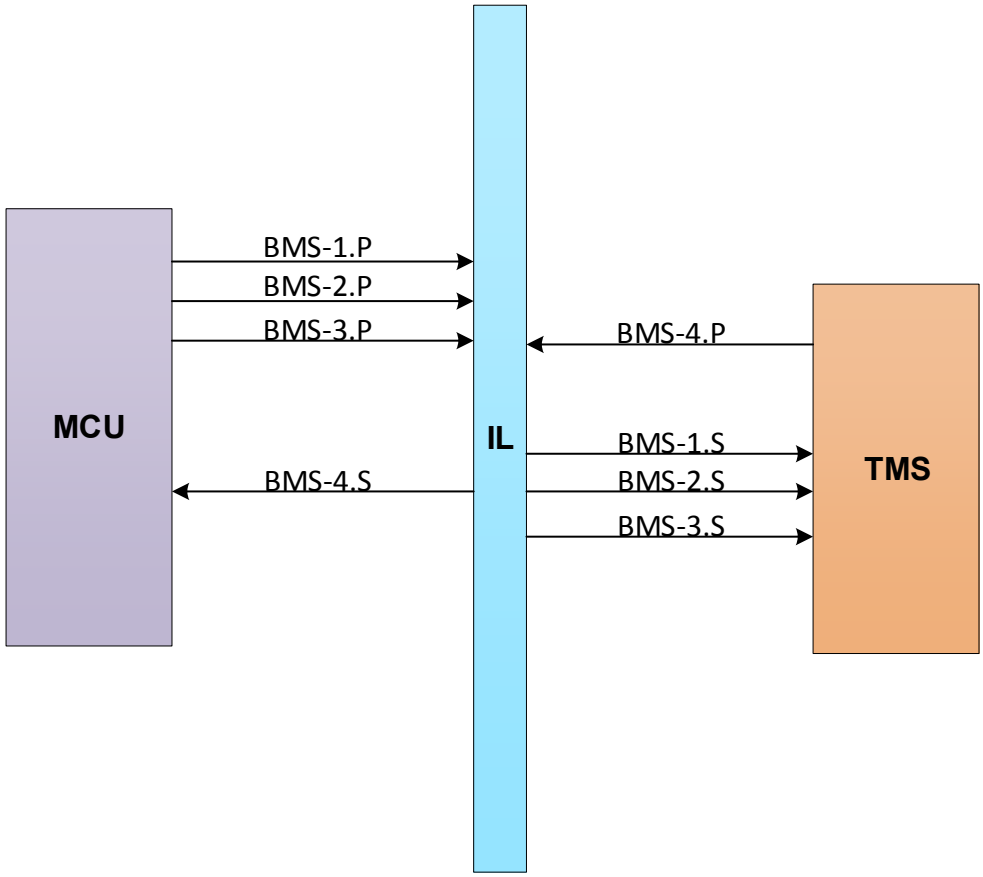


**Figure 9-2 Interface Overview – On Board Monitoring System**

The table below shows a summary of the interface related to the On Board Monitoring System BMS and the use case.

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| BMS Publishing | | | | | | | |
| BMS-1 | BMS | TMS | Data standard message with wagon stationary | Data on position and diagnostic state of wagon and dangerous goods, without alarms and with the wagon stationary | 9.3.1 | D7.2 6.3.10/12/13 Step 1 | Y |
| BMS-2 | BMS | TMS | Data standard message with wagon in motion | Data on position and diagnostic state of wagon and dangerous goods, without alarms and with the wagon in motion | 9.3.2 | D7.2 6.3.10/12/13 Step 1 | Y |
| BMS-3 | BMS | TMS | Alarm message | Alarm notification on wagon or dangerous goods. | 9.3.3 | D7.2 6.3.10/12/13 Step 3, 4 | Y |
| BMS Subscribing | | | | | | | |
| BMS-4 | TMS | BMS | Wagon safety procedure | Procedure to follow to secure the train/wagon | 9.4.1 | D7.2 6.3.10/12/13 Step 5, 6, 7 | |

**Table 9-1 Freight Wagon On Board Monitoring System Interface Summary**

## 9.3 Data Published by On board monitoring system to Integration Layer

This is the data published by the On board monitoring System to the Integration Layer available for a TMS and other systems to use.

### 9.3.1 BMS-1 Data standard message with wagon stationary

This is the data sent by MCU when the wagon is stationary. This includes details such as the position of the wagon, the type of wagon and of dangerous goods, finally all the data measured by sensors network on board the wagon.

#### 9.3.1.1 *Data standard message with wagon stationary Properties*

| Interface BMS-1 Properties | |
|---|---|
| Interface ID | BMS-1 |
| Interface Title | Data standard message with wagon stationary |
| Publisher | The BMS shall be able to publish the data within section 9.3.1.2 to the integration layer. |
| Publish Trigger | When a train journey is created, the MCU is configured with the overall data of the journey, and with the data of the wagon in which it is installed.<br><br>The MCU is equipped with an acceleration sensor.<br>MCU will publish the “Data standard message with wagon stationary” data to the Integration Layer until the acceleration of the wagon is 0, which is until the wagon is stationary. |
| Expected Frequency | Dynamic<br>Approx. published 1 time per 20 minutes, for as long as the wagon is stationary. |
| Subscribers | TMS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Data standard message with wagon stationary” data related to a specified “Train ID” and “MCU ID” |
| Persistence | The Integration Layer shall persist “Data standard message with wagon stationary” data until it receives a new “Data standard message with wagon stationary” with the same “Train ID” and “MCU ID” or a new “Data standard message with wagon in motion” with the same “Train ID” and “MCU ID”. |
| Length of Validity | The Integration Layer shall identify the “Data standard message with wagon stationary” data as Valid until it is overwritten. |
| Historical Depth | The Integration Layer shall provide the last “Data standard message with wagon stationary” data received when a read request is made. |

**Table 9-2 BMS-1 Data standard message with wagon stationary Properties**

#### 9.3.1.2 *Data standard message with wagon stationary Data*

| Data standard message with wagon stationary | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Train ID | Number of the Train | Integer |
| MCU_ID | ID of the MCU or wagon | Integer |

| | | |
|---|---|---|
| WTyp | Type of wagon | Integer (code) |
| DGTyp | Type of dangerous goods | Integer (code) |
| DGQuant | Quantity or weight of DG | Integer |
| TimeStamp | Current Date and Time | DateTime |
| GPS_Lat | Current Latitude | String |
| GPS_Lon | Current Longitude | String |
| Speed | Current wagon speed | Float |
| Sensor Node_1 (*) | ID of the Sensor | Integer |
| Measure_1_1_Type | Measure 1 of sensor node 1 typology | Integer (code) |
| Measure_1_1_Alarm | Measure 1 of sensor node 1 Alarm severity | Integer (code) |
| Measure_1_1_Value | Measure 1 of sensor node 1 value | float |
| Measure_2_1_Type | Measure 2 of sensor node 1 typology | Integer (code) |
| Measure_2_1_Alarm | Measure 2 of sensor node 1 Alarm severity | Integer (code) |
| Measure_2_1_Value | Measure 2 of sensor node 1 value | float |
| ……. | | |
| Measure_M_1_Type | Measure M of sensor node 1 typology | Integer (code) |
| Measure_M_1_Alarm | Measure M of sensor node 1 Alarm severity | Integer (code) |
| Measure_M_1_Value | Measure M of sensor node 1 value | float |
| Sensor Node_2 (*) | ID of the Sensor | Integer |
| {all measures of Sensor Node 2} | | |
| ……. | | |
| Sensor Node_N (*) | ID of the Sensor | Integer |
| {all measures of Sensor Node N} | | |

(*): The Attributes of Sensor Node 1 are to be replicated for the number of sensor nodes (N) connected to the MCU

**Table 9-3 BMS-1 "Data standard message with wagon stationary" Data**

### 9.3.2 BMS-2 Data standard message with wagon in motion

This is the data sent by MCU when the wagon is in motion. This includes details such as the position of the wagon, the speed of the wagon, the type of wagon and of dangerous goods, finally all the data measured by sensors network on board the wagon.

#### 9.3.2.1 *Data standard message with wagon in motion Properties*

| Interface BMS-2 Properties | |
|---|---|
| Interface ID | BMS-2 |
| Interface Title | Data standard message with wagon in motion |
| Publisher | The BMS shall be able to publish the data within section 9.3.2.2 to the integration layer. |
| Publish Trigger | When the acceleration sensor of MCU measures a value other than 0, that is the wagon is in motion, the MCU will publish the "Data standard message with wagon in motion" data to the Integration Layer, with the frequency detailed |

| | |
|---|---|
| | below, , for as long as the wagon is in motion. |
| Expected Frequency | Dynamic<br>Approx. published 1 time per 5 minutes, for as long as the wagon is in motion |
| Subscribers | TMS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Data standard message with wagon in motion” data related to a specified “Train ID” and “MCU ID” |
| Persistence | The Integration Layer shall persist “Data standard message with wagon in motion” data until it receives a new “Data standard message with wagon in motion” with the same “Train ID” and “MCU ID” or a new “Data standard message with wagon stationary” with the same “Train ID” and “MCU ID”. |
| Length of Validity | The Integration Layer shall identify the “Data standard message with wagon in motion” data as Valid until it is overwritten. |
| Historical Depth | The Integration Layer shall provide the last “Data standard message with wagon in motion” data received when a read request is made. |

**Table 9-4 BMS-2 Data standard message with wagon in motion Properties**

#### 9.3.2.2 *Data standard message with wagon in motion Data*

| Data standard message with wagon stationary | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Train ID | Number of the Train | Integer |
| MCU_ID | ID of the MCU or wagon | Integer |
| WTyp | Type of wagon | Integer (code) |
| DGTyp | Type of dangerous goods | Integer (code) |
| DGQuant | Quantity or weight of DG | Integer |
| TimeStamp | Current Date and Time | DateTime |
| GPS_Lat | Current Latitude | String |
| GPS_Lon | Current Longitude | String |
| Speed | Current wagon speed | Float |
| Sensor Node_1 (*) | ID of the Sensor | Integer |
| Measure_1_1_Type | Measure 1 of sensor node 1 typology | Integer (code) |
| Measure_1_1_Alarm | Measure 1 of sensor node 1 Alarm severity | Integer (code) |
| Measure_1_1_Value | Measure 1 of sensor node 1 value | float |
| Measure_2_1_Type | Measure 2 of sensor node 1 typology | Integer (code) |
| Measure_2_1_Alarm | Measure 2 of sensor node 1 Alarm severity | Integer (code) |
| Measure_2_1_Value | Measure 2 of sensor node 1 value | float |
| ……. | | |
| Measure_M_1_Type | Measure M of sensor node 1 typology | Integer (code) |
| Measure_M_1_Alarm | Measure M of sensor node 1 Alarm severity | Integer (code) |
| Measure_M_1_Value | Measure M of sensor node 1 value | float |
| Sensor Node_2 (*) | ID of the Sensor | Integer |

| | | |
|---|---|---|
| {all measures of Sensor Node 2} | | |
| …… | | |
| Sensor Node_N (*) | ID of the Sensor | Integer |
| {all measures of Sensor Node N} | | |

(*): The Attributes of Sensor Node 1 are to be replicated for the number of sensor nodes (N) connected to the MCU

**Table 9-5 BMS-2 "Data standard message with wagon in motion" Data**

### 9.3.3 BMS-3 Alarm message

This is the data sent by MCU when one or more measures are out of limits, that is in alarm. This includes details such as the position of the wagon, the speed of the wagon, the type of wagon and of dangerous goods, finally the type, source and value of the measure(s) in alarm.

#### 9.3.3.1 *Alarm message Properties*

| Interface BMS-3 Properties | |
|---|---|
| Interface ID | BMS-3 |
| Interface Title | Alarm message |
| Publisher | The BMS shall be able to publish the data within section 9.3.3.2 to the integration layer. |
| Publish Trigger | When the MCU measures a value or more value out of limits, the MCU will publish the "Alarm message" data to the Integration Layer, both with the wagon stationary and in motion. |
| Expected Frequency | BMS-3 is published only once per alarm. |
| Subscribers | TMS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Alarm message" data related to a specified "Train ID" and "MCU ID" |
| Persistence | The Integration Layer shall persist "Alarm message" data until a read request is made. |
| Length of Validity | The Integration Layer shall identify the "Alarm message" data as Valid until a read request is made. |
| Historical Depth | The Integration Layer shall provide the last "Alarm message" data received when a read request is made. |

**Table 9-6 BMS-3 Alarm message Properties**

#### 9.3.3.2 *Alarm message Data*

| Alarm message | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Train ID | Number of the Train | Integer |
| MCU_ID | ID of the MCU or wagon | Integer |

| | | |
|---|---|---|
| WTyp | Type of wagon | Integer (code) |
| DGTyp | Type of dangerous goods | Integer (code) |
| DGQuant | Quantity or weight of DG | Integer |
| TimeStamp | Current Date and Time | DateTime |
| GPS_Lat | Current Latitude | String |
| GPS_Lon | Current Longitude | String |
| Speed | Current wagon speed | Float |
| Sensor Node_Alarm (*) | ID of the Sensor that has detected the measure in alarm | Integer |
| Measure_Alarm_Type | Measure 1 of sensor node 1 typology | Integer (code) |
| Measure_Alarm_Level | Measure 1 of sensor node 1 Alarm severity | Integer (code) |
| Measure_Alarm_Value | Measure 1 of sensor node 1 value | float |
| …… | | |

(*): The Attributes of Sensor Node_Alarm are to be replicated for any other sensors with in alarm measurements.

**Table 9-7 BMS-3 "Alarm message" Data**

## 9.4 Data Read or Subscribed by BMS system to Integration Layer

This is the data read or subscribed to by the On Board Monitoring System from the Integration Layer.

### 9.4.1 BMS-4 Wagon safety procedure

When TMS receives the notification of one or more alarms, following an analysis of these, if actions are needed to secure the train to which the wagon with active alarms belongs, TMS publish the "Wagon safety procedure" data.

#### 9.4.1.1 *Wagon safety procedure Properties*

| Interface BMS-4 Properties | |
|---|---|
| Interface ID | BMS-4 |
| Interface Title | Wagon safety procedure |
| Publisher | The TMS shall be able to publish the data within section 9.4.1.2 to the integration layer. |
| Publish Trigger | When the TMS receives the notification of one or more alarms, following an analysis of these, if actions are needed to secure the train to which the wagon with active alarms belongs, TMS publish the "Wagon safety procedure" data to the Integration Layer. |
| Expected Frequency | BMS-4 is published only once per alarm. |
| Subscribers | TMS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Wagon safety procedure" data related to a specified "MCU ID". The "MCU ID" |

| | |
|---|---|
| | must be relative to an MCU installed on the locomotive. |
| Persistence | The Integration Layer shall persist "Wagon safety procedure" data until a read request is made. |
| Length of Validity | The Integration Layer shall identify the "Wagon safety procedure" data as Valid until a read request is made. |
| Historical Depth | The Integration Layer shall provide the last "Wagon safety procedure" data received when a read request is made. |

**Table 9-8 BMS-4 Wagon safety procedure Properties**

#### 9.4.1.2 *Wagon safety procedure Data*

| Alarm message | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Train ID | Number of the Train | Integer |
| MCU_ID | ID of the MCU installed on the locomotive | Integer |
| Wtyp_alarm | Type of wagon with alarm active | Integer (code) |
| DGTyp | Type of dangerous goods | Integer (code) |
| DGQuant | Quantity or weight of DG | Integer |
| TimeStamp | Current Date and Time | DateTime |
| Proc | Procedure to be performed | Integer (code) |

**Table 9-9 BMS-4 "Wagon safety procedure" Data**

# 10 Optimal Time Slot and Itinerary for Dangerous Goods

## 10.1 Use Case summary

**Use Case ID (D7.2 5.3.11) Optimal Time slot and Itinerary for DG**

The use case describes an innovative scenario to determine the optimal time window and the optimal itinerary to carry the dangerous goods from a starting point A to an arrival point B, also minimizing the risk of accidents along the railway resulting in damage of infrastructure, buildings and people.

The solution of this optimal allocation problem is based on the algorithm “Branch and Bound”, and keeps in account parameters of wagons and dangerous goods, infrastructures near the railway, social and climatic aspects and emergency related items.

## 10.2 Interface Summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with “.P” are the publish side and interfaces with “.S” are the subscribe side. Although some of the interfaces belong to TMS or the FRU, as these are described from the perspective of this use case, they are all currently identified as “OTI” interfaces.

