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In2Rail

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Deliverable D7.1

State-of-the-Art and High Level Requirements

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Executive Summary

The overall aim of the In2Rail project is to set the foundation for a resilient, cost-efficient, high capacity, and digitalised European rail network.

There are three In2Rail sub-projects relating to Intelligent Mobility Management (I2M). one of which is WP7. This WP deals with the definition of the functional specification of future TMS/dispatching systems.

This document is the first deliverable in WP7 and describes the first part of work done in WP7.1 to produce a matrix with high level requirements of TMS/dispatching systems.

An analysis of the current state-of-the-art in the field has been completed for existing EU funded projects like On-Time, Capacity4Rail and MODAIR which have been reviewed and functional as well as non-functional requirements have been generated. Chapter 3.3 contains a list of all projects included in the analysis.

To have a better overview of the requirements, a functional requirement breakdown has been prepared before the research starts; see Chapter 3.1. All requirements are stored within a matrix that contains the structure of the functional breakdown. The structure has been adapted during the whole research process.

Besides the analysis of EU-projects, National projects, RailNetEurope (RNE) and other EU documents have been included in the scope of the investigation to find the full set of requirements of the TMS/dispatching systems within the scope of I^2M.

The analysis has been conducted by several In2Rail partners and the inputs consolidated to from a comprehensive set of requirements. The resulting requirements matrix has been subjected to a structured review process.

The requirements matrix that has been generated represents the state of the art functional and non-functional requirements of the I^2M-part of a TMS/dispatching system.

Complementary to the state of the art analysis of requirements, research and development into appropriate KPI's has also been performed incorporating already developed KPIs from existing EU funded and National Projects have been consulted to generate a first scope of KPIs for the evaluation of the outputs of the In2Rail project.

The actual high-level requirements for the future Traffic Management System / dispatching system have been collected (see document attachment “INR-WP07-T-SYS-001-00_Requirements Matrix_00I.xlsx” referenced in Appendix 8.1).

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Abbreviations and acronyms

Abbreviation / Acronyms	Description
EU	**E**uropean **U**nion
IM	**I**nfrastructure **M**anager: see §5.
I²M	**I**ntelligent **M**obility **M**anagement: Information developed as a strategically critical asset: • A standardised approach to information management and dispatching system enabling an integrated Traffic Management System (TMS). • An Information and Communication Technology (ICT) environment supporting all transport operational systems with standardised interfaces and with a plug and play framework for TMS applications. • An advanced asset information system with the ability to 'nowcast' and forecast network asset statuses with the associated uncertainties from heterogeneous data sources.
KPI	**K**ey **P**erformance **I**ndicator
LCC	**L**ife **C**ost **C**ycle: refers to the total cost of ownership over the life of an asset.
PRM	**P**erson with **R**educed **M**obility: see §5.
TOC	**T**rain **O**perating **C**ompany: see §5.
TMS	**T**raffic **M**anagement **S**ystems: see §5.
TRL3	**T**echnology **R**eadiness **L**evel **3**: product technology has a proof-of-concept model built.
WP7	**W**ork **P**ackage **7**: System Engineering of Intelligent Mobility Management (I²M) of In2Rail.

1 Background

This document constitutes the first issue of Deliverable D7.1 "State-of-the-Art and high level requirements" in the framework of the Project titled "Innovative Intelligent Rail" (Project Acronym: In2Rail; Grant Agreement No 635900).

The overall objective of Work Package 7 – WP7 – is to provide the specification to validate the Intelligent Mobility Management (I²M) open integrated platform for Traffic Management Systems (TMS) and dispatching systems of the future. WP7 is strongly coupled with two others work packages, 8 and 9. It covers three topics coming in different development stages of the future Traffic Management System (Figure 1):

- *WP7.1*: to carry out the requirement analysis;
- *WP7.2*: to specify a Standard Operators' Workstation allowing the display and control of all services and functions applied in an integrated traffic control centre;
- *WP7.3*: to validate an integrated I²M TRL3 proof-of-concept built around the Integration and Application Layer, the Demand Management functionalities and the 'nowcasting' and forecasting of the network assets status.

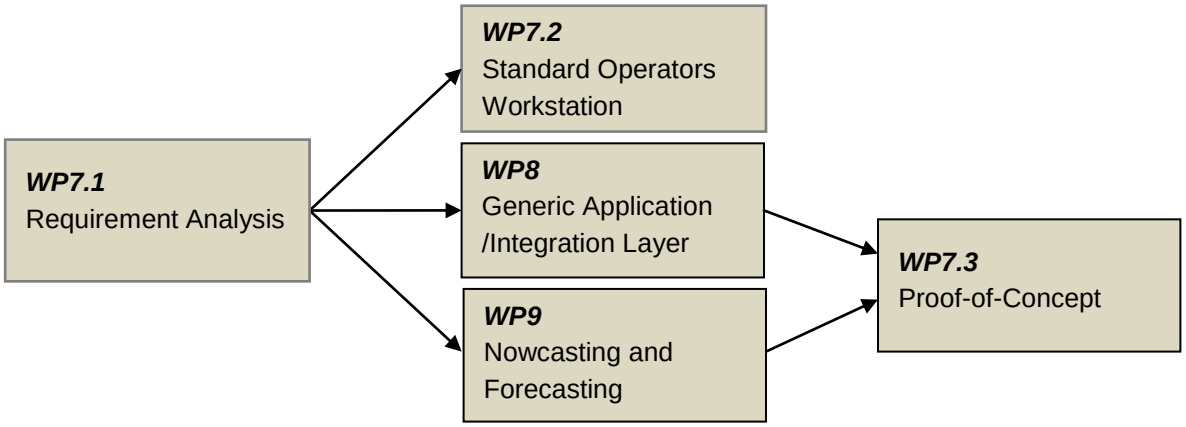


Figure 1 – Simplified integration of WP7 with WP8 and 9

The aim of WP7.1 is to define the requirements, functional and specific non-functional (e.g., performance, security, safety, etc.), that have to be fulfilled by TMS/dispatching systems.

Deliverable D7.1 is the result of the first step of WP7.1, the analysis of the current state-of-the-art. The requirements collected at that stage will be consolidated with an IN²RAIL internal analysis to challenge the first gathered results, insert specific requirements and describe them with more precision. This work will be provided in deliverable D7.2.

Final client expectations, mainly passengers, will be investigated to evaluate potential impact on functional and non-functional requirements and make sure IMs and TOCs will be able to fulfil them. In this activity, EU law will be considered, such as rail passengers' rights or PRM requirements.

2 Objective / Aim

This document was created to draw a picture of the as is situation. The reports of various ongoing or previous EU-funded research studies, National studies and tender documents have been consulted for this purpose. In the first step the actual high-level requirements which have to be fulfilled by a future Traffic Management System / dispatching system have been collected (see requirements document “INR-WP07-T-SYS-001-00_Requirements Matrix_00I.xlsx”). Second, an analysis was conducted during which the requirements were evaluated according to their importance. The resulting matrix of consolidated requirements along with Key Performance Indicators (KPI) represents the basis for further steps in Task 7.1.2. Each KPI has been described with a short explanation of its impact in order to help choose relevant requirements for each WP7 task.

Additionally current standardization activities relevant for TMS have been analysed. Some of them where documented in the requirements matrix. Standardization activities of service oriented architectures are represented in the Appendix (section 8.1), as they are strongly relevant for the WP8.1 and WP8.2 – one of the tasks there is selection of the appropriate middleware for the future TMS.

3 High level requirements

The state-of-the-art analysis has been conducted to identify the actual high level requirements expected from rules, processes and methods used by infrastructure managers, and always from the perspective of intelligent mobility management. For this task, existing EU-funded projects, National projects as well as EU regulation documents (from the European Commission or others bodies such as Rail Net Europe) were worked through. The requirements discovered as a result are recorded in a functional and non-functional requirement matrix, which constitute an attachment to Deliverable D7.1 (IN²RAIL reference document INR-WP07-T-SYS-001-01).

The matrix contains 3 sections:

- **Section 01**: this section is the Requirement Matrix for the state-of-the-art. It contains all functional and non-functional requirements collected;
- **Section 02**: this section provides a complete list of documents used to collect the High Level Functional Requirements during the state-of-the-art activity;
- **Section 03**: this section describes the different lists used in the generation of the matrix requirements.

The matrix contains different levels for an easy overview, in which the requirements themselves are shown as level 5 and accordingly level 6 for more details of the data for the requirement.

- Levels 1 and 2: define the capability asked of the system *(light description)*
- Levels 3 and 4: define the principal feature of the system *(light description)*
- Level 5: is used to describe the high level requirement *(detailed description)*
- Level 6: is used to define the data needed for the requirement *(detailed description)*

For each requirement collected, the following information has been entered within the respective column:

- **Req. Id**: this is a unique number in the global matrix. This number is specific to the In2Rail project;
- **Level**: the level identified above;
- **Title**: describes the general purpose of the requirement;
- **Description**: gives the description of the requirement for IN²RAIL project;
- **Collector** and **Date of collection**: IN²RAIL partner who collected the requirement;
- **Source**: identification of the section and the document where the requirement has been collected. The reference used is described in Section 02;
- **Extract**: this column contains the facsimile of the original requirement if a rewording has been made. The main purpose is to find any elements of the context that permit a clear understanding of the initial requirement;
- **Type of the requirement**: the complete list of types is defined in Section 3;
- **Requirement link to another(s) one(s)**: given if the requirement is linked to or depends on another requirement;
- **Level of Innovation**: this part has not been filled in during state-of-the-art activity;

- **Data exchange required**: indicates whether the requirement requires data exchange (internal or external exchange). This column has not been filled in during state-of-the-art activity due to a lack of information in the original documents;
- **Comments**: any comments that allow clarification of the requirement or provide traceability of the requirement.

3.1 Presentation of the functional requirement breakdown

The first activity was to define a high level requirement breakdown structure capable of being used by each partner during collection activities. This structure has been developed drawing on experience from:

- Business Operation Models,
- Infrastructure and Rolling Stock Assessment Models,
- Classical Technical Requirements,
- Classical Non-Functional Requirements.

Below these four key areas are several sub-sections shown to represent the processes and technical issues of a traffic management system. Table 1 shows the complete final version of the functional requirement breakdown.

The column “Evolution” shows the modifications made to the requirement matrix breakdown during the requirement collection activity. This data shows that more than 54% of the initial matrix breakdown evolved during this activity in order to remain true to the requirements collected from the different sources.

In order to confirm that the selected requirement matrix breakdown was consistent with the on-going projects, it has been compared to the Principal Feature extract from the TMS program of Network Rail. The result of this work is presented in Figure 2. The figure 2 below Table 2 shows in a diagram view where the requirements/components could be located in the future TMS/dispatching system and how they interacting.

Requirement Matrix Breakdown	Evolution [1]
1. Business operation requirements	
1.1. Planning of trains	
1.1.1. Path allocation	Modified
1.1.1.1. Train and Infrastructure compatibility	
1.1.1.2. Path request	
1.1.1.3 Path modification by RU	
1.1.1.4. Path alteration by IM	
1.1.1.5. Path cancellation	
1.1.2. Train characteristics	
1.1.2.1. Path and train number(s)	
1.1.2.2. Train composition	
1.1.2.3. Service relationships	
1.1.3. Works and maintenance - planning and capacity allocation	Modified
1.1.3.1. Works and maintenance forecast	Modified
1.1.3.2. Works and maintenance planning	
1.1.3.3. Capacity request	Added
1.1.3.4. Capacity cancellation	
1.1.3.5. Allocation impact	
1.1.3.5. Communication and dissemination	Added
1.1.4. Works and maintenance characteristics	Modified
1.1.4.1. Works and maintenance IDs and references	Modified
1.1.4.2. Works and maintenance time and geographical limits	Modified
1.1.4.3. Works and maintenance - other characteristics	Modified
1.1.5. Other infrastructure restrictions - planning and capacity allocation	Added
1.1.5.1. Other infrastructure restrictions - planning	Added
1.1.5.2. Capacity request	Added
1.1.5.3. Capacity cancellation	Added
1.1.5.4. Allocation impact	Added
1.1.5.5. Communication and dissemination	Added
1.1.6. Other infrastructure restrictions characteristics	Added
1.1.6.1. Other infrastructure restrictions IDs and references	Added
1.1.6.2. Other infrastructure restrictions time and geographical limits	Added
1.1.6.3. Other infrastructure restrictions - other characteristics	Added
1.2. Operation of trains	
1.2.1. Train preparation	Modified
1.2.2. Train running	Modified
1.2.3. Train forecast	
1.2.4. Advice driver	
1.2.5. Crew and train resource management	
1.2.6. Train connections	Added

Requirement Matrix Breakdown	Evolution [1]
1.2.7. Target timetable / Production plan	Added
1.3. Operation of works and maintenance	
1.3.1. Work delays	
1.3.2. Work cancellation	
1.4. Traffic control and management under perturbations	Modified
1.4.1. Decision making	Modified
1.4.2. Resource re-scheduling (track, rolling stock, crew)	Modified
1.4.2.1. IM resource re-allocation (track, etc.)	Added
1.4.2.2. RU resource re-allocation (rolling stock, crew, etc.)	Added
1.4.3. Perturbation cause and attribution	Modified
1.4.3.1. Location	
1.4.3.2. Associated information	
1.4.4. Access to process and instructions for application	
1.5. Operational Information for freight and passenger services	Modified
1.5.1. General requirements for communication	Added
1.5.2. Service disruption information between station managers, railway undertakings and infrastructure managers	Modified
1.5.2.1. Train running interrupted	Modified
1.5.2.2. Delay information	Modified
1.5.2.3. Train journey modification (cancellation, rerouting, retiming, etc.)	Modified
1.5.3. Information in stations	Modified
1.5.3.1. Normal service	Modified
1.5.3.2. Adaptation of service due to work	Modified
1.5.3.3. Disrupted service	Modified
1.5.4. Information in vehicle	Modified
1.5.4.1. Normal service	Modified
1.5.4.2. Adaptation of service due to work	Modified
1.5.4.3. Disrupted service	Modified
1.5.5. Coordination between stations and vehicle passenger information	Modified
1.5.6. Intermodal connection for passenger service	Modified
1.5.6.1. During normal service	Modified
1.5.6.2. During disrupted service	Modified
1.5.7. Intermodal connection for freight service	Modified
1.5.7.1. During normal service	Modified
1.5.7.2. During disrupted service	Modified
1.6. Post-operational feedback analysis	Modified
1.6.1. Production of KPIs	Modified
1.6.1.1. Customer satisfaction	Added
1.6.1.2. Quality of service analysis	Added
1.6.1.3. Data quality	Added

Requirement Matrix Breakdown	Evolution [1]
1.6.2. Evaluate TOC/IM penalties	Modified
1.6.3. Analyse energy consumption	Modified
2. Infrastructure and rolling stock disruption assessment requirements	Modified
2.1. Infrastructure disruption information and handling	Modified
2.1.1. Infrastructure disruption information management	Added
2.1.2. Handling restrictions with impact to train path or train running	
2.2. Rolling stock disruption and crew impairment information and handling	Modified
2.2.1. Rolling stock disruption and crew impairment information management	Added
2.2.2. Handling restriction with impact on train path or train running	
2.2.3. Handling restriction with impact on level of service	
2.2.4. Handling restriction with impact on rolling stock resource management	
3. Technical requirements	
3.1. General information exchange characteristics	
3.1.1. User profiles and associated authorized functions	
3.1.2. Organization parameters	
3.1.3. Traceability and classification of message	
3.1.4. Information between computers and mobile phones with different modes (charts, forums, emails, SMS, etc.)	
3.1.5. Statistics calculation on information exchanges (patterns, messages, etc.)	
3.2. Technical architecture	
3.2.1. Processes (user lists, process, client portal, etc.)	
3.2.2. Technologies (external connections, etc.)	
3.2.3. Norms and instructions	
3.3. Data integration	
3.3.1. Get static infrastructure data	
3.3.2. Get versatile infrastructure data	
3.3.3. Get rolling stock data	
3.3.4. Condense data	
3.3.5. Customize data	Added
4. Other non-functional requirements	
4.1. Security of information system	
4.1.1. Security level and confidentiality (signing, encrypting, certificate for messages, etc.)	
4.1.2. Reliability and integrity	
4.1.3. Availability	
4.1.3.1. For transmission service	Added
4.1.4. Maintainability and ability to evolve	
4.2. Sizing information	
4.2.1. Number of messages to be treated and data volume	
4.2.2. Number of users	

Requirement Matrix Breakdown	Evolution (1)
4.2.3. Number of connections	
4.3. Performance	
4.3.1. Time	Modified
4.1.3.1. For data display	Added
4.1.3.2. For data exchange	Added
4.3.2. Visual sharing of information	
4.3.3. Bandwidth	
4.4. Ergonomics	
4.4.1. Optimization of tasks	
4.4.2. Link with databases and limitation of manual operations	
4.4.3. Possibility for on-distance common work	
4.4.4. Ease of use	

(1) Evolution of the requirement matrix breakdown when collecting requirements

Figure 1 - Requirement Matrix Breakdown used in the attachment to Deliverable D7.1

Principal Feature	Intended Functionality *(extract from [NR TMS Doc 1])*	Section [(2)]
Real Time Plan Distribution	Maintains the current plan by combining the day plan and any operational on-the-day changes. Distributes the plan for automatic or manual implementation, and includes information on planned possessions.	1.2.7
Contingency Planning	Building and storing predefined and agreed plan modifications to be electronically implemented during times of perturbation.	1.4.1
Real Time Planning	Manages changes to the current plan as a result of VSTP requests, direct manipulation (e.g., via Train Graph), automatic conflict resolution or the implementation of contingency plans. Also includes management and modification of possession plans on-the-day.	1.4.2
Validate Plan	Analyses the current plan for viability, including: route availability, sectional running times, consist, load, crew information and planned possessions.	1.2.7 1.3.2 1.5.2
Train Consist and Load Information	A single store of data provided by operating companies to be used to improve the quality of plan changes and validate that train paths are permitted. Also used to facilitate better predictions of train running performance.	1.1.2 1.2.5 1.2.6
Train Crew Information	A single store of data provided by operating companies to be used to improve the quality of plan changes. This information is assumed to be voluntarily provided.	2.2.1 2.2.2 2.2.3 2.2.4
Emergency Possession Planning	Enables emergency on-the-day possessions to be planned.	1.1.3
Predict Operational Situation	Predicts where each train will be and at what time, based upon the current operational situation (incidents, delays, etc.) and individual train performance.	1.2.3 1.3.1
Identify Conflicts	Checks for path conflicts with the current plan, possessions and infrastructure availability, and calculates the consequential delay. An assumption is made that the plan is already consistent for crew and consist – conflicts with these are analysed as part of the 'validate plan' capability.	1.4.1 1.2.3
Resolve Conflicts	Suggests options to mitigate conflicts and predicts the associated improvement to delay. Includes changes to the plan and advisory speeds.	1.4.1
Train Prioritisation	Determines the relative priorities of trains based upon configurable rules (such as train class or delay) to aid conflict resolution.	1.4.1
Train Location Tracking	Combines multiple sources of train movement data (e.g., TD, GPS, etc.) to conclusively determine where a train is on the network and its current lateness. Also includes a software train describer function based upon track circuit data from the Remote Interlocking Interface (RIF) via the Infrastructure Indications Distribution capability.	1.2.2

