ERJU SYSTEM PILLAR

T3-SystemDefinition

CMS & TMS System Definition

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Abstract	The document focuses mainly on the system boundaries for CMS and TMS, overview of the interactions with different layers, links to functional requirements and operational processes
Config Item	System Definition
Document ID	30 Deliverables/TMS-SYDEF-ES-007_00#714359 T3-SystemDefinition
Classification	Public
Status	Open
Version	1.0
Revision	714359
Last Change Date	24.09.2025
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INFO: History table is not displayed, because this document is in status **doc_open**.
RULE: History table is not displayed, in statuses: { draft doc_open doc_inprogress doc_contentApproval doc_contentDecision }
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1 History of Changes

Nr.	Changes	Leaders/Authors
0.1	Initial draft - System Description	Matthias Krista, Raghda Mohamed
	Comments	Marcus Völker
0.2	Initial draft - System Interfaces	Raghda Mohamed
	Comments	Marcus Völcker, Matthias Krista
0.3	Initial draft - System Interfaces addition	Raghda Mohamed
	Comments	Marcus Völcker, Matthias Krista
0.4	Initial draft - System Requirements	Raghda Mohamed
	Comments	Marcus Völcker, Matthias Krista
0.5	Initial Draft - Finalise System Interfaces	Raghda Mohamed, Simona Di Loreto
0.6	Draft for Internal Review (DLs)	Matthias Krista, Raghda Mohamed
	Review	Marco Nanni, Marcus Völcker
0.7	Draft for Internal Review (Contributors)	Marcus Völcker, Matthias Krista, Raghda Mohamed
	Review	Simona Di Loreto, Patrick Konix
0.8	First Delivery Version	Raghda Mohamed confirmed by Marco Nanni and Marcus Völcker
0.9	• Comments MG Review • Removed occurrences of type "Reference" for those WI where this type was misused according to the Reference Usage Guideline published by EET team.	Matthias Krista, Sebastian Uhlich Marco Nanni

2 System Definition Capacity and Traffic Management Systems (CMS & TMS)

This document is the CMS & TMS system definition. The structure of the document follows in principle the structure given by EN 50126 for system definitions. Not all chapters required by EN 50126 are filled currently. The current version is focusing on the functional description of the CMS & TMS. Further chapters are added when needed and agreed by the steering board. **[**SPT3TMS-10073 **]**

3 System Objectives (intended purpose) And Its Mission Profile

System objectives can be found here System Objective, chapter 3.

4 System Boundary

CMS & TMS interact with various systems, and users fulfilling different tasks. Some of the interactions deal with CMS & TMS as a black box, when CMS & TMS just perform actions that do not require an in-detail description. Other interactions deal with them as a white box, where CMS & TMS components are mentioned in detail along with their performed actions. Some scenarios contain only interaction between systems, or where human factor is insignificant, and hence they are considered as interactions with technical systems, while others are triggered or done by humans, and hence belong to the “interactions with humans” sections as classified below. **[**SPT3TMS-10076 **]**

4.1 Interaction With Technical Systems

A Messaging Module will enable communication between all national and central systems of the Digital Capacity Management (DCM) enabling interfaces between systems and access to central databases. Such interfaces can be built and used by all stakeholders. In addition to technical interfaces accessibility via web applications will be ensured to secure easy access for all stakeholders. The Railway Infrastructure System (RIS) will be the main database to provide common infrastructure data for all DCM systems. **[**SPT3TMS-10078 **]**

With central and national IT implemented and synchronised, communication between the systems must be established. For that purpose, interfaces between the systems shall be established based on common standards, i.e., TAF/TAP TSI via a Common Interface (CI). The communicated items are structured in messages (for example PathRequestMessage). This approach will allow stakeholders to reach a higher level of automated communication between systems and further enhance the quality and speed of processes and products. For the sector, namely Applicants, this would also mean that machine-to-machine communication is happening in the same standard TAF/TAP TSI via CI (ROC-to-RIM or ROC-to-DCM) **[**SPT3TMS-10079 **]**

All communication between systems will follow the mandatory standards of TAF and TAP TSI. **[**SPT3TMS-10080 **]**

The federated approach implies a complex system of interfaces, that will be generally mentioned in this document, and further specified in more technical ones.

4.1.1 Interfaces within Central Systems

Central systems shall be connected, as specified above, through interfaces, namely a messaging module. The systems (European Capacity Management Tool (ECMT), Temporary Capacity Restriction (TCR) and Path Coordination System (PCS-CB)) will all rely on the same topology (RIS) and will be able to exchange data through messages (TSI compliant). The following list, shows some of the needs that will be met (not exhaustive): **[**SPT3TMS-10082 **]**

- The TCR tool data shall be synchronised on a daily base and sent to the ECMT so that the ECMT database of available capacity is always up-to-date
- ECMT tool outputs shall be sent to PCS-CB through the messaging module so that the capacity offer in the form of Capacity Supply is available for booking.
- Any actions taken through the PCS-CB (allocation, cancellation, optimisation, modification, or alteration of paths) must be sent back through the messaging module to ECMT in order to keep the Capacity Supply updated.