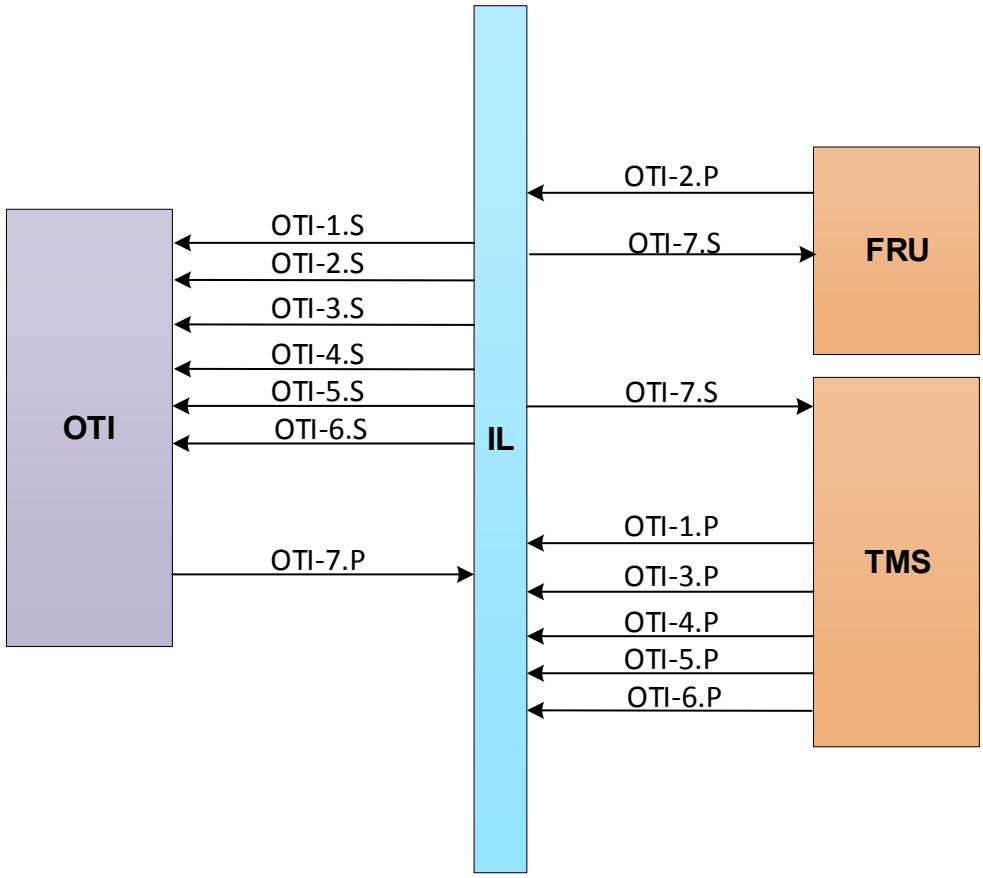


**Figure 10-1 Interface Overview - Optimal Time Slot and Itinerary for Dangerous Goods**

The table below shows a summary of the interface related to Optimal Time Slot and Itinerary for Dangerous Goods

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| OTI Publishing | | | | | | | |
| OTI-7 | OTI | TMS, FRU | Optimal Itinerary and Time slot | The optimal itinerary and time slot to carry dangerous goods, calculated by OTI module | 10.3.1 | D7.2 5.3.11 Step 3, 4 | Y |
| OTI Subscribing | | | | | | | |
| OTI-1 | TMS | OTI | General-Data | General data about the train journey | 10.4.1 | D7.2 5.3.11 Steps 2 | Y |
| OTI-2 | FRU | OTI | Wagons-Data | Detailed data about wagons and dangerous goods | 10.4.2 | D7.2 5.3.11 Steps 2 | Y |
| OTI-3 | TMS | OTI | Itin-Infra | Factors related to railway infrastructure (for each itinerary) | 10.4.3 | D7.2 5.3.11 Steps 2 | Y |
| OTI-4 | TMS | OTI | Itin-Social | Factors related to social aspects (for each itinerary) | 10.4.4 | D7.2 5.3.11 Step 2 | Y |
| OTI-5 | TMS | OTI | Itin-Clima | Factors related to climatic aspects (for each itinerary) | 10.4.5 | D7.2 5.3.11 Steps 2 | Y |
| OTI-6 | TMS | OTI | Itin-Emergency | factors related to emergency response (for each itinerary) | 10.4.6 | D7.2 5.3.11 Steps 2 | Y |

**Table 10-1 Optimal Time Slot and Itinerary for Dangerous Goods Interface Summary**

## 10.3 Data Published by Optimal Time Slot and Itinerary for Dangerous Goods (OTI) to Integration Layer

This is the data published by the Optimal Time Slot and Itinerary for Dangerous Goods to the Integration Layer available for a TMS and other systems to use.

### 10.3.1 OTI-7 Optimal Itinerary and Time Slot

This is the Optimal Itinerary and Time Slot calculated by the algorithm “Branch and Bound”, based on all the data available in input, detailed in the section 10.4, and published to the Integration Layer.

#### 10.3.1.1 *Optimal Itinerary and Time Slot Properties*

| Interface OTI-7 Properties | |
|---|---|
| Interface ID | OTI-7 |
| Interface Title | Optimal Itinerary and Time Slot |
| Publisher | The OTI shall be able to publish the data within section 10.3.1.2 to the integration layer. |
| Publish Trigger | When a train journey carrying dangerous goods is created, the TMS and FRU publishes to IL main characteristics of the train and of the dangerous goods (quantity and typology), all data related to population, cities, villages, countries , industrial sites of the areas where the railway lines pass.<br>The OTI module using all the data available, estimates the optimal itinerary (among those available) and the optimum time slot in which carry out the established itinerary , to minimize the risk of accidents along the railway resulting in damage of infrastructure, buildings and people.<br>The OTI module publishes the results to the Integration Layer. |
| Expected Frequency | OTI-7 is published once for each train carrying dangerous goods created in TMS |
| Subscribers | TMS, FRU |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Optimal Itinerary and Time Slot” data related to a specified “Train ID” |
| Persistence | The Integration Layer shall persist “Optimal Itinerary and Time Slot” until the “Opt_Date_time_end ” is 48 hours in the past. |
| Length of Validity | The Integration Layer shall identify the “Optimal Itinerary and Time Slot” data as Valid until it is deleted, which occurs once the train number ID has reached its final destination. |
| Historical Depth | The Integration Layer shall provide the last “Optimal Itinerary and Time Slot” data received when a read request is made. |

**Table 10-2 OPT-7 Optimal Itinerary and Time Slot Properties**

#### 10.3.1.2 *Optimal Itinerary and Time Slot Data*

| Optimal Itinerary and Time Slot | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Train ID | Number of the Train | Integer |
| StartPointA | Latitude and Longitude of point A (start) | string |
| EndPointB | Latitude and Longitude of point B (arrival) | string |
| Opt_Itin | Number of the Optimum Itinerary | Integer (code) |
| Opt_Date_time_start | Optimum Date and Time to start the train journey | DateTime |
| Opt_Date_time_end | Optimum Date and Time to end the train journey | DateTime |

**Table 10-3 OTI-7 "Optimal Itinerary and Time Slot" Data**

## 10.4 Data Read or Subscribed by Optimal Time Slot and Itinerary for Dangerous Goods (OTI) to Integration Layer

This is the data read or subscribed to by the "Optimal itinerary and time slot" from the Integration Layer.

### 10.4.1 OTI-1 General-Data

When a train journey, with the train carrying dangerous goods, is created, TMS publish general data about the train journey to the Integration Layer, available for the OTI module.

#### 10.4.1.1 *General-Data Properties*

| Interface OTI-1 Properties | |
|---|---|
| Interface ID | OTI-1 |
| Interface Title | General-Data |
| Publisher | The TMS shall be able to publish the data within section 10.4.1.2 to the integration layer. |
| Publish Trigger | When a train journey carrying dangerous goods is created, the TMS publishes to IL main characteristics of the train and the number and codes of the possible itineraries that the train can pass through to go from point A (starting point) to point B (arrival point). |
| Expected Frequency | OTI-1 is published once for each train carrying dangerous goods created in TMS |
| Subscribers | OTI |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "General-Data" data related to a specified "Train ID" |
| Persistence | The Integration Layer shall persist "General-Data" until the "Max_arrival_time" is 48 hours in the past. |
| Length of Validity | The Integration Layer shall identify the "General-Data" data as Valid until it is deleted, which occurs once the train number ID has reached its final destination. |

| | |
|---|---|
| Historical Depth | The Integration Layer shall provide the last "General-Data" data received when a read request is made. |

**Table 10-4 OTI-1 General-Data Properties**

#### 10.4.1.2 *General-Data Data*

| General Data | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Train ID | Number of the Train | Integer |
| StartPointA | Latitude and Longitude of point A (start) | string |
| EndPointB | Latitude and Longitude of point B (arrival) | string |
| Nwag | Number N of wagons belonging to the train | Integer |
| Nwag_DG | Number N of wagons carrying dangerous goods belonging to the train | Integer |
| Mitin | Number M of possible itineraries to go from A to B | Integer |
| Itin-1-ID (*) | Code of Itinerary n.1 | Integer |
| Itin-2-ID | Code of Itinerary n.2 | Integer |
| ..... | | |
| Itin-M-ID | Code of Itinerary n.M | Integer |

(*): The Attribute Itin-1-ID is repeated for the number of possible itinerary (M)

**Table 10-5 "General-Data" Data**

### 10.4.2 OTI-2 Wagons-Data

When a train journey, with the train carrying dangerous goods, is created, FRU publish the details of the wagons carrying dangerous goods and characteristics of the dangerous goods to the Integration Layer, available for the OTI module.

#### 10.4.2.1 *Wagons-Data Properties*

| Interface OTI-2 Properties | |
|---|---|
| Interface ID | OTI-2 |
| Interface Title | Wagons-Data |
| Publisher | The FRU shall be able to publish the data within section 0 to the integration layer. |
| Publish Trigger | When a train journey carrying dangerous goods is created, the FRU publishes to IL main characteristics, number and details, of the wagons carrying dangerous goods and the physical details of the dangerous goods itself. |
| Expected Frequency | OTI-2 is published once for each train carrying dangerous goods created in TMS |
| Subscribers | OTI |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Wagons-Data" data related to a specified "Train ID" |
| Persistence | The Integration Layer shall persist "Wagons-Data" until the "Max_arrival_time" is 48 hours in the past. |

| | |
|---|---|
| Length of Validity | The Integration Layer shall identify the "Wagons-Data" data as Valid until it is deleted, which occurs once the train number ID has reached its final destination. |
| Historical Depth | The Integration Layer shall provide the last "Wagons-Data" data received when a read request is made. |

**Table 10-6 OTI-2 Wagons-Data Properties**

#### 10.4.2.2 *Wagons-Data Data (*)*

| Wagons-Data | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Wagon ID | ID or number of the wagon | Integer |
| Wagon_POS | Position of the wagon in the train | Integer |
| WTyp | Type of wagon | Integer (code) |
| DGTyp | Type of dangerous goods | Alphanumeric |
| DGQuant | Quantity or weight of DG | Float |
| DGClass | Class of dangerous goods | Integer (code) |
| DGExpl | Flag to identify if explosive | True/False |
| DGEmerg | Emergency code related to dangerous goods | Integer (code) |

**(*) There is one instance of this table for any wagon belonging to the train**

**Table 10-7 "Wagons-Data" Data**

### 10.4.3 OTI-3 Itin-Infra

When a train journey, with the train carrying dangerous goods, is created, TMS publish the details of elements related to the infrastructures of the possible itineraries that the train can run across to go from point A to point B to the Integration Layer, available for the OTI module.

#### 10.4.3.1 *Itin-Infra Properties*

| Interface OTI-3 Properties | |
|---|---|
| Interface ID | OTI-3 |
| Interface Title | Itin-Infra |
| Publisher | The TMS shall be able to publish the data within section 10.4.3.2 to the integration layer. |
| Publish Trigger | When a train journey carrying dangerous goods is created, the TMS publishes to IL full details of the elements related to the infrastructures of the itineraries that the train can pass through to go from point A (starting point) to point B (arrival point). |
| Expected Frequency | OTI-3 is published once for each train carrying dangerous goods created in TMS |
| Subscribers | OTI |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Itin-Infra" data related to a specified "Train ID" |
| Persistence | The Integration Layer shall persist "Itin-Infra" until the "Max_arrival_time" is 48 |

| | |
|---|---|
| | hours in the past. |
| Length of Validity | The Integration Layer shall identify the "Itin-Infra" data as Valid until it is deleted , which occurs once the train number ID has reached its final destination. |
| Historical Depth | The Integration Layer shall provide the last "Itin-Infra" data received when a read request is made. |

**Table 10-8 ITI-3 Itin-Infra Properties**

#### 10.4.3.2 *Itin-Infra (*)*

| Itin-Infra | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Itin ID | Number of the itinerary | Integer (1..M) |
| Itin_Volt_type | Voltage type | AC/DC |
| Itin_Volt_value | Voltage value [V] | Integer |
| Itin_NTracks | Number of tracks | Integer |
| Itin_Guage | Gauge [mm] | Integer |
| Itin_Slope | Maximum longitudinal slope [‰] | Integer |
| Itin_alt_min | Minimum altitude [m asl] | Integer |
| Itin_alt_max | Maximum altitude [m asl] | Integer |
| Itin_category | Line Category | Code |
| Itin_Speed_lim | Speed Limit [km/h] | Integer |
| Itin_Tr_type | type of railway traffic | Code |
| Itin_Veh_gau | Line vehicle gauge | Code |
| Itin_tunnel_num | Line tunnels number | Integer |
| Itin_bridge_num | Line bridges number | Integer |
| Itin_Station_num | Line bridges number | Integer |
| Itin_Inter_p_num | Line Intersection points number | Integer |
| Itin_Cross_num | Line level crossing number | Integer |

**(*) There is one instance of this table for any possible itinerary**

**Table 10-9 "Itin-Infra" Data**

### 10.4.4 OTI-4 Itin-Social

When a train journey, with the train carrying dangerous goods, is created, TMS publish the details of social aspects related to possible itineraries that the train can run across to go from point A to point B to the Integration Layer, available for the OTI module.

#### 10.4.4.1 *Itin-Social Properties*

| Interface OTI-4 Properties | |
|---|---|
| Interface ID | OTI-4 |
| Interface Title | Itin-Social |
| Publisher | The TMS shall be able to publish the data within section 10.4.4.2 to the integration layer. |
| Publish Trigger | When a train journey carrying dangerous goods is created, the TMS publishes to |

| | |
|---|---|
| | IL full details of the social aspects related to the itineraries that the train can pass through to go from point A (starting point) to point B (arrival point). |
| Expected Frequency | OTI-4 is published once for each train carrying dangerous goods created in TMS |
| Subscribers | OTI |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Itin-Social" data related to a specified "Train ID" |
| Persistence | The Integration Layer shall persist "Itin-Social" until the "Max_arrival_time" is 48 hours in the past. |
| Length of Validity | The Integration Layer shall identify the "Itin-Social" data as Valid until it is deleted, which occurs once the train number ID has reached its final destination. |
| Historical Depth | The Integration Layer shall provide the last "Itin-Social" data received when a read request is made. |

**Table 10-10 OTI-4 Itin-Social Properties**

#### 10.4.4.2 *Itin-Social (*)*

| Itin-Social | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Itin ID | Number of the itinerary | Integer (1..M) |
| Itin_rangeInt | Range of interest [m] | Integer |
| Itin_town | Number of towns/villages near the railway | Integer |
| Itin_peo_dens | People average density [n/km²] | Integer |
| Itin_territ | Territorial context | String |
| Itin_Land_use | Land intended use | String |
| Itin_indust | Number of industrial sites with high accident risk | Integer |
| Itin_comm | Number of commercial/logistic sites | Integer |
| Itin_hosp | Number of hospitals | Integer |
| Itin_schools | Number of schools | Integer |
| Itin_Chur | Number of churches | Integer |

**(*) There is one instance of this table for any possible itinerary**

**Table 10-11 "Itin-Social" Data**

### 10.4.5 OTI-5 Itin-Clima

When a train journey, with the train carrying dangerous goods, is created, TMS publish the details of climatic aspects related to possible itineraries that the train can run across to go from point A to point B to the Integration Layer, available for the OTI module.

#### 10.4.5.1 *Itin-Clima Properties*

| Interface OTI-5 Properties | |
|---|---|
| Interface ID | OTI-5 |

| | |
|---|---|
| Interface Title | Itin-Clima |
| Publisher | The TMS shall be able to publish the data within section 10.4.5.2 to the integration layer. |
| Publish Trigger | When a train journey carrying dangerous goods is created, the TMS publishes to IL full details of the climatic aspects related to the itineraries that the train can pass through to go from point A (starting point) to point B (arrival point). |
| Expected Frequency | OTI-5 is published once for each train carrying dangerous goods created in TMS |
| Subscribers | OTI |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Itin-Clima" data related to a specified "Train ID" |
| Persistence | The Integration Layer shall persist "Itin-Clima" until the "Max_arrival_time" is 48 hours in the past. |
| Length of Validity | The Integration Layer shall identify the "Itin-Clima" data as Valid until it is deleted, which occurs once the train number ID has reached its final destination. |
| Historical Depth | The Integration Layer shall provide the last "Itin-Clima" data received when a read request is made. |

**Table 10-12 OTI-5 Itin-Clima Properties**

### 10.4.5.2 *Itin-Clima (*)*

| Itin-Clima | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Itin ID | Number of the itinerary | Integer (1..M) |
| Itin_Temp_Max | Max Temperature about the itinerary area [°C] | Integer |
| Itin_Temp_Min | Min Temperature about the itinerary area [°C] | Integer |
| Itin_Temp_Med | Medium Temperature about the itinerary area [°C] | Integer |
| Itin_Press_Med | Medium Pressure about the itinerary area [mbar] | Integer |
| Itin_Solar_Med | Medium Solar Radiation about the itinerary area [kW/m²] | Integer |
| Itin_Hum_Med | Medium Humidity about the itinerary area [%] | Integer |
| Itin_Wind_dir | Wind direction about the itinerary area | string |
| Itin_Wind_speed | Wind speed about the itinerary area [m/s] | Integer |
| Itin_Cloud | Night cloud cover about the itinerary area [%] | Integer |
| Itin_Pasquill | Pasquill stability Class about the itinerary area | Integer (code) |
| Itin_Soil | Soil roughness about the itinerary area | Integer (code) |

**(*) There is one instance of this table for any possible itinerary**

**Table 10-13 "Itin-Clima" Data**

### 10.4.6 OTI-6 Itin-Emergency

When a train journey, with the train carrying dangerous goods, is created, TMS publish the details of emergency response related to possible itineraries that the train can run across to go from point A to point B to the Integration Layer, available for the OTI module.