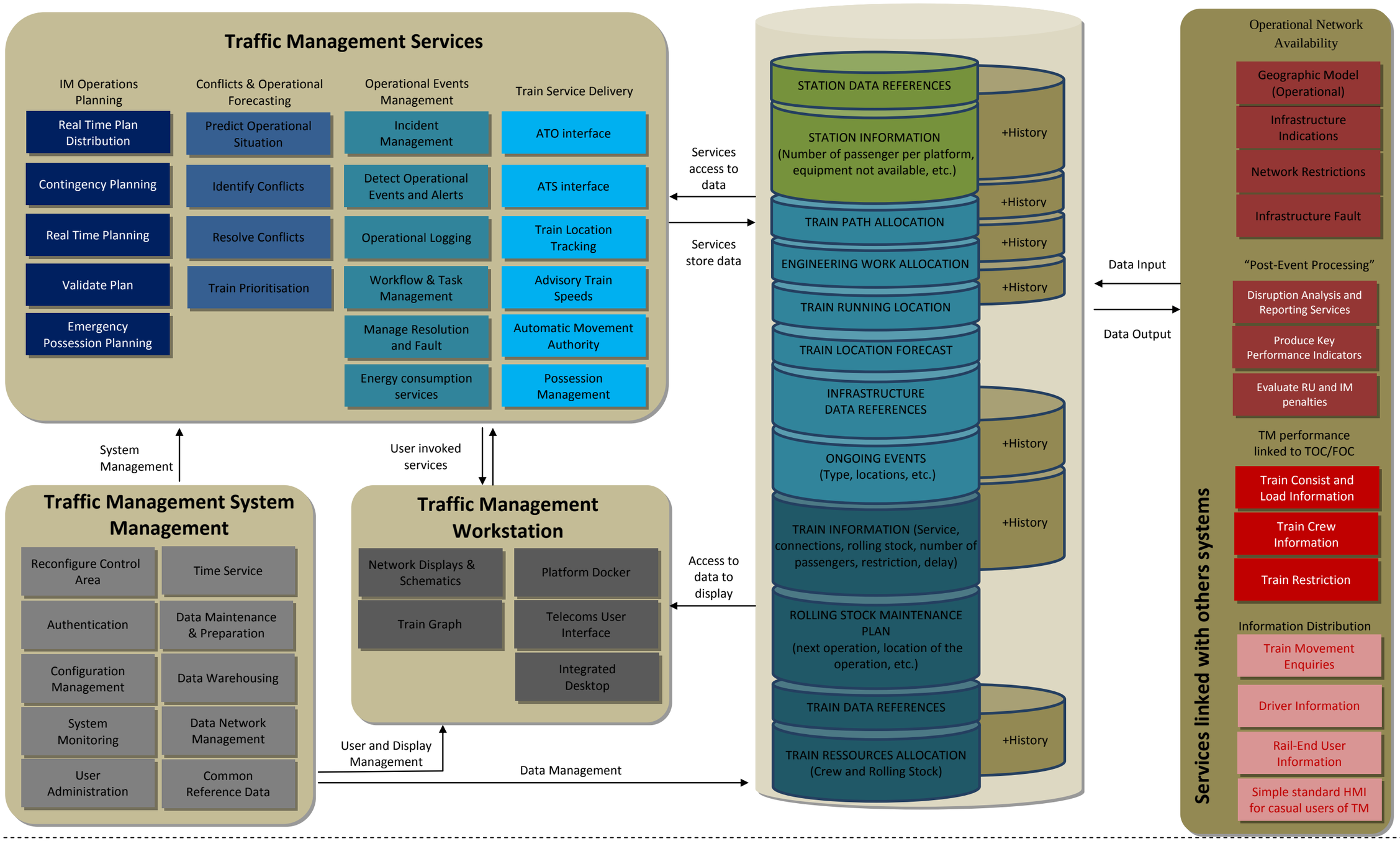
Principal Feature	Intended Functionality *(extract from [NR TMS Doc 1])*	Section [2]
Possession Management	Workflow tool to facilitate the electronic take-over and hand-back of possession worksites, tracking work progress and influencing permitted train movements.	1.3.1
Advisory Train Speeds (DAS interface)	An interface to pass TM data into Driver Advisory systems. DAS systems per se are not in scope.	1.2.4
Automatic Movement Authority	Consumes the real time plan and coordinates the appropriate implementation by issuing updated plans to conventional ARS systems, automatically setting routes via the RIF. Includes a facility to allow routes to be set manually.	1.4.1
Infrastructure Indications Distribution	Receives and stores indication data from the RIF such as signals, points and track circuits. Makes this available for Train Location Tracking and replay of events through the appropriate Network Displays and Schematics.	1.1.4
ATO interface	An interface to pass TM data into Automatic Train Operation systems. ATO systems per se are not in scope.	1.2.2
ATS interface	An interface to pass TM data into Automatic Train Supervision systems. ATS systems per se are not in scope.	1.2.2
Geographic Model (Operational)	Stores static data on the network geography and infrastructure such as track, points, stations, bridges as well as the corresponding schematics, routes and control regions.	3.3.1
Network & Traffic Restrictions	Maintains a digital catalogue of known issues impacting train movements including infrastructure availability and condition, incidents, speed restrictions and operating notices. Also includes information on train faults that may impact other vehicle movements.	1.1.5 1.1.6 1.2.1
Infrastructure Faults	Maintains a catalogue of infrastructure faults.	2.1.1 2.1.12
Incident Management	Coordinates the tracking and management of operational events that have an impact on train movements. Includes interaction with fault management systems, possession management and resulting signaller forms.	1.4.1 1.4.2
Operational Events and Alerts	Processes a range of data sources to identify issues that may impact the operational situation and raises alerts/alarms where appropriate.	1.4.3
Operational Logging	An integrated logging platform recording automatic and manual observations and actions relating to the operation of the railway.	3.1.3
Workflow and Task Management	Provides workflow and task management capabilities specifically to support Incident Management	1.4.4
Manage Resolution of Faults	Helps manage the resolution of faults.	1.4.3
RIF	A standard interface between the core system located at the ROCs and Signalling, Operational Voice Telecommunications and CCTV assets distributed around the network.	Requirement in each section identified

Principal Feature	Intended Functionality *(extract from [NR TMS Doc 1])*	Section [2]
		with type "ExtComm"
Reconfigure Control Area (between ROCs)	Enables the dynamic reconfiguration of workstations between ROCs to meet operational demand. Interacts with the necessary infrastructure and telecoms systems to enable communications and control authorisation to move with a workstation.	3.1.2
Integrated Desktop	Provides a standardised platform that Traffic Management users will interface with to access the user-based functions of all other capabilities, including Administration, Support & Maintenance functions.	4.4.1 4.4.2 4.4.3 4.4.4
Network Displays and Schematics	A set of workstation visualisations and overlays showing the state of the railway by augmenting multiple sources of information such as the location of trains, routes set, signal aspects and infrastructure condition. Also includes a manual route setting interface for RIF enabled areas.	4.3.2 4.4.1 4.4.4
Train Graph	Plots the current and predicted location of trains, highlighting any conflicts and enabling direct manipulation of the current plan.	4.3.2 4.4.1 4.4.4
Level-crossing CCTV Monitoring	Manages the display of live CCTV streams and interfaces for controlling cameras (e.g., wipers, floodlights, etc,). Primarily for level crossings and tail lamp monitoring.	Not considered
Telecoms UI	A set of functions to deliver an integrated telecoms capability to the TM user.	Requirement in each section identified with type "ExtComm"
Platform Docker	To assist the operator to effectively manage train movements within stations.	4.3.2 4.4.1 4.4.4
Training and Development	A capability to support training of users, replay of historic train movements and simulation of train activity.	Not considered
System Monitoring	To allow the TM system itself to be monitored, managed and maintained.	4.1.4
Authentication	To facilitate the approval and authorisation of activity.	3.1.1
Data Network Management	To allow the Data Network to be monitored, managed and maintained.	3.3.4 3.3.5
Common Reference Data	Contains the underlying reference data that defines the infrastructure.	3.3.1
Configuration Management	To allow the configuration of the TM system to be maintained.	4.1.4
Data Maintenance and Preparation	To allow business rules to be created and maintained.	4.1.4
Time Service	To ensure that all solution components utilise a common and accurate time source.	4.1.2

Principal Feature	Intended Functionality *(extract from [NR TMS Doc 1])*	Section [(2)]
User Administration	To allow system user profiles to be created and maintained.	3.2.1
Data Warehousing	A store of TM data, separate from the operational system, to support reporting and analysis.	3.3
Train Movement Enquiries	Reports the movements of trains over time to support downstream business processes and support ad hoc operational enquiries. Also includes location simplifiers to signallers in manually signalled areas.	1.2.2 1.2.3
Drivers Advisory Information	Provides relevant information to train drivers on incidents and other restrictions in the vicinity.	1.2.4
Information Distribution	A group of functions to facilitate distribution outbound from Traffic Management for the purposes of providing on-the-day information to other rail industry users, both internal and external to NR.	1.5.3 1.5.4
Post-event processing	Functions (currently within TRUST) that are triggered by on-the-day activity and support Network Rail in discharging its commercial responsibilities, e.g., Reliability Events, Delay Reports.	1.6.1.2 1.6.2
CIS Integration	An interface to pass TM data into Customer and Passenger Information System (CIS & PIS). CIS & PIS systems per se are not in scope.	1.5.1
Real Time Simplifier	Provides a simple standard HMI for casual users of TM.	1.5.1

(2) Section of the requirement matrix breakdown

Figure 2 - Comparison of Requirement Matrix Breakdown with Principal Feature extract from the TMS program of Network Rail


Traffic Management Services
IM Operations Planning
Real Time Plan Distribution
Contingency Planning
Real Time Planning
Validate Plan
Emergency Possession Planning
Conflicts & Operational Forecasting
Predict Operational Situation
Identify Conflicts
Resolve Conflicts
Train Prioritisation
Operational Events Management
Incident Management
Detect Operational Events and Alerts
Operational Logging
Workflow & Task Management
Manage Resolution and Fault
Energy consumption services
Train Service Delivery
ATO interface
ATS interface
Train Location Tracking
Advisory Train Speeds
Automatic Movement Authority
Possession Management
Services access to data
Services store data
STATION DATA REFERENCES
STATION INFORMATION (Number of passenger per platform, equipment not available, etc.)
TRAIN PATH ALLOCATION
ENGINEERING WORK ALLOCATION
TRAIN RUNNING LOCATION
TRAIN LOCATION FORECAST
INFRASTRUCTURE DATA REFERENCES
ONGOING EVENTS (Type, locations, etc.)
TRAIN INFORMATION (Service, connections, rolling stock, number of passengers, restriction, delay)
ROLLING STOCK MAINTENANCE PLAN (next operation, location of the operation, etc.)
TRAIN DATA REFERENCES
TRAIN RESSOURCES ALLOCATION (Crew and Rolling Stock)
+History
Data Input
Data Output
Operational Network Availability
Geographic Model (Operational)
Infrastructure Indications
Network Restrictions
Infrastructure Fault
"Post-Event Processing"
Disruption Analysis and Reporting Services
Produce Key Performance Indicators
Evaluate RU and IM penalties
TM performance linked to TOC/FOC
Train Consist and Load Information
Train Crew Information
Train Restriction
Information Distribution
Train Movement Enquiries
Driver Information
Rail-End User Information
Simple standard HMI for casual users of TM
Services linked with others systems
System Management
User invoked services
Traffic Management System Management
Reconfigure Control Area
Time Service
Authentication
Data Maintenance & Preparation
Configuration Management
Data Warehousing
System Monitoring
Data Network Management
User Administration
Common Reference Data
Traffic Management Workstation
Network Displays & Schematics
Platform Docker
Train Graph
Telecoms User Interface
Integrated Desktop
Access to data to display
User and Display Management
Data Management
Data in relation to Station
Data in relation to Infrastructure
Data in relation to Railway
Data to be kept for history access. Others data are kept until the train (including related path) has arrived at its final destination.

3.2 Methods used

3.2.1 How requirements have been collected

All requirements from documents analysed have been subjected to a selection process. Elements have been extracted and collected for In2Rail state-of-the-art. The selection has been made considering the following criteria.

- **Consistent**: the requirement does not contradict any other requirement and is fully consistent with all authoritative external documentation;
- **Current**: the requirement has not been made obsolete by the passage of time. This point will be fully analysed in the next activity of Work Package 7.1. Results will be presented in deliverable D7.2;
- **In line with In2Rail scope**: exclude any requirements from previous project defined as prototype or demonstrator. For this point, the collectors have to be aware that it can be hard to differentiate between requirements and solution descriptions, which could lead to the consideration of solutions as business requirements. To avoid such confusion, the project context analysed has to be considered.

Note: that two other criteria should also be considered: a requirement has to be reachable and verifiable. The analysis of these two points is to be part of next step of work package 7.1.

Once a requirement was selected, the following method has been used to extract it in order to address all relevant scenarios:

- If requirement is:
  - Already described and presented as a requirement in the document analysed: transfer the requirement to the functional matrix [file attached to this document];
  - Extract from a text in the document analysed: copy and paste the original text and propose a first requirement description. This is important to keep the context of the source and be sure the understanding is not altered.
- If requirement exists twice from different sources, described in different words:
  - Choose the requirement meeting the best requirement formulation: unitary, unambiguous, non-conjugated, complete;
  - Keep (for traceability reasons) in the functional matrix the requirement not selected with the indication "Collector", "Date" and "Source" and indicate in the “Status Column” the status “Overlap another requirement”;
- If requirement can be stored in several sections of the breakdown structure:
  - Requirement has to be inserted only once;
  - Choose the most suitable section: refer to similar requirements, ask main contributor.
- If the source analysed gives direct links between the requirement collected and other requirements:

    - Link of dependence: the requirement can be achieved only if another one exists;
    - Link of coherence / performance: the requirement is relevant only if another (other) requirement(s) exist(s);
    - Indicate it in the column “Link” and the Id_Requirement linked is indicated in the comment column;
- Always
    - Identify the status (informative, compulsory, etc.) or the importance of the requirement if the status is not clearly defined;
    - Collect the data required to fulfil the requirement if existing: type of data, data format, etc.

Once a requirement was extracted, the following method has been used to reformulate it:

- When the requirement was already described and presented as a requirement in the document analysed, the reformulation was limited to make sure the word “Shall” was used when the requirement had a compulsory status or “Should” in the other cases (recommended, informative, etc.);
- When the requirement was extracted, the rewording had to respect the following points:
    - **Unitary**: the requirement addresses one and only one thing;
    - **Unambiguous**: the requirement is concisely stated without recourse to technical jargon, acronyms, or other esoteric verbiage. It expresses objective facts, not subjective opinions. It is subject to one and only one interpretation. Vague subjects, adjectives, prepositions, verbs and subjective phrases are avoided. Negative statements and compound statements are avoided;
    - **Non-Conjugated**: the requirement hasn’t needed to be written as two separate requirements;
    - **Complete**: the requirement is fully stated in one place with no missing information.

3.2.2 How requirements have been consolidated

The number of sources used to collect requirements is significant: 41 documents and their origin is multiple: European projects, normative documents, infrastructure manager projects, etc. The harmonisation of the requirements quickly increased.

The perfect way to work would have been to give to a single person the consolidation work to carry out. The In2Rail timeframe required splitting in different part this activity between partners; a common way to handle the splitting has been defined:

- Each partner for the part s/he has to control:
    - Control similar requirement(s), if they exist:
        - Choose the requirement meeting the best requirement formulation: unitary, unambiguous, non-conjugated, complete;
        - Keep (for traceability reasons) in the functional matrix the requirement not selected with the indication "Collector", "Date" and "Source" and indicate in the “Status Column” the status “Overlap another rq”;

    - Make sure reformulation:
        - Is coherent with the original requirement and adjust if required;
        - Uses the verb “Shall” and “Should” correctly and adjust it if required;
    - Make sure:
        - “Status/Importance” of the requirement is correctly fulfilled or correct it;
        - “Type” is coherent with the requirement or correct it.
- One partner has to cross check the different sections created to distribute the work:
    - Identify if there exists similar requirements stored in different sections of the distribution of work defined above;
    - Control the global requirement Id uniqueness and correct it if necessary.

3.3 List of elements analysed

This chapter gives the list of the project, regulation document and third party documents that have been identified and considered for the state-of-the-art activity. For each project a short description has been done and the interest for Intelligent Mobility Management (I^2M) part of In2Rail is indicated.

3.3.1 European Project

Project	Description	Interest for I²M of In2Rail	
On-Time	Open and common communication and data models based on open standards (e.g., RailML developments). Common components and data flows between TMS building blocks and services.	Yes	SOA architectures and open and common communication and data models based on open standards.
MAXBE	Wayside and on board train hot boxes inspection.	Yes	The results of this project provide information about the interface with the system and the data collection from proposed inspection tools. Two deliverables have been analysed from MAXBE, D5.1 and D5.2. Note that due to MAXBE D5.1 deliverable being too far from In2Rail interest, no requirements were collected.
MODAIR	Give a clear view of the current state of intermodality and co-modality in European airports, deliver a roadmap for future research and provide the European Union with a structured group of experts able to help choose the best ways of implementing the connectivity of airports with other transport modes.	Yes	MODAIR produced a list of passenger requirements for intermodality at airports in relation with I²M of In2Rail interest.

Project	Description	Interest for I²M of In2Rail	
CREAM	CREAM has defined advanced customer-driven business models for railway undertakings and intermodal operators. CREAM has analysed the operational and logistic prerequisites for developing, setting up and demonstrating seamless rail freight and intermodal rail/road and rail/short sea/road services on a Trans-European mega-corridor between the Benelux countries and Turkey/Greece. On this basis the CREAM partners developed different business cases, which were integrated into an innovative corridor-related freight service concept.	Yes	The results of this project give a direct list of requirements available in relation to I²M of In2Rail's interests.
TIGER and its subprojects IPORT, INTERMODAL2015	TIGER is the acronym for "Transit via Innovative Gateway concepts solving European - intermodal Rail needs". The TIGER project is a Large Scale Integrated Collaborative Project for the development of rail transport in competitive and co-modal freight logistics chains.	Yes	The results of this project provide good material to extract requirements in relation to I²M of In2Rail's interests.
VIWAS	ViWaS (Viable Wagonload Production Schemes) is a project that searches for solutions, strengthening the competitiveness of single wagonload and wagongroup transport.	Yes	The results of this project provide good material to extract requirements in relation to I²M of In2Rail's interests.