[SPT3TMS-10083 **]**

4.1.1.1 Interfaces Between Central System and RIMs/Allocation Bodies (ABs) National Systems

National and Central systems must be connected, through interfaces, preferably through the Common Interface (CI). National RIMs/ABs can choose (also temporarily) other ways to provide data to central systems, for example via GUI and upload wizard, if so available, although the final goal is to automate the entire process and have it fully TSI compliant. The following list, shows some of the needs that will be met (not exhaustive): **[**SPT3TMS-10085 **]**

- RIMs provide data to ECMT in order to create capacity model, and lately capacity supply. The interface is both in and outbound as the ECMT is also expected to identify possible mismatches between neighbouring networks and therefore corrections might be needed
- RIMs provide data to the TCR tool. Also in this case, the interface is both in and outbound in order to allow the coordination capability of the TCR tool
- The national booking system and PCS-CB are continuously exchanging data as the actual allocation of paths is a responsibility of the RIMs/ABs and therefore, wherever the Applicant chooses to place its request and wherever the requests is processed, the two (or more) systems have to communicate continuously.

[SPT3TMS-10086 **]**

4.1.2 Interfaces Between RIMs/Allocation Bodies (ABs) National Systems

There will not be a “proper” interface between RIMs/ABs national systems. They will communicate through the Common Interface (inbound/outbound, TSI compliant) **[**SPT3TMS-10088 **]**

4.1.3 Interfaces Outside The DCM/CMS Tools

The DCM IT landscape is meant to support the capabilities of the CMS. However, the outputs of the CMS process impact on other processes and therefore interfaces with these processes will have to be built, namely: **[**SPT3TMS-10090 **]**

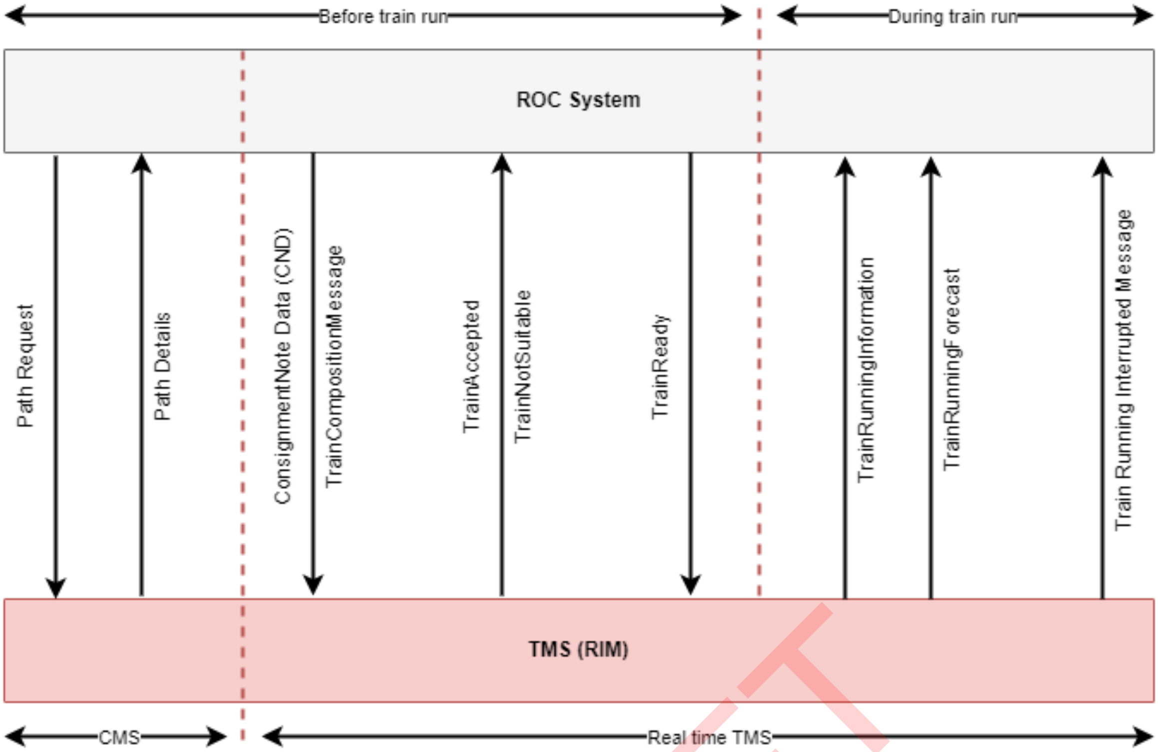
Interfaces with systems supporting TMS and incident management: these interfaces must be as automatic as possible, TSI compliant and both inbound/outbound (the situation of traffic, in case of incidents, might impact on the decision-making of capacity allocation on the short term) **[**SPT3TMS-10091 **]**

Interfaces with billing systems: once a path is proposed, a contract must be signed according to most of the national legislation, therefore, data concerning allocation of paths should be transmitted to the sales department of national RIMs/ABs. Also, in case of cancellation or modification of paths, depending on the valid commercial conditions can have an impact on the final price the ROC has to pay; therefore, also these data needs to be communicated in an automatic, simplified way to the national RIMs/ABs billing system.
[SPT3TMS-10092 **]**

4.1.4 Interfaces Between CMS & TMS and Network Layer

CMS & TMS shall communicate with Network layer via TAF / TAP TSI. A brief description on the interface can be found here: CMS & TMS TSI Related Topics .

Below is the description of the messages along with their direction.