#### 10.4.6.1 *Itin-Emergency Properties*

| Interface OTI-6 Properties | |
|---|---|
| Interface ID | OTI-6 |
| Interface Title | Itin-Emergency |
| Publisher | The TMS shall be able to publish the data within section 10.4.6.2 to the integration layer. |
| Publish Trigger | When a train journey carrying dangerous goods is created, the TMS publishes to IL full details of the emergency response aspects related to the itineraries that the train can pass through to go from point A (starting point) to point B (arrival point). |
| Expected Frequency | OTI-6 is published once for each train carrying dangerous goods created in TMS |
| Subscribers | OTI |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Itin-Emergency" data related to a specified "Train ID" |
| Persistence | The Integration Layer shall persist "Itin-Emergency" until the "Max_arrival_time" is 48 hours in the past. |
| Length of Validity | The Integration Layer shall identify the "Itin-Emergency" data as Valid until it is deleted, which occurs once the train number ID has reached its final destination. |
| Historical Depth | The Integration Layer shall provide the last "Itin-Emergency" data received when a read request is made. |

**Table 10-14 OTI-6 Itin-Emergency Properties**

#### 10.4.6.2 *Itin-Emergency (*)*

| Itin-Emergency | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Itin ID | Number of the itinerary | Integer (1..M) |
| Itin_rangeInt | Range of interest [m] | Integer |
| Itin_fire_brig | Number of fire brigade headquarters | Integer |
| Itin_Aid | Number of emergency first aid | Integer |
| Itin_Vehi_speed | Medium speed emergency vehicles [Km/h] | Integer |
| Itin_Trav_time | Medium travel time emergency vehicles [min] | Integer |

**(*) There is one instance of this table for any possible itinerary**

**Table 10-15 "Itin-Emergency" Data**

# 11 Timetable Optimization Module

## 11.1 Use Case summary

**Use Case ID (D7.2 5.3.14) Optimize timetable region**

In the annual (long-term) timetable planning process, FRUs submit train requests (delivery commitment requests) to a request system (RS) managed by the IM. Based on these requests and using a timetable planning system (TPS), the timetable planner at the IM creates a timetable draft for (a region of) the railway network. The timetable draft can include non-regulated conflicts and may also not be optimized according to relevant evaluation criteria. To tune the timetable, the planner at the IM uses a timetable optimization module (TOM), which calculates an optimal timetable based on the draft, while respecting the constraints in the requests. The optimization is based on some evaluation criteria. The planner can iteratively adjust the criteria and reoptimize until he/she is satisfied.

**Use Case ID (D7.2 5.3.15) Add train to timetable**

In ad hoc timetable planning, the IM must add a new train request (delivery commitment request) from an FRU to an existing timetable. When planning for the new request, the IM cannot change established delivery commitments, but there can nevertheless exist some flexibility in the timetable, allowing changes that do not violate the established delivery commitments. Thus, the new request should be added utilizing the available free capacity and the flexibility in the existing timetable. The planner at the IM uses the timetable optimization module to find a way to insert the new train request that is feasible with respect to capacity restrictions from infrastructure, the existing timetable, and selected timetable optimization criteria. The planner can iteratively adjust the criteria and reoptimize until he/she is satisfied.

## 11.2 Interface Summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with ".P" are the publish side and interfaces with ".S" are the subscribe side.

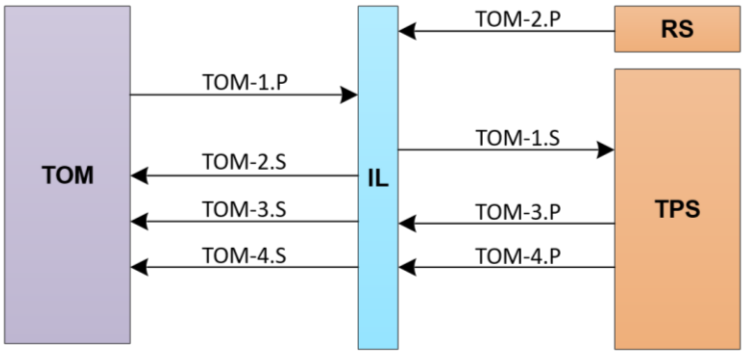


**Figure 11-1 Interface Overview – Timetable Optimization Module**

The table below shows a summary of the interfaces related to the timetable optimization module and the use cases.

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| TOM Publishing | | | | | | | |
| TOM-1 | TOM | TPS | Optimized Timetable | A timetable optimized by the Timetable Optimization Module. | 11.3.1 | D7.2 5.3.14 Step 5, D7.2 5.3.15 Step 5 | |
| TOM Subscribing | | | | | | | |
| TOM-2 | RS | TOM | Delivery Commitment Request | A request for a train. | 11.4.1 | D7.2 5.3.14 Step 1, D7.2 5.3.15 Step 1 | |
| TOM-3 | TPS | TOM | Planning Conditions | Infrastructure data, time separation of train events, and possessions. | 11.4.2 | D7.2 5.3.14 Step 1, D7.2 5.3.15 Step 1 | |
| TOM-4 | TPS | TOM | Input Timetable | A timetable that is to be optimized or to which a new train is to be added. | 11.4.3 | D7.2 5.3.14 Step 1, D7.2 5.3.15 Step 1 | |

**Table 11-1 Timetable Optimization Module Interface Summary**

## 11.3 Data Published by Timetable Optimization Module to Integration Layer

This is the data published by the Timetable Optimization Module to the Integration Layer available for a Timetable Planning System and other systems to use.

Any "admitted values" surrounded in curly braces "{ }" is an instance of a different table in this chapter.

### 11.3.1 TOM-1 Optimized Timetable

These data describe a timetable (for a certain railway network and a certain period of time) that has been optimized by the Timetable Optimization Module. This includes details such as the arrival and departure times of the trains in the timetable.

#### 11.3.1.1 *Optimized Timetable Properties*

| Interface TOM-1 Properties | |
|---|---|
| Interface ID | TOM-1 |
| Interface Title | Optimized Timetable |
| Publisher | The TOM shall be able to publish the data within sections 11.3.1.2, 11.3.1.3, and 11.3.1.4 to the integration layer. |
| Publish Trigger | When an optimized timetable has been created (and the timetable planner has approved it), the TOM shall publish it to the Integration Layer. |
| Expected Frequency | Dynamic<br>May be published 1 time per 5 minutes if the planners use the TOM frequently. |
| Subscribers | TPS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Optimized Timetable" data related to a specified train assignment or train number, control point or pair of control points, and/or period of time. |
| Persistence | The Integration Layer shall persist "Optimized Timetable" data at least until every Date of every Train Timetable has passed or until the data are deleted on request by the planner or replaced by a new version. |
| Length of Validity | The Integration Layer shall identify "Optimized Timetable" data as valid until they are deleted on request by the planner or replaced by a new version. |
| Historical Depth | The Integration Layer shall provide the last "Optimized Timetable" data received when a read request is made. |

**Table 11-2 TOM-1 Optimized Timetable Properties**

#### 11.3.1.2 *Timetable Control Point*

Arrival and departure times and their related parameters for a train at a control point of the route. Based on Table 8.26 (Timetable Control Point) in X2Rail-2 D6.1.

| Timetable Control Point | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Control Point | Reference to an identified location (node) where it is allowed to define a time value for a train movement (stop or pass). | String |
| Committed Arrival Time | Arrival time of the train at the control point, stated as a delivery commitment from the IM | Time |

| | | |
|---|---|---|
| | to the FRU. Only defined if an arrival time has been included in the corresponding delivery commitment request from the FRU. | |
| Technical Arrival Time | Arrival time of the train at the control point. This time is internal to the IM. | Time |
| Committed Departure Time | Departure time of the train from the control point, stated as a delivery commitment from the IM to the FRU. Only defined if a departure time has been included in the corresponding delivery commitment request from the FRU. | Time |
| Technical Departure Time | Departure time of the train from the control point. This time is internal to the IM. | Time |
| Movement Type | Defines if the train stops or passes at the control point. | Listed [Stop, Pass] |
| Arrival Track | Identification of the control point track where it is defined that the train arrives at the control point. | String |
| Departure Track | Identification of the control point track where it is defined that the train leaves the control point. | String |
| Stop Type | Scheduled kind of stop defined for a train. | Listed [Commercial stop, Technical stop, …] |

**Table 11-3 TOM-1 "Optimized Timetable" (Timetable Control Point) Data**

#### 11.3.1.3 *Train Timetable*

Timetable for a single train, potentially running on several dates. Based on Table 8.27 (Scheduled Timetable) in X2Rail-2 D6.1.

| Train Timetable | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Train number | Train number | Numeric |
| N x Date | The start dates of the train. | Complex [Date] |
| Train Assignment | Concept to keep together trains that run on different dates and have timetables that are similar but include variations in routes, traffic exchange, times or other characteristics. | Numeric |
| N x Timetable Control Point | Set of ordered Timetable Control Points defining the complete timetable for the train. | Complex [{Timetable Control Point}] |

**Table 11-4 TOM-1 "Optimized Timetable" (Train Timetable) Data**

#### 11.3.1.4 *Full Timetable*

This is the full timetable for the railway network and period.

| Full Timetable | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| N x Train Timetable | All included timetables for single trains. | Complex [{Train Timetable}] |

**Table 11-5 TOM-1 "Optimized Timetable" (Full Timetable) Data**

## 11.4 Data Read or Subscribed to by the TOM from the Integration Layer

This is the data read or subscribed to by the Timetable Optimization Module from the Integration Layer.

Any "admitted values" surrounded in curly braces "{ }" is an instance of a different table in this chapter.

### 11.4.1 TOM-2 Delivery Commitment Request

These data describe a request for a train. This includes requested arrival and departure times as well as restrictions modelling situations that require the linking of the departure or arrival of two trains.

#### 11.4.1.1 *Delivery Commitment Request Properties*

| Interface TOM-2 Properties | |
|---|---|
| Interface ID | TOM-2 |
| Interface Title | Delivery Commitment Request |
| Publisher | The RS shall be able to publish the data in sections 11.4.1.2, 11.4.1.3, 11.4.1.4, and 11.4.1.5 to the integration layer. |
| Publish Trigger | When an FRU has submitted a delivery commitment request, the RS shall publish it to the Integration Layer. |
| Expected Frequency | Dynamic<br>May be published 1 time per 5 minutes if delivery commitment requests are submitted frequently. |
| Subscribers | TOM |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Delivery Commitment Request" data related to a specified train assignment or variant number, control point or pair of control points, and/or period of time. |
| Persistence | The Integration Layer shall persist "Delivery Commitment Request" data until they are deleted on request by the FRU or replaced by a new version. |
| Length of Validity | The Integration Layer shall identify the "Delivery Commitment Request" data as valid until they are deleted on request by the FRU or replaced by a new version. |
| Historical Depth | The Integration Layer shall provide the last "Delivery Commitment Request" data received (for a certain train assignment or variant number and a certain period of time) when a read request is made. |

**Table 11-6 TOM-2 Delivery Commitment Request Properties**

#### 11.4.1.2 *Requested Timetable Control Point*

This is the requested arrival and departure times and their related parameters for a train at a control point of the route. Based on Table 8.26 (Timetable Control Point) in X2Rail-2 D6.1.

| Requested Timetable Control Point | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Control Point | Reference to an identified location (node) where it is allowed to define a time value for | String |

| | | |
|---|---|---|
| | a train movement (stop or pass). | |
| Requested Arrival Time | The arrival time at the control point requested by the FRU. | Time |
| Earliest Arrival Time | The earliest arrival time at the control point accepted by the FRU. | Time |
| Latest Arrival Time | The latest arrival time at the control point accepted by the FRU. | Time |
| Requested Departure Time | The departure time from the control point requested by the FRU. | Time |
| Earliest Departure Time | The earliest departure time from the control point accepted by the FRU. | Time |
| Latest Departure Time | The latest departure time from the control point accepted by the FRU. | Time |
| Minimum Dwell Time | Minimum stop duration for the train. | Numeric |

**Table 11-7 TOM-2 "Delivery Commitment Request" (Requested Timetable Control Point) Data**

#### 11.4.1.3 *Requested Train Timetable Part*

A Requested Train Timetable Part is a part of a Requested Train Timetable where a certain timing load (which is associated with a group of train types characterized by their rolling stock, weight, and maximum speed) is used. Based on Table 8.27 (Scheduled Timetable) in X2Rail-2 D6.1.

| Requested Train Timetable Part | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Timing Load Name | The name of the timing load. | String |
| N x Requested Timetable Control Point | Set of ordered Requested Timetable Control Points defining the requested timetable part for the train. | Complex [{Requested Timetable Control Point}] |
| Length | The length of the train. | Numeric |

**Table 11-8 TOM-2 "Delivery Commitment Request" (Requested Train Timetable Part) Data**

#### 11.4.1.4 *Requested Train Timetable*

This is the requested timetable for a single train, potentially running on several dates.

| Requested Train Timetable | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Variant Number | Identifies the train variant, of which there might be several belonging to the same Train Assignment. | Numeric |
| N x Date | The start dates of the train. | Complex [Date] |
| Train Assignment | Concept to keep together trains that run on different dates and have timetables that are similar but include variations in routes, traffic exchange, times or other characteristics. | Numeric |

| | | |
|---|---|---|
| Category | Category describing the train and the priority of the train. | Listed [Freight fast, Freight flexibility, Trunk commuter, Regional max, Distant standard, …] |
| N x Requested Train Timetable Part | Set of ordered Requested Train Timetable Parts defining the requested timetable for the train. | Complex [{Requested Train Timetable Part}] |
| Anchor Point | The Control Point where the deviations in the timetable from the requested arrival and departure times will usually be the smallest. | String |

**Table 11-9 TOM-2 "Delivery Commitment Request" (Requested Train Timetable) Data**

#### 11.4.1.5 *Trains Restriction*

The restrictions model situations that require linking the departure or arrival of two trains at a point because of operating reasons or because of transfers of rolling stock, crew members or passengers between the trains. Based on Table 8.64 (Trains Restriction) in X2Rail-2 D6.1.

| Trains Restriction | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Control Point | Reference to an identified Node where the restriction is defined. | String |
| Train 1 | The first train (timetable) involved in the restriction. | {Requested Train Timetable} |
| Train 2 | The second train (timetable) involved in the restriction. | {Requested Train Timetable} |
| Category | Category describing the priority of the restriction. | Listed [Connection Freight transport high, Connection Passenger service high, …] |
| Restriction Type | Type of restriction according to the affected element. | Listed [Rolling stock, Crew, Passengers, …] |
| Train 1 Event | Event affected by the restriction of the first Train. | Listed [Arrival, Departure] |
| Train 2 Event | Event affected by the restriction of the second train. | Listed [Arrival, Departure] |
| Lapse | Minimum time between both events. | Numeric |

**Table 11-10 TOM-2 "Delivery Commitment Request" (Trains Restriction) Data**

### 11.4.2 TOM-3 Planning Conditions

These data describe infrastructure, time separation of train events, and possessions.