Project	Description	Interest for I²M of In2Rail	
Capacity4Rail	Research work on infrastructure (SP1), train dispatching and timetable planning (SP3) and monitoring (SP4). Recommendations for Open-Source and Open-Interface for advanced railway monitoring applications.	Yes *Partial **	The results of Capacity4Rail give recommendations for Open-Source and Open-Interfaces for advanced railway monitoring applications. Nevertheless, Capacity4Rail is an ongoing project and Partners considered that the In2Rail project must not work on non-consolidated documents from other projects. ** For the present deliverable, only D32.1 deliverable has been analysed. Considering the date of issue of others deliverables to be analysed from CAP4RAIL, D7.2 deliverable of In2Rail will integrate[1] the gap between the present deliverable and* • *CAP4RAIL D34.1 deliverable: Data notation and modelling* • *CAP4RAIL D34.2 deliverable: Verified data architecture*
MERLIN	Optimisation concepts and proposals for minimising energy demand.	Yes *To be done*	The results should provide a better understanding of the influence of railway operations and procedures on energy demand. It gives a RailML for real-time data exchange on SOA architectures and the documents available provide good examples to describe the network. Deliverable to be analysed is D4.1 which is not public. A specific request has been formulated to get access to the document.
INTEGRAIL	Proposed approaches and demonstrators for intelligent communication infrastructure, including information system architecture and semantic data structure.	Yes *To be done **	The results of this project provide good material to extract requirements in relation to I²M of In2Rail's interests ** Due to activity plan modification, the analysis of those results will be inserted in In2Rail D7.2 deliverable.*
MAINLINE	Life cycle assessment tool and findings regarding modern technologies for tunnel and bridge inspection and repair.	No	Results are focused on cost evaluation methods for specific parts of the infrastructure. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
SMART RAIL	Complementary to MAINLINE with a life cycle assessment tool for other structures		

[1] If the date of issue of CAP4RAIL document planned is respected. Note that D7.2 deliverable from In2Rail will not be delayed to merge CAP4RAIL elements.

Project	Description	Interest for I²M of In2Rail	
PM'n'IDEA	Predictive maintenance methods for Metro and Light Rail Transport systems.	No	Results are focused on the method of the maintenance process. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
RAIL ENERGY	Calculation methods and simulation models for rail power supply systems.	No	Results are focused on very specific models related to the rail power supply system and will not bring any relevant elements for a Traffic Management System. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
AUTOMAIN	Research results on mechanised track maintenance (tamping and grinding); Lean analysis of working methods and processes to reduce possession times, research results and demonstration of advanced switch monitoring and track inspection, decision support tool for maintenance planning and scheduling.	No	Results are focused on the method of the maintenance process in order to improve efficiency and reliability in order to reduce the cost of track maintenance. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
INTERAIL	Integrated high speed inspection system based on a modular design.	No	Results are focused on non-destructive testing of railway track. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
GaLoROI	Development of a certifiable safety-relevant satellite based on-board a train localisation unit to be used on low traffic density railway lines. GaLoROI will mainly serve for train control but also for train integrity monitoring, train and fleet management, green driving and furthermore for track inspection, especially for diagnosis during operational movement.	No	The GaLoROI topic was to develop a satellite based ATP for secondary lines. The In2Rail project assumes a black box ATP for TMS. The way it is done is not relevant for TMS, with signalling, ETCS or satellite. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
UGTMS	Adaptation of the ERTMS specifications for urban railway systems.	No	Many functional requirements are available regarding the specific of an urban railway TMS. Some of them (probably very few) might be relevant. Depends on the extent to which urban railways are in the scope of In2Rail. There might also be some ideas for the methodology.
ACEM-Rail	Analyses systems for track analysis (video, ultrasonic, fibre optic, etc.) and planning of preventive/corrective maintenance (labour, materials used, machinery used and tools).	No	Results are focused on non-destructive testing of railway track. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.

Project	Description	Interest for I²M of In2Rail	
EURAXLES	EURAXLES aims to bring the risk of failure of railway axles to such a minimum level that it will no longer be considered as a significant threat to the safe operation of the European interoperable railway system. At the same time, it shall keep the cost of maintenance to a reasonable level and minimise the risk of service disruption.	No	Results are focused on rolling stock engineering issues. The results are outside the scope of In2Rail state-of-the-art and high level requirements collection of I²M of In2Rail.
D-RAIL	Development of the future rail freight system to reduce the occurrences and impact of derailment.	No	Results are focused on track engineering issues. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
INNOTRACK	Analysis of major EU track maintenance costs and sub-structure, track, S&C, LCC and logistics research results.	No	Results are focused on new track structures, condition monitoring, and logistics. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
SUSTAINABLE BRIDGES	Bridge assessment methods.	No	Results are focused on bridge maintenance and engineering issues. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
SUSTRAIL	Optimised track and substrate design and component selection to increase sustainable freight traffic as part of mixed traffic operations.	No	Results are focused on track engineering issue. The results are outside the scope of the state-of-the-art and high level requirements collection of I²M of In2Rail.
ECOHUBS	EcoHubs provides models and capabilities for cooperation and communication between multimodal terminal network stakeholders, amplifying, thus, their joint capabilities. It also establishes common value added services which, combined with existing services, facilitate end-to-end co-modal, low-CO_2 transport solutions that maximise utilisation of terminal and logistics resources and transform multimodal terminals into green hubs.	No	The analysis of the results of this project did not permit the collection of requirements in relation to the interests of I²M of In2Rail.

3.3.2 National projects from Infrastructure Manager

National Project				Interest for I²M of In2Rail
Name	*Description*	*Status of the document used*	*Owner*	
NTL project	The National Traffic Control project of Trafikverket (in Swedish "Nationell TågLedning") aims to increase delivery capability, increase efficiency and reduce vulnerability of the Swedish railway network. This project will deliver processes, a system and support for operator education.	System Requirement Specifications used for development	Trafikverket	Analysis has been carried out on the System Requirement Specifications of the future National Traffic Management System under development by Trafikverket.
Future Traffic Management within Network Rail	This National project is set to help replace 800 signal boxes with 12 state-of-the-art rail operating centres over the next 15-30 years. The new highly automated systems will allow larger areas of the network to be controlled from fewer locations, and will help increase capacity and improve reliability through more effective handling of disruption. The different train operators should also be using common systems to maximise the benefits the new technology will bring.	Request for proposal	Network Rail	The analysis has been carried out on the requirements of the request for proposal used by Network Rail. Those requirements have been developed and tested since 2012 on a traffic management software prototype, using real-time information to mock up how the new system will control the railway in the future.

3.3.3 Other documents

Documents			Interest for I²M of In2Rail
Title	*Description*	*Owner*	
Guidelines for Corridor One Stop Shop	The guidelines present the approach to the Corridor OSS setup and tasks, agreed within RNE, based on the Regulation EU 913/2010 and relevant RNE documents.	Rail Net Europe	This document provides requirements related to International Path Allocation and Pre-Arranged Paths in relation to the interests of I²M of In2Rail.

Documents			Interest for I²M of In2Rail
Title	*Description*	*Owner*	
European General Terms and Conditions of use of railway infrastructure	This document has been issued to apply to all contracts involving the use of railway infrastructure for the purpose of transport by rail. The scope of application shall be international or international and domestic transport by rail. It provides basic contractual conditions of the use of railway infrastructure.	Rail Net Europe	This document has been analysed to collect elements concerning the evaluation of TOC/IM penalties in relation to the interests of I²M of In2Rail.
Handbook for the European Performance Regime (EPR)- Guidelines for actual and potential users	This document provides information on the European Performance Regime (EPR) system. This system monitors quality in terms of punctuality and delay causes, which supports performance improvement in international train traffic and foresees the possible application of financial penalties to bad performance.	Rail Net Europe	This document has been analysed to collect elements concerning the post-operational feedback analysis performed in relation to the interests of I²M of In2Rail.
Framework for setting up a Freight Corridor Traffic Management System	This document's aim is to set up an overall framework of standard procedures and tools supporting traffic management along the Rail Freight Corridors (RFCs). These procedures fulfil the requirements contained in the Freight Regulation (EU Reg. 913/2010) in Articles 16, 17 and 19 (see Part 1 for details).	Rail Net Europe	The analysis has been performed to collect requirements from the tasks definition in appendix concerning freight corridor traffic management for Train Operation Performance Management
Guidelines for Freight Corridor Punctuality Monitoring	This document describes the basic processes needed to carry out a regular activity of quality monitoring and analysis within the framework of the Rail Freight Corridors (RFCs) established by the Freight Regulation (EU Reg. 913/2010).	Rail Net Europe	The analysis has been performed to collect requirements related to data collection, performance analysis and action plan and implementation in relation to the interests of I²M of In2Rail.
Handbook for Train Information System – TIS – Data Quality Management	This document's aim is to provide a structured procedure to check the quality of the data, according to the needs that emerged in the past.	Rail Net Europe	This document has been analysed to collect elements concerning the post-operational feedback analysis performed in relation to the interests of I²M of In2Rail.
Procedures for international ad hoc path request management	This handbook describes the process by which applicants may request and obtain international paths during the running of a timetable.	Rail Net Europe	This document has been analysed to collect elements concerning the Short term path in relation to the interests of I²M of In2Rail.

Documents			Interest for I²M of In2Rail
Title	*Description*	*Owner*	
Brochure of the Charging Information System	The Charging Information System (CIS) is an infrastructure charge information system for Railway Undertakings (RUs), provided by infrastructure managers and allocation bodies. The web-based application provides fast information on charges related to the use of European rail infrastructure and estimates the price for the use of international train paths within minutes.	Rail Net Europe	The analysis of this document did not provide any requirements in relation to the interests of I²M of In2Rail.
TAF TSI - Annex D.2 : appendix E - common interface	This document describes how, using the principles of semantic integration, the freight railways and infrastructure managers of the European rail industry will exchange data and implement the telematics application for freight regulation through an information exchange architecture.	European Union	This regulation document is mandatory, it specifies requirement to interface systems between RU and IM. This topic is in relation to the interests of I²M of In2Rail.
TAF TSI - Annex D.2 : appendix F – TAF TSI data and message model	Message data model.	European Union	This regulation document is mandatory. The list of data model has been considered in the requirement matrix. But at this stage, the detailed data structures have not been collected.
TAF TSI - Annex D.2 : appendix reference files	Functional requirements specifications (FRS), which identify the functional, data and performance requirements needed to implement the common reference files as needed to fulfil the TAF TSI vision and the high-level requirements stated in the regulation. The following reference files are contained in this specification: - Location identification - Company identification - Keeper's rolling stock databases The specification addresses various issues for the reference files including data security and access, operational issues and data content.	European Union	This regulation document is mandatory, it specifies requirement to interface systems between RU and IM. This topic is in relation to the interests of I²M of In2Rail.

Documents			Interest for I²M of In2Rail
Title	*Description*	*Owner*	
TAP TSI Annex B.56 - RU/IM communication application guide	This document explains the TAP and TAF messages derived from both regulations, giving a hint on their legal status, explains their usage; the overall architecture, the establishment and use of the reference data and relevant code list.	European Union	This regulation document is useful for implementation but did not permit to collect more requirements.

4 Key Performance Indicators

The state-of-the-art activity of WP7.1 of IN²RAIL related to the Key Performance Indicator - KPI - did not permit, as initially envisioned to find direct links between requirements collected from the elements analysed (see §3.3) and a common agreed set of KPIs in the railway sector.

Indeed the aim of this work has been to present KPIs used in the following domains and present a list of potential KPIs for the IN²RAIL project. Of course, this list has to be considered as a first step; it will be consolidated in a second stage and confirmed by WP7.3.

- Qualitative key performance indicators that are tightly linked to business model of railway actors: infrastructure manager, authorized body.
  - Long distance passenger services
  - Passenger public transport services
  - Freight services
- Operational key performance indicators that permit the assessment of the performance of a TMS programme.

Considering that IN²RAIL will make advances towards achieving overall objectives of the rail sector, each KPI has been linked to four main objectives:

- Improved services and customer quality;
- Reduced system costs (including investment and operating costs);
- Enhanced interoperability;
- Simplified business processes.

Except for freight services, the state-of-the-art shows that the performance measurement focuses mainly on the quality of service in public passenger transport. In Europe, this notion, particularly for public service delegation contracts, is covered by two standards:

- one relating to its definition - EN 13816,
- the other to its measurement - EN 15140.

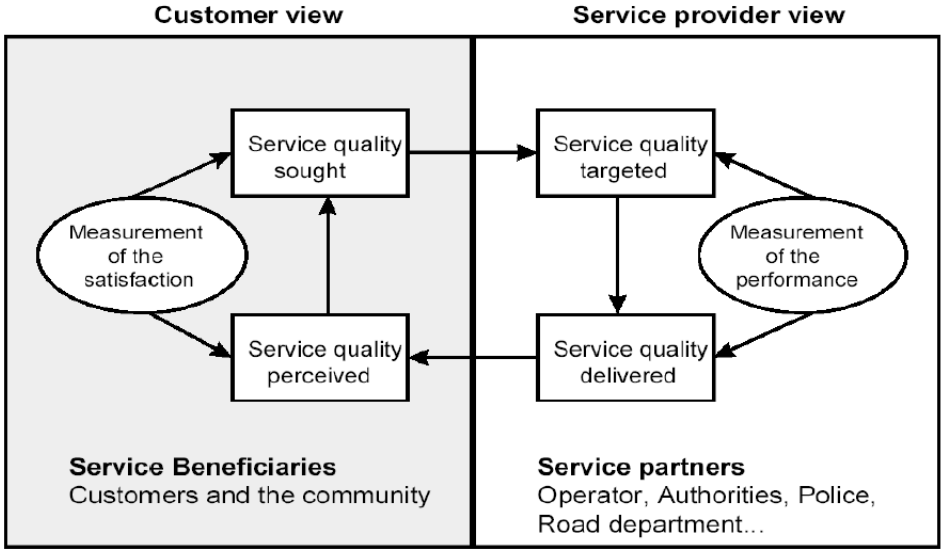
The EN13816 (Transportation. Logistics and services. Public passenger transport. Service quality definition, targeting and measurement) requires definition of the service quality, which shall be relevant, specific, and customer focused. Decisions about what to monitor should be based on the customer priorities: each measurement should have a specific purpose. The standard identifies eight criteria of quality of service:

Criteria	Definition
Service offering	Modes, network, operation, adequacy and attractiveness of the offer, service reliability
Accessibility	From the outside, inside the network, availability of tickets
Information	General, in normal situation, disturbed situation

Criteria	Definition
Duration	Duration of the journey, time
Attention to the client	Commitment, client interface , personal, assistance, purchase of securities
Comfort	Operation of equipment, seating and space staff, passenger comfort, environmental conditions, complementary facilities
Security	Protection against aggression, accident prevention, emergency management
Environmental impact	Pollution, natural resources, infrastructure

Table 3 – Eight criteria of quality of service with description

The standard is based on the concept of 'quality of service lifecycle' shown in Figure 2.



(Source: European Committee for Standardization, 2002)

Figure 2 – Source from EN13816 – figure 1.1 – Service Quality Loop

The performance measurement considers mostly the service provider view. Typically some performance indicators are defined in a contract between a transportation authority and the service provider, who tries to fulfil them. In most cases during the post processing the collected information about train movements and in best case incident information is combined to the specified performance indicators. During the operation the operators try to optimise performance indicators without support from the TMS. In the following sections the single performance indicators are structured and analysed on their applicability for the future TMS.

4.1 Key Performance Indicator for IN²RAIL

The following paragraph gives a synthesis of the KPI defined and monitored by the actor for its business evaluation. The detailed KPIs are given in paragraph 4.2 to 4.7.

Teachings of this synthesis are:

- For each topic (capacity, punctuality, etc.) each actor has defined its proper high level KPI according to its own issues and contracts. Those high level KPIs are most often based on basic KPIs directly related to an identified measurement.

  Example: Public Performance Measure provided by Network Rail is a high level KPI which combines train delay at arrival according to National rules. This measure is also used for other KPIs such as “Delay per 100 train.km”.

  Teaching 1: Rather than defining high level KPIs for In2Rail, it is recommended in next step of WP7.1 to identify the common elements to be monitored that will be called Root KPI. This analysis has to be done based on the high level KPI identification below.

- The way to define the certain notion is not uniform and varies from one actor to another.

  Example: when is a train considered to be on-time or not?

	Network Rail	Authority for the Quality of Service in Transport in France	Rail Net Europe
Freight train	Delay of 14’59’’	Delay of 14’59’’	Defined by each freight corridor
Long distance passenger service	Delay of 9’59’’	Delay of 4’59’’ if journey time is under 1h30min Delay of 9’59’’ if journey time is between 1h30min and 3h00min Delay of 14’59’’ if journey time is over 3h00min	Not applicable
Others	Delay of 4’59’’	Delay of 5’59’’	Not applicable

Teaching 2: The “low KPIs” have to be monitored as accurately as possible in order to let the rail actor tune the measurement to their own application.

- Complex KPI definitions used by rail actors evolve from one period to another.

  Example: some of the indicators between Network Rail's Control Periods 4 and 5have been modified.

  Teaching 3: Any solution defined for a future system shall offer an appropriate adaptability to modify any high level KPI during life of the system.