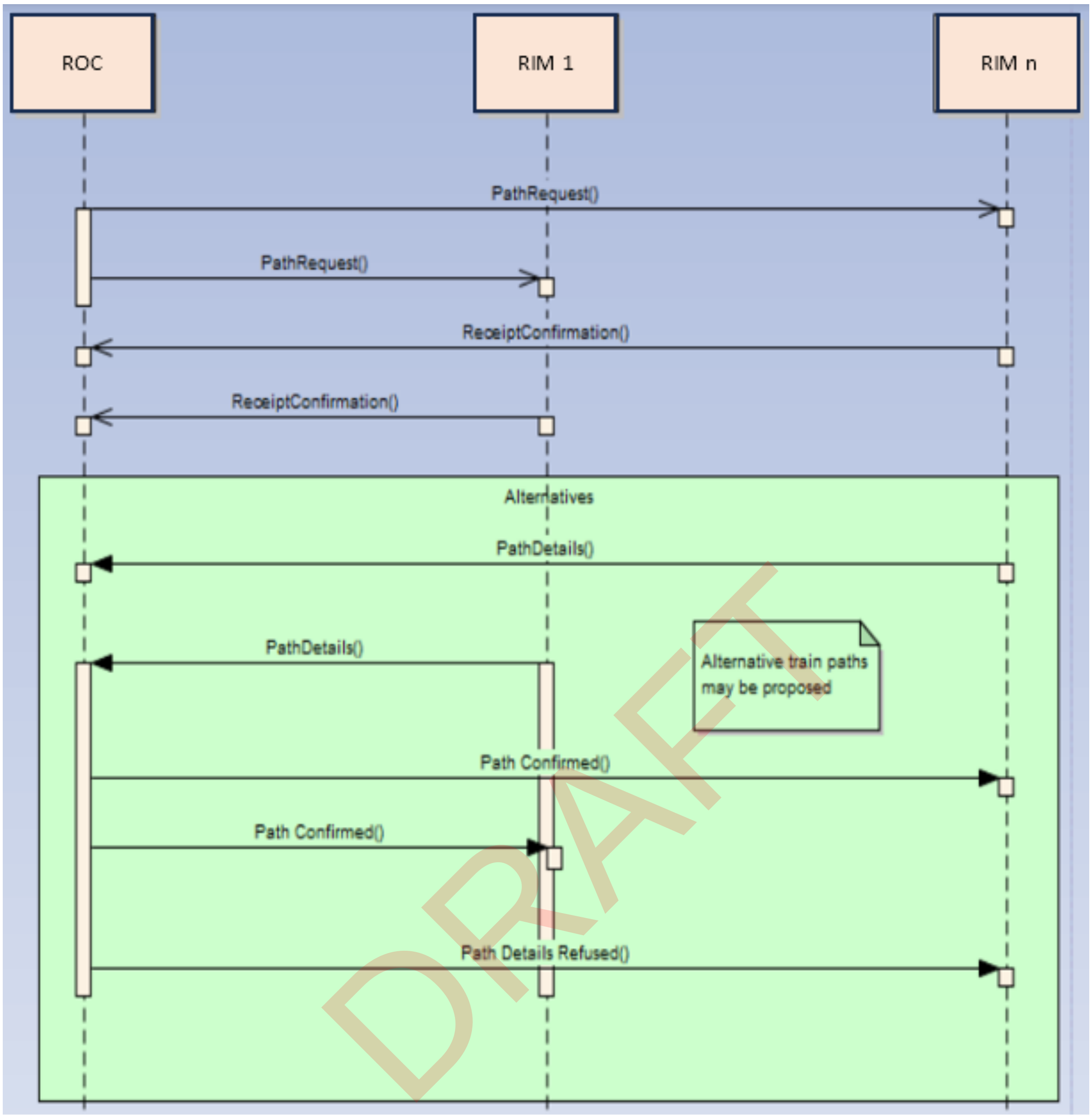


[SPT3TMS-10094 **]**

Figure 1 Interfaces between CMS & TMS & Network Layer

4.1.4.1 Path Request

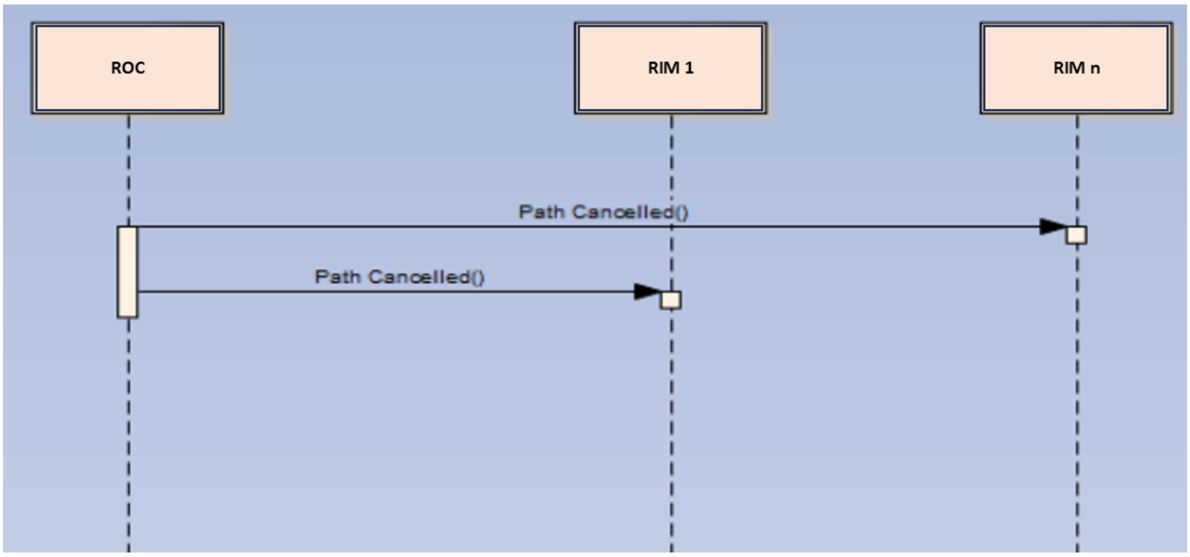
This request is the beginning of capacity ordering. The ROC sends train path request to the relevant RIMs. A path request is sent from the ROC planning system to the RIM planning system. It receives a Path Request Number used to retrieve the answer or to modify the request. The RIMs send the receipt confirmation to the ROC, if the required response cannot be made available in real-time. During planning phase with national systems, the existing Path Request Number (or the existing Dossier Number) is used by RIMs and ROCs to link path request(s) and answer(s). Agreed Train Number can also be used. Each RIM sends to the requested ROC the path details for its section, ROC then either confirms the path details with the concerned RIM or rejects it and request a new one as shown in **Figure 2**. **[**SPT3TMS-10096 **]**



[SPT3TMS-10097 **]**

Figure 2 Path Request sequence diagram

In some cases, the path is not accepted and then the ROC needs to cancel the request as shown in **Figure 3** below. Every involved RIM which is part of the planned train path must be informed via message, that part or all the capacity is cancelled by the ROC and is available again. The RIM shall not react. **[**SPT3TMS-10098 **]**