#### 11.4.2.1 *Planning Conditions Properties*

| Interface TOM-3 Properties | |
|---|---|
| Interface ID | TOM-3 |
| Interface Title | Planning Conditions Properties |
| Publisher | The TPS shall be able to publish the data in sections 11.4.2.2, 11.4.2.3, 11.4.2.4, 11.4.2.5, 11.4.2.6, and 11.4.2.7 to the integration layer. |
| Publish Trigger | When planning conditions have been entered in a TPS, it shall publish them to the Integration Layer. |
| Expected Frequency | Rather static<br>Base version is published 1 time per year, updates are published more frequently. |
| Subscribers | TOM |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Planning Conditions" data related to specified nodes or tracks, and/or a specified period of time. |
| Persistence | The Integration Layer shall persist "Planning Conditions" data until they are deleted on request by the planner or replaced by a new version. |
| Length of Validity | The Integration Layer shall identify the "Planning Conditions" data as valid until they are deleted on request by the planner or replaced by a new version, or until the end of their validity period (as indicated in the data). |
| Historical Depth | The Integration Layer shall provide the last "Planning Conditions" data received (for a certain railway network and a certain period of time) when a read request is made. |

**Table 11-11 TOM-3 Planning Conditions Properties**

#### 11.4.2.2 *Track*

This is a physical track (one of potentially several) in a link between two nodes (stations or similar) in a railway network.

| Track | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Origin | References one of the endpoints (nodes) of the track, namely the one that is reached first by a train travelling in the preferred direction of the track. | {Node} |
| Destination | References one of the endpoints (nodes) of the track, namely the one that is reached last by a train travelling in the preferred direction of the track. | {Node} |
| Length | Length of track. | Numeric |
| Track ID | Unique identifier of the track. | String |
| Start of validity period | The start of validity for these data | Datetime |
| End of validity period | The end of validity for these data | Datetime |

**Table 11-12 TOM-3 "Planning Conditions" (Track) Data**

#### 11.4.2.3 *Timing Link*

A Timing Link provides the minimum run time between two subsequent nodes for a certain timing load. The minimum run time is different depending on the stop pattern of the train.

| Timing Link | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Timing Load Name | The name of the timing load. | String |
| Track | References the track that the timing link is for. | {Track} |
| Preferred direction | Indicates if this timing link is for the preferred direction of the track. | Boolean |
| Stop-stop time | Minimum run time between the two endpoints if the train stops at both of them. | Numeric |
| Stop-full speed time | Minimum run time between the two endpoints if the train stops at the first one but moves at full speed at the second one. | Numeric |
| Full speed-stop time | Minimum run time between the two endpoints if the train moves at full speed at the first one but stops at the second one. | Numeric |
| Full speed-full speed time | Minimum run time between the two endpoints if the train moves at full speed at both of them. | Numeric |
| Start of validity period | The start of validity for these data | Datetime |
| End of validity period | The end of validity for these data | Datetime |

**Table 11-13 TOM-3 "Planning Conditions" (Timing Link) Data**

#### 11.4.2.4 *Node*

A location (station, stopping point, signal …) where it is allowed to define a time value for a train movement (stop or pass).

| Node | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Name | A unique name for the node. | String |
| Node ID | A unique identifier (signature) for the node. | String |
| Type | Type of the node. | Listed [Station, Stopping point, Signal, …] |
| N x Node Track | The tracks that make up the node. | Complex [{Node Track}] |
| Start of validity period | The start of validity for these data | Datetime |

| | | |
|---|---|---|
| End of validity period | The end of validity for these data | Datetime |

**Table 11-14 TOM-3 "Planning Conditions" (Node) Data**

#### 11.4.2.5 *Node Track*

This is a track that is part of a node.

| Node Track | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Track ID | Unique identifier of the track. | String |
| Length | Length of track. | Numeric |
| Platform Length | Length of platform. | Numeric |
| Start of validity period | The start of validity for these data | Datetime |
| End of validity period | The end of validity for these data | Datetime |

**Table 11-15 TOM-3 "Planning Conditions" (Node Track) Data**

#### 11.4.2.6 *Time separation of train events at nodes*

When the timetable is constructed, two arrival or departure events, associated one-to-one with two trains, must often be appropriately separated in time. The purpose of the separation can be to enforce headways on double tracks or buffer times at meeting/overtaking nodes. The time separation required sometimes depends on which node tracks that the trains are scheduled to arrive at/depart from, on the types of the trains, and on the order in which the trains arrive at/depart from the node.

| Time Separation | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| First Event | The type of the event that happens first. | Listed [Arrival, Departure] |
| Second Event | The type of the event that happens second. | Listed [Arrival, Departure] |
| N x Node Track 1 | Identifies the group of node tracks to which the track used by the train involved in the first event belongs. | Complex [{Node Track}] |
| N x Node Track 2 | Identifies the group of node tracks to which the track used by the train involved in the second event belongs. | Complex [{Node Track}] |
| N x Timing Load Name 1 | Identifies the group of train types to which the train involved in the first event belongs. | Complex [String] |
| N x Timing Load Name 2 | Identifies the group of train types to which the train involved in the second event belongs. | Complex [String] |
| Direction | Indicates if the two trains travel in the same direction or in different directions. | Listed [Same, Different] |
| First Train Stops | Indicates if the train involved in the first | Boolean |

| | | |
|---|---|---|
| | event stops. | |
| Second Train Stops | Indicates if the train involved in the second event stops. | Boolean |
| Separation Time | The minimum time between the first event and the second event. | Numeric |
| Start of validity period | The start of validity for these data | Datetime |
| End of validity period | The end of validity for these data | Datetime |

**Table 11-16 TOM-3 "Planning Conditions" (Time Separation) Data**

#### 11.4.2.7 *Possession*

Data related to a possession. Based on Table 8.98 (Scheduled Data) in X2Rail-2 D6.1.

| Possession | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Related Restriction | Whether the possession causes a restriction in speed or a closure. | Listed [Temporary Speed Restriction, Close] |
| N x Track | The track(s) affected by the possession. | Complex [{Track}] |
| Maximum Speed | Limit of speed when the possession is running. | Numeric |
| Possession Start Time | Scheduled datetime for the activation of the possession. | Datetime |
| Possession End Time | Scheduled datetime for the deactivation of the possession. | Datetime |

**Table 11-17 TOM-3 "Planning Conditions" (Possession) Data**

### 11.4.3 TOM-4 Input Timetable

These data describe a timetable (for a certain railway network and a certain period of time) that is to be optimized or to which a new train is to be added. This includes details such as the arrival and departure times of the trains in the timetable.

#### 11.4.3.1 *Input Timetable Properties*

| Interface TOM-4 Properties | |
|---|---|
| Interface ID | TOM-4 |
| Interface Title | Input Timetable |
| Publisher | The TPS shall be able to publish the data within sections 11.4.3.2, 11.4.3.3, and 11.4.3.4 to the integration layer. |
| Publish Trigger | When a timetable has been created (and the timetable planner has approved it), the TPS shall publish it to the Integration Layer. |
| Expected Frequency | Dynamic<br>May be published 1 time per 5 minutes if the planners make timetable changes frequently. |
| Subscribers | TOM |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Input Timetable" data related to a specified train assignment or train number, control |

| | |
|---|---|
| | point or pair of control points, and/or period of time. |
| Persistence | The Integration Layer shall persist "Input Timetable" data at least until every Date of every Train Timetable has passed or until the data are deleted on request by the planner or replaced by a new version. |
| Length of Validity | The Integration Layer shall identify the "Input Timetable" data as valid until they are deleted on request by the planner or replaced by a new version. |
| Historical Depth | The Integration Layer shall provide the last "Input Timetable" data received when a read request is made. |

**Table 11-12 TOM-4 Input Timetable Properties**

#### 11.4.3.2 *Timetable Control Point*

Arrival and departure times and their related parameters for a train at a control point of the route. The data for the timetable control point is the same as Table 11-3 TOM-1 "Optimized Timetable" (Timetable Control Point) Data.

#### 11.4.3.3 *Train Timetable*

This is the timetable for a single train, potentially running on several dates. The data for the train timetable is the same as Table 11-4 TOM-1 "Optimized Timetable" (Train Timetable) Data.

#### 11.4.3.4 *Full Timetable*

This is the full timetable for the railway network and period. The data for the full timetable is the same as Table 11-5 TOM-1 "Optimized Timetable" (Full Timetable) Data.

# 12 Conflict Detection and Resolution

## 12.1 Use Case summary

Use Case ID (D7.2 5.3.17) Conflict Detection

Use Case ID (D7.2 5.3.18) Conflict Resolution

The use case describes an innovative scenario for interaction between TMS and operators among each other with the goal to reduce delays and increase the network throughput. The TMS provides the operators with services for management of local solutions (each operator can handle his part of the network) and algorithms for conflict detection and resolution. For this purpose, the algorithms must be provided with the current state of the infrastructure and operations.

## 12.2 Interface summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with ".P" are the publish side and the interfaces with ".S" are the subscribing side. The interfaces belonging to this use case are annotated with DSS (Decision Support System) to show the integrated workflow of the use case.

The Operator's workstation is used for representation of the conflicts and resolution proposals to the operator, ATT provides the Conflict Detection and resolution module with the current train positions, Automatic Route Setting uses the resulting timetable for automatic route settings, and ATO uses the forecasted trips for calculation of the optimised journey profiles.

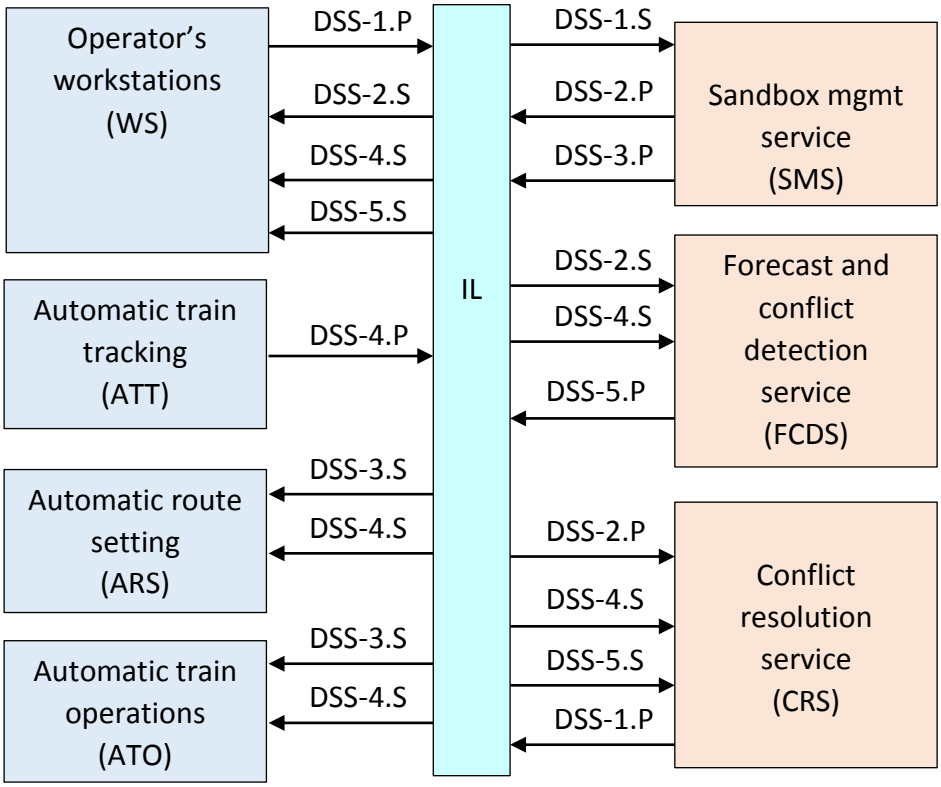


**Figure 12-1 Interface overview - Decision Support System**

The table below shows the summary of the interfaces related to the Decision support system and the use case.

Note that where there are multiple publishers these are separate logical interfaces, both publishing the same data to the same subscriber.

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Prototyped |
|---|---|---|---|---|---|---|
| DSS-1 | WS, CRS | SMS | Change requests | Requests for modification of the Real Time Traffic plan (RTTP). | 13.3.1 | Y |
| DSS-2 | SMS | FCDS, CRS, WS | Sandbox content | Sandbox data as a snapshot and set of delta modifications. | 13.3.2 | Y |
| DSS-3 | SMS | ARS, ATO | RTTP | Representation of the Real Time Traffic Plan as a set of objects (restrictions, trips). | 13.3.2 | Y |
| DSS-4 | ATT | FCDS, CRS ARS, ATO | Train positions and speeds. | Unified train positions and speeds on the abstract network graph. | 13.3.4 | Y |
| DSS-5 | FCDS | WS, CRS | Detected conflicts | Conflicts detected on each sandbox (operator-specific). | 13.3.5 | Y |

**Table 12-1 Conflict Detection and Resolution Interface Summary**

## 12.3 Interface details

This is the data published by the listed services involved into the use case.

### 12.3.1 DDS-1 Change requests

This data defines modifications the source system wants to apply on some sandbox (partial version of the RTTP). Normally these requests are issued by the operators to be analysed (simulated, conflict detection etc) before activation.

The same interface is used by the conflict resolution service, which plays the same role as a human operator – it is constructing modified RTTP to resolve conflicts.

#### 12.3.1.1 *Change request Properties*

| Interface DSS-1 Properties | |
|---|---|
| Interface ID | DSS-1 |
| Interface Title | Change requests |
| Publisher | The operator's workstation and conflict resolution service. |
| Publish Trigger | When operator modifies a future operational task, e.g. increase the loading time of the train in harbour due to a delay of the ship.<br><br>When the operator modifies the state of the infrastructure by inserting or modifying a temporal speed restriction.<br><br>When conflict resolution module creates a new solution, it publishes required modifications on ILayer |
| Expected Frequency | Dynamic<br>Approx. published 1 time per minute. |
| Subscribers | TMS, Conflict detection |
| Filter | The Integration Layer shall provide the Sandbox-management-service with the ability to read "Change requests" data related to a specified "Sandbox". This is achieved by assignment of a separated topic per sandbox. |
| Persistence | The Integration Layer shall not persist the Change Requests, as they become quickly invalid. |
| Length of Validity | The validity of the message identifies the sandbox management system, which is responsible for its removal after handling (acceptance or rejection). |
| Historical Depth | The Integration Layer shall provide the last "Change request" data received when a read request is made. |

**Table 12-2 Change request Properties**

#### 12.3.1.2 *Change request data*

| Change request | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Next change set ID | ID of the next free Change Set in the sandbox. | Numeric |
| ChangeSet | Object containing modification commands. | Object ChangeSet |
| UpdateOffsetId | If the value is > 0, represents the ID = | Numeric |

| | | |
|---|---|---|
| | nextChangeSetId – UpdateOffsetId, which shall be updated by this ChangeRequest | |
| Undo | If true, the ChangeRequest requires to "remove" (undo) all ChangeSets after nextChangeSetId – UpdateOffsetId | boolean |
| Timestamp | UTC time offset to epoch in microseconds, when the ChangeSet was created. | UInt64 |
| ChangeSet.Sender | ID of the sending application, optional if the sender is not the sandbox user. | Alphanumeric |
| ChangeSet.Commands | Objects representing atomic modification of the RTTP. | Object Command |
| Command.ObjectRef | Reference to the object to be modified | String |
| Command.AttributeId | Id of the attribute of the object to be modified | integer |
| Command.OperationType | Type of command to be applied to the attribute. | SET/REMOVE/INSERT |
| Command.index | If the modified attribute is a sequence, the index represents the position of the field to be modified. | Uint32 |
| Command.value | Union representing the new value of the attribute | Object Any |
| Command.invalid | If true annotates, that this command is not valid | boolean |

**Table 12-3 Change request data**

### 12.3.2 DDS-2 Sandbox content

The sandbox content consists of a list of ChangeSet-Objects.

#### 12.3.2.1 *Sandbox content properties*

| Interface DSS-2 Properties | |
|---|---|
| Interface ID | DSS-2 |
| Interface Title | Sandbox content |
| Publisher | Sandbox management service |
| Publish Trigger | When sandbox management service receives a ChangeRequest it evaluates it and applies to the sandbox content by appending or updating a ChangeSet-object into the sandbox-topic. |
| Expected Frequency | Dynamic<br>Approx. published 1 time minute. |
| Subscribers | Forecast and conflict detection service, Conflict resolution service, Operator's workstations. |
| Filter | No filtering is required. |
| Persistence | The Integration Layer shall handle the sandboxes as configured – some of the must be persisted (e.g. the final published sandbox), some of them can be transient (e.g. private sandbox of the Conflict-resolution-service). |
| Length of Validity | The Integration Layer shall identify the published "ChangeSets" data as valid until the proposals are in the past. |

| | |
|---|---|
| Historical Depth | The Integration Layer shall provide the last “ChangeSet” data received when a read request is made. |

**Table 12-4 Sandbox content properties**

The ChangeSet-Objects are already specified in the table “change request data”.

### 12.3.3 DSS-3 Representation of the Real Time Traffic Plan

The RTTP is published in two ways:

- As a master sandbox collecting all modifications since last snapshot
- As a set of objects: Trips, planned Possessions etc.

In this section only Trips are defined. The sandbox service applies all modifications to the data model and publishes the trips on configured topic in the IL.

#### 12.3.3.1 *Trip properties*

| Interface DSS-3 Properties | |
|---|---|
| Interface ID | DSS-3 |
| Interface Title | Trips |
| Publisher | Sandbox management service |
| Publish Trigger | When sandbox management service modifies the master sandbox. |
| Expected Frequency | Dynamic<br>Approx. published 1 time per minute. |
| Subscribers | ATO, ARS, Operator’s workstations. |
| Filter | No filtering is required. |
| Persistence | The Integration Layer shall handle trips transient. |
| Length of Validity | The Integration Layer shall identify the published “ChangeSets” data as valid until the proposals are in the past. |
| Historical Depth | The Integration Layer shall provide the last “ChangeSet” data received when a read request is made. |

**Table 12-5 Trip properties**

#### 12.3.3.2 *Trip Data*

| Trip data | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Trip ID | ID for full journey related to the train. | Alphanumeric |
| Tasks | A set of operational tasks to be implemented on the trip. | Object Task (and inherited) |
| Path | A list of NetElements with their direction representing the way of the trip in the abstract railway network. | Object DirNetElement |
| Description | Basic information about the train – start and end points of the network, published name etc. | Object TripDescription |
| Task.ID | Id of the task | Alphanumeric |

| | | |
|---|---|---|
| Task.OpPoint | Operational point, in which the task must be implemented. | Reference (string) |
| Task.startTime | Time at which the task shall start | DateTime |
| Task.durationTime | Planned task duration in seconds | Numeric |
| Task.netElement | NetElement on which the task must be implemented | Reference (string) |
| Task.pos | Position on the NetElement, on which the task must be implemented | Numeric in [cm] |
| Task.taskUnion | Union containing additional information to the task type. | Object OpTaskUnion |

**Table 12-6 Trip Data**

Further objects (OpTaskUnion, DirNetElement, inherited classes from TaskType) are defined in D6.2 in X2Rail-2.

### 12.3.4 DSS-4 Train positions and speeds.

There are different sources of the train position, which depend on the technical implementation. Here a generalized representation is required.