PERFORMANCE UNDER NORMAL OPERATION

KPI	*Defined for (by)*	*Main rail objective*
CAPACITY		
Number of trains running	Freight service (RNE)	Improved services and customer quality
Number of trains scheduled (Path train)	Passenger service (AQST)	Improved services and customer quality
Train-km (run)	Passenger service (NR) Freight service (NR) Freight service (RNE)	Improved services and customer quality
Number of available passenger (ton - for freight) kilometres	TMS assessment (TRV)	Improved services and customer quality
Peak headway targets by line (minimum interval between two trains)	Metro service	Improved services and customer quality
Percentage of passengers that waited less than the reference headway	Metro service	Improved services and customer quality
MEET THE TIMETABLE PLANNED		
Total number of trains operated by each TOC / FOC which use alternative route	TMS Assessment (NR)	Simplified business processes

PERFORMANCE UNDER DISRUPTION

KPI	*Defined for (by)*	*Main rail objective*
PUNCTUALITY		
Train Punctuality	TMS assessment (TRV)	Improved services and customer quality

KPI	*Defined for (by)*	*Main rail objective*
▪ Number of minutes of delayed trains	Freight service (RNE) Passenger service (AQST) Passenger service (NR) Freight service (NR) TMS Assessment (NR)	Improved services and customer quality
▪ Right time	Passenger service (NR)	Improved services and customer quality
▪ Average delays	Freight service (RNE) Passenger service (NR)	Improved services and customer quality
▪ Average delay of trains late at departure	Passenger service (AQST)	Improved services and customer quality
▪ Average delay of trains late at arrival	Passenger service (AQST)	Improved services and customer quality
▪ Average delay at departure	Passenger service (AQST) TMS Assessment (NR)	Improved services and customer quality
▪ Average delay at arrival	Passenger service (AQST) TMS Assessment (NR)	Improved services and customer quality
▪ Maximum lateness during journey	TMS Assessment (NR)	Improved services and customer quality
▪ Delay per 100 train.km	Freight service (NR)	Improved services and customer quality
▪ Percentage of trains delayed at departure	Passenger service (AQST)	Improved services and customer quality
▪ Percentage of trains delayed at arrival	Passenger service (AQST) Passenger service (NR) Freight service (NR)	Improved services and customer quality

KPI	*Defined for (by)*	*Main rail objective*
▪ Percentage of actual service delivered that meets schedule time	Metro service	Improved services and customer quality
▪ Number of trains late at arrival	Passenger service (AQST) Freight service (RNE)	Improved services and customer quality
Passenger Punctuality		
▪ Proportion of passengers arriving with less than 5 minutes late to their final station throughout the overall service (metro, bus and commuter train)	Passenger service (AQST) Metro service	Improved services and customer quality
▪ Lost customer hours	Metro service	Improved services and customer quality
Journey Time (JT)	TMS Assessment (TRV) Passenger service (NR) Freight service (NR)	Improved services and customer quality
▪ Excess Journey time	Metro service Passenger service (NR) Freight service (NR)	Improved services and customer quality
▪ Excess Running Time through a Core Section of Route	TMS Assessment (NR)	Improved services and customer quality
▪ Passenger Demand Forecasting Handbook bases on a generalized journey time	Metro service	Improved services and customer quality
▪ Average speed of freight trains	Freight service (RNE)	Improved services and customer quality
CONNECTIVITY		
Passenger (freight) interchange time between services	TMS Assessment (TRV)	Improved services and customer quality Enhanced interoperability

KPI	*Defined for (by)*	*Main rail objective*
Excess wait time	Metro service	Improved services and customer quality
RESILIENCE		
Resilience (RS)	TMS Assessment (TRV)	Improved services and customer quality
PASSENGER CONFORT		
Number and severity of jerks of EC defined comfort level	TMS Assessment (TRV)	Improved services and customer quality
Crowding density: average number of passengers stander per m^2 trains in most heavily loaded section in peak period	Metro service	Improved services and customer quality
Maximum crowding on the train in peak hour, per line, per peak direction: must not exceed 100% of planning standard	Metro service	Improved services and customer quality
Percentage of peak services at above 135% seat capacity	Metro service	Improved services and customer quality
ENERGY		
Energy (kWh) consumed by vehicles in unit time	TMS Assessment (TRV)	Reduced system costs
RESSOURCE USAGE		
Car kilometre between train failure causing delay > 5 min	Metro service	Reduced system costs
Track Utilisation, Rolling stock utilisation, crew utilisation	TMS Assessment (TRV)	Reduced system costs
Percentage of rolling stock available for service in peak period	Metro service	Reduced system costs
INFORMATION		
Delay causes	Freight service (RNE) Passenger service (AQST)	Improved services and customer quality

KPI	*Defined for (by)*	*Main rail objective*
	Passenger service (NR) Freight service (NR)	
Availability of dynamic passenger information in stations and train (for service disruption)	Metro service	Improved services and customer quality
Percentage of passengers that have access to real time travel information during service disruption	Metro service	Improved services and customer quality
Percentage of staff interactions that offer correct ticketing and route information	Metro service	Improved services and customer quality
Data completeness	Freight service (RNE)	Improved services and customer quality

PERFORMANCE UNDER MAJOR DISRUPTION

KPI	*Defined for (by)*	*Main rail objective*
CANCELLATION		
Number of cancelled trains	Passenger service (AQST) Freight service (RNE) TMS Assessment (NR)	Improved services and customer quality
Cancellation and Significant Lateness	Passenger service (NR)	Improved services and customer quality
Percentage of trains cancelled	Passenger service (AQST)	Improved services and customer quality

4.2 Performance indicators defined for passenger services – Public Authority view (source: French Authority of the Quality of Service in Transport)

This chapter presents the performance indicators used by the French Authority of the Quality of Service in Transport (AQST). This authority ensures the improvement of the quality of service, including the regularity and punctuality, in all types of transport of passengers and the quality of the information distributed to travellers in normal situations as well as degraded or disrupted situations.

DEFINITION OF INDICATORS FOR LONG DISTANCE JOURNEYS

Three sets of indicators are defined:

- Indicators of train cancellations: they measure the number of planned train and the number of trains cancelled in relation to the planned traffic;
- Indicators for delay to the departure of trains: they measure the accuracy of the trains at the time they leave station relative to the public timetable;
- Indicators for train delay at the final station: measures the accuracy of trains on arrival at the final station relative to the public timetable.

KPI	***Description***
Number of cancelled train services	Number of cancellations of scheduled train services
Percentage of train services cancelled	Number of train services cancelled during a period of X calendar months relative to the number of trains scheduled for the same period (in %)
Percentage of train services delayed at departure from origin station *(monthly or average for X months)*	Number of trains late departing during a X calendar months period relative to the total number of services provided over the same period (in %);
Average delay of train services late at departure *(monthly or X months)*	Cumulative (from the first whole minute) minutes late departing recorded by train services during a period of X calendar months, divided by the number of train services late at the start over the same period
Average delay at departure *(monthly or X months)*	Cumulative number of minutes late initially recorded by all train services during a period of X calendar months divided by the total number of train services departing during the same period
Percentage of train services delayed at destination station	Number of train services late on arrival for a period of X months total -/number of services provided over the same period (in %);

KPI	Description
(monthly or X months)	
Average delay of train services late at arrival *(monthly or X months)*	Cumulative number of minutes of delay on arrival recorded by late train services during a period of X calendar months divided by the total number of train services arriving during the same period
Average delay at arrival *(monthly or X months)*	Cumulative number of minutes of delay on arrival recorded by all train services during a period of X calendar months divided by the total number of train services arriving at the terminal station over the same period

Arrangements for monitoring and measurement of punctuality

By convention, the trains departing or arriving with a delay lower than or equal to the threshold of control are not considered as late within the meaning of the indicator.

Trains late at the start: the control threshold is 5 minutes. Only trains entering with a delay exceeding 5 minutes are taken into account, regardless of the service and the relationship considered.

Trains late at the destination: only trains entering with a delay exceeding the threshold of control are taken into account. In this case, the delay is counted for all of its duration (from the first minute of delay). The thresholds of control for the measurement of the arrival punctuality, regardless of the service are:

- 5 minutes to a less than 1h30min scheduled journey time,
- 10 minutes for an scheduled journey time of between 1h30min and 3h00min,
- 15 minutes for a 3h00min or greater scheduled journey time.

Average delay of all trains: the number of minutes of delay (departure or arrival) taken into account over the period considered corresponds to the sum of the minutes of delay recorded by all trains, including those which have a delay lower than or equal to the threshold of control. The average delay of trains is calculated by dividing this number by the total number of trains (departure or arrival) over the same period.

The seconds are not taken into account; the data in minutes are rounded by default.

DEFINITION OF INDICATORS FOR PUBLIC SERVICE PASSENGER TRANSPORT

KPI	Description
Number of trains scheduled	It defines a Public Service Transport provided by railway from end to end, commercial and load, within the perimeter

KPI	Description
	of the convention between the Provider and the Authority. A train is not considered in this data if it is been announced as cancelled before 4 PM on the afternoon before.
Number of trains cancelled	A cancelled train is a train whose schedule was known to passengers and whose run has been removed, even partially, without being able to be announced early enough. This currently applies to deletions which could not be announced before 4 PM on the afternoon before.
Number of trains late at arrival	The number of trains with a delay at arrival of more than 5min 59s at the final station. Delays are those actually perceived by passengers and are not alleviated by any contractual neutralisation for exceptional external reasons.
Delay causes	-

On the Paris railway network, the density of passenger flow and stops, associated with the multiplicity of journeys, led the Regional Authority – STIF - to define with its providers (RATP and SNCF) a specific indicator for the punctuality, that is closer to the perception of passengers.

KPI	Description
Proportion of passengers arriving less than 5 minutes late to their final station throughout the overall service (metro, bus and commuter train)	On the basis of counts and field surveys, flows of passengers on a given line are modelled by time slice for each ride from one station to another one of the line. The comparison between these theoretical times and actual train movement at each station allows the collection of the number of passengers arriving less than 5 minutes late at their final destination. The result is the ratio of the number of these passengers to the total number of passengers on the line.

Example


12h00
3min late: 12h18
instead of 12h15
8min late: 12h33
instead of 12h25
Station A
100 passengers get on train 1
Station B
80 passengers get off train 1 with less than 5min of delay
10 passengers get on train 1
Station C
30 passengers get off train 1 with more than 5min of delay
Passenger Punctuality
$\frac{80}{100+10} = 72{,}7\%$

4.3 Performance indicators defined for passenger and freight services – Infrastructure Manager View (source: Network Rail)

This section presents the performance indicators used by Network Rail for its 2015 Annual Return [NR 2015 Annual Report] for Control Period 5. As this is the first year of Control Period 5 (CP5) a number of new measures are reported in this Annual Return for the first time.

The indicators collected from the Annual Return have been complemented by those provided on Network Rail's public webpage http://www.networkrail.co.uk/about/performance/

KPI	***Description***
COMMON	
Delay minutes	Delays experienced by passenger and freight train operators are broken down into two 'responsibility groups', Network Rail attributed delays and those attributed to train operators
Journey time	This measure calculates the average speed (in miles per hour) of passenger trains scheduled to operate on a sample Wednesday
Possession Disruption Index	The Possession Disruption Index for Passengers (PDI-P) and Freight (PDI-F) measures the excess journey time that passengers and freight operators experience as the result of planned engineering and maintenance work.
Train km	
Customer satisfaction	Network Rail's Customer Satisfaction survey (conducted by GfK) took place during October and November 2013. This is a survey of the senior managers from the train and freight operators in Great Britain, both franchised and open access.
PASSENGERS SERVICE	
Public Performance Measure	The percentage of trains arriving on-time at their destination where on-time means: ▪ Long distance operators: not more than 9'59'' late ▪ All other operators: not more than 4'59'' late Trains counted under Cancellation and Significant Lateness (see below) are excluded from this indicator calculation.
Cancellation and Significant Lateness	This KPI is a regulatory output measure for England & Wales in CP4. Number and percentage of passenger trains (franchised and open access operators) which are cancelled in part or full, or which arrive at their final destination 30 or more minutes later than the time shown in the public timetable.

KPI	***Description***
Average lateness	This measures the average lateness of a passenger as they alight from their train. For each train, this is calculated by multiplying the number of passengers expected to alight at main stations by the punctuality to the nearest minute at those stops. If the train is cancelled, the result is calculated by multiplying the number of expected passengers by 1.5 times the service frequency on that route.
Right time	Right Time is defined as the number and percentage of passenger trains (for both franchised and open access operators) which arrive at or before their final destination at or before the time shown in the public timetable.
Passenger satisfaction	The National Passenger Satisfaction (NPS) survey is commissioned by Passenger Focus, with two surveys each year in spring and autumn.
FREIGHT SERVICE	
Freight delivery metric	Punctuality of all freight services at destination as well as taking into account the cancellations (not planned) as a result of Network Rail performance. Punctuality failures are defined as those not arriving at destination within 15 minutes of plan and where Network Rail has caused more than 15 minutes of delay during the journey.
Arrival to fifteen minutes	This is a measure of the percentage of freight trains that have successfully arrived at destination within 15 minutes of scheduled time. Unlike FDM it covers all forms of delay.
Delay per 100 train km	

4.4 Performance indicators defined for freight service – Infrastructure Manager view (source: Rail Net Europe)

To fulfil the requirements of article 19 of the EU Regulation 913/2010, §1.3 and §2.4 of [RNE Doc 1] state that the management board of a freight corridor shall monitor the performance of rail freight services on its corridor and publish the results of this monitoring once a year. The management board shall organise a satisfaction survey of the users of the freight corridor and shall publish the results once a year.

Therefore, the management board of the corridor must adopt punctuality targets and monitor performance. RNE has provided Guidelines for Freight Corridor Punctuality Monitoring (Guideline - Punctuality Monitoring - [RNE Doc 2]) to help the management board choose the KPIs, implement train performance management, and monitor performance.

§3.3 of [RNE Doc 2] proposes a set of indicators which should be decided by the management board and then monitored.

KPI	***Description***
Number of trains	All international trains running on the corridor (both freight and passenger). The counting should be done at defined points within a given timeframe. Corridor organisations will define the timeframe for measurement and will also define the measuring points based on the sections in which major changes in the number of trains can be expected (e.g., main hubs).
Punctuality	Thresholds for punctuality measurement are not defined by RNE guidelines and have to be decided by each management board of a freight corridor.
Delays: average, minutes	Each corridor organisation should define threshold values for monitoring punctuality. Several thresholds can be defined as well. Trains that are running early shall be generally considered as trains on time. However, each corridor organisation can consider the creation of separate reports about trains running early. For the calculation of the average delay, all the negative values (e.g., trains running early) should be considered as zero, so they will not have any impact on the average delay value. Punctuality should be measured according to the actual performance within the corridor, therefore lateness should be considered only if there is a positive delta between punctuality at entry into the corridor and exit from the Corridor, to neutralise the effects of non-punctuality outside

KPI	*Description*
	the corridor.
Train-km (run)	All international trains running on the corridor (both freight and passenger). This indicator will be used to monitor traffic flow trends along the corridor. The indicator should include all international trains and, as a first step, the total train-kilometres (from origin to final destination) of trains on the corridor should be counted. If the corridor is defined precisely enough, it will be possible to measure only the train-kilometres run on the corridor.
Average speed of freight trains	Actual speed compared to a target one. The goal of this indicator is the comparison between the target journey time and the actual journey time. As a first step, the measurement of average speeds should be done only between the origin/entry to the corridor and final destination/exit from the corridor. Several origin/entry to the corridor – final destination/exit from the corridor relations could be defined at the same time. As a second step, the measurement could also be done in the various subsections, as defined by corridor organisations.
Cancellations	Should be measure on a sample of trains.
Delay causes	Should be measure on a sample of trains. A certain comparability of the number of registered cases (delay codes) between the different IMs has to be ensured.
Data completeness	Should be measure on a sample of trains.

4.5 Performance indicators defined to assess NR TMS programme performance (Source: Network Rail)

The following KPIs were extracted from chapter 5 of [NR TMS Doc 8].

KPI	***Description***
Number of trains cancelled	Total number of trains operated by each TOC / FOC which were cancelled for their full journey or for part of their journey.
Total Delay-Minutes	UK main-line railway practice specifies delay attribution thresholds (whose value may be different in different regions within the UK main-line railway network). Delays to trains which are less than the relevant delay attribution threshold are still recorded but do not have to be explained (attributed), whereas train delays greater than or equal to the relevant delay attribution threshold are not only recorded but also have to be explained (attributed). Lateness and delay are both non-negative quantities. A train which e.g., passes a Recording Point on its journey 2 minutes early has a lateness there of 0 minutes (NOT -2 minutes). Although early running of trains should not be rewarded (since early-running trains may themselves cause problems and require regulation), neither should early running of trains be punished (unlike late running of trains).
Lateness at final destination	If the actual and planned (timetabled) times at which a train arrives at its final destination are A and P respectively, then that train's lateness at final destination is calculated as : max (A – P, 0) The result of this calculation must be rounded to the half-minute below.
Lateness departing	At the origin of a train's journey, if the train's actual and planned (timetabled) departure times are A and P, respectively, then the train's lateness departing from the origin of its journey is calculated as : max (A – P, 0)
Lateness arriving	At a location within a train's journey where that train is scheduled to stop, then if the train's actual and planned (timetabled) arrival times at that location are A and P respectively, then the train's lateness arriving at that scheduled stop is again : max (A – P, 0)

KPI	***Description***
Maximum lateness during journey	The train's maximum lateness during its journey is the maximum of: ▪ The train's lateness departing from the origin of its journey, ▪ The train's lateness arriving at each scheduled stop on its journey, ▪ The train's lateness departing from each scheduled stop on its journey, ▪ The train's lateness arriving at the final destination of its journey.
Excess Running Time through a Core Section of Route	A designated core section of route within the modelled portion of the UK main-line railway network will be defined by a pair of Recording Points (which will therefore also be mandatory timing points) A and B, where A and B are such that a unique line of route exists between A and B (and so no alternative line of route exists for trains planned (timetabled) to travel from A to B or vice versa). The excess running time between A and B is defined for those trains whose planned journeys include the section of line from A to B (both inclusive) or from B to A (both inclusive).
Total number of trains operated by each TOC / FOC which use alternative route	Trains which are routed via an alternative running line or platform on the same line of route.

4.6 Performance indicators defined to assess NTL programme performance (Source: ON-TIME project)

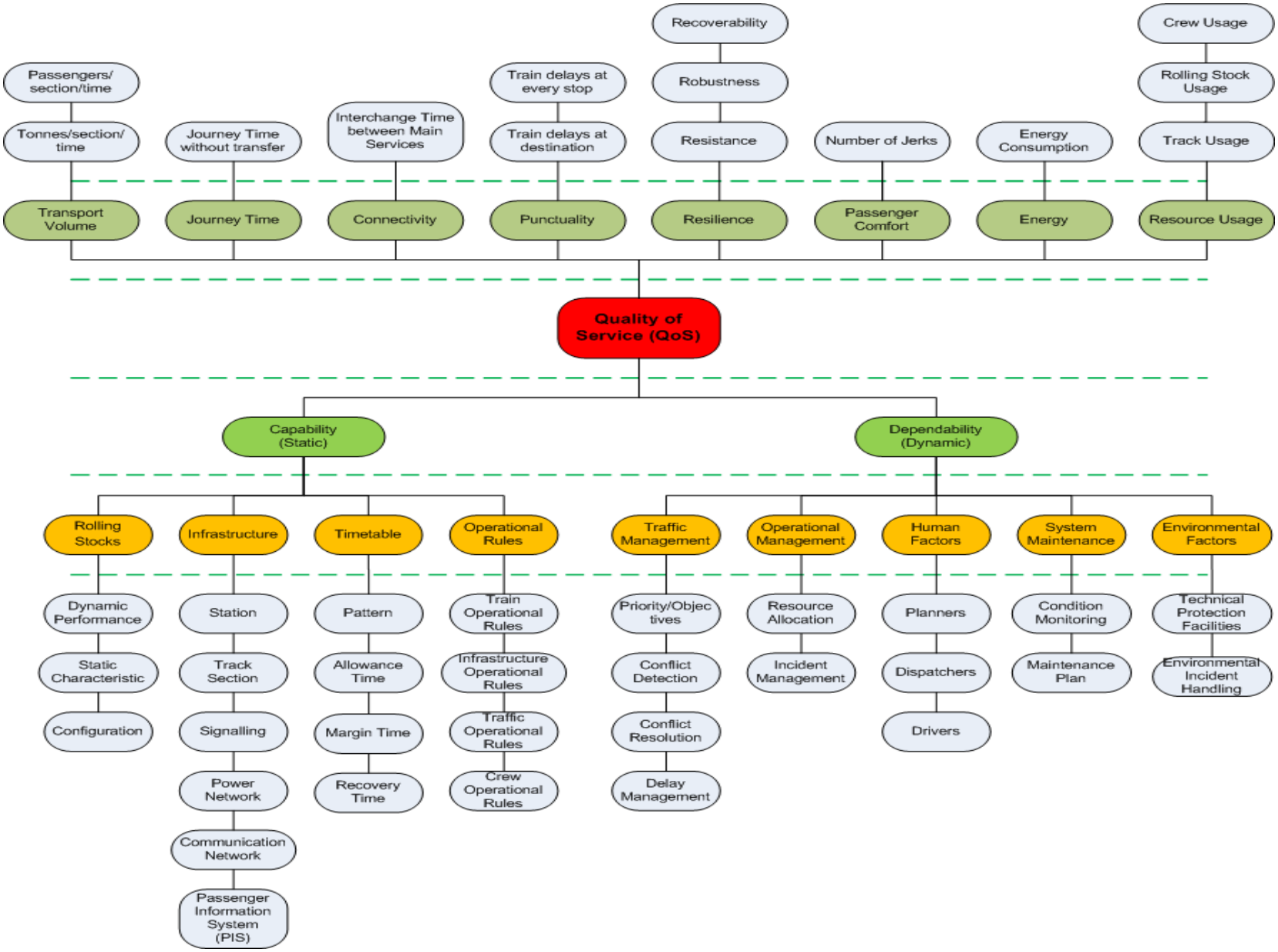
The National Traffic Control project of Trafikverket, in Swedish “Nationell TågLedning” – NTL, aim to increase delivery capability, increase efficiency and reduce vulnerability for Swedish railway network.