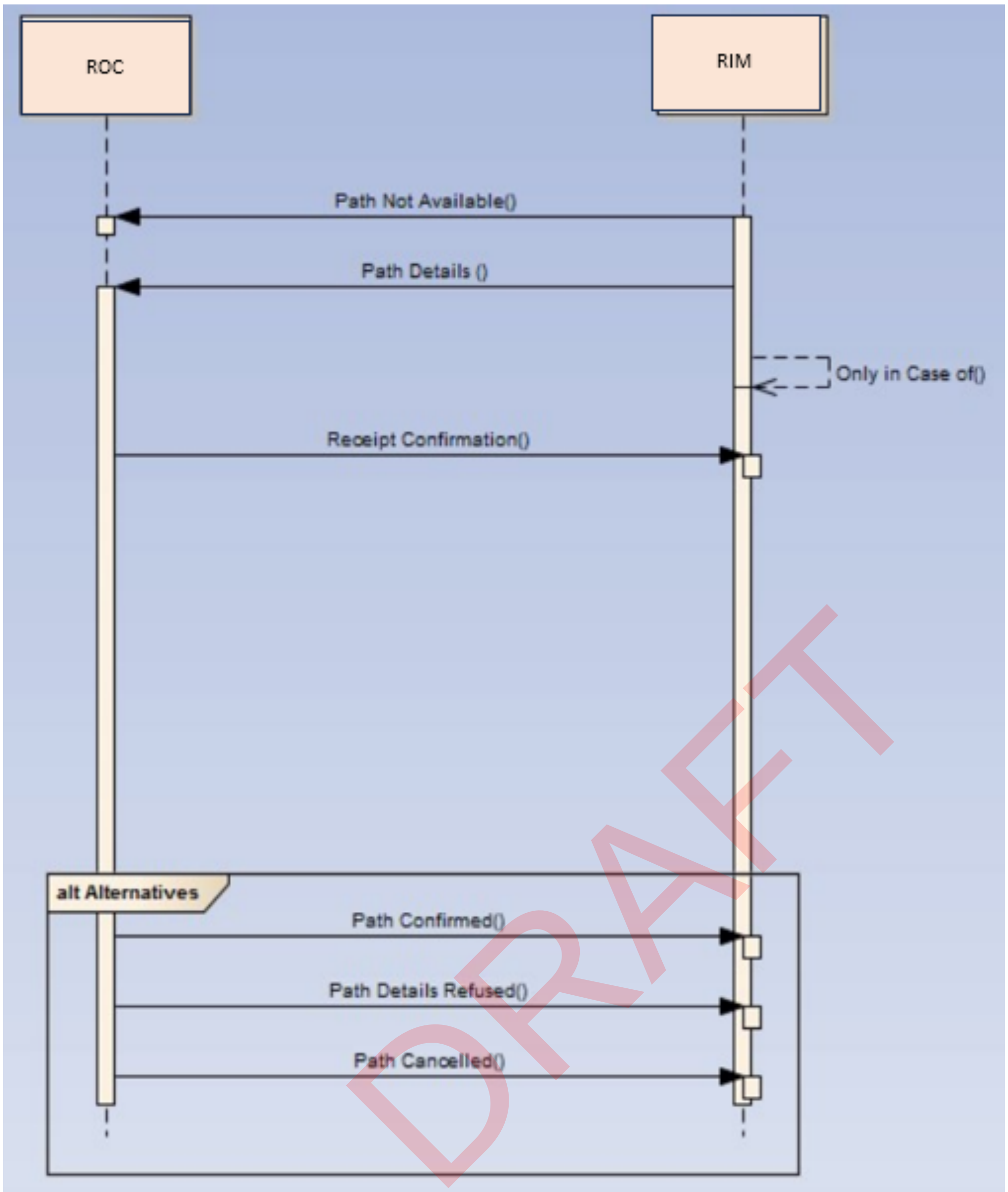


[SPT3TMS-10099 **]**

Figure 3 Path cancellation sequence diagram

4.1.4.2 Path Details

Where a path request for traffic (either passenger or freight) running across one or more networks is placed in sufficient time ahead of the operation, the RIMs will be able to deliver full harmonisation for the path details for all of the sections that comprise the whole journey. Full harmonisation is when the complete journey for the traffic, covering all of the respective path sections, has been able to be fully validated by the RIMs involved and all times are confirmed, especially those where the train changes from one RIM to another. As shown in **Figure 4**. **[**SPT3TMS-10101 **]**



[SPT3TMS-10102 **]**

Figure 4 Path not available sequence diagram

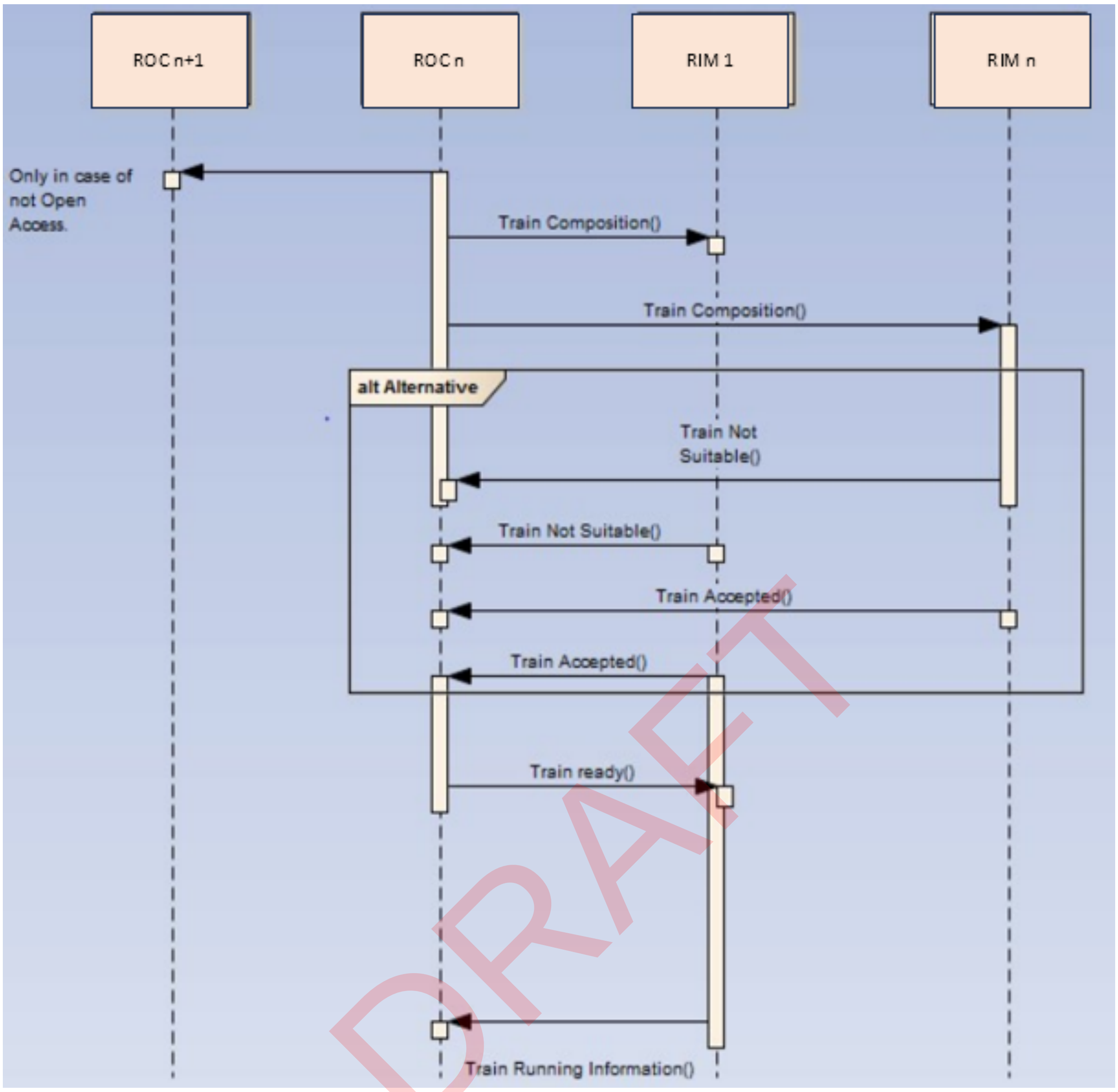
4.1.4.3 Consignment Note Data

For freight services, ROC sends RIM information on all hazardous materials onboard, present in every wagon. The purpose of this message is to store or update information on hazardous materials and make it accessible to all stakeholders. The message must contain information on the train like journey details, goods information like type of hazardous materials, and acceptance of the carrier. **[**SPT3TMS-10104 **]**

4.1.4.4 Train Composition Message

ROC sends the train composition message to all relevant RIMs, with which the ROC has a path contract for a journey section of the path if IM contractually requires receiving train composition message. Whenever there is a change in the composition during the journey of a train, the ROC responsible has to update this message to all parties involved. **[**SPT3TMS-10106 **]**

Figure 5 shows the messages flow for a train preparation sequence along with the involved entities.