#### 12.3.4.1 *Train position properties*

| Interface DSS-3 Properties | |
|---|---|
| Interface ID | DSS-4 |
| Interface Title | Train position |
| Publisher | Automatic train tracking |
| Publish Trigger | Time based every 3-10 seconds if the train is moving. |
| Expected Frequency | Dynamic<br>Approx. published 100 times per second |
| Subscribers | ATO, ARS, Operator's workstations, FCDS, CRS. |
| Filter | No filtering is required. |
| Persistence | The Integration Layer shall handle trip positions transient (without persistence). |
| Length of Validity | The Integration Layer shall identify the published "Train positions" data as valid for 1 minute. |
| Historical Depth | The Integration Layer shall provide the last "Train position" data received when a read request is made. |

**Table 12-7 Train position properties**

#### 12.3.4.2 *Train position data*

| Train position | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| trip | Reference to the trip | Reference (string) |
| netElement | NetElement on which the train front was. | Reference (string) |
| Timestamp | UTC time in microseconds since epoch. | UInt64 |
| estimatedFrontPos | Position of the front of the train on the NetElement | Uint32 [cm] |
| estimatedRearOffset | Represents the estimated offset of the rear compared to the front. | Uint32 [cm] |

| | | |
|---|---|---|
| mostRestrictiveFrontOffset | Represent secure front position as offset to the estimatedFrontPos forwared | Uint32 [cm] |
| mostRestrictiveRearOffset | Represent secure rear position as offset to the estimatedFronPos backwards | Uint32 [cm] |
| direction | Movement direction based on the NetElement | Nominal/Reverse |
| speed | Estimated train speed in [km/h] | Uint32 |
| trainLength | Estimated train length | Numeric in [cm] |
| integrityConfirmed | Defines, if the train integrity is confirmed in a safe manner. | boolean |

**Table 12-8 Train position data**

### 12.3.5 DSS-5 Detected conflicts.

Detected conflicts represent a list of conflicts for dedicated sandbox (each sandbox has its own conflicts).

#### 12.3.5.1 *Conflicts properties*

| Interface DSS-5 Properties | |
|---|---|
| Interface ID | DSS-5 |
| Interface Title | Conflict |
| Publisher | Forecast and conflict detection service |
| Publish Trigger | Train movement<br>Modification of the Trip-Task<br>Modification of the infrastructure |
| Expected Frequency | Dynamic<br>Approx. published 1 time per second |
| Subscribers | Operator's workstations, CRS. |
| Filter | No filtering is required. |
| Persistence | The Integration Layer shall handle trip positions transient (without persistence). |
| Length of Validity | The Integration Layer shall identify the published "Conflict" data as valid the conflict is in the past. |
| Historical Depth | The Integration Layer shall provide the last "Conflict" data received when a read request is made. |

**Table 12-9 Conflicts properties**

#### 12.3.5.2 *Conflict data*

| **Conflict definition** | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Id | Id of the conflict which shall be referenced by conflict resolution. | String |
| IssuedTimestamp | Time of validity of conflict definition. If one of the objects defined in this conflict changed afterwards, the conflict | Timestamp |

| | | |
|---|---|---|
| | definition is assumed as invalid. | |
| ConflictType | Defines the type of the conflict. | Listed [InvalidLink, InvalidValue, LimitedResource] |
| Object | Defines the path to the main object of the conflict:<br><br>- Containing invalid data link or<br>- Containing invalid data value or<br>- Limited resource (e.g. track) | Object Path according to CDM definition. |
| InvalidAttributeId | Defines the attribute id in Object providing invalid link or invalid value. | Integer |
| ExpectedAttrValue | Hint for the expected value for the invalid-object-value. | Any (double, string, int, enumerator) |
| ConflictingObjectLinks | The limited-resource conflict occurs if several objects use shared object concurrently. Usage can be identified as “linking”. In this attribute paths with conflicting links are stored. | Object-Attribute Path according to CDM definition with maxOccurs=”unbounded”. The order of conflicting objects is according to the planned sequence of limited-resource-occupation. |
| Severity | Defines the severity of the conflict. In case of Error the train operation will be impossible, in case of warning probably not optimal. | Listed [Warning, Error] |
| ExpectedResolutionTime | Most of the conflicts can be solved short before operation – so the operator can structure his work as required. | Timestamp |
| InvalidLinkReason | There are several reasons for invalidity of a link – it could be<br><br>- temporary not available (e.g. a track due to maintenance)<br>- Not available (e.g. due to | Listed [TemporaryNotAvailable, NotAvailable,<br><br>NotExisting] |

| | | |
|---|---|---|
| | cancellation)<br>- Not existing in IL (e.g. reference to the not yet planned or imported trip) | |
| ObjectType | The type of the main object as defined by CDM. It can be used to associate conflict resolution to different systems in a customer specific installation. The object type is implicitly encoded in the Object path. | String [Module.ClassName] |
| JustificationRef | Reference to Object with justification. It replaces the common used error-codes. | String [reference] |

**Table 12-10 Conflict data**

# 13 Container Management System

## 13.1 Use Case summary

Use Case ID (D7.2 5.3.19) Optimizing container delivery to ports

The use case describes an innovative scenario for interaction between a Container Management System (CMS) and TMS with the goal to provide smooth and fast delivery of containers to ports. The TMS provides the CMS with up to date and accurate information on train status which enables the CMS to provide up to date and accurate information on container status at any time. The CMS provides TMS with additional information of containers, wagons and train by putting this data on the Integration Layer.

## 13.2 Interface Summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with ".P" are the publish side and interfaces with ".S" are the subscribe side. Although some of the interfaces belong to TMS or the FRU, as these are described from the perspective of this use case, they are all currently identified as "CMS" interfaces.

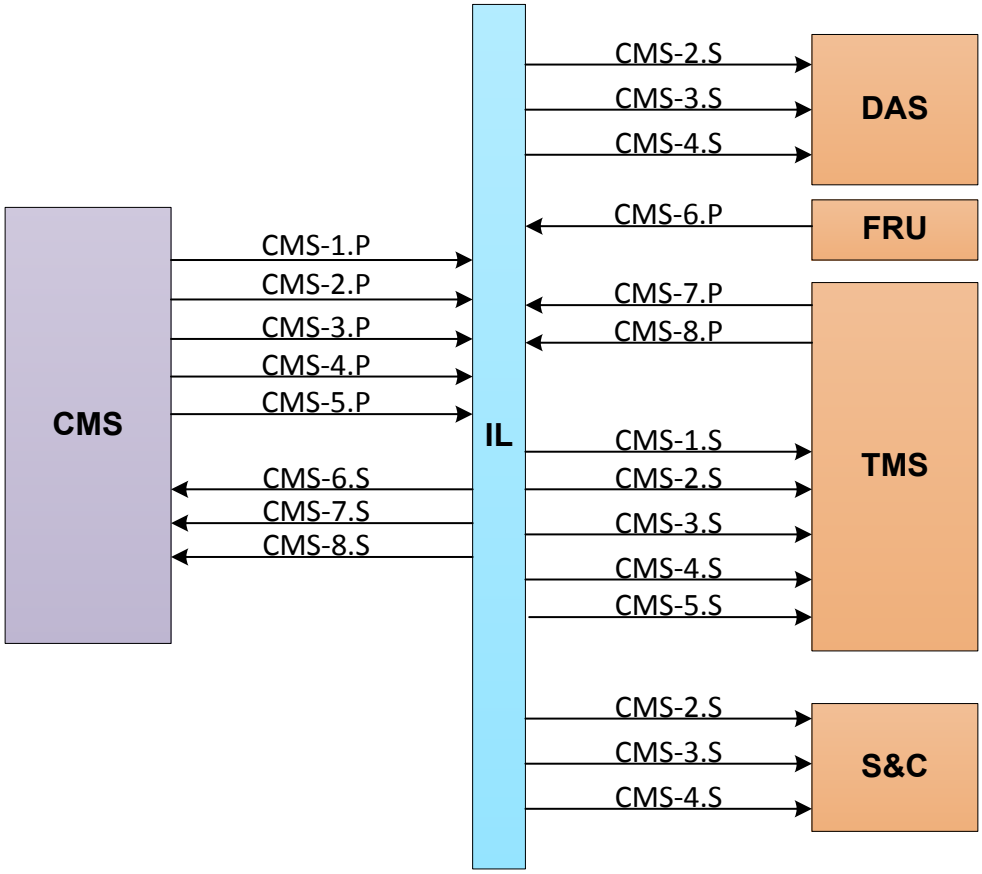


**Figure 13-1 Interface Overview - Container management System**

The table below shows a summary of the interface related to the container management system and the use case.

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| CMS Publishing | | | | | | | |
| CMS-1 | CMS | TMS | Container Journey | Data on the overall journey of a container, which may involve multiple journey legs. | 13.3.1.213.3.1 | D7.2 5.3.19 Step 2 | |
| CMS-2 | CMS | TMS, S&C, DAS, ATO | Container Contents | Data on the contents of a container, weigh, dangerous goods etc. | 13.3.2.2 | D7.2 5.3.19 Steps 1,2 | |
| CMS-3 | CMS | TMS, S&C, DAS, ATO | Physical Container Details | Data on physical size, type and weight of container. | 13.3.3.2 | D7.2 5.3.19 Steps 1,2 | |
| CMS-4 | CMS | TMS, S&C, DAS, ATO | Container Journey Leg | Origin and destination of a journey leg, including times. Assignment of journey leg to a specific transport vehicle. | 13.3.4.2 | D7.2 5.3.19 Steps 1 | Y |
| CMS-5 | CMS | TMS | Request Schedule Modification | Data required for requesting a modification to a train plan in TMS. | 13.3.5.2 | D7.2 5.3.19 Step 8 | |
| CMS Subscribing | | | | | | | |
| CMS-6 | FRU | CMS | Train to Container Assignment | Data on which train service the container is assigned to travel on. | 13.4.1.2 | D7.2 5.3.19 Step 1 | |
| CMS-7 | TMS | CMS | Actual Train Position | Data on the actual position of a train at reporting locations. | 13.4.2.213.4.3.1 | D7.2 5.3.19 Steps 6,7 | Y |
| CMS-8 | TMS | CMS | Train Forecast | Data on forecasted times a train will be at major locations. | 13.4.3.2**Error! Reference** | D7.2 5.3.19 Steps 4,6,7 | Y |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | **source not found.** | | |

**Table 13-1 Container Management System Interface Summary**

## 13.3 Data Published by CMS system to Integration Layer

This is the data published by the Container Management System to the Integration Layer available for a TMS and other systems to use.

Any “admitted values” surrounded in curly braces “{ }” is an instance of a different table in this chapter.

### 13.3.1 CMS-1 Container Journey

This is the data for the overall container journey from origin to final destination. This includes details such as the overall start time and location, and end time and location of the containers journey. This also contains data on the current status of the journey and which container journey leg is currently in progress.

#### 13.3.1.1 *Container Journey Properties*

| Interface CMS-1 Properties | |
|---|---|
| Interface ID | CMS-1 |
| Interface Title | Container Journey |
| Publisher | The CMS shall be able to publish the data within section 13.3.1.2 to the integration layer. |
| Publish Trigger | When a container journey is created, the CMS shall publish the “Container Journey” data to the Integration Layer<br><br>When the value of any “Container Journey” attributes, except for “Forecasted Journey Departure” and “Forecasted Journey Arrival Time” change, CMS shall publish the “Container Journey” data to the Integration Layer<br><br>When the value for “Forecasted Journey Departure Time” or “Forecasted Journey Arrival Time” change by 5 minutes or more, in comparison to the last published value for those attributes, the CMS shall publish the “Container Journey” data to the Integration Layer<br><br>If the Previously published value for “Forecasted Journey Departure Time” or “Forecasted Journey Arrival Time” is NULL, when any change to the value of these attributes occurs, the CMS shall publish the “Container Journey” data to the Integration Layer |
| Expected Frequency | Dynamic<br><br>Approx. published 1 time per 5 minutes per container if forecast changes frequently. |

| | |
|---|---|
| Subscribers | TMS, Conflict detection |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Container Journey" data related to a specified "Container Journey ID" |
| Persistence | The Integration Layer shall persist "Container Journey" data until the "Audited Journey Arrival Time" is 24 hours in the past. |
| Length of Validity | The Integration Layer shall identify the "Container Journey" data as Valid until the "Audited Journey Arrival Time" is 24 hours in the past. |
| Historical Depth | The Integration Layer shall provide the last "Container Journey" data received when a read request is made. |

**Table 13-2 CMS-1 Container Journey Properties**

#### 13.3.1.2 *Container Journey Data*

| Container Journey | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Container Journey ID | ID for full journey related to a container. This may involve multiple journey legs using different modes of transport. | Alphanumeric |
| Container Journey Status | Status of the container journey | List [e.g. planned, in progress, cancelled, complete, loaded, etc] |
| Current container Journey Leg | The ID of the Current container Journey Leg | Alphanumeric |
| Journey Origin Location | Origin location of the journey. | Alphanumeric |
| Planned Journey Departure Time | Planned start time of the journey. | DateTime |
| Forecasted Journey Departure Time | Forecasted start time of the journey. | DateTime |
| Audited Journey Departure Time | Real time the journey started. | DateTime |
| Journey Destination Location | Destination Location of the journey. | String |
| Planned Journey Destination Time | Planned time of arrival at destination. | DateTime |
| Forecasted Journey Arrival Time | Forecasted time of arrival at destination | DateTime |
| Audited Journey Arrival Time | Real time of arrival at destination. | DateTime |

**Table 13-3 CMS-1 "Container Journey" Data**

### 13.3.2 CMS-2 Container Contents

These are the details of the container contents. This can be used to inform whether dangerous goods are being transported.

#### 13.3.2.1 *Container Contents Properties*

| Interface CMS-2 Properties | |
|---|---|
| Interface ID | CMS-2 |
| Interface Title | Container Contents |
| Publisher | The CMS shall be able to publish the data in section 13.3.2.2 to the integration layer. |
| Publish Trigger | When Container Contents are assigned to a container journey the CMS shall publish “Container Contents” data to the Integration Layer<br><br>When any attributes within “Container Contents” change value, the CMS shall publish the “Container Contents” data to the Integration Layer |
| Expected Frequency | Dynamic<br><br>Approx. published 1 time per 24 hours per container. |
| Subscribers | TMS, S&C |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Container Contents” data related to a specified “Container Journey ID” |
| Persistence | The Integration Layer shall persist the published “Container Contents” data until the “Container Journey” has ended or the “Container Contents” data is overwritten for the same “Container Journey ID”. |
| Length of Validity | The Integration Layer shall identify the published “Container Contents” data as valid until the “Container Journey” has ended. |
| Historical Depth | The Integration Layer shall provide the last “Container Journey” data received when a read request is made. |

**Table 13-4 CMS-2 Container Contents Properties**

#### 13.3.2.2 *Container Contents Data*

| Container Contents | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Container Journey ID | ID for full journey related to a container. This may involve multiple journey legs using different modes of transport. | Alphanumeric |

| | | |
|---|---|---|
| Contents class | Class of contents | Alphanumeric |
| Contents Description | Description of contents | Alphanumeric |
| Weight | Weight of contents | UnitOfMeasurement: Alphanumeric |
| | | Value: Numeric |
| Dangerous Goods Flag | Flag to identify if contents are dangerous goods | True/False |
| Dangerous Goods Class | Class of dangerous goods | Alphanumeric |
| Dangerous Goods Explosive Flag | Flag to identify if explosive | True/False |
| Dangerous Goods Emergency Code | Emergency code related to dangerous goods | Alphanumeric |
| Additional Information | Additional Information can be required depending on port of destination or national customs requirements | Alphanumeric |

**Table 13-5 CMS-2 Container Contents Data**

### 13.3.3 CMS-3 Physical Container Details

This is the physical container details of the container. This can be used to understand the weight and size of each container.

#### 13.3.3.1 *Physical Container Details Properties*

| Interface CMS-3 Properties | |
|---|---|
| Interface ID | CMS-3 |
| Interface Title | Physical Container Details |
| Publisher | The CMS shall be able to publish the data in section 13.3.3.2 to the integration layer. |
| Publish Trigger | When “Physical Container Details” are assigned to a container journey the CMS shall publish the “Physical Container Details” data to the Integration Layer.<br><br>When any attributes within “Physical Container Details” change value, the CMS shall publish the “Physical Container Details” data to the Integration Layer |
| Expected Frequency | Dynamic<br><br>Approx. published 1 time per 24 hours per container. |

| | |
|---|---|
| Subscribers | TMS, S&C, ATO, DAS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Physical Container Details" data related to a specified "Container Journey ID" |
| Persistence | The Integration Layer shall persist the published "Physical Container Details" data until the "Container Journey" has ended or the "Physical Container Details" data is overwritten for the same "Container Journey ID". |
| Length of Validity | The Integration Layer shall identify the published "Physical Container Details" data as valid until the "Container Journey" has ended. |
| Historical Depth | The Integration Layer shall provide the last "Container Journey" data received when a read request is made. |

**Table 13-6 CMS-3 Physical Container Details Properties**

### 13.3.3.2 *Physical Container Details Data*

| Physical Container Details | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Container Journey ID | ID for full journey related to a container. This may involve multiple journey legs using different modes of transport. | Alphanumeric |
| Physical Container ID | ID of physical Container | Alphanumeric |
| Container Type | Code to identify container type | Alphanumeric Code |
| Container Length | Length of Container | UnitOfMeasurement: Alphanumeric |
| | | Value: Numeric |
| Container Height | Container Height | UnitOfMeasurement: Alphanumeric |
| | | Value: Numeric |
| Container Width | Container Width | UnitOfMeasurement: Alphanumeric |
| | | Value: Numeric |
| Unloaded Weight | Weight of the container when unloaded. | UnitOfMeasurement: |

| | | |
|---|---|---|
| | | Alphanumeric<br>Value: Numeric |
| Loaded Weight | Weight of the container when loaded. | UnitOfMeasurement: Alphanumeric<br>Value: Numeric |
| Additional Information | Additional Information can be required depending on port of destination or national customs requirements | Alphanumeric |

**Table 13-7 CMS-3 Physical Container Details Data**

### 13.3.4 CMS-4 Container Journey Leg

This is the data for each journey leg. This is used for each vehicle the container travels on. A specific transport ID such as a train service is assigned to each container leg. The Container Journey Leg Status could feed other processes that rely on confirmation of loading.