The performance activity of this project is based on the results of European Project ON-TIME. The aim of the ON-TIME project was to improve railway customer satisfaction through increased capacity and decreased delays for passenger and freight. The ON-TIME project developed methods, processes and algorithms that enable railway undertakings to significantly increase the available capacity.

Main areas of activity:

- Robust / resilient timetable development
- Operational management of small-scale disruptions
- Operational management of large-scale disruptions
- Driver advisory systems (DAS)
- Distributed process and information architecture

Three areas required comparative measures to define “good” solutions: robust timetables, large and small-scale disruption management algorithms. The ON-TIME project led to the development of a standard evaluation framework: Key Performance Indicators (KPIs), metrics, and rules for evaluation which are based around Quality of Service (QoS).


Recoverability
Crew Usage
Passengers/ section/time
Train delays at every stop
Robustness
Rolling Stock Usage
Tonnes/section/ time
Journey Time without transfer
Interchange Time between Main Services
Train delays at destination
Resistance
Number of Jerks
Energy Consumption
Track Usage
Transport Volume
Journey Time
Connectivity
Punctuality
Resilience
Passenger Comfort
Energy
Resource Usage
Quality of Service (QoS)
Capability (Static)
Dependability (Dynamic)
Rolling Stocks
Infrastructure
Timetable
Operational Rules
Traffic Management
Operational Management
Human Factors
System Maintenance
Environmental Factors
Dynamic Performance
Station
Pattern
Train Operational Rules
Priority/Objec tives
Resource Allocation
Planners
Condition Monitoring
Technical Protection Facilities
Static Characteristic
Track Section
Allowance Time
Infrastructure Operational Rules
Conflict Detection
Incident Management
Dispatchers
Maintenance Plan
Environmental Incident Handling
Configuration
Signalling
Margin Time
Traffic Operational Rules
Conflict Resolution
Drivers
Power Network
Recovery Time
Crew Operational Rules
Delay Management
Communication Network
Passenger Information System (PIS)

KPI	Description
Transport Volume (TV)	$TV = \max f(V^P, V^F, V^{PD}, V^{FD}, w_m^{TV})$ subject to c_j^{TV} *Where:* V^P = *number of available passenger kilometres per unit time;* V^F = *number of available cargo tonne kilometres per unit time;* V^{PD} = *passenger kilometres demand per unit time;* V^{FD} = *cargo tonne kilometres demand per unit time* *Weighting functions are dependent on operating priorities of a line or network.*
Journey Time (JT)	$\mathrm{JT} = \min \mathrm{f}(\mathrm{T_i}, \mathrm{T_i^M}, \mathrm{w_m^{JT}})$ subject to $\mathrm{c_j^{JT}}$ *Where:* T_i = *total planned journey time between station i and i+1 (no transfer);* T^M_i = *minimum sectional running time between station i and i+1*
Connectivity (CN)	$\mathrm{CN} = \min \mathrm{f}(\mathrm{I_i^P}, \mathrm{I_i^F}, \mathrm{I_i^{PM}}, \mathrm{I_i^{FM}}, \mathrm{w_m^{CN}})$ subject to $\mathrm{c_j^{CN}}$ *Where:* I^P_i = *ith passenger interchange time between services;* I^F_i = *ith freight interchange time between services;* I^{PM}_i = *ith minimum passenger interchange time between services;* I^{FM}_i = *ith minimum freight interchange time between services*
Punctuality (PT)	$PT = min\, f(L_{ij}, w_m^{PT})$ *subject to* c_j^{PT} *Where:* L_{ij} = *deviation in time of service i at location j from the timetable* *Weighting functions could incorporate the passenger numbers on the train.*
Resilience (RS)	*Stability:* $RS1 = min\, f(R, P, D, w_m^{RS1})$ *subject to* c_j^{RS1} *Robustness:* $RS2 = min\, f(R, P, D, w_m^{RS2})$ *subject to* c_j^{RS2} *Recoverability:* $RS3 = min\, f(R, P, D, w_m^{RS3})$ *subject to* c_j^{RS3} *Overall resilience is a combination of some or all of the RS terms:* $RS = f(RS1, RS2, RS3, w_m^{RS})$ *Where:* *R = time to recover;* *P = peak delay;* *D = integral of total delay*
Passenger Comfort (PC)	$\mathrm{PC} = \min \mathrm{f(J,\ w_m^{PC})}$ subject to $\mathrm{c_j^{PC}}$ *Where:* *J = number and severity of jerks of EC defined comfort level*
Energy (EG)	$\mathrm{EG} = \min \mathrm{f}(\mathrm{E^P}, \mathrm{E^F},\ \mathrm{w_m^{EG}})$ subject to $\mathrm{c_j^{EG}}$ *Where:* E^P = *energy (kWh) consumed by passenger vehicles in unit time;* E^F = *energy (kWh) consumed by freight vehicles in unit time*

KPI	Description
Resource Usage (RU)	*Track Utilisation:* $RU1 = min\, f(K, K^D, w_m^{RU1})$ *subject to* c_j^{RU1} *Rolling Stock Utilisation:* $RU2 = min\, f(S, w_m^{RU2})$ *subject to* c_j^{RU2} *Crew Utilisation:* $RU3 = min\, f(U, w_m^{RU3})$ *subject to* c_j^{RU3} *Overall Resource Usage:* $RU = f(RU1, RU2, RU3, w_m^{RU})$ *Where:* *K = track usage % in time period (minutes) as per UIC406;* *KD = level of traffic demand;* *S = average % rolling stock in use over time period, relative to max. available;* *U = number of paid man-hours worked by crew over given time period*

4.7 Performance indicators in metro and commuter rail case (Source: Community of Metros)

An interesting study about measurements in metro and commuter railways is provided in [Anderson et al. 2013]. A top 10 of service quality indicators measured by CoMET (Community of Metros) and Nova are shown in Figure 3.

	Most Common Indicators Used by Metros	**Innovative / Good Practice Measures by Metros (Eu=European Metro, Am=American, As=Asian)**
Availability	% of rolling stock available for service in the peak period % of actual service delivered that meets scheduled service Car kilometres between train failure causing delays ≥ 5mins	Number of unplanned full station closures - measured each service day (Eu) Occasions when passengers exceed the maximum capacity of a station (Am) Peak headway targets by line (minimum interval between two trains) (As)
Accessibility	% of escalators and elevators available for service % of Ticket Vending Machines available across the network	% of customers affected by the unavailability of escalators (Eu) Target: 96% passengers should not get stuck in lift for +15mins (Eu)
Information	Availability of dynamic passenger information in stations and trains (for service disruptions) Mystery Shopper Survey to evaluate quality of passenger information	% of passengers that have access to real time travel information during service interruptions (Eu) % of staff interactions that offer correct ticketing and route information (Eu)
Time	% of trains operated on time (2,3 and 5 minutes delay threshold) % of passenger journeys on time (2,3 and 5 minutes delay threshold)	Excess Journey Time (EJT) (Eu) Lost Customer Hours (LCH) (Eu) Excess Wait Time (EWT) (Eu) Passenger affected ratio (% passengers delayed by 5 minutes or more) (As) % of passengers that waited less than the reference headway (non-peak hours) (Eu)
Customer Care	Ratio of complaints / passenger Passenger enquiry response time - X% of customer complaints addressed within X number of days Overall Customer Satisfaction Score	General Perceived Quality Index: overall index is calculated weighting the rating of each aspect according to its importance (Eu) Monitoring and evaluation: % of satisfaction (rating 3 and above) in Supervisors' monitoring/evaluation at Customer Service Officers' call handling (As)
Comfort	Crowding density: average number of passengers standing per m^2 trains in most heavily loaded section in peak period Temperature on trains and in station must not exceed pre-set standards Perceived cleanliness rating in stations and trains (survey)	Maximum crowding on the train in peak hour, line by line, peak direction: must not exceed 100% of planning standard (As) % of Peak Services at above 135% seat capacity (As) Agreed standard between operator and regulator that there should be no more than 4 passengers per m^2 in the train (Eu)
Security	Incidence of fatalities to staff and passengers Rate of passenger accidents (per passenger) Incidence of crime in trains and stations	Criminal cases that result in system interruption, influencing passengers' safety and property security in every 1 million passenger kilometres (As) Perceived security rating (regarding assault and robbery) (Eu) Area of graffiti removed (as m^2) (As)
Environmental Impact	*No indicators reported*	*No indicators reported*

Figure 3 – Top 10 Service quality indicators measured by CoMET and Nova Metros. Source [Anderson et al. 2013].

A good source of performance indicators is provided in the Passenger Demand Forecasting Handbook (PDFH) [ATOC 2015]. It proposes a formula for calculation of demand change:

$$I_j = (GJT_{new} / GJT_{base})^e$$

with

I – Index for change in demand
GJT – weighted Generalised Journey Time
e – elasticity to time

The demand calculation is based on a generalized journey time, which seems to be calculated as follows:

$$GJT = \begin{matrix} (T_{inVehicle} + T_{delay} \cdot k_1) \cdot k_2(C,Q) + \\ T_{waiting} \cdot k_3(C,Q) + \\ P_{Interchange} \end{matrix}$$

With

$T_{inVehicle}$ *- Passenger Time in vehicle*

T_{delay} *- Average delay. The evidence shows that each additional minute of average delay is equivalent to several minutes of journey time. Factor* k_1 *represents this fact.*

C *- Crowding in train or station*

Q *- Quality of train or station*

k_2 *- is a factor which is a function of crowding in the train and the train quality.*

k_3 *- is a factor which is a function of crowding at the station and the station quality.*

$P_{Interchange}$ *- is a penalty due to interchange between services. Typically one interchange equals to 10 minutes of journey time in metro use case.*

Although most of the criteria for demand increasing are static from the TMS point of view, the delay and crowding can be measured and influenced by the traffic management system. Especially in the metro use case the number of vehicles per service can be adjusted to the current demand increasing the service frequency, reducing crowding and waiting time at platforms.

5 Conclusions

The aim of this report has been to generate a list of state-of-the-art functional and non-functional requirements of a future TMS/dispatching system within the scope of I^2M. This requirement matrix should now be used as a base for further adaption of the matrix in the continued work in WP 7.1.

A workshop, held in Paris at the beginning of September, permitted the construction of the first step of a vision for a future traffic management system where new rail actor needs have been highlighted. The use case definition and analysis plan for the end of 2015 will permit the completion of this first version of high level requirements and will provide more detailed requirements. The use case work is planned to be combined with infrastructure manager interviews and client expectation analysis.

Concerning the KPI proposals, these have to be confirmed within the WP7.3 activity. Then the requirements related to those KPIs will be defined by WP7.1 and included in the requirement matrix. This iteration and requirements development is foreseen for the first quarter of 2016 and results will be included in deliverable D7.2.

6 Common Glossary

Term	Abb.	Description	Collected from
A			
Access party	-	Means either: - a licensed railway undertaking or, to the extent authorised by each Member State, another party seeking to procure a train path in the working timetable for the operation of railway service on its territory with commercial or public-service intent. Examples of such authorised parties may be public authorities, or any other party having an access contract or - an international group of such parties, which is also known as an applicant group or access party group	Commission Regulation (EU) No 454/2011 of 5 May 2011
Access to telecommunication network	-	Use of the Infrastructure Managers' telecommunications network, in conjunction with the operation of trains	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Ad hoc capacity allocation	-	Allocation of capacity by an Infrastructure Manager or Allocation Body outside the time scale it normally uses.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Ad hoc request	-	An Applicant's request for an individual train path (available as spare capacity) outside the time scale that the Allocation Body normally uses.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Advisory speed	-	The speed at which the train is supposed to drive to match the timetable	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Advisory Group	AG		

Term	Abb.	Description	Collected from
Algorithm	-	A defined procedure to find a feasible solution of a particular problem in a finite number of steps.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Allowance	-	The time added into the nominal timetable to compensate the additional train sectional running times, dwell times and other scheduled process times due to unavoidable variability of physical characteristics, driver behaviours, passengers boarding and alighting variations and other potential influencing factors to train operations in real life conditions.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Alternative route	-	Different route that may be taken to reach the same destination.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Alternative route	-	Another route between the same origin and destination where there is substitutability between the two routes for the operation of the freight or passenger service concerned by the railway undertaking.	Commission Regulation (EU) No 34/2012
Arrival date/time, actual	-	Means the actual date (And time) of arrival of means of transport.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Arrival (Estimated Time)	ETA	Means the Estimated time of arrival of a train at a specific point, e.g., handover point, interchange point, train destination.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Arrival date/time, planned	-	Means the date (And time) of arrival of means of transport in the timetable.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Arrival delay, actual	-	Means the time difference between the arrival date/time actual and the arrival date/time Planned.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Arrival delay, actual	-	A deviation of the arrival time from the scheduled arrival time at a station.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65

Term	Abb.	Description	Collected from
			Reference: Yuan, J. and Hansen, I. A. (2007). Optimising Capacity Utilisation of Stations by Estimating Knock-On Train Delays. Transportation Research Part B 41(2) , 202-217.
Arrival delay, expected	-	Means the time difference between the arrival date/time Estimated and the arrival date/time Planned.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Automatic Train Control System	ATCS	An Automatic Train Control system is where the train receives data at all times in order to maintain the correct speed and prevent trains from passing stop signals if the driver should fail to react.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Automatic Train Operation	ATO	Driver-less trains or trains not requiring the person in the cab to physically 'drive' them.	*[NR TMS Doc 7]*
Automatic Train Protection	ATP	-	*[NR TMS Doc 7]*
Attributing system	-	Means an electronic system hosting the catalogue of transport services for which a transport service provider authorises distributors to issue travel documents.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Attributor	-	Means a company managing an attributing system. May be a carrier.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Authorised Public Body	AB	Means a public authority having a statutory obligation or right to provide members of the public with travel information and also refers to the public authority which is responsible for the enforcement of Regulation (EC) No 1371/2007 pursuant to Article 30 of the Regulation.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Automatic Route Setting	ARS	Signalling function that determines the optimum routeing of trains in an area based on the timetable, their current position, their priority and their destination, and automatically requests the required routes when they are free. Applied to both an implementation and the generic technology.	*[NR TMS Doc 7]*

Term	Abb.	Description	Collected from
Availability	-	Means the information (transport service, type of offer, tariff, other service) that can actually be obtained by a passenger at a given point in time, for a specific train. Not to be confused with offer, indicating that a transport service, type of offer, tariff, other service is offered in the initial planning, but could be sold out and is therefore not obtainable by a passenger at a given time point, for a specific train.	Commission Regulation (EU) No 454/2011 of 5 May 2011
B			
Berth	-	Generally the section of track between two signals (for movements in one direction).	
Blocking time	-	The time interval in that a section of track is allocated to the exclusive use of one train and therefore blocked to other trains.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
block detector	-	A device that detects whether a specific block (section) of track is occupied or not. Most commonly used for signalling and collision prevention.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Block train	-	A freight train in which all the wagons are of a similar specification. The train moves a block from one origin to one destination, without intermediate remarshalling. Often, the entire train will carry the same commodity but it may also consist of container-carrying wagons.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Block train	-	A specific form of a direct train with only as many wagons as needed, running between two transhipment points without intermediate marshalling.	TAF TSI - Commission Regulation (EU) No 62/2006
Border point	-	The location at which an international border is formally crossed. For the UK, this will involve customs and nationalisation personnel.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013

Term	Abb.	Description	Collected from
Buffer time	-	The time added into the nominal timetable (between train slots) to reduce or avoid propagation of knock-on delays among running trains due to initial and/or primary train delays.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
C			
Cadenced timetable / cadenced path system	-	A timetable that has set service intervals or departure times.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Cancellation of a path (path cancellation)	-	When a planned train movement is cancelled, either by the Railway Undertaking or by the Infrastructure Manager.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Cancellation of a path (path cancellation)	-	Path cancellation by RU: whether the path was booked as part of long-term planning or at short notice, the RU must always be able to cancel a booked path. - path cancellation by IM: if something occurs (for example an obstacle on the path) and the booked path is no longer available, the IM must inform the RU as soon as it knows this. This can happen at any time between the moment the train path is contracted and the departure of the train.'	TAF TSI - Commission Regulation (EU) No 62/2006
Cancellation of a train (train cancellation)	-	The 'cancellation of a train', as mentioned in the TAF TSI Regulation, concerns a train that is already running. As a train cancellation does not lead automatically to a (partial) path cancellation and vice-versa, it is important to distinguish in the 'train running phase' between a 'partial path cancellation' and a 'train cancellation':- train runs from A to B, ends its journey at B and does not continue from B to C at all: * train is cancelled, path is partially cancelled- train runs from A to B, stops its journey at B and does not continue from B to C at all, but another train uses the path scheduled from B to C: * only the train is cancelled- train runs from A to B, and then to E via D, instead of via C: * path is partially cancelled (B – C – E), but train is not cancelled.	TAF TSI - Commission Regulation (EU) No 62/2006