[SPT3TMS-10107 **]**

Figure 5 Train preparation sequence diagram

Remark: During the train preparation also a Train Path Not Available message can occur, since this message can be sent at any time between the moment the train path is contracted and the departure of the train. This is not included in this diagram.

4.1.4.5 Train Accepted

After the receipt of the train composition the RIM may verify the entries against the contracted path if the contract between RIM and ROC explicitly allows this. Depending on the contractual agreement between the RIM and the ROC and on regulatory requirements, the RIM may also advise the ROC if the train composition is acceptable for the booked path. This is affected with the optional Train Accepted message. If the train is not suitable for the previously agreed path, the RIM may inform the ROC, with the optional Train Not Suitable message. In this case the ROC must recheck the train composition. **[**SPT3TMS-10109 **]**

4.1.4.6 Train Not Suitable

This message is optional and exclusive for freight services. RIM first verifies the train composition message entries against the contracted path, RIM sends it back to the ROC indicating that the train composition provided in the previous message is not suitable for the previously agreed path. This message is considered as a response to the message sent providing the train composition.((European Railway Agency, TAF-TSI Master Plan, 2013, S. 23)) [SPT3TMS-10111]

4.1.4.7 Train Ready

The ROC must conduct some protocols to be able to complete the process. The ROC must define the checks and tests to ensure that any departure is undertaken safely (e.g., doors, load, brakes), then the ROC informs the RIM when a train is ready for access to the network according to TSI standards. Eventually, the ROC must inform the RIM of any anomaly affecting the train or its operation having possible repercussions on the train's running prior to departure and during the journey.((European Railway Agency, TAP TSI ANNEX B.56 RU/IM COMMUNICATION APPLICATION GUIDE, 2013, S. 105)) The message is sent through GSM medium as proposed by TSI. [SPT3TMS-10113]

4.1.4.8 Train Running Information

RIMs must provide information whenever a train arrives at, departs from, or pass through a reporting point. The relevant train information is shared by the RIM to the ROCs so the ROCs can share it with the ROC controllers, but not the drivers, and also between the different RIMs included in a train journey. Whenever a train passes between multiple RIMs areas of control, the first RIM must handover the data to the succeeding one until the train arrives at its final destination.((European Railway Agency, TAF-TSI Master Plan, 2013, S. 27)) The time limit to send the message after the train has reached the reporting point is defined by national rules or contractual agreement. In practice, the sending is done in "real time" in case of electronic tracking and tracing systems, the time limit must be agreed in case of manual input in the IT system((European Railway Agency, TAP TSI ANNEX B.56 RU/IM COMMUNICATION APPLICATION GUIDE, 2013, S. 110)). [SPT3TMS-10115]

4.1.4.9 Train Running Forecast

The RIM in charge is responsible for sending all the related forecast calculations of a specific train to the ROC who booked the path. In case of handover, the information must be shared with the new RIM or ROC taking over. [SPT3TMS-10117]

4.1.4.10 Train Running Interrupted Message

RIM sends this message to the concerned ROC, or to the next RIM in case the train path is interrupted. This message is sent only for those trains that are directly interrupted by any disruption factor and for which a further run cannot be forecasted. This message is only sent on special cases and is not required for normal trains without disruption. If the disruption happens at a location that was not registered in the reference file, will be allocated to the next known location in the reference file. The exact location where the disruption happened may be specified as well but only using the free text field. A decision then must be made and agreed between RIM and ROC to either delay, cancel or reroute the train. [SPT3TMS-10121]

4.1.4.11 Delay Justification

This information was originally included in the Train Running Information Message, but as this message is sent in real time when the cause of the delay is usually not yet known at the time of transmission. Therefore, a separate message was proposed as it is already practice according UIC leaflet 407-1. This message is issued by the RIM to the contracted ROC as soon as reasonably possible to provide the cause of an additional delay in a train's journey. In one message only one delay event in a specific reporting point and only one delay cause should be reported. Messages should be sent at the moment when the code for a delay is specified and always when the code is changed. If the national system codes the delay automatically at the moment it happens with the default code, e.g., 00, this should not be sent. Only the codes consistent with the coding in the new UIC Leaflet 450-2 should be reported. In this message every delay should be reported - not only those happening at the reporting location. Delays occurring at points not included in reference file will be shifted to the next reference file point. In case the cause of the delay is changed (but the delay duration stays the same), the updated message with the new delay code and status alteration will be sent. In case the original delay time is changed (e.g., split of delay into more causes) the deletion of original message must be sent and new messages with the new codes must be sent. **[**SPT3TMS-10123 **]**

This message is issued following receipt of an enquiry about the train delay performance. It delivers a report of all the actual delta t values concerning a specified train at all reporting points within network of particular RIM and causes of all additional delays. There are two main parts in the message: **[**SPT3TMS-10124 **]**

1. Train Location report – consisting of the list of all the actual delta t values in all reporting stations (Handover, Interchange, Handling and Reporting points).
2. Delay event report – consisting of the list of all the delay events (additional delays). If no delay is recorded this report does not have to be made. In this report every additional delay should be reported – not only those happening at the reporting location but also those occurring at points not included in the reference files. Additional delays occurring at points not included in reference files will be shifted to the next reference file point. All the delay causes should be reported. If the national system codes the additional delay automatically at the moment it happens with the default code, e.g., 00, or if the code 00 is used to specify that the cause is not known, these cases should not be reported. Only the codes consistent with the coding in the new UIC Leaflet 450-2 should be reported.