#### 13.3.4.1 *Container Journey Leg Properties*

| Interface CMS-4 Properties | |
|---|---|
| Interface ID | CMS-4 |
| Interface Title | Container Journey Leg |
| Publisher | The CMS shall be able to publish the data in section 13.3.4.2 to the integration layer. |
| Publish Trigger | When a “Container Journey Leg” is created, the CMS shall publish the “Container Journey Leg” data to the Integration Layer.<br><br>When the value of any “Container Journey Leg” attributes, except for “Forecasted Journey Leg Departure Time” and “Forecasted Journey Leg Arrival Time” change, CMS shall publish the “Container Journey Leg” data to the Integration Layer<br><br>When the value for “Forecasted Journey Leg Departure Time” or “Forecasted Journey Leg Arrival Time” change by 5 minutes or more, in comparison to the last published value for those attributes, the CMS shall publish the data in “Container Journey Leg” data to the Integration Layer |

| | |
|---|---|
| | If the Previously published value for "Forecasted Journey Leg Departure Time" or "Forecasted Journey Leg Arrival Time" is NULL, when any change to the value of these attributes occurs, the CMS shall publish the "Container Journey Leg" data to the Integration Layer |
| Expected Frequency | Dynamic<br><br>Approx. published 1 time per 5 minutes per container. |
| Subscribers | TMS, Stock&Crew, DAS, ATO |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Container Journey Leg" data related to a particular "Container Journey ID" or "Transport Operational ID" |
| Persistence | The Integration Layer shall persist the published "Container Journey Leg" data until the "Container Journey" has ended or the "Container Journey Leg" data is overwritten for the same "Container Journey ID". |
| Length of Validity | The Integration Layer shall identify the published "Container Journey Leg" data as valid until the "Container Journey" has ended. |
| Historical Depth | The Integration Layer shall provide the last "Container Journey" data received when a read request is made. |

**Table 13-8 CMS-4 Container Journey Leg Properties**

#### 13.3.4.2 *Container Journey Leg Data*

| Container Journey Leg | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Container Journey ID | ID for full journey related to a container. This may involve multiple journey legs using different modes of transport. | Alphanumeric |
| Container Journey Leg ID | ID of this container journey leg | Alphanumeric |
| Container Journey Leg Status | Status of the container journey leg | List [e.g. planned, in progress, cancelled, complete etc] |
| Journey Leg Origin Location | Location of the start of this journey leg e.g. depot name. | Alphanumeric |
| Planned Journey Leg Departure Time | Planned time for departure from the journey leg origin location. | DateTime |
| Forecasted Journey Leg Departure Time | Forecasted start time of the journey leg. | DateTime |

| | | |
|---|---|---|
| Audited Journey Leg Departure Time | Real time of departure from the journey leg origin location. | DateTime |
| Journey Leg Destination Location | Location of the End of this journey leg e.g. depot name. | Alphanumeric |
| Planned Journey Leg Arrival Time | Planned time for arrival from the journey leg origin location. | DateTime |
| Forecasted Journey Leg Arrival Time | Forecasted time of arrival at destination | DateTime |
| Audited Journey Leg Arrival Time | Real time of arrival from the journey leg origin location. | DateTime |
| Transportation mode | Mode of Transport, e.g. Train/Ship | List |
| Transport Operational ID | For Train this will be the Operational Train Identifier. | Alphanumeric |
| Loaded Location on transport vehicle | This is the location of the container on the loaded vehicle. | {Container Loaded Position} |

**Table 13-9 CMS-4 Container Journey Leg Data**

This table is the data used to locate the container on each vehicle.

| Container Loaded Position | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| ID of loaded location | ID of specific location container is loaded. i.e. Wagon ID for Freight Trains. | Alphanumeric |
| Container Position on loaded vehicle | Distance of container front of loaded location. | UnitOfMeasurement: Alphanumeric |
| | | Value: Numeric |

**Table 13-10 CMS-4 Container Loaded Position Data**

### 13.3.5 CMS-5 Request Schedule Modification

This is the data used by the CMS to request a modification to the plan of the transport service that is used for a particular “Container Journey Leg”. This is intended to request a delay to a service if there are problems related to containers being available when scheduled.

#### 13.3.5.1 *Request Schedule Modification Properties*

| Interface CMS-5 Properties | |
|---|---|
| Interface ID | CMS-5 |

| | |
|---|---|
| Interface Title | Request Schedule Modification |
| Publisher | The CMS shall be able to publish the data in section 13.3.5.2 to the integration layer. |
| Publish Trigger | When the CMS requires a schedule change for an “Operational Transport ID” assigned to a “Container Journey Leg” it shall publish the “Request Schedule Modification” data to the Integration Layer. |
| Expected Frequency | Dynamic<br><br>Approx. published 10 times per 24 hours per container. |
| Subscribers | TMS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Request Schedule Modification” data related to a particular “Transport Operational ID” |
| Persistence | The Integration Layer shall persist the published “Request Schedule Modification” data the “New requested time” is in the past. |
| Length of Validity | The Integration Layer shall identify the published “Request Schedule modification” data as valid until the “New requested time” is in the past. |
| Historical Depth | The Integration Layer shall provide the last “Container Journey” data received when a read request is made. |

**Table 13-11 CMS-5 Request Schedule Modification Properties**

#### 13.3.5.2 *Request Modification to Plan Data*

The data for this interface can be found in Chapter 8.2.2.2 “Modify Train” of “X2Rail-2 D6.1 System Requirement Specification (SRS) for the Integration Layer”[3]

## 13.4 Data Read or Subscribed by CMS system to Integration Layer

This is the data read or subscribed to by the Container Management System from the Integration Layer.

The diagram below shows the relationship between the tables in this section. Any “admitted values” surrounded in curly braces “{ }” is an instance of a different table in this chapter.

### 13.4.1 CMS-6 Train to Container Assignment

This is the data that assigns a transport ID to a particular “Container Journey Leg” and therefore to a specific container. This triggers many of the other data exchanges and is used by the CMS to identify which train service the “Container Journey Leg” will be assigned to.

#### 13.4.1.1 *Train to Container Assignment Properties*

| Interface CMS-6 Properties | |
|---|---|
| Interface ID | CMS-6 |
| Interface Title | Train Assignment |
| Publisher | The FRU system shall be able to publish the data in section 13.4.1.2 to the integration layer. |
| Publish Trigger | When a container is assigned to a train service, the FRU system shall publish the "Train to Container Assignment" data to the Integration Layer.<br><br>When a container assigned to a train service is unassigned to a train service, the FRU system shall publish the "Train to Container Assignment" data to the Integration Layer.<br><br>When a container currently assigned to a train service, is assigned to a different train service, the FRU system shall publish the "Train to Container Assignment" data to the Integration Layer. |
| Expected Frequency | Dynamic<br><br>Approx. published 1 time per 24 hours per container. |
| Subscribers | CMS, TMS, S&C |
| Filter | The Integration Layer shall provide the subscriber with the ability to read "Train to Container Assignment" data related to a particular "Transport Operational ID"<br><br>The Integration Layer shall provide the subscriber with the ability to read "Train to Container Assignment" data related to a particular "Container Journey Leg ID" |
| Persistence | The Integration Layer shall persist the published "Train to Container Assignment" data until the "Planned Unloading Location Arrival Time" is 24 hours in the past. |
| Length of Validity | The Integration Layer shall identify the published "Train to Container Assignment" data as valid until the "Planned Unloading Location Arrival Time" is 24 hours in the past. |
| Historical Depth | The Integration Layer shall provide the last "Container Journey" data received when a read request is made. |

**Table 13-12 CMS-6 Train to Container Assignment Properties**

#### 13.4.1.2 *Train to Container Assignment Data*

| Train Service ID assigned to Container | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| FRU Company | UIC Company Code for Freight Company | UIC Company Code |
| Operational Train Number | UK = Train ID<br>Mainland Europe = Operational Train Number | Alphanumeric |
| Operational Train Identifier | Further details used to identify the train service. | {TransportOperationalIdentifiers} |
| Loading Location | Location the container will be loaded onto the train service | Alphanumeric |
| Planned Loading Location Departure Time | Time the train will depart the loading location. | DateTime |
| Unloading Location | Location the container will be unloaded from the train service. | Alphanumeric |
| Planned Unloading Location Arrival Time | Time the train will arrive at the unloading location. | DateTime |
| Order ID/container journey Leg ID | | Alphanumeric |

**Table 13-13 CMS-6 Train to Container Assignment Data**

### 13.4.2 CMS-7 Actual Train Position

CMS will subscribe to updates of the actual train position of any train service that a "Container Journey Leg" is subscribed to. This will allow it to track the progress of the container.

#### 13.4.2.1 *Actual Train Position Properties*

| Interface CMS-7 Properties | |
|---|---|
| Interface ID | CMS-2 |
| Interface Title | Container Contents |
| Publisher | The TMS shall be able to publish the data in section 13.4.2.2 to the integration layer. |
| Publish Trigger | When Train Position Data is generated for Stations or Depots, TMS shall publish the "Actual Train Position" data to the integration layer. |

| | |
|---|---|
| Expected Frequency | Dynamic<br><br>Approx. published 2 times per 5 minutes per train. |
| Subscribers | CMS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Actual Train Position” data related to a particular “Transport Operational ID” |
| Persistence | The Integration Layer shall persist the published “Actual Train Position” data until the “Actual Time” is 24 hours in the past. |
| Length of Validity | The Integration Layer shall identify the published “Actual Train Position” data as valid until the “Actual Time” is 24 hours in the past. |
| Historical Depth | The Integration Layer shall provide the last “Container Journey” data received when a read request is made. |

**Table 13-14 CMS-7 Actual Train Position Properties**

### 13.4.2.2 *Actual Position of Train Data*

| Actual Position Update of Train | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Reporting IM | UIC code of reporting Infrastructure manager | Numeric |
| Operational Train Number | Train service number/headcode | Alphanumeric |
| Train Operational Identification | Further details used to identify the train service. | {TransportOperationalIdentifiers} |
| ReportingPointAbbr | Abbreviated form of Location that reporting time is relevant to. (e.g. operating point/control point) | Alphanumeric |
| ReportingPointLong | Long form of Location that reporting time is relevant to. (e.g. operating point/control point) | Alphanumeric |
| ActivityType | Description of activity/movement type at related locations. E.g. arrival, departure, pass-through. | Numeric Code |
| ActualTime | DateTime of the time the train reported at the location. | DateTime |

| | | |
|---|---|---|
| DeviationReason | Reason for deviation from targeted schedule. | Numeric Code |

**Table 13-15 CMS-7 Actual Position of Train Data**

### 13.4.3 CMS-8 Train Forecast

CMS will subscribe to the forecast of any train that is assigned to a container. This will allow it to provide a more accurate ETA for other systems, and stakeholders.

#### 13.4.3.1 *Train Forecast Properties*

| Interface CMS-8 Properties | |
|---|---|
| Interface ID | CMS-8 |
| Interface Title | Train Forecast |
| Publisher | The TMS shall be able to publish the data in section 13.4.3.2 to the Integration Layer. |
| Publish Trigger | When the value for “Forecast Time” for a Station or Depot is 5 or more minutes different from the previous published time, TMS shall publish the “Train Forecast” data to the Integration Layer. |
| Expected Frequency | Dynamic<br>Approx. published 30 times per 5 minutes per container. (i.e. if there are 30 stations in trip and all are 5 minutes late) |
| Subscribers | CMS |
| Filter | The Integration Layer shall provide the subscriber with the ability to read “Train Forecast” data related to a particular “Train Operational Identifier” and “Forecast Location Abbr”. |
| Persistence | The Integration Layer shall persist published “Train Forecast” data until “Actual Train Position” for the same location is received for the same “Train Operational Identifier”. |
| Length of Validity | The Integration Layer shall identify the “Train Forecast” data as valid until “Actual Train Position” for the same location is received for the same “Train Operational Identifier”. |
| Historical Depth | The Integration Layer shall provide the last “Container Journey” data received when a read request is made. |

**Table 13-16 CMS-8 Train Forecast Properties**

#### 13.4.3.2 *Train Forecast Data*

| Train Forecast | | |
|---|---|---|
| **Attribute** | **Attribute description** | **Admitted values** |
| Reporting IM | UIC code of reporting Infrastructure manager | Numeric |
| Operational Train Number | Train service number/headcode | Alphanumeric |
| Train Operational Identification | Further details used to identify the train service. | {TransportOperationalIdentifiers} |
| Forecast Location Abbr | Abbreviated form of Location that Forecast is relevant to. (e.g. operating point/control point) | Alphanumeric |
| Forecast location Long | Long form of Location that Forecast is relevant to. (e.g. operating point/control point) | Alphanumeric |
| Activity Type | Description of activity/movement type at related locations. E.g. arrival, departure, pass-through. | Numeric Code |
| Forecast Time | DateTime of the new forecast time | DateTime |
| Deviation Reason | Reason for deviation from targeted schedule. | Numeric Code |

**Table 13-17 CMS-8 Train Forecast Data**

# 14 Automated Mining Train Operation

## 14.1 Use Case summary

The use cases describe the life cycle of the automated operation of mining trains with moving block.

**Use Case ID (D7.1 18.1) Automated dispatch of an Available Train**

A train that is available for a Mission is assigned a mission by the TCC, based on the data provided by the CPS. The train then proceeds to the mission target location. The train is operated fully automatic, driverless and with moving blocks, managed by the TCC. In the path the train is checked for integrity; profile and derailment and weighed. When the train arrives at the target location it awaits further instruction to proceed with the mission or receive a new/follow on mission.

**Use Case ID (D7.2 5.3.20 – D7.1 18.2) Remote Controlled Train Loading**

A train moves to the correct starting location in a loading area and informs the operator that it is ready for remote control. The operator takes possession of the train for remote control. The operator drives the train remotely and loads the train as it moves. This is done until the train is fully loaded or the loading area runs out of bulk material. The operator confirms that loading is complete, putting the train back in automatic mode and ready for next mission.

**Use Case ID (D7.2 5.3.21 – D7.1 18.3) Automated Train unloading**

The train approaches a loading area. As the unloader takes over movement of the train, the AOS disengages traction and odometer and re-engages both when unloading is complete. The train then leaves the loading area, proceeds to predefined waiting point, and is ready for a new mission.

## 14.2 Interface Summary

The diagram below shows the direction of each interface described in this chapter. Interfaces with ".P" are the publish side and interfaces with ".S" are the subscribe side.

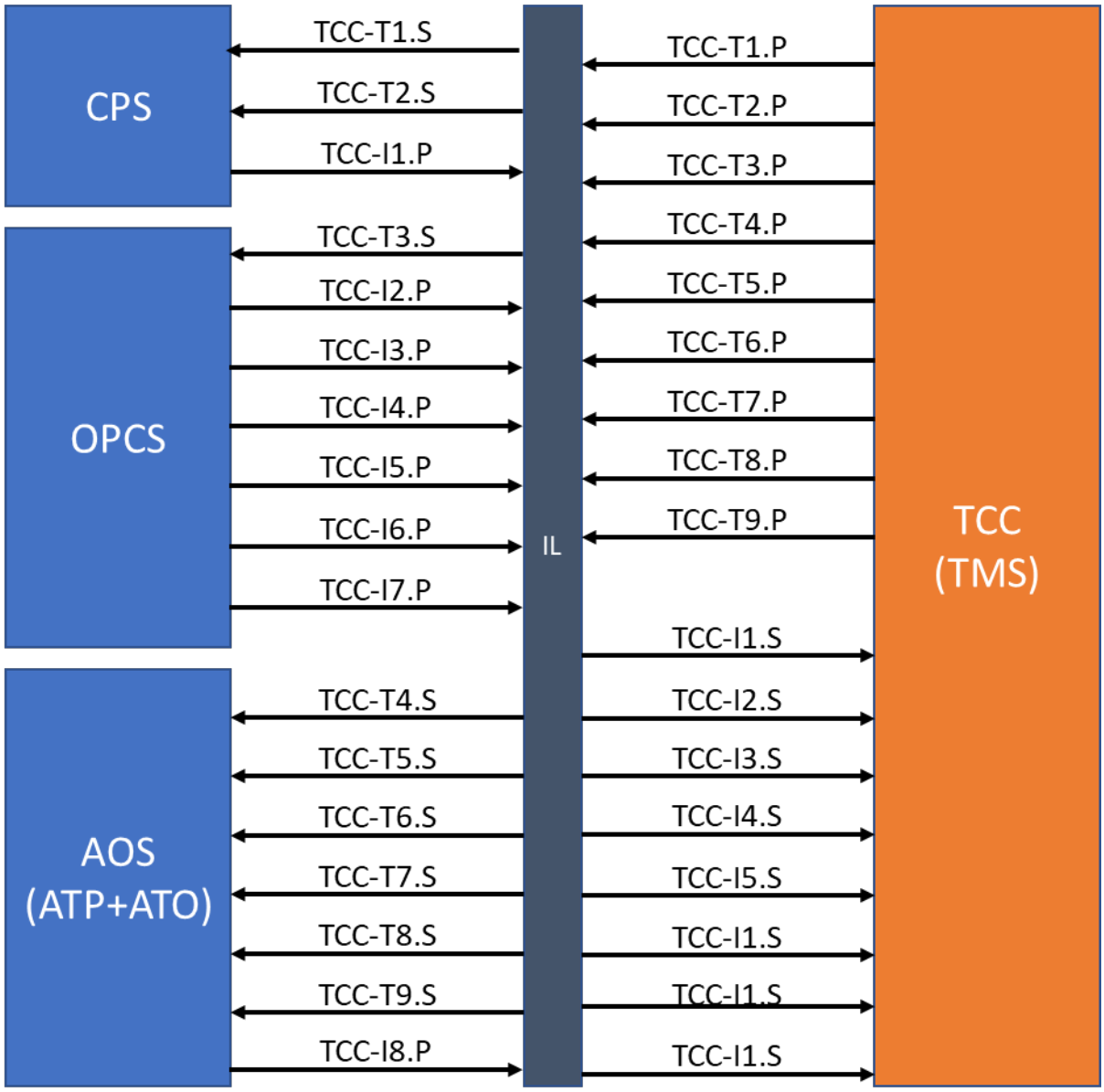


**Figure 14-1 - Interface Overview - Automated Mining Train Operation**

The table below shows a summary of the interface related to the container management system and the use case.