Term	Abb.	Description	Collected from
Cancellation of a train (train cancellation)	-	A scheduled train shall be deemed to be cancelled if it has not been announced as cancelled early enough (the eve of its circulation scheduled at 4 pm).	French Authority of the Quality of Service in Transport (AQST) http://www.qualitetransports.gouv.fr/trains-grandes-lignes-r179.html
Capability	-	Maximum throughput that can be maintained with the technical and organised characteristics of a railway.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Capacity reservation for maintenance	-	A situation in which capacity on the network (for example, train paths available during the night) is used to carry out infrastructure maintenance.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Capacity restrictions, tunnel restrictions, bridge restrictions	-	(Reduced) availability of infrastructure imposed by the Infrastructure Manager due to its own needs for managing the infrastructure. This can include restrictions on route opening hours and on times of possessions for maintenance, renewal and enhancement works.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Catalogue of international train paths	-	A document listing international train paths that have been pre-constructed and harmonised by the IMs.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Catalogue path	-	Catalogue Paths are concrete, published path offers to the customers, both for external (RU/applicant) and internal (IM/AB) use. They are pre-constructed paths offered either on whole corridors or corridor sections, or on lines not covered by a corridor but involving a border point. Catalogue paths may be used for the annual timetable as well as for late request, ad-hoc requests and instant capacity. They may be the result of combining available 'system paths' (see definition) but may as well have very differing parameters. They have a significant	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013

Term	Abb.	Description	Collected from
		advantage compared to non-catalogue paths: immediate availability of the path characteristics. This is made possible by advance coordinated scheduling by the countries involved.	
Carrier	-	Means the contractual railway undertaking with whom the passenger has concluded a transport contract or a series of successive railway undertakings which are liable on the basis of such a contract.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Coach group	-	Group of one or more coaches that do not run for the whole route of a train. They can be pulled by a single train but only for part of its route, or they can be pulled by one train for part of their route and then be disconnected from that train and coupled to another.	ERA/TD/2012-16/INT
Coach ID	-	Means the unique identification number of a coach.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Contingency plan	-	Plan to be drawn up by the IM, listing the various bodies to be informed in the event of serious incidents or serious disturbance to train movements.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Crossing	-	An assembly of rails that enables two tracks or two pair of tracks to cross each other at grade.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference: UIC Code 406: Capacity (1st Ed.). Paris: International Union of Railways (UIC).
Corridor Performance Coordinator	CPC	-	Rail Net Europe - GLOSSARY OF TERMS

Term	Abb.	Description	Collected from
			RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Customer	-	Means a person who intends to buy, is buying, or has bought a railway product for him/herself or for other person(s). May therefore be different from passenger (see passenger).	Commission Regulation (EU) No 454/2011 of 5 May 2011
D			
Data Quality Management	DQM		
Days of operation	-	A conventional representation used to indicate in which days of a given time period a service is present or not. It consists of a string of as many digits as there are days in the given time period, with value 1 for the days when the service is present and value 0 for the others. When the time period is one week, for patterns repeated equally every week, it is possible to use the alternative representation of the “working week”.	ERA/TD/2012-16/INT
Dangerous goods / hazardous materials (HazMat) / restricted articles	-	Dangerous goods are the United Nation's official term for Hazardous Materials. These are materials and objects of which the carriage is prohibited under the RID (International regulation on the carriage of dangerous goods by rail) or authorised only under certain conditions, because they are substances / articles that have dangerous properties that can cause injury to people, and damage to the environment, property and other goods, unless they are correctly handled during transport - including movement, loading, unloading, storage and other handling. A few examples: explosive substances and articles, gases, flammable liquids, toxic substances, radioactive materials.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Delay	-	Means the time difference between the time the passenger was scheduled to arrive according to the published timetable and the time of his/her actual or expected arrival.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Delay	-	The deviation from either a scheduled event or process.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65

Term	Abb.	Description	Collected from
Delay	-	Time during which some action is awaited but does not take place. Train delays: mostly used when a train circulates or/and arrives later than planned in the timetable. A 'primary delay' is a delay that directly affects the train; a 'secondary delay' (or knock-on delay or cascading delay) is a delay caused by a primary delayed train. The definitions of delay thresholds (as well as the measurement of delay) vary widely around the world (for example, in Japan only trains with less than a minute's delay are defined as 'on time'). In 2008, the UIC recommended to set the threshold value at 5 minutes.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Delay Attribution	-	The accurate identification of the causes for delays, cancellations, diversions and other events is of prime importance to enable all parties involved to create action plans to improve operational performance. Delay causes have been codified by the UIC in Leaflet 450 – 2, Delay coding and delay cause attribution process (2008).	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Departure date/time, actual	-	Time of this train.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Departure date/time, actual	-	The time at which a train actually departs from a station or other point of origin.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Departure date/time, estimated	-	Means the date (And time) of departure of means of transport based on current forecast.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Departure date/time, planned	-	Means the date (And time) of departure of means of transport in the timetable.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Departure date/time, planned	-	The time at which a train is scheduled to depart from a given point of origin.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Departure delay, actual	-	Means the time difference between the actual departure date/time and the Planned departure date/time.	Commission Regulation (EU) No 454/2011 of 5 May 2011

Term	Abb.	Description	Collected from
Departure delay, actual	-	A deviation of the departure time from the scheduled departure time at a station.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Departure delay, expected	-	Means the time difference from the departure date/time and the expected departure date/time.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Dispatchers	-	The crews or the agents who monitor and control the train running and routing.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Dispatchers	-	The dispatcher is an employee of a transport company who sends out trains, buses, trucks, or cars according to a schedule; they control the departure of vehicles according to weather conditions and in the interest of efficient service.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Display	-	Means any dynamic visual device located either in stations or on the inside/outside of trains for the purpose of informing passengers.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Disruption	-	See "Perturbation (Major)".	-
Distributor	-	Means an undertaking providing legal and technical capacity to issuers to sell rail products or to provide on line-facilities to customers to buy rail products. Besides, the distributor can offer services to issuers by assembling O-Ds carried out by different carriers into complete journeys as required by the traveller. The distributor may be a carrier.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Domestic journey	-	Means a passenger journey by rail whereby a passenger does not cross a border of a Member State.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Domestic rail passenger service	-	Means a rail passenger service which does not cross a border of a Member State.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Dwell time	-	The elapsed time from the time that a train stops at a station platform until it starts moving again.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles,

Term	Abb.	Description	Collected from
			definitions and Requirements" - Chapter 8 - Page 60-63 of 65
E			
Engineering works	-	Technical works on the rail track, including construction and alteration.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Essential requirements	-	Means all the conditions set out in Annex III to Directive 2008/57/EC which must be met by the trans-European rail system, the subsystems, and the Interoperability Constituents including interfaces.	Commission Regulation (EU) No 454/2011 of 5 May 2011
European Railway Agency	ERA	Means the Agency established pursuant to Regulation (EC) No 881/2004/EC of the European Parliament and of the Council of 29 April 2004 establishing a European Railway Agency.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Exceptional consignment / transport / load	-	An exceptional transport causes particular difficulties (as a result of its size, weight or packaging) as regards the fixed installations or wagons of one of the networks/RUs to be used. Because of that, it can only be allowed to run under special technical or operating conditions. Examples: test trains, out-of-gauge loads, heavy axle load vehicles.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Exceptional consignment / transport / load	-	A consignment is considered as exceptional if its external dimensions, its weight or its features in relation to the fixed equipment or wagon of a railway/RU involved in the transport cause particular difficulties, and therefore, it can only be accepted under special technical or operating conditions. (More details are in Art. 1.2.).	UIC leaflet 502-1, Article 1.1
Exchanged data	-	Data interchanged between at least two entities (in this case, data generated and processed by the IMs).	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
F			
Fault Management System	-	Software system: Network Rail's corporate system for managing the logging and resolution of faults occurring in the infrastructure / assets.	

Term	Abb.	Description	Collected from
Forecast	-	Means the best estimate of an event (e.g., arrival, departure or passing time of a train).	Commission Regulation (EU) No 454/2011 of 5 May 2011
Forecast point	-	Means a target point for which the forecast is generated. It may relate to arrival, departure, passage or handover.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Freight Operating Company	FOC	A company with access rights to operate freight trains on the railway network.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
G			
General Conditions of Carriage	GCC	Means the conditions of the carrier in the form of general conditions or tariffs legally in force in each Member State and which have become, through the conclusion of the contract of carriage, an integral part of it.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Graphical User Interface	GUI	A representation that allows someone to interact with a computer (or system) through a metaphor of direct manipulation of graphical images and widgets in addition to text.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
H			
Handover point	-	Means the point where the responsibility changes from one infrastructure manager to another.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Handover time (estimated)	ETI	-	-
Headway	-	The necessary time interval or space between two successive trains on the same track. From precedence train's head to the following train's head.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
I			

Term	Abb.	Description	Collected from
Incident	-	Any occurrence, other than accident or serious accident, associated with the operation of trains and affecting the safety of operation.	OTIF definition
Infrastructure	-	The fixed and capital equipment needed for running, maintaining, signalling and dispatching trains.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
In2Rail project	I2R	-	
Infrastructure Manager	IM	Means any body or undertaking that is responsible in particular for establishing and maintaining railway infrastructure. This may also include the management of infrastructure control and safety systems. The functions of the infrastructure manager on a corridor or part of a corridor may be allocated to different bodies or undertakings.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Infrastructure Manager	IM	A body responsible for development, operation and maintenance of the railway infrastructure.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Infrastructure Manager	IM	An undertaking or an authority which manages railway infrastructure'. In particular, 'manager' means the person who makes railway infrastructure available and who has responsibilities in accordance with the laws and prescriptions in force in the State in which the infrastructure is located'.UK: IMs are sometimes called 'track managers'.	OTIF definition
Infrastructure Performance Manager	IPM	-	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Information provider	-	The RU making available the timetable of a whole train.	ERA/TD/2012-16/INT

Term	Abb.	Description	Collected from
Initial delay (entry delay)	-	A delay recorded at the cordons of an investigate network when a train enters.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
Interchange between carriers	-	Means the transfer of control from one railway undertaking to another for practical operational, safety and liability reasons. Examples are: - successive railway undertakings - trains with substitute carriers - the transfer of information between different railway undertakings.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Interchange point	-	Means the location where the control of the train is transferred from one railway undertaking to another railway undertaking Regarding a train running, the train is taken over from one railway undertaking by the other railway undertaking, which now owns the path for the next section of the journey.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Interchange time (estimated)	ETI	-	-
Inter locking	-	An arrangement by which points and signals are electrically or otherwise interconnected in a way so that each movement follows the other in a sequence.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
Intermediate point	-	Means the location which defines the start or end point of a journey section. This may be an interchange, handover or handling point, for example.	Commission Regulation (EU) No 454/2011 of 5 May 2011

Term	Abb.	Description	Collected from
International journey	-	Means a passenger journey by rail crossing the border of at least one Member State.	Commission Regulation (EU) No 454/2011 of 5 May 2011
International rail passenger service	-	Means a rail passenger service which crosses a border of at least one Member State.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Interoperability constituent	-	Means any elementary component, group of components, subassembly or complete assembly of equipment incorporated or intended to be incorporated into a subsystem upon which the interoperability of the trans-European rail system directly or indirectly depends. The concept of a constituent covers both tangible objects and intangible objects, such as software.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Itinerary segment	-	Section of the route of a train, usually defined in order to describe service elements and facilities that are available for only part of the route. Synonym : travel segment.	ERA/TD/2012-16/INT
J			
Joining to	-	The operation by which two trains, having run separately until now, meet in a station and are there coupled to each other to continue the journey together but keeping each its original train number.	ERA/TD/2012-16/INT
Journey	-	Means the movement of a passenger (or several passengers travelling together) from a location A to a location B.	Commission Regulation (EU) No 454/2011 of 5 May 2011
K			
Knock-on delay	-	The secondary delay due to either a short headway times or late transfer connection.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
L			

Term	Abb.	Description	Collected from
Long term planning	-	The planning process used to develop the annual timetable.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
M			
Man Machine Interface	MMI	-	
N			
National Enforcement Body	NEB	Organisations designated by each member State, according to art. 30 of Regulation 1371/2007, to guarantee its good application. The list of NEBs is on http://ec.europa.eu/transport/passengers/rail/rail_en.htm.	ERA/TD/2012-16/INT
Node	-	Points of a network in which at least two lines converge.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference: UIC Code 406: Capacity (1st Ed.). Paris: International Union of Railways (UIC).
O			
Objective function	-	A mathematical representation of the objective that is aimed at in terms of the decision variables.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Operating Central Center	OCC	Term to describe a future traffic management centre with signalling and control processing combined.	-

Term	Abb.	Description	Collected from
One stop shop	OSS	An international partnership between rail infrastructure managers providing a single point of contact for rail customers for the purposes of: - ordering specified train paths in international freight traffic - monitoring the movement of the entire train - generally also invoicing track access charges on behalf of infrastructure managers.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Operator	-	The carrier operating a train for (part of) its route.	ERA/TD/2012-16/INT
Original delay (primary delay)	-	A delay generated within the network and not caused by other trains.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
P			
Passenger	-	Means a person who intends to make, or is making, or has made a journey using the transport services and other services of one or more railway undertakings May be different from customer (see customer).	Commission Regulation (EU) No 454/2011 of 5 May 2011
Path	-	Means the infrastructure capacity needed to run a train between two places over a given time-period (route defined in time and space).	Commission Regulation (EU) No 454/2011 of 5 May 2011
Path number	-	Means the number of the defined train path.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Person In Charge Of Possession	PICOP	-	-
Person In Charge Of Work	PICOW	-	-

Term	Abb.	Description	Collected from
Person with Reduced Mobility	PRM	Persons with Reduced Mobility' (PRM) means all people who have difficulty when using trains or the associated Infrastructure.	Identified in §2.2 of the Commission Regulation (EU) n° 2008/164/EC of 7 Marche 2008
Perturbation	-	An extra influence on a system that causes it to deviate slightly.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
Perturbation (Minor)	-	A minor perturbation is a perturbation not planned that can be resolved through correction by an ICT system with no human intervention. IM/RU communication will be between systems.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" Chapter 1.1 - Page 7 of 65
Perturbation (Major)	-	A major perturbation is a perturbation not planned that can only be resolved with human intervention to make decisions about the redisposition of resources (paths, crew, rolling stock). These decisions will need RU/IM communication between both human and ICT system.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" Chapter 1.1 - Page 7 of 65
Perturbation (Major)	-	Disruptions to operations means unforeseen events which affect the safety, punctuality and smooth operation of traffic, such as accidents, demonstrations, environmental or climatic influences, technical failure of railway infrastructure or rolling stock, incidents linked to the operation of railway infrastructure or rolling stock.	
Perturbation (Major)	-	When some disorder on the rail network leads to disruption of the rail services provided by IMs to RUs, and consequently to train services provided by RUs to their customers.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition,

Term	Abb.	Description	Collected from
			December 2013
Perturbation (Extensive)	-	Extensive disruption to traffic" occurs when train services on at least one main railway line are suspended for more than six hours.	ZUROSTAT - ITF - UNECE - Glossary for Transport Statistics - 4th edition - ISBN 978-92-821-0294-7
Platform	-	Means the area at a station to alight from/board trains.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Possession (specific to UK)	-	Network Rail takes possession of the rail network to undertake maintenance, renewal or enhancement of the network. Network Rail compensates train operators for possessions under the provisions of Schedule 4 of the Track Access Agreement, and sometimes under Part G of the Network Code.	-
Primary data	-	Means the basic data as reference data input for messages or as the basis for functionality and calculation of derived data.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Product	-	Means a type of train with determined types of services (e.g., high speed, bicycle storage places, PRM accommodation, couchette and/or sleeping cars, dining cars, take-away facilities, etc.) which are linked to relevant prices and may be linked to specific conditions.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Public Time Table	PTT	See “Time Table (Public)”.	-
Pulling Train	-	The train to which a coach group is coupled.	ERA/TD/2012-16/INT
Punctuality	-	Defined as the percentage of the trains that arrive at a location with a delay less than a certain time in minutes.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
Q			

Term	Abb.	Description	Collected from
R			
Rail Freight Corridor	RFC	-	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Rail system	-	Means (as in 'trans-European rail system') the structure, as described in Annex I (Directive 2008/57/EC), composed of lines and fixed installations, of the trans-European transport network, built or upgraded for conventional rail transport and combined rail transport, plus the rolling stock designed to travel on that infrastructure.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Railway network	-	A train system or a particular area including all train running elements which can communicate with other networks.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Railway undertaking	RU	Means any public or private undertaking the principal business of which is to provide services for the transport of goods and/or passengers by rail, with a requirement that the undertaking must ensure traction; this also includes undertakings which provide traction only.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Railway undertaking	RU	Bodies, such as train operating companies and freight operating companies, responsible for the operation of passenger and freight trains.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Real Time Plan Distribution	-	Maintains the current plan by combining the day plan and any operational on-the-day changes. Distributes the plan for automatic or manual implementation, and includes information on planned possessions.	§1.1 from [*NR TMS Doc 1]*
Recovery time	-	The time added into the nominal timetable to be reserved for the trains to be recovered from delays by using effective train operation strategies.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page

Term	Abb.	Description	Collected from
			60-63 of 65
Registry	-	A tool made available by the Governance Entity to keep track of all resources made available by resource producers, that the authorised resource consumers can consult to find at which address the resource can be found and by which method it can be accessed.	ERA/TD/2012-16/INT
Regular vs. Short Term processes	-	Regular means a process when performed within a period which is equal to or more than 7 days. Short term means a process when performed within a period which is less than 7 days.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Reliability	-	The ability of a system or component to perform as designed.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Reporting point	-	Means either passing points used by an infrastructure manager to provide train running information (only) or points where forecasts are generated.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Repository	-	Means the storage of data similar to a database and data dictionary; however, it usually encompasses a comprehensive information management system environment. It must include not only descriptions of data structures (i.e. entities and elements), but also Metadata of interest to the enterprise, data screens, reports, programs, and systems.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Requirements (operational)	-	Conditions linked to railway operations (planning, crewing, movement and control of trains).	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Rescheduling	-	Identifying and resolving conflict which may arise during actual operations. The goals are to minimise the overall delay and return as fast and as close as possible to the original timetable.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and

Term	Abb.	Description	Collected from
			Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
Reservation provider	-	The railway company, which is responsible for the reservation of a train.	ERA/TD/2012-16/INT
Rail Net Europe	RNE		Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Route	-	Means the geographical line to be taken from a starting point to a point of destination.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Route	-	Consecutive lines and nodes as a whole, between a defined source and target.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference: UIC Code 406: Capacity (1st Ed.). Paris: International Union of Railways (UIC).
Route planning	-	Planning the train route at the station for the sake of the minimum pass time of the passing trains.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Route section	-	Means a part of a route.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Routing station	-	A station where a train passes by without stopping, that is included in the schedule of that train to help match the timetable data to the tariff data	ERA/TD/2012-16/INT