[SPT3TMS-10125 **]**

4.1.5 Interfaces Between CMS & TMS and Routing Layer

The detailed description of the interface between CMS & TMS and the routing layer can be found here: Concept Interface CMS_TMS & CCS

4.2 Interactions with Humans

Below are the scenarios that involve human interaction. These interactions are either triggered by human being or involved decision making by humans. The interactions are divided into interactions with CMS and with TMS. **[**SPT3TMS-10128 **]**

4.2.1 CMS

4.2.1.1 Planning a Train Path

The use case aims to provide a plan for a train path. The ROC requests the train path plan from the Capacity Planner. The ROC can provide a detailed request, otherwise the CMS will place default parameters for the calculations and processing. The Sectional Run Time Calculator then details the train's schedule along with the specified itinerary according to the simulated dynamic behaviour of the rolling stock on the tracks. The calculation only considers the specified train's features and installations excluding other trains scheduling or movements. The Timetable Conflict Detection then details the expected performance of the other trains on the same line, the target timetable of the previous trains along with the specified train. After that The Capacity Management looks for possible conflicts based on the planned results either between the timetables or due to infrastructure dependencies. If there is a conflict, the capacity management communicates it to the rejects the request and informs the ROC with the results and reasons. If not, the Capacity Planner accepts the request, informs the ROC with the new path, and updates other systems like TMS , Passenger Information System and Automatic Route Setting.((Shift2Rail

& X2RAIL-2, X2R2-D63-Use Cases: Deliverable D6.3 Description of Use-Cases for new TMS Principles, 2020, S. 21)). **[**SPT3TMS-10131 **]**

4.2.1.2 Modify Train Path

The use case aims to provide a modified plan to a train path. The ROC requests a modification to the train path plan from the Capacity Planner.. The Capacity Planner requests an analysis from the Sectional Run Time Calculator, which runs a simulation based on the modified plan. The simulation only considers the specified train's features and installations excluding other trains scheduling or movements. The Timetable Conflict detection then details the expected performance of the other trains on the same line, the target timetable of the previous trains along with the specified train. After that The Capacity Management looks for possible conflicts based on the predicted or simulated results either between the timetables or due to infrastructure dependencies. If there is a conflict, the capacity management communicates rejects the request and informs the ROC with the results and reasons. If not, the Capacity Planner accepts the modification, informs the ROC with the new path, and updates the timetable and feeds the Passenger Information System & Automatic Route Setting.((Shift2Rail & X2RAIL-2, X2R2-D63-Use Cases: Deliverable D6.3 Description of Use-Cases for new TMS Principles, 2020, S. 24)). **[**SPT3TMS-10133 **]**

4.2.1.3 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. 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. Contribution to advanced freight operation: All communications in the above-mentioned process are carried out via the web interface attached to the TMS Integration Layer, which can be a game changing factor in the effectiveness of the whole train request management process. Therefore, the involved parties can communicate their needs in real time and the negotiation process can be carried out effectively. This digitalised path request process allows for web-based ad-hoc train path requests via a web browser, using for instance, a web application. ((Shift2Rail, Use-Cases for advanced Freight operation, 2019, S. 18)). **[**SPT3TMS-10135 **]**

4.2.1.4 Cancel Train Path

The use case aims to provide a cancellation plan of a train either to one or more itineraries. The ROC requests a cancellation of the train plan from the Capacity Planner. The Capacity Planner accepts the cancellation (manual or automatic), informs the ROC, and remove the itinerary from the timetable and feeds the Passenger Information System & Automatic Route Setting.((Shift2Rail & X2RAIL-2, X2R2-D63-Use Cases: Deliverable D6.3 Description of Use-Cases for new TMS Principles, 2020, S. 28)) **[**SPT3TMS-10137 **]**

4.2.1.5 Assign/Modify Consist to Mission/Itinerary

The use case aims to add or change a train consist to the itinerary after the execution of any of the first two use cases, to ensure a high quality in operating the railway and to support the Vehicle Management. CMS must verify that consistency conditions are fulfilled and notify the Vehicle Management when this is not the case. The process in Use Case 1 for planning a Train Path can be done with a virtual Train Unit (Train formation), but that the virtual Train Unit will be replaced with a specific consist in due time prior to departure of the mission in order to check consistency and to react on inconsistencies before delays are realized.