| Interface ID | Publisher | Subscriber | Interface Title | Interface Description | Data Description | Related Use Case Steps | Prototyped |
|---|---|---|---|---|---|---|---|
| TCC Publishing | | | | | | | |
| TCC-T1 | TCC | CPS | Loading-Unloading Status | Quantity loaded in each car, and if estimated or weighed. | 14.3.1 | BT_NEW:4, D7.2.5.3.20:8, D7.2.5.3.21:5 | Y |
| TCC-T2 | TCC | CPS | Loading Area in Use | If the loading area is in use by a train or not | 0 | D7.2.5.3.20:2, D7.2.5.3.20:8 | Y |
| TCC-T3 | TCC | OPCS | Mission Status | Which trains have a mission and which loading and unloading areas they are assigned. | 0 | BT_NEW:2,6, D7.2.5.3.20:3,8, D7.2.5.3.21:7 | Y |
| TCC-T4 | TCC | AOS | ATO Remote Control | Remote control command to train, with direction speed and when load is completed. | 0 | D7.2.5.3.20:4 | Y |
| TCC-T5 | TCC | AOS | Movement Authority | Where the train can move, including all data needed to do so. | 0 | BT_NEW, D7.2.5.3.20, D7.2.5.3.21 | Y |
| TCC-T6 | TCC | AOS | Position Report Request | Request for train position, as well as radio check | 0 | BT_NEW, D7.2.5.3.20, | Y |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | D7.2.5.3.21 | |
| TCC-T7 | TCC | AOS | Stop Train | Command to for train to stop as appropriate. Requires new MA to start. Used to change sent MA. | 0 | BT_NEW | Y |
| TCC-T8 | TCC | AOS | Emergency Alert | Request immediate stop of train. | 0 | BT_NEW, D7.2.5.3.20, D7.2.5.3.21 | Y |
| TCC-T9 | TCC | AOS | Revoke Emergency Alert | Command to revoke Emergency Alert | 0 | BT_NEW, D7.2.5.3.20, D7.2.5.3.21 | Y |
| TCC Subscribing | | | | | | | |
| TCC-I1 | CPS | TCC | Loading Area Data | Amount and quality of ore in loading area for mission assignment. | 14.4.1 | BT_NEW | Y |
| TCC-I2 | OPCS | TCC | Location Status | If loading or unloading area is available for mission and entry. | 0 | BT_NEW, D7.2.5.3.20, D7.2.5.3.21 | Y |
| TCC-I3 | OPCS | TCC | Desk in Control | Settings which desk is in control of which train during loading. | 0 | D7.2.5.3.20 | Y |
| TCC-I4 | OPCS | TCC | Movement Request | Set speed and direction of train. | 0 | D7.2.5.3.20:4 | Y |
| TCC-I5 | OPCS | TCC | Train Status | Request train speed. | 0 | D7.2.5.3.20:4-7 | Y |
| TCC-I6 | OPCS | TCC | Loading Finished | Flag that train can resume mission in | 0 | D7.2.5.3.20:8 | Y |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Automatic mode when loading is finished. | | | |
| TCC-I7 | OPCS | TCC | Load Profile | If the train has the correct profile or if there is things sticking out. | 0 | BT_NEW, D7.2.5.3.20 | Y |
| TCC-I8 | AOS | TCC | Position Report | Present position, speed and train status | 0 | BT_NEW, D7.2.5.3.20, D7.2.5.3.21 | Y |

**Table 14-1 Automated Mining Train Operation Interface Summary**

## 14.3 Data Published by TCC to Integration Layer

### 14.3.1 TCC-T1 Loading-Unloading Status

| Interface Properties | |
|---|---|
| Interface ID | TCC-T1 |
| Interface Title | Loading-Unloading Status |
| Publisher | TCC |
| Publish Trigger | Change in load status, i.e. loading, weighing or unloading is complete. |
| Expected Frequency | Dynamic - Depending on route length, and the number of trains. Every 10 minutes to 10 hours per train. |
| Subscribers | CPS |
| Filter | N/A |
| Persistence | 5 days |
| Length of Validity | Until train service is in the past. |
| Historical Depth | As defined in Persistence. |
| Safety-Related | N/A |

**Table 14-2 TCC-T1 Loading-Unloading Status Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| cycleNumber | Counter, set by IL | Integer |
| engineId | Engine Identity | String |
| CarId | Id of Carts | String |
| loadId | Loading Area Identity | String |
| quality | Product quality | String |
| unloadId | Unloading Area Identity | String |
| weight | Train weight | Integer |
| weighted | Estimated weight or not | Boolean |
| noCars | Number ore cars | Integer |
| date | Date time | Timestamp |

**Table 14-3 TCC-T1 Loading-Unloading Status Data**

### 14.3.2 TCC-T2 Loading Area in Use

| Interface Properties | |
|---|---|
| Interface ID | TCC-T2 |
| Interface Title | Loading Area in Use |
| Publisher | TCC |
| Publish Trigger | Loading commences and finishes |
| Expected Frequency | Dynamic – hourly to multiple time per hour |
| Subscriber | CPS |
| Filter | N/A |
| Persistence | Until updated. |

| | |
|---|---|
| Length of Validity | Until updated. Valid for approximately 1 hour after final update. |
| Historical Depth | Snapshot |
| Safety-Related | N/A |

**Table 14-4 TCC-T2 Loading Area in Use Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| loadId | Loading Area Identity | String |
| Status | Ore pass status (in use, not in use) | Boolean |

**Table 14-5 TCC-T2 Loading Area in Use Data**

### 14.3.3 TCC-T3 Mission Status

| Interface Properties | |
|---|---|
| Interface ID | TCC-T3 |
| Interface Title | Mission Status |
| Publisher | TCC |
| Publish Trigger | Start of mission |
| Expected Frequency | Dynamic – hourly to multiple times per hour |
| Subscriber | OPCS |
| Filter | N/A |
| Persistence | Until the end of mission |
| Length of Validity | Until the end of mission |
| Historical Depth | Snapshot |
| Safety-Related | N/A |

**Table 14-6 TCC-T3 Mission Status Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| LocationName | Name of the Location (Loading and Unloading) | Integer |
| TrainID | Locomotive Id | Integer |
| DeskInControl | 1 if operators desk allocated, otherwise 0 | Boolean |
| MissionStatus | Code for how the mission proceed | Integer |

**Table 14-7 TCC-T3 Mission Status Data**

### 14.3.4 TCC-T4 ATO Remote Control

| Interface Properties | |
|---|---|
| Interface ID | TCC-T4 |
| Interface Title | ATO Remote Control |
| Publisher | TCC |
| Publish Trigger | Movement Request or before time-limit for new speed order. |
| Expected Frequency | Dynamic – Multiple times per minute |

| | |
|---|---|
| Subscriber | AOS |
| Filter | None |
| Persistence | None |
| Length of Validity | *T_REMOTE - Defined time-limit for new speed order otherwise train stops* |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-8 TCC-T4 ATO Remote Control Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_MESSAGE_TYPE | 7 | Integer |
| V_SPEED | Requested speed (0 for stop) | Integer |
| T_REMOTE | Time-limit for new speed order otherwise train stops | Integer |
| B_DIRECTION | Direction of movement | Bitmap |
| [0..1] ATO_PROFILE_CONTROL | Profile control triggered or released | {ATO_PROFILE_CONTROL} |
| [0..1] LOAD_FINISHED | Indicates load process completion | {int : 15} |

**Table 14-9 TCC-T4 ATO Remote Control Data**

### 14.3.5 TCC-T5 Movement Authority

| Interface Properties | |
|---|---|
| Interface ID | TCC-T5 |
| Interface Title | Movement Authority |
| Publisher | TCC |
| Publish Trigger | New route/mission for train |
| Expected Frequency | Dynamic - multiple per hour |
| Subscriber | AOS |
| Filter | None |
| Persistence | Until end of Movement Authority, or as indicated in KEEP_TRACK_DATA |
| Length of Validity | Until end of Movement Authority, or until *Stop Train* or *Emergency Alert* is issued, or the train experiences an emergency. |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-10 TCC-T5 Movement Authority Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_MESSAGE_TYPE | 4 | Integer |
| T_VALID | Time out for the execution of MA | Integer |
| V_SPEED | Ceiling speed at the beginning of this MA. | Integer |
| G_GRADIENT | The gradient at the beginning of this MA. | Integer |

| | | |
|---|---|---|
| A_BRAKEABILITY | Deceleration capability | Integer |
| B_DIRECTION | Travel direction and train orientation | Bitmap |
| Q_ROUTE_TYPE | Type of route. | Integer |
| NID_TRACK | End of MA position, Track | Integer |
| D_POSITION | End of MA position, Distance | Integer |
| D_MA_MARGIN | The allowed margin for the vehicle to stop before the end of the MA. | Integer |
| [0..1] KEEP_TRACK_DATA | Do not delete any track data until on Location | {int : 25} |
| [0..1] LOCATION_DATA | Always present in a LocationEnd MA. May be present in normal MA, to inform of current destination | {LOCATION_DATA} |
| [0..1] ATO_STOP_POSITION | May be present in LocationEnd MA | {ATO_STOP_POSITION} |
| [0..1] PANTO_START_POSITION | Pantograph position to use from start. It can be present in an MA to an idling train or in other situations where an MA from scratch is sent. | {PANTO_START_POSITION} |
| [0..n] TRACK_DATA | One block for each new Track in this MA. If the direction has changed since the last MA: one block for every Track from the (new) rear end of the train. | { TRACK_DATA } |
| [0..n] BALISE_DATA | One block for each new balise | { BALISE_DATA } |
| [0..n] GRADIENT_DATA | One block for each new gradient change | { GRADIENT_DATA } |
| [0..n] CEILING_SPEED_DATA | One block for each new ceiling speed change | { CEILING_SPEED_DATA } |
| [0..n] ACOUSTIC_SIGNAL | One block for each new signal instruction | { ACOUSTIC_SIGNAL } |
| [0..n] PANTOGRAPH_SHIFT | One block for each new pantograph shift position | { PANTOGRAPH_SHIFT } |
| [0..n] TRACK_DATA_ITEM | Various track data items like free rolling, and odometer disabled | { TRACK_DATA_ITEM } |

**Table 14-11 TCC-T5 Movement Authority Data**

### 14.3.6 TCC-T6 Position Report Request

| Interface Properties | |
|---|---|
| Interface ID | TCC-T6 |
| Interface Title | Position Report Request |
| Publisher | TCC |
| Publish Trigger | Timer, regular updates required. |
| Expected Frequency | Dynamic – Every few seconds |
| Subscriber | AOS |
| Filter | None |
| Persistence | None |
| Length of Validity | Until replied or failed |

| | |
|---|---|
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-12 TCC-T6 Position Report Request Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_MESSAGE_TYPE | 1 | Integer |

**Table 14-13 TCC-T6 Position Report Request Data**

### 14.3.7 TCC-T7 Stop Train

| Interface Properties | |
|---|---|
| Interface ID | TCC-T7 |
| Interface Title | Stop Train |
| Publisher | TCC |
| Publish Trigger | Route change that requires change in *Movement Authority* Issued |
| Expected Frequency | Dynamic – Infrequent |
| Subscriber | AOS |
| Filter | None |
| Persistence | Validity |
| Length of Validity | Until new *Movement Authority* is issued. |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-14 TCC-T7 Stop Train Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_MESSAGE_TYPE | 8 | Integer |
| Q_STOP | Reason for stop | Integer |

**Table 14-15 TCC-T7 Stop Train Data**

### 14.3.8 TCC-T8 Emergency Alert

| Interface Properties | |
|---|---|
| Interface ID | TCC-T8 |
| Interface Title | Emergency Alert |
| Publisher | TCC |
| Publish Trigger | Any safety critical incident |
| Expected Frequency | Dynamic - Infrequent |
| Subscriber | AOS |
| Filter | None |
| Persistence | Validity |

| | |
|---|---|
| Length of Validity | Until *Revoke Emergency Alert* is sent |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-16 TCC-T8 Emergency Alert Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_MESSAGE_TYPE | 3 | Integer |
| Q_ALERT | Alert code | Integer |

**Table 14-17 TCC-T8 Emergency Alert Data**

### 14.3.9 TCC-T9 Revoke Emergency Alert

| Interface Properties | |
|---|---|
| Interface ID | TCC-T9 |
| Interface Title | Revoke Emergency Alert |
| Publisher | TCC |
| Publish Trigger | Emergency resolved |
| Expected Frequency | Dynamic - After Emergency Alert |
| Subscriber | AOS |
| Filter | None |
| Persistence | None |
| Length of Validity | None (as not persisted) |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-18 TCC-T9 Revoke Emergency Alert Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_MESSAGE_TYPE | 9 | Integer |

**Table 14-19 TCC-T9 Revoke Emergency Alert Data**

## 14.4 Data Read or Subscribed by TCC from the Integration Layer

### 14.4.1 TCC-I1 Loading Area Data

| Interface Properties | |
|---|---|
| Interface ID | TCC-I1 |
| Interface Title | Loading and Unloading Area Data |
| Publisher | CPS |
| Publish Trigger | Change in loading station level or quality |
| Expected Frequency | Dynamic, few times per hour. |
| Subscriber | TCC |

| | |
|---|---|
| Filter | N/A |
| Persistence | Until Area is no longer used. |
| Length of Validity | Until changed. Valid for approximately 1 hour after final update. |
| Historical Depth | Non- snapshot data. |
| Safety-Related | No |

**Table 14-20 TCC-I1 Loading Area Data Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| loadId | Loading Area Identity | String |
| quality | Product quality | String |
| level | Level in the loading area | Integer |

**Table 14-21 TCC-I1 Loading Area Data Data**

### 14.4.2 TCC-I2 Location Status

| Interface Properties | |
|---|---|
| Interface ID | TCC-I2 |
| Interface Title | Location Status |
| Publisher | OPCS |
| Publish Trigger | After inspection and other events such as cleaning, that make the area available or unavailable |
| Expected Frequency | Dynamic – Many times per hour. |
| Subscriber | TCC |
| Filter | None |
| Persistence | Until sequence number restarts |
| Length of Validity | Until new status is published |
| Historical Depth | See persistence |
| Safety-Related | Yes |

**Table 14-22 TCC-I2 Location Status Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| SeqNo | Sequence number | Integer |
| LocationName | Name of the Location | String |
| Status | Status of location if the train has access to proceed or not | Integer |
| Text | Text field for TCC log | String |

**Table 14-23 TCC-I2 Location Status Data**

### 14.4.3 TCC-I3 Desk In Control

| Interface Properties | |
|---|---|
| Interface ID | TCC-I3 |
| Interface Title | Desk in Control |

| | |
|---|---|
| Publisher | OPCS |
| Publish Trigger | Operator is informed of Train at the Loading area and takes control. |
| Expected Frequency | Dynamic – At least ones per loading unloading cycle. |
| Subscriber | TCC |
| Filter | None |
| Persistence | Until *Loading Finished* |
| Length of Validity | Valid as long as Customer operations centre (OPCS) is running. |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-24 TCC-I3 Desk In Control Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| TrainID | Locomotive unique ID | Integer |
| LocationName | Name of the Location | String |
| DeskID | The ID of the operator desk user | String |
| StatusCode | Return code to indicate if the request went through | Integer |

**Table 14-25 TCC-I3 Desk In Control Data**

### 14.4.4 TCC-I4 Movement Request

| Interface Properties | |
|---|---|
| Interface ID | TCC-I4 |
| Interface Title | Movement Request |
| Publisher | OPCS |
| Publish Trigger | Change to speed, or before time-out |
| Expected Frequency | Dynamic – Every few seconds |
| Subscriber | TCC |
| Filter | None |
| Persistence | Defined in *SpeedTimeout* |
| Length of Validity | Defined in *SpeedTimeout* (“In seconds, if no new request is sent before the train stops.”), or until new message |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-26 TCC-I4 Movement Request Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| TrainId | Locomotive unique ID | Integer |
| LocationName | Name of the Location | String |
| Speed | In % of maximum speed. Driving backward is indicated with | Integer |

| | | |
|---|---|---|
| | a minus (-) sign. 0 = stop. | |
| SpeedTimeout | In seconds, if no new request is sent before the train stops. | Integer |
| CarUnderShute | Returned by TCC, the number of the car under the shute. | Integer |
| StatusCode | Return code to indicate if the request went through | Integer |