Term	Abb.	Description	Collected from
S			
Schedule	-	The timetable data related to a specific train, with its origin, transit and destination stations and the corresponding times of departure, arrival and passage.	ERA/TD/2012-16/INT
Service number	-	The number identifying a given transport service (train or coach group) offered in the timetable of an operator.	ERA/TD/2012-16/INT
Service provider	-	Means the responsible entity providing any services linked to the transport of passengers.	ERA/TD/2012-16/INT
Short notice path request	-	Means the individual request for a path according to Article 23 of Directive 2001/14/EC due to additional transport demands or operational needs.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Short term planning	-	The planning process used to handle changes to the published annual timetable.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Short Term processes	-	See Regular vs. Short Term processes.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Service Interface for Real Time Information	SIRI	Service Interface for Real Time Information SIRI is an XML protocol to allow distributed computers to exchange real-time information about public transport services and vehicles. SIRI is based on the Transmodel abstract model for public transport information.	ERA/TD/2012-16/INT
Sole carrier	-	Means a carrier that operates a transport service independently of other carriers.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Splitting from	-	The operation by which two trains, having run until now coupled to each other but with different train numbers, stop in a station and are divided from each other to continue separately their journeys keeping each its original train number.	ERA/TD/2012-16/INT
Stakeholders	-	Means any person or organisation with a reasoned interest in train service delivery e.g.: - Railway undertaking - Coach / Locomotive provider - Driver/train crew provider- Infrastructure manager (IM) - Fleet manager - Passenger	Commission Regulation (EU) No 454/2011 of 5 May 2011

Term	Abb.	Description	Collected from
Station	-	Means a railway location where a passenger train can start, stop or end.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Station	-	Points of a network where overtaking, crossing or direction reversals are possible, including marshalling yards.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference: UIC Code 406: Capacity (1st Ed.). Paris: International Union of Railways (UIC).
Stability	-	The ability of a system or component to compensate for delays and return to the desired state.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
Station manager	SM	Means an organisational entity in a Member State, which has been made responsible for the management of a railway station and which may be the infrastructure manager.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Substation	-	A substation is a part of a station. For example, part of a station can be dedicated to high speed traffic, another to regional traffic and another to urban traffic.	ERA/TD/2012-16/INT
Substitute carrier	-	Means a railway undertaking, which has not concluded a transport contract with the passenger, but to whom the railway undertaking that is party to the contract has entrusted, in whole or in part, the performance of the transport by rail.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Switch	-	Another term for a pair of points.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and

Term	Abb.	Description	Collected from
			Requirements" - Chapter 8 - Page 60-63 of 65
T			
Technical Specification for Interoperability	TSI	Means a specification adopted in accordance with Directive 2008/57/EC by which each subsystem or part subsystem is covered in order to meet the Essential Requirements and ensure the interoperability of the rail system.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Train Information System	TIS	(formerly Europtirails)	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Time Table	TT	Means the list of commercial transport services offered by a railway undertaking during a given time interval.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Time Table (Public)	PTT	Timetable published for use by passengers and to calculate Public Performance Measure, Note contrast with Working Timetable.	*[NR TMS Doc 7]*
Time Table (Working)	WTT	Available within the rail industry purely for operational use. It includes details of all Long Term Plan freight and passenger schedules, including empty stock movements to/from depots and fuelling points.	*[NR TMS Doc 7]*
Timetabling	-	Aim at determining a periodic for a set of trains that does not violate track capacities and satisfies some operational constraints.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Track	-	Tracks are the route ways of a railway system to support and guide trains.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65

Term	Abb.	Description	Collected from
Traffic diagram	-	A time-distance diagram that contains the train paths of all trains that run on a line.	Identified in ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65 Reference Hansen, I. A. and Pachl, J. (2008). Railway timetable and traffic. 2008: Eurailpress: Hamburg.
Traffic Management System	TMS	A traffic control-command and supervision/management system, such as ERTMS in the railway sector.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Traffic Control Centres Communication	TCC Com	-	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Traffic control system	-	A large-scale distributed industrial control system. A train-traffic-control system has many station-level subsystems doing the traffic control, several train-line-level systems managing the station-level subsystems, and a central supervising system. Train traffic control is performed from control centres, where train dispatchers monitor and control the traffic.	Rail Net Europe - GLOSSARY OF TERMS RELATED TO RAILWAY NETWORK STATEMENTS - Fifth Edition, December 2013
Train Cancellation	-	See: “Cancellation of a train”.	-
Train Describer	-	A Train Describer is an electronic system connected to the signalling control system or interlocking which displays a given ‘train identity’ in the appropriate berth on a mimic diagram. The position of the train identity will be updated by the train describer by using changes to ‘state of railway’ inputs to step the description to the next berth.	-

Term	Abb.	Description	Collected from
Train operating company	TOC	A company with access rights to operate passenger trains on the railway network.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Train path	-	Means the train route defined in time and space.	Commission Regulation (EU) No 454/2011 of 5 May 2011
Train path	-	That part of capacity of the railway infrastructure which is necessary to schedule or run a train with a requested speed profile.	ON-TIME project deliverable D.1.1, reference ONT-WP01-DEL-001, title "Principles, definitions and Requirements" - Chapter 8 - Page 60-63 of 65
Train running interrupted	-	Means that the continuation of the train is unknown based on local circumstances at the time and in the opinion of the parties involved. If the Delay is known, the infrastructure manager sends a train running forecast message.	Commission Regulation (EU) No 454/2011 of 5 May 2011
U			
V			
W			
Working Time Table	WTT	See “Time Table (Working)”.	-
Working week	-	A conventional representation used to indicate in which days of a week a service is present or not, as an alternative to the generic method of the “days of operation”. The days from Monday to Sunday are indicated with the digits 1 to 7, and only the digits corresponding to the days when the service is present are listed).	ERA/TD/2012-16/INT
X			
Y			
Z			

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8 Appendices

8.1 Requirements Matrix

The actual high-level requirements for the future Traffic Management System / dispatching system have been collected in the document "INR-WP07-T-SYS-001-00_Requirements Matrix_00I.xlsx

8.2 Standardisation Activities on SOA Architectures

This chapter provides an overview on potentially interesting standardisation activities on Service Oriented Architecture architectures from other sectors.

Detailed information has been collected from different domains. Following the schema below, all available material found is reported in the present document.

- Name of the system
- Source information
- Domain of application of the system
- General information on the system
- System description
- Interest of using SoA for this system

8.2.1 Standard ISO/IEC TR 30102

SOURCE INFORMATION

Document: Joint Technical Committee ISO/IEC JTC 1, Information technology, Subcommittee SC 38, Distributed application platforms and services (DAPS) - Information technology – Distributed Application Platforms and Services (DAPS) – General technical principles of Service Oriented Architecture, 2012.

DOMAIN OF APPLICATION OF THE SYSTEM:

Domain independent

GENERAL INFORMATION ON THE SYSTEM:

Partners involved: Joint Technical Committee ISO/IEC JTC 1, Information technology, Subcommittee SC 38, Distributed application platforms and services (DAPS).

Network / Country concerned: Worldwide application

Date of creation of the system (or last update): 2012

SYSTEM DESCRIPTION

Purpose

Service Oriented Architecture (SOA) is an architectural style that supports service orientation and is a paradigm for business and IT. This architectural style is for designing systems in terms of services available at an interface and the outcomes of services. A service is a logical representation of a repeatable business activity that has specified outcomes, is self-contained, may be composed of other services and is a “black box” to consumers of the service.

SOA is an architectural style that has the following distinguishing characteristics:

- is based on the design of the services and processes – which mirror real-world business activities – comprising the enterprise (or inter-enterprise) business processes;
- Service representation utilizes business descriptions to provide context (i.e., business process, goal, rule, policy, service interface, and service component) and implementations of services are provided use processes and service composition;
- places unique requirements on the infrastructure – it is recommended that implementations use open standards to realize interoperability and location transparency;
- Implementations are environment-specific – they are constrained or enabled by context and must be described within that context;
- It requires strong governance of service representation and implementation;
- It requires criteria to determine what a “good service” is.

Business requirements and services descriptions

SOA has become a business organization and technology hot spot that is recognized and respected in industry. Many companies have developed SOA enterprise architecture, solutions and products world-wide. At the same time, an increasing number of solutions are being implemented using SOA in many different industries.

SOA principles defined in ISO/IEC TR 30102 are applicable to software engineering and can also be applicable to system engineering in order to formalize service-based systems (i.e., complex systems, federation of systems, systems of systems, enterprise architecture).

A service is a logical representation of a set of repeatable activities that has specified outcomes, is self-contained, may be composed of other services, and is a “black box” to consumers of the service. Service is agnostic to whether the concept is applied to the classical notion of a business domain or the classical notion of an IT domain. A service can have one or more providers or consumers, and produces outcomes that are of value to its consumers.

To a consumer, a service is a black box, in other words, if two services have the same service contract and when given the same inputs will produce the same effects, they are equivalent to the consumer and should be able to be used interchangeably. To a provider, a service is a means of exposing capabilities and the implementation determines equivalency. Therefore, two services that have the same inputs and produce the same effects but use different mechanisms are not equivalent.

As a service itself is only a logical representation, any service is performed by something. The something that performs a service must be opaque to anyone interacting with it. Services can be performed by elements of other types than systems. This includes elements such as software components, human actors, and tasks.

Key non-functional requirement

The Management and Security layer supports non-functional requirement related issues as a primary feature/concern of SOA and provides a focal point for dealing with them in any given solution. It provides the means of ensuring that a SOA meets its requirements with respect to: monitoring, reliability, availability, manageability, transactionality, maintainability, scalability, security, safety, life cycle, etc.

Architecture and database

The architectural principles in SOA are driven to a degree by the importance of the 3 independence principles for SOA: location independence, implementation independence and protocol independence:

- Location independence: there are no preferred locations for a service consumers and service providers. They could transparently both be located on the same system, or in different organization in different physical locations.
- Implementation independence: there are no requirements for specific platform or implementation technologies for service consumers and service providers to adopt. They should not be aware of the others parties’ technical environment or implementation details to inter operate.
- Protocol independence: services can be exposed and consumed with a variety of transport protocols and message protocols. There may be a matchmaking protocol or component in the middle for interoperability purposes. In case of different protocols Enterprise Service Buses may perform the connection between heterogeneous services;

otherwise there can be an agreement to use an interoperability profile such as defined by WS-I (WebServices-Interoperability).

The SOA Reference Architecture (SOA RA) has ten layers representing ten key clusters of considerations and responsibilities that typically emerge in the process of designing a SOA solution.

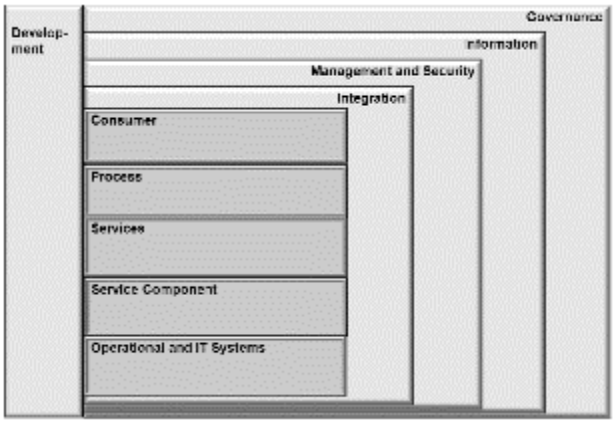

Figure 1 – Reference Architecture for SOA Solutions

Figure 1 depicts a SOA as a set of logical layers. One layer does not solely depend upon the layer below it and is thus named a partially-layered architecture: a consumer can access the Process Layer or the Service Layer directly, but not beyond the constraints of a SOA architectural style.

For example, a given SOA solution may exclude a Process Layer and have the Consumer Interface Layer interacting directly with the Service Layer. Such a solution would not benefit from the business value proposition associated with the Process Layer however that value could be achieved at a later stage by adding the layer. In this sense the SOA Reference Architecture represents SOA with a partially layered architecture. The degree to which a given organization realizes the full SOA Reference Architecture will differ according to the level of SOA maturity they exhibit, and the underlying requirements of the organization. Three of the horizontal layers (light grey) address the implementation and interface with a service (the Operational Systems Layer, the Service Component Layer and the Services Layer). Three of the horizontal layers support the consumption of services (the Process Layer, the Consumer Interface Layer and the Integration Layer). Four of them (dark grey) support cross-cutting aspects of a more supporting (sometimes called non-functional or supplemental) nature (the Information Architecture Layer, the Management and Security Layer, the Integration Layer and the Governance Layer). The SOA RA as a whole provides the framework for the support of all the elements of a SOA, including all the components that support services and their interactions.

Interfaces

Service interfaces define the way in which other elements can interact and exchange information with a service as the outcome of a request in the definition of a service. It is important that services have simple, well-defined interfaces. This makes it easy to interact with them, and

enables other elements to use them in a structured manner. The concept of an interface includes the notion that defines the parameters for information passing in and out of them when invoked. The specific nature of how an interface is invoked and how information is passed back and forth differs between domains. Service interfaces are typically, but not necessarily, message-based (to support loose-coupling). Furthermore, service interfaces are always defined independently from any particular service implementation (to support loose-coupling and service mediation).

Any service must have at least one service interface. There can be constraints on the allowed interaction on a service interface such as only certain value ranges allowed on given parameters. Depending on the nature of the service and the service interface in question, these constraints may be defined either formally or informally (the informal case being relevant at a minimum for certain types of real-world services). The same service interface can be an interface of multiple services. This does not mean that these services are the same, nor even that they have the same effect; it only means that it is possible to interact with all of them in the manner defined by the service interface in question.

INTEREST OF USING SOA FOR THIS SYSTEM:

Business-oriented SOA takes ‘service’ as its basic element to constitute and integrate information systems so that they are suitable for a wider variety of application requirements. Some of the benefits of using SOA are improvement in the efficiency of development of information systems, efficiency of integration and efficiency of re-use of IT resources. It also enables agile and rapid response of information systems to ever-changing business needs.

8.2.2 Digital Aeronautical Information Management (D-AIM)

SOURCE INFORMATION

Website: https://www.eurocontrol.int/services/digital-aeronautical-information-management-d-aim

Document: Roger Li, D-AIM DELIVERABLE 2 “D-AIM architecture description” - 2007

DOMAIN OF APPLICATION OF THE SYSTEM

The system is applicable in the aviation domain.

GENERAL INFORMATION ON THE SYSTEM

Partners involved: D-AIM is a joint project:

- Swedish Air Navigation Service Provide
- LFV (public enterprise operating air navigation services for civil and military customers in Sweden)
- EUROCONTROL (European Organisation for the Safety of Air Navigation)

Clients of the system: Aeronautical Information Management community / Users are any client that extracts or receives D-AIM content.

Network / Country concerned: Sweden

Date of creation of the system (or last update): 2009

SYSTEM DESCRIPTION

Purpose

The objective of Digital Aeronautical Information Management (D-AIM) is to create a test-bed for one of the foundations of future Air Traffic Management (ATM), which is information sharing and it aims at establishing an overall environment for sharing the required information. In order to achieve this, D-AIM will adopt a standard-and Service Oriented Architecture (SOA). SOA allows static and dynamic aeronautical information to be merged and shared in a data-hub that serves as a “one-stop-shop” for users. By adopting a standards-based approach, data are made available in a standardized exchange format through standardized interfaces.

Static and dynamic aeronautical information is made available to users through web-services. Provision of information from Metrological and Aeronautical Information Services data sources via web-services is increasing automation for the service provider and data integrator, opens new areas of service and is in-line with the goal of a paperless environment. The geo-spatial dimension is essential if the information is to be available when and where needed by users. The filtering of the information increases the situational awareness of the user and helps to prevent information over-flow and reduce costly data management.

D-AIM is using standardized interfaces and data link infrastructure for provision of ground-to-ground information sharing as well as ground-to-air information sharing, integrating Aeronautical Information Management and Data Link communication as a common ground for interoperable

technology trials. D-AIM serves the Aeronautical Information Management community to meet future Air Traffic Management requirements of updated aeronautical information, by progressing with automation and integration of data in a new service provision platform.

Business requirements and services descriptions

In the future European Air Traffic Management system, airspace users shall have a right of access to any airspace whenever required by their operations. Predictability is an important issue to achieve an efficient flow at the airports. The corresponding need for aeronautical information that follows these requirements should be met by the same access principle: timely access to the required information, in a standardised format adaptable to specific needs and through common interfaces.

Aeronautical information users need smart solutions that are data driven whereby different sources of information can interoperate seamlessly. Users want to focus on their own operations avoiding cumbersome and costly data integration efforts. Hence users want to use intelligent services that integrate information in such manners that information becomes directly exploitable in the daily business, both in terms of integration into systems for advanced automation and in terms of exception handling, requiring human inspection. User needs are pointing at a one-stop shop for interoperable aeronautical information including the geospatial dimension.

In terms of productivity and cost saving the intent should be to maximise automation of aeronautical information usage and allow efficient information analysis when exceptions (e.g., rejected flight plan) are encountered. A geospatial and temporal handling of the data brings several benefits whereof increased system performance is one, increased safety is another.

Typical examples of user requirements are:

- Temporary information such as runway and taxiway closure and failure of navigational aids, traditionally issued as NOTAMs (NOtice To AirMen), is required to be integrated in an operative context for Air Traffic Services and aircraft operators, to increase situational awareness and prevent incidents like runway incursion.
- Updates of pre-flight bulletins, notifications of changes in weather conditions or significant weather, and information about restricted areas along the intended flight-path or within an area, should be accessible based on the location of the user. The information should be able to be graphically visualised on cockpit displays. This timely information could pave the way for a paperless cockpit environment.
- Information about the availability of restricted areas, amongst other in-flight information, is currently received from Air Traffic Services through voice communication. Allowing the pilot to visualise the information on-demand in a geospatial application facilitates timely decision-making. Air Traffic Services efficiency is improved by reducing the time spent on routine voice communications.

A D-AIM service can be seen as the provision of a (tailor-made) product on demand, including what the user asks for, delivered and presented in a generic way, suitable for a specific user need. The D-AIM Server would be able to collect data from sources on the internal network as well as from secure sources on the internet. In the same way the D-AIM server would be able to provide services to both internal users, such as a Flight Information Service server or Air Traffic

Services system, via the internal network, as well as to external users, connecting to the D-AIM server via the internet.

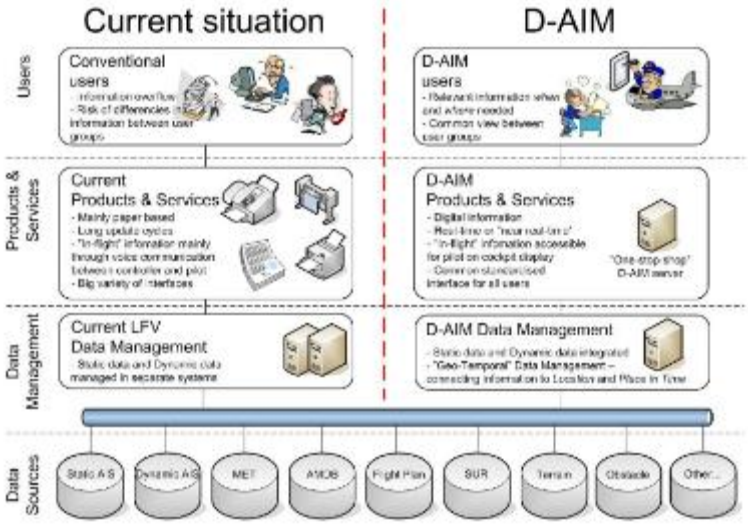

Figure 2 – Differences and benefits with D-AIM compared to current situation

Architecture and database

Figure 3 represents the architecture of D-AIM, with the D-AIM server in the middle being sort of a one-stop-shop with a “catalogue” listing all the aeronautical and metrological services and products that can be provided. The user specifies what he/she wants to have to the D-AIM server, which picks up the very latest information from the different sources. The D-AIM server sorts, filters and packages the information so that the user only receives what he needs at that particular occasion.