((Shift2Rail & X2RAIL-2, X2R2-D63-Use Cases: Deliverable D6.3 Description of Use-Cases for new TMS Principles, 2020, S. 32)) [SPT3TMS-10139]

4.2.1.6 Modify Features of Vehicle

This use case outlines the structure for a ‘Modify features of vehicle’ function. Features of a vehicle are on the one hand often subject to planned changes over the lifecycle of the vehicle and must be considered within an advanced CMS. On the other hand, vehicle features can change due to instant hardware and/or software failures. Especially, these vehicle features that will affect the routing and the running time calculation of the vehicle as well as features that change the behaviour of the vehicle within the safety logic must be transmitted to the advanced CMS by the responsible actor (e.g., ROC Operational Manager) instantly to enable TMS to solve possible conflicts that were caused by these changes.((Shift2Rail & X2RAIL-2, X2R2-D63-Use Cases: Deliverable D6.3 Description of Use-Cases for new TMS Principles, 2020, S. 43)). [SPT3TMS-10141]

4.2.2 TMS

4.2.2.1 Train Movement Forecasting & Conflict Detection

This use cases explains the calculation scenario that TMS perform to provide an accurate forecast about the future status of a train. The TMS has to provide an advanced forecasting calculation functionality to be able to show the train dispatcher the forecasted movement of all the trains that are running at over next 2 hours. This functionality must be highly configurable to be able to define the expected behaviour of each train. This configuration should allow different behaviours for train groups to be defined based on their physical and commercial characteristics and/or the planned route and should also define specific behaviours for specific trains. The forecast calculation must be an automatic function that the TMS must do for each train that is running every second.((In2Rail, INR-WEB-D-UNI-070-01_-_D7.2_-_I2M_Consolidated_Functional_and_Non-functional_requirements: Deliverable D7.2 I2M Consolidated Functional and Non-functional requirements: INNOVATIVE INTELLIGENT RAIL, 2016, S. 71)). [SPT3TMS-10144]

4.2.2.2 Manage Temporary Traffic Restrictions

This use case represents the operation of adding or modifying or removing a temporary restriction to the real time traffic plan in order to take it into account in all the processes involved in the management of the train traffic. These restrictions are very important for the running of the trains because they can modify train delay. This is why the TMS must use this information for the forecast calculation process. The management of these restrictions is the responsibility of an entity external to the TMS. The RIM temporary restrictions administrator is responsible for deciding that a restriction is required and for determining all the characteristics of the restriction. The Actor RIM train dispatcher manager is responsible for managing these restrictions in order to include all the changes informed by the restriction administrator.((In2Rail, INR-WEB-D-UNI-070-01_-_D7.2_-_I2M_Consolidated_Functional_and_Non-functional_requirements: Deliverable D7.2 I2M Consolidated Functional and Non-functional requirements: INNOVATIVE INTELLIGENT RAIL, 2016, S. 35)). [SPT3TMS-10146]

4.2.2.3 Solve Train Path Real time Conflicts

This use case describes the path to solve train path conflicts. For each itinerary (trip) a set of degrees of freedom are specified, e.g.

- Minimum waiting time at specific location.
- Latest arrival time at specific location.
- Connection to other itineraries (one train waits for a delayed one).
- Allowed tracks to be used, e.g., due to limitations of axle load.

- Minimum platform length.

[SPT3TMS-10148]

In case of violation one of these degrees of freedom the TMS starts the conflict solution process by modifying the itineraries. In most cases even for the improved operational situation some itineraries will still violate the degrees of freedom. These violations must be accepted by the ROC (in their Operation Management department) (ROCOM). ROCs involved into the conflict solution scenario provide their Acceptances/Modification Requests into Integration Layer influencing the conflict solution process. At the end of these cycles the current conflict solution scenario is accepted by all ROCs and is stored into the Itineraries-Topic.((Shift2Rail & X2RAIL-2, X2R2-D63-Use Cases: Deliverable D6.3 Description of Use-Cases for new TMS Principles, 2020, S. 53)) [SPT3TMS-10149]

5 Operational Processes Influencing The System

Link to Chapters 4 and 5 in Operational Processes document : CMS & TMS Operational Processes

6 Functional Requirements

6.1 CMS Functional Requirements

CMS Functional Requirements

6.2 TMS Functional Requirements

TMS Functional Requirements

7 References

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8 Glossary

AB Allocation Body **[**SPT3TMS-13009 **]**
CI Common Interface **[**SPT3TMS-13011 **]**
CMS Capacity Management system **[**SPT3TMS-12984 **]**
DCM Digital Capacity Management **[**SPT3TMS-13005 **]**
ECMT European Capacity Management Tool **[**SPT3TMS-13003 **]**
ERA European Railway Agency **[**SPT3TMS-12991 **]**
GUI Graphical User Interface **[**SPT3TMS-13007 **]**
PCS Path Coordination System **[**SPT3TMS-13008 **]**
RIM Rail Infrastructure Manager **[**SPT3TMS-12957 **]**
RIS Railway Infrastructure System **[**SPT3TMS-13006 **]**
ROC Rail Operating Company **[**SPT3TMS-12956 **]**
TAF/TAP Telematics Applications for Freight/Passenger Services **[**SPT3TMS-13004 **]**
TCR Temporary Capacity Restriction **[**SPT3TMS-12963 **]**
TMS Traffic Management System **[**SPT3TMS-12967 **]**
TSI Technical Specifications for Interoperability **[**SPT3TMS-13010 **]**