**Table 14-27 TCC-I4 Movement Request Data**

### 14.4.5 TCC-I5 Train Status

| Interface Properties | |
|---|---|
| Interface ID | TCC-I5 |
| Interface Title | Train Status |
| Publisher | OPCS |
| Publish Trigger | OPCS needs updated train status |
| Expected Frequency | Dynamic – multiple times per minute |
| Subscriber | TCC |
| Filter | None |
| Persistence | Until replied |
| Length of Validity | Until next request |
| Historical Depth | For Validity period |
| Safety Related | Yes |

**Table 14-28 TCC-I5 Train Status Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| TrainID | Locomotive unique ID | Integer |
| LocationName | Name of the Location | String |
| CurrentSpeed | Train reported speed (1/10 km/h) returned by TCC | Integer |
| StatusCode | Return code to indicate train status | Integer |

**Table 14-29 TCC-I5 Train Status Data**

### 14.4.6 TCC-I6 Loading Finished

| Interface Properties | |
|---|---|
| Interface ID | TCC-I6 |
| Interface Title | Loading Finished |
| Publisher | OPCS |
| Publish Trigger | Operator presses Loading Finished button |
| Expected Frequency | Once per loading cycle, every few minutes |
| Subscriber | TCC |
| Filter | None |
| Persistence | Until replied |
| Length of Validity | Until replied |

| | |
|---|---|
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-30 TCC-I6 Loading Finished Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| TrainId | Locomotive unique ID | Integer |
| LocationName | Name of the Location | String |
| LoadedStatus | Load status of the train. | Integer |
| StatusCode | Return code to indicate train status | Integer |

**Table 14-31 TCC-I6 Loading Finished Data**

### 14.4.7 TCC-I7 Load Profile

| Interface Properties | |
|---|---|
| Interface ID | TCC-I7 |
| Interface Title | Load Profile |
| Publisher | OPCS |
| Publish Trigger | Load Profile check triggered |
| Expected Frequency | Dynamic – Infrequent |
| Subscriber | TCC |
| Filter | None |
| Persistence | Validity |
| Length of Validity | Until new message issued |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-32 TCC-I7 Load Profile Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| TrainId | Locomotive unique ID | Integer |
| LocationName | Name of the Location | String |
| LoadProfileStatus | Load Profile code. | Integer |

**Table 14-33 TCC-I7 Load Profile Data**

### 14.4.8 TCC-I8 Position Report

| Interface Properties | |
|---|---|
| Interface ID | TCC-I8 |
| Interface Title | Position Report |
| Publisher | AOS |
| Publish Trigger | Any communication from TCC |
| Expected | Dynamic – Every few seconds |

| | |
|---|---|
| Frequency | |
| Subscriber | TCC |
| Filter | Nonce |
| Persistence | Validity |
| Length of Validity | Until next Position Report Request or failure to thereof. |
| Historical Depth | None |
| Safety Related | Yes |

**Table 14-34 TCC-I8 Position Report Properties**

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_MESSAGE_TYPE | 132 | Integer |
| NID_TRACK | Position, Track | Integer |
| D_POSITION | Position of trailing end of the train. | Integer |
| B_DIRECTION | Travel direction and train orientation | Bitmap |
| V_SPEED | The velocity of the train in cm/s | Integer |
| B_TRAIN_STATUS | Status of the train as a bitmap. | Bitmap |
| D_WINDOW | Current position confidence interval | Integer |
| NID_TRACK | Current MA target, Track | Integer |
| D_POSITION | Current MA target, distance on Track. | Integer |
| Q_ATP_MODE | Current ATP mode | Integer |
| Q_ATO_MODE | Current ATO mode | Integer |

**Table 14-35 TCC-I8 Position Report Data**

## 14.5 Blocks for TCC and AOS

Blocks/Objects within the above data sets, marked with {} in type.

### 14.5.1 ACOUSTIC_SIGNAL

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 12 | Integer |
| NID_TRACK | Identification of Track | Integer |
| D_POSITION | Position of train front when signalling | Integer |
| Q_SIGNAL | Type of signal | Integer |

**Table 14-36 ACOUSTIC_SIGNAL Data**

### 14.5.2 ATO_PROFILE_CONTROL

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 13 | Integer |
| Q_PROFILE | Triggered or released | Integer |
| D_REVERSE | Maximum distance to move, if triggered | Integer |
| B_DIRECTION | Permitted movement direction, if triggered. | Bitmap |

**Table 14-37 ATO_PROFILE_CONTROL Data**

### 14.5.3 ATO_STOP_POSITION

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 11 | Integer |
| NID_TRACK | Identification of Track | Integer |
| D_POSITION | Position of train front when stopped | Integer |

**Table 14-38 ATO_STOP_POSITION Data**

### 14.5.4 BALISE_DATA

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 4 | Integer |
| NID_TRACK | Identification of Track | Integer |
| D_POSITION | Position of the balise | Integer |
| NID_BG | Identification of balise | Integer |

**Table 14-39 BALISE_DATA Data**

### 14.5.5 CEILING_SPEED_DATA

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 6 | Integer |
| NID_TRACK | Identification of Track | Integer |
| D_POSITION | Position of speed change. | Integer |
| V_SPEED | New ceiling speed cm/s (0.. 65535) | Integer |
| Q_TRAIN_END | If the ceiling speed-change is valid at the front or rear of the train. | Boolean |
| Q_SPEED | Reason for change in ceiling speed. | Integer |

**Table 14-40 CEILING_SPEED_DATA Data**

### 14.5.6 GRADIENT_DATA

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 5 | Integer |
| NID_TRACK | Identification of Track | Integer |
| D_POSITION | Position of gradient change | Integer |
| G_GRADIENT | Gradient. | Integer |

**Table 14-41 GRADIENT_DATA Data**

### 14.5.7 LOCATION_DATA

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 1 | Integer |
| TID_LOCATION | Location name | Integer |
| NID_LOCATION_TYPE | Location type | Integer |

**Table 14-42 LOCATION_DATA Data**

### 14.5.8 PANTOGRAPH_SHIFT

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 17 | Integer |
| NID_TRACK | Identification of Track | Integer |

| | | |
|---|---|---|
| D_POSITION | Position of pantograph change. | Integer |
| Q_PANTO_POSITION | Requested position of the pantograph, valid when traveling towards leg 1 on Track. | Integer |
| Q_SUPERVISION | Type of supervision, valid when traveling towards leg 1 on Track. | Integer |
| Q_PANTO_POSITION | Requested position of the pantograph, valid when traveling towards leg 0 on Track. | Integer |
| Q_SUPERVISION | Type of supervision, valid when traveling towards leg 0 on Track. | Integer |

**Table 14-43 PANTOGRAPH_SHIFT Data**

### 14.5.9 PANTO_START_POSITION

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 26 | Integer |
| Q_PANTO_POSITION | Wanted position of the pantograph | Integer |

**Table 14-44 PANTO_START_POSITION Data**

### 14.5.10 TRACK_DATA

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 3 | Integer |
| NID_TRACK | Identification of Track | Integer |
| D_POSITION | The distance at leg 0 | Integer |
| D_POSITION | The distance at leg 1 | Integer |
| B_DIRECTION | Travel direction and orientation. | Integer |
| NID_PREVIOUS_TRACK | Identification of previous Track. | Integer |

**Table 14-45 TRACK_DATA Data**

### 14.5.11 TRACK_DATA_ITEM

| Attribute | Attribute description | Admitted values |
|---|---|---|
| NID_BLOCK_TYPE | 22 | Integer |
| Q_TRACK_DATA_TYPE | Type of track data | Integer |
| NID_TRACK | Identification of Track | Integer |
| D_POSITION | Position of the item in Track | Integer |

**Table 14-46 TRACK_DATA_ITEM Data**

# 15 Conclusions

The aim of this report was to identify functional and non-functional requirements for freight related topics integrated into the Integration Layer. A wide spectrum of use cases covering interactions between TMS and Freight Management Systems have been explored to provide data structures for Freight related data Topics on an Integration Layer, as well as properties of those topics to aid the continuing development of the CDM. These have been built on top of the data structures gathered as part of the Deliverable 6.1 “System Requirement Specification (SRS) for the Integration Layer” from X2Rail2 [3].

This deliverable is intended as an input for Impact-2 Prototypes, and will provide the basis for carrying out the activities in FINE-2. It is recommended the data topics defined in this deliverable are taken further in both the FINE-2 and X2Rail-4 projects, utilising feedback from prototypes to assess any modifications or additions required. It is key that any amendments to the data structures of X2Rail2 D6.1 made in X2Rail-4 take this deliverable into consideration.

# 16 References

[1] D7.2 Use cases for advanced freight operations, Impact-2, grant agreement: 777513
[2] D8.4 Interface Control Document for Integration Layer Interfaces, external/Web interfaces and Dynamic Demand Service, In2Rail, grant agreement: 635900
[3] D6.1 System Requirement Specification (SRS) for the Integration Layer, X2Rail-2, grant agreement: 777465. Draft Version Dated 11.12.2019.
[4] D8.3 Description of Integration Layer and Constituents, In2Rail, grant agreement: 635900
[5] In2Smart European Project (shift2rail.org/project/in2smart/), GA ID: 730569.

# 17 Antitrust Statement

While some activities among competitors are both legal and beneficial to the industry, group activities of competitors are inherently suspect under the antitrust/ competition laws of the countries in which our companies do business.
Agreements between or among competitors need not be formal to raise questions under antitrust laws. They may include any kind of understanding, formal or informal, secretive or public, under which each of the participants can reasonably expect that another will follow a particular course of action or conduct. Each of the participants in this initiative is responsible for seeing that topics which may give an appearance of an agreement that would violate the antitrust laws are not discussed. It is the responsibility of each participant in the first instance to avoid raising improper subjects for discussion, notably such as those identified below.

It is the sole purpose of any meeting of this initiative to provide a forum for expression of various points of view on topics

- (i) that are strictly related to the purpose or the execution of the initiative,
- (ii) that need to be discussed among the participants of the initiative,
- (iii) that are duly mentioned in the agenda of this meeting and
- (iv) that are extensively described in the minutes of the meeting.

Participants are strongly encouraged to adhere to the agenda. Under no circumstances shall this meeting be used as a means for competing companies to reach any understanding, expressed or implied, which restricts or tends to restrict competition, or in any way impairs or tends to impair the ability of members to exercise independent business judgment regarding matters affecting competition.

As a general rule, participants may not exchange any information about any business secret of their respective companies. In particular, participants must avoid any agreement or exchange of information on topics on the following non-exhaustive list:

1. Prices, including calculation methodologies, surcharges, fees, rebates, conditions, freight rates, marketing terms, and pricing policies in general;
2. any kind of market allocation, such as the allocation of territories, routes, product markets, customers, suppliers, and tenders;
3. production planning; marketing or investment plans; capacities; levels of production or sales; customer base; customer relationships; margins; costs in general; product development; specific R&D projects;
4. standards setting (when its purpose is to limit the availability and selection of products, limit competition, restrict entry into an industry, inhibit innovation or inhibit the ability of competitors to compete);
5. codes of ethics administered in a way that could inhibit or restrict competition;
6. group boycotts;
7. validity of patents;
8. ongoing litigations.

# 18 APPENDIX A: Updated Use Cases

The following use cases are new, and therefore not included in Impact-2 Deliverable D7.2 [1], or are updated from use cases in D7.2.

## 18.1 Automated dispatch of an Available Train

This is a new use case, not previously included in Impact-2 D7.2 [1], to extend the related use cases (D7.2 5.3.20 and 5.3.21).

| | |
|---|---|
| Title | Automated dispatch of a train to loading, unloading or waiting location |
| Actors | AOS (ATO+ATP), TCC (incl. ATTM), |
| Output | Success: Train arrives at loading, unloading area<br>Minimal: Train arrives at waiting location |
| Input | Train ready for Mission |
| Description | |
| A train that is available for a Mission is assigned a mission by the TCC, based on the data provided by the CPS. The train then proceeds to the mission target location. The train is operated fully automatic, driverless and moving blocks, managed by the TCC. In the path the train is checked for integrity; profile and derailment and weighed. When the train arrives at the target location it awaits further instruction to proceed with the mission or receive a new/follow on mission. | |
| Flow | |
| 1. TCC/ATTM receives train ready for Mission<br>2. TCC/ATTM identifies where to send train (loading, unloading or waiting location) based on data CPS and calculates the route<br>3. TCC transmits MA to AOS on the train with all relevant parameters<br>4. Train proceeds within set parameters and reports location and speed<br>5. 2-4 repeats until the train reaches its destination<br>6. Train reaches destination<br>a. The train is handed over to loading/unloading area<br>b. The train arrives at the waiting area, stops and waits for new dispatch | |
| Alternate Flows | |
| 4.1 Integrity Check<br>a) Train passes Derailment Detector or Profile Check | |

b) Derailment Detector or Profile Check fails
c) TCC requests an immediate stop by an emergency alert from the AOS and informs the operator
d) AOS stops the train
e) The fault is checked and/or rectified
f) The Operator acknowledges the emergency alert and train proceeds from 2.

4.2 Weighing

a) The train passes a weighing bridge and each individual car is weighed

| Data Register (specific application data only) |
|---|
| OPCS →TCC<br>OpLevel<br>GroupStatus<br>LocationStatus<br>MissionStatus<br>LoadProfile<br>TCC →CPS<br>WeighedCarLoad<br>TCC → AOS<br>MovementAuthority<br>PositionReportRequest<br>AOS →TCC<br>PositionReport |
| **Result** |
| The entire operation is done fully automated, with moving blocks. There is no need for human intervention/cost, and the trains can run tighter together than with fixed blocks with more effective mission assignments. |
| **Related KPIs** |
| Higher throughout of Ore:<br>• Higher utilization of trains<br>• Higher utilization of loading and unloading areas<br>• Faster accommodation of changes i.e. blocked loading and unloading stations.<br>• Train density<br><br>Savings in cost of drivers:<br>• Less risk for drivers, as well as less hazard pay, therefore<br>• Time for a driver to get to a from trains<br><br>Savings in track equipment installation and maintenance |

## 18.2 Remote Controlled Train Loading

This is an updated version of use case "5.3.20 Movement Control in Train Dispatch Area" in Impact-2 D7.2 [1].

| | |
|---|---|
| Title | Train movement control in the loading area for bulk materials. |
| Actors | AOS, TCC, Loading Operator |
| Output | Success: All cars of the train are loaded, and the train is ready to start its train service<br>Minimal: Some or none of the cars of the train are loaded, and the train is ready to be assigned a new Loading Area. |
| Input | Train with empty cars assigned to the Loading Area for loading, the train route has reached the Loading Areas border. |
| Description | |
| A train moves to the correct starting location in a loading area and informs the operator that it is ready for remote control. The operator takes possession of the train for remote control. The operator drives the train remotely and loads the train as it moves. This is done until the train is fully loaded or the loading area runs out of bulk material. The operator confirms that loading is complete, putting the train back in automatic mode and ready for next mission. | |
| Flow | |
| 1. Train Loading Operator is informed of the train at the Loading Area border and inspects the Train Loading Area for readiness<br>2. TCC Extend the train route into the Train Loading Area allowing the train to move to a position with the first empty car under the shaft.<br>3. Train moves to the stopping point.<br>4. Loading Operator takes control of the train, sets train speed, which TCC sends to ATO<br>5. ATO moves train at the set speed.<br>6. Loading Operator operates the chute, so the cars are loaded<br>7. 6 is repeated until the last car is loaded, or the chute runs out of ore<br>8. Loading Operator confirms the train is loaded and ready for Mission. | |

| Data Register (specific application data only) |
|---|
| OPCS→TCC<br>MissionStatus<br>GroupStatus<br>LocationStatus<br>DeskInControl<br>MovementRequest<br>LoadingFinished<br>TCC → CPS<br>PreliminaryCarLoad<br>SetOrePassStatus<br>TCC →AOS<br>MovementAuthority<br>ATORemoteControl<br>PositionReportRequest<br>AOS →TCC<br>PositionReport |
| **Result** |
| The entire process is managed remotely by a single operator, that is immediately available for the next loading station. |
| **Related KPIs** |
| Savings in cost of drivers:<br>• Less risk for drivers, as well as less hazard pay consequently<br>• Time for a driver to get to a from trains |

## 18.3 Automated Train Unloading

This is an updated version of use case "5.3.21 Movement control in unloading area (Car Dumper)" in Impact-2 D7.2 [1].

| | |
|---|---|
| Title | Movement control of the train driving through an Unloading Area |
| Actors | AOS, TCC |
| Output | All cars of the train consist will be unloaded and the train is ready for a new Mission. |
| Input | Fully or partially loaded assigned to the unloading area. The train route has reached the unloading area border. |

| Description |
|---|
| The train approaches a loading area. As the unloader takes over movement of the train, the AOS disengages traction and odometer and re-engages both when unloading is complete. The train then leaves the loading area, proceeds to predefined waiting point, and is ready for a new mission. |
| **Flow** |
| 1. TCC Extend the train route into the unloading area to the commence unloading position.<br>2. Train moves to the commence unloading position.<br>3. TCC requests free-roll from AOS<br>4. Unloading commences until the train is unloaded.<br>5. ATO to disengages free-roll.<br>6. TCC sends the train to holding point and sets train for new Mission |
| **Data Register (specific application data only)** |
| OPCS → TCC<br>GroupStatus<br>LocationStatus<br>MissionStatus<br>TrainStatus<br>TCC → CPS<br>UnloadEvent<br>TCC →AOS<br>MovementAuthority<br>PositionReportRequest<br>AOS →TCC<br>PositionReport |
| **Result** |
| Completely automated unloading. |
| **Related KPIs** |
| Savings in cost of drivers:<br>• Less risk for drivers, as well as less hazard pay consequently<br>• Time for a driver to get to a from trains |