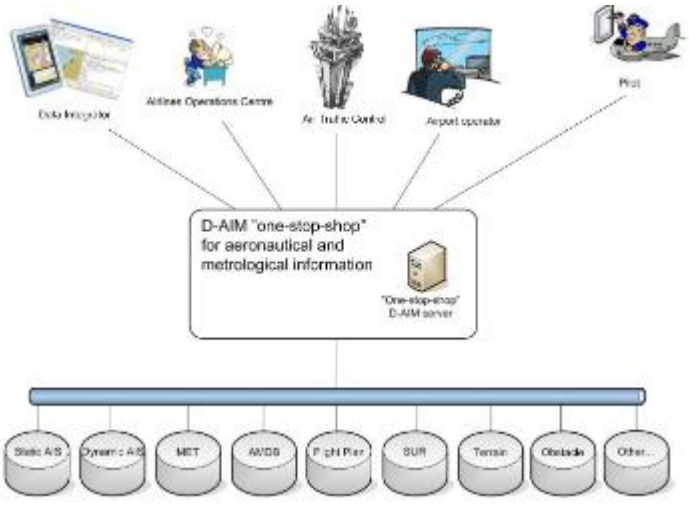

Figure 3 – Architecture of D-AIM

Figure 4 below depicts the network architecture that would be needed to facilitate the D-AIM services. The D-AIM server would be accessible both from the internet and the company internal network.

When deploying the D-AIM infrastructure, network security issues will be taken into consideration. Secure data distribution can be accomplished in several ways and could include the use of protected Virtual Private Network (VPN) connections in combination with firewalls and monitoring of data traffic.

Figure 4 depicts a series of relevant data sources that may be adapted to the D-AIM services network. D-AIM provides a generic solution to the concept of aeronautical information sharing, independent from data types, local contexts and implementation choices. The benefits compared to current network architecture are that all users of aeronautical and metrological information would only need one access point for this information instead of many.

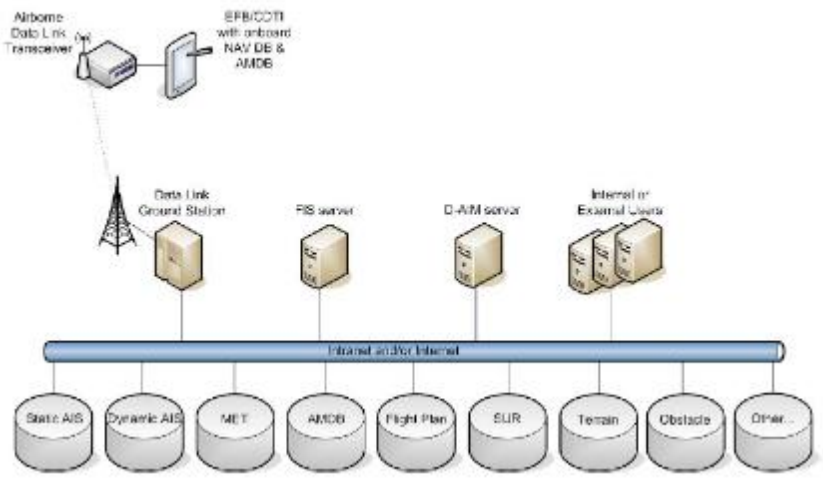

Figure 4 – Network architecture to facilitate D-AIM services

Interfaces

D-AIM is using standardised interfaces and data link infrastructure for provision of ground-to-ground information sharing as well as ground-to-air information sharing, integrating Aeronautical Information Management and Data Link communication as a common ground for interoperable technology trials. D-AIM serves the Aeronautical Information Management community to meet future Air Traffic Management requirements of updated aeronautical information, by progressing with automation and integration of data in a new service provision platform.

User system complexity would benefit from having open, standardised exchange formats and interfaces. This is something that could increase flexibility and competition in terms of choosing system provider. Altogether this will allow establishing an aeronautical data chain that can be

optimised in terms of data encoding and interchange, enabling a lean information interchange process.

Message formats

Standard data content and exchange formats are used; their meaning is defined through data modelling.

Global interoperable data exchange is based on the:

- Standardisation of data content and meaning through data modelling
- Standardisation of interfaces to provide well defined means to access data and enable seamless interoperation

The main characteristics of interoperability are:

- <Temporal> Rich temporality to support timely information filtering and decision making
- <Open> Based on documented standards to facilitate community adoption
- <Geospatial> Rich geo-referencing to support location based and decision making
- <Global> Worldwide participation and applicability
- <Standards> Based on leveraged standards to reduce costs

Communication protocols

The following global interoperability standards are adopted:

- Global AIM Data Models
- Service Orientated Architecture
- Geomatic Standards
- World Wide Web Consortium
- The Organisation for the Advancement of Structured Information Standards

Use Cases

A number of possible use cases and scenarios applicable in the D-AIM context have been identified.

TWY/RWY closure

The intent of D-AIM is to complement the NOTAM system with a digital equivalent that allows users to extract the required information and update the current situational picture. Hence information transmitters such as the current NOTAM system and the CASCADE trials may become users of D-AIM. However, to demonstrate the full potential of D-AIM, it will be required to experiment with NOTAM and Data-link like applications, since D-AIM envisages a fully enabled geospatial and temporal approach. By an integrated static and dynamic data management, aeronautical information update messages sent as an xml-message can be geo-spatially displayed on a Cockpit Display of Traffic Information in combination with Geographic Information System AMDB data.

Temporary Segregated Areas Status

Another example of the aeronautical information update message is graphical display of Temporary Segregated Area (TSA) status. It provides an update to the current navigation

database when a restriction area with permanent permission required is available, or an update about the status of other types of airspace. Currently this information is sometimes available to the users through the NOTAM format but most of the time the pilots have to request the information from the Air Traffic Services through voice communication. This D-AIM use case will make the Temporary Segregated Area status, once initiated by the Air Traffic Services, available automatically and graphically displayed on the Air Traffic Services display as well as on the pilot's Cockpit Display of Traffic Information.

Significant Meteorological Information

SIGMET, or Significant Meteorological Information, is a weather advisory that contains meteorological information concerning the safety of all aircraft in a certain area during a certain time. Examples of such information could concern severe turbulence, icing, thunderstorm, sandstorm, volcanic ash etc. The users of SIGMET information can be pilots in-flight and pre-flight, Airlines Operations Centre (AOC) as well as Air Traffic Control (ATC).

METAR

A METAR message is a prognosis weather message that is produced for each airport. On medium and long-range flights the METAR can be of interest to receive in-flight since it is updated every 30 minutes. The pilot will then be aware of possible adverse weather conditions at the airport and can make a decision whether to redirect to another airport. METAR for other airports along or nearby the intended flight route can also be delivered in flight.

METREPORT

On the contrary to the METAR message, which is a prognosis, the MET REPORT is a report containing the current weather situation at the airport. The MET REPORT is also updated every 30 minutes unless there is a significant change, if so it is updated instantaneously. The MET REPORT could be delivered to the aircraft in a demand mode. However the MET REPORT could also be suitable for a broadcast mode for aircraft lacking the demand mode capability, e.g., general aviation aircraft.

INTEREST OF USING SOA FOR THIS SYSTEM:

This allows static and dynamic aeronautical information to be merged and shared through data-hubs. By adopting a standards-based approach, data is made available in a standardised exchange format through standardised interfaces.

8.2.3 System Wide Information Management (SWIM)

SOURCE INFORMATION:

Website: http://www.faa.gov/nextgen/programs/swim/

DOMAIN OF APPLICATION OF THE SYSTEM

The system is applicable in the aviation domain.

GENERAL INFORMATION ON THE SYSTEM

Partners involved

Aviation Industry and Trade and Representation Groups represent the aviation community, including government organizations, airlines, airspace users, airport associations, labor unions, and aviation service and equipment suppliers. Through these associations, the SWIM Program is able to not only gain understanding of other aviation industry initiatives but also identify potential subscribers of SWIM-compliant data within industry.

The following represent industry partners of SWIM:

- Alliance
- ARINC
- Lockheed Martin
- MOSAIC ATM
- Passur
- Rockwell Collins
- Sabre
- Sensis
- Veracity

Airline partners are critical to the success of the SWIM Program. Airline partners enable SWIM to gain an understanding of the needs of the aviation industry, enabling the Federal Aviation Administration to provided world-class capabilities to support needed information management requirements.

The following represent airline partners of SWIM:

- American Airlines
- Delta Airlines
- FedEx
- JetBlue
- United Airlines
- USAIR

Several key international partners are involved:

- The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations
- Single European Sky Air Traffic Management (ATM) Research Joint Undertaking (SESAR JU): a public-private partnership that includes European Organization for the Safety of Air Navigation (EUROCONTROL), the European Commission, other states, and European industry service providers and airport organizations
- Japan Civil Aviation Bureau (JCAB), the Air Navigation Service Provider (ANSP) in Japan
- AirServices Australia (ASA), the Australian ANSP.

Industry or TI developers

The John A. Volpe National Transportation Systems Center and Massachusetts Institute of Technology's (MIT) Lincoln Laboratories provide aviation expertise and coordination with the

SWIM Program. The Volpe team was tasked with developing a SWIM-compliant Integrated Terminal Weather Service (ITWS) Prototype, while MIT Lincoln Labs is developing the SWIM-compliant Corridor Integrated Weather Service (CIWS) Prototype. SWIM's Flight Data Publication Service (FDPS) is also being developed at Volpe.

Clients of the system

Clients of SWIM are data producers (to collect the information they have access to so it can be shared through a single source) and data consumers (to provide easy access to the information they need).

SYSTEM DESCRIPTION

Purpose

System Wide Information Management (SWIM) enables the sharing of information between diverse systems enabling the Next Generation Air Transportation System (NextGen) to deliver the right information to the right place at the right time. The program achieves this by providing the IT Service Oriented Architecture (SOA) enterprise infrastructure necessary for National Airspace System systems to share and reuse information and increase interoperability. SOA is a way of organizing IT assets, policies, practices, and frameworks that enable application functionality to be provided and consumed as services that can be invoked, published and discovered. This infrastructure enables systems to publish information of interest to National Airspace System users, request and receive information from other National Airspace System services, and support National Airspace System security requirements. Further, SWIM provides governance to National Airspace System programs to ensure services are SWIM compliant and meet all Federal Aviation Administration SOA standards.
SWIM's approach allows software applications in the National Airspace System to interact with one another through information services that can be accessed without knowledge of an application's underlying platform implementation. This simplifies interface requirements to existing National Airspace System systems and ensures new systems can be built with minimum technology (hardware, software, and data definition) constraints. SWIM also enables the transition to net-centric National Airspace System operations, and from tactical conflict management to strategic, trajectory-based operations.
The System Wide Information Management (SWIM) Program is being implemented in segments. In each segment, a set of National Airspace System services is being developed and integrated via SWIM. Enterprise infrastructure is added to support the implementation of capabilities associated with the segments. SWIM enterprise infrastructure will enable systems to request and receive information when they need it, subscribe for automatic receipt, and publish information as appropriate. This will provide for sharing of information among diverse systems.

Business requirements and services descriptions:

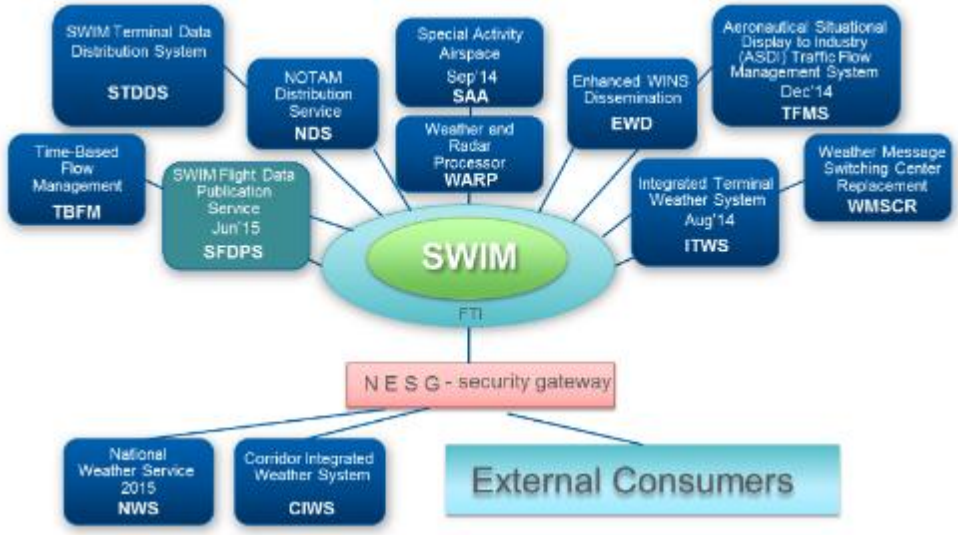

Figure 5 – SWIM services

The SWIM services, as represented in Figure 5 are:

- SFDPS: SWIM Flight Data Publication Service (SFDPS) will provide a variety of En Route flight data, such as flight plans, beacon codes, and handoff status. SFDPS will also disseminate data regarding airspaces, such as Sector configuration data, route status, Special Activity Airspace (SAA) status, and altimeter settings;
- TBFM: Time Based Flow Management (TBFM) will provide a variety of aircraft metering information, airport configuration and adaptation data;
- STDDS: SWIM Terminal Data Distribution System (STDDS) provides surface movement data (ASDE-X), Runway Visual Range (RVR), and a variety of departure event data;
- NDS: NOTAM Distribution Service;
- WARP: Weather and Radar Processor;
- SAA: Special Activity Airspace;
- EWD: Enhanced WINS (Windows Internet Naming Service) Dissemination;
- ITWS: Integrated Terminal Weather System (ITWS) provides a variety of weather information in graphic and textual forms, such as wind shear and microburst predictions, storm cell and lightning information, and terminal area winds aloft;
- TFMS: Traffic Flow Management (TFMS) will provide Aircraft Situation Display (ASDI) data, which will include aircraft scheduling, routing, and positional information
- WMSCR: The Weather Message Switching Center Replacement System (WMSCR) collects, processes, stores, and disseminates textual aviation weather products such as Altimeter data.

INTEREST OF USING SOA FOR THIS SYSTEM

SOA is a way of organizing IT assets, policies, practices, and frameworks that enable application functionality to be provided and consumed as services that can be invoked, published, and discovered. SOA makes an organization's IT better suited for interoperability among

heterogeneous environments; one can interconnect between organizations regardless of their supported infrastructure, which opens doors to delegation, sharing, and reuse of existing services. This simplifies building interfaces to existing end systems and ensures new systems and applications can be created and more quickly integrated in order to create the new functionality needed for NextGen.

8.2.4 Banking Industry Architecture Network (BIAN)

SOURCE INFORMATION

Website: https://bian.org/
Documents

- Rackham G. - Introduction to BIAN – 2015, version 4.2
- Rackham G. - Applying the BIAN Standard – 2015, version 4.3
- Rackham G. - Design Principles & Techniques – 2015, version 4.4
- Rackham G. - Developing Content– 2015, version 4.4

DOMAIN OF APPLICATION OF THE SYSTEM

The system is applicable in the banking domain.

GENERAL INFORMATION ON THE SYSTEM

Company:

BIAN is intended to be highly member driven through BIAN Working Groups and includes various management roles that are considered to ensure the integrity of the Association and make the organization function effectively and efficiently.

BIAN's principal organizational entities include:

- General Assembly – maintain BIAN structure and elect Board of Directors
- Board of Directors –provide strategic direction and management of BIAN and resource the Secretariat
- BIAN Executive Director – reports to the Board of Directors on content delivery, marketing, PR and acquisition
- Committees, Advisors and General Secretariat – ensure the integrity and quality of work products and provides operational and program management
- BIAN Working Groups – member-led teams that create BIAN's standards

Partners involved

BIAN Members are represented in all organizational units excluding the Secretariat. BIAN is independent and is financed by its members. BIAN has one type of membership giving all members an equal vote and power.

Clients of the system: banking industry

Level of development of the system: The system is under development; in the next releases, in Q3 2015 and Q2 2016, further improvements will be done and the development will be completed.

Date of creation of the system (or last update): Last update of the system has been performed on May 2015.

SYSTEM DESCRIPTION

Purpose

The Banking Industry Architecture Network (BIAN) is an association of banks, solution providers and educational institutions with the shared aim of defining a service operation standard for the banking industry. BIAN's expectation is that a standard definition of the business functions and service interactions that describe the general internal workings of any bank will be a significant benefit to the industry.

At the core of BIAN's proposition is the adoption of a service oriented approach to architecting the systems that support the bank. This approach is fundamentally different from the prevailing 'process–centric' designs. To underscore this critical difference a comparison can be made with architectural disciplines when applied to the highly tangible problem of designing the layout of a city as opposed to the much less tangible design of a commercial enterprise such as a bank.

Business requirements and services descriptions

The BIAN Service Landscape is a reference structure that categorizes and organizes BIAN Service Domains for ease of access. Different criteria can be used to classify and organize Service Domains that would result in different layouts of the standard set of BIAN Service Domains. BIAN uses a 'primary' Service Landscape view based on agreed categorizations that have been refined in use by the BIAN membership.

In particular, the BIAN Service Landscape v4.0 is based on the MagicDraw repository and delivers: 7 Business Areas, 36 Business Domains, 280 Service Domains, 1960 candidate Service Operation and 178 Business Scenarios.

The BIAN Metamodel is a detailed and comprehensive (UML) model that defines all the BIAN design structures – it is fully documented elsewhere in its own guide. The Metamodel has three elements that capture the design of the BIAN Service Landscape:

- Business Area is the highest-level classification. A business area groups together a broad set of business capabilities. For the BIAN Service Landscape they are defined to be aspects of business activity that have similar supporting application and information-specific needs.
- Business Domain at the next level, business domains define a coherent collection of capabilities within the broader business area. In the BIAN Service Landscape the business domains are associated with skills and knowledge recognizable in the banking business.
- Service Domain is the finest level of partitioning, each defining unique and discrete business capabilities. The Service Domains are the 'elemental building blocks' of a service landscape. The Service Domain relates to generic capabilities that do not vary in their scope, but the definitions of the Business Domain and Business Area are classifications that are specific to a particular Service Landscape layout. The Service Landscape layout can be varied depending on use.

Figure 6 depicts the design principles and techniques content, describing the key design concepts and techniques employed in the BIAN approach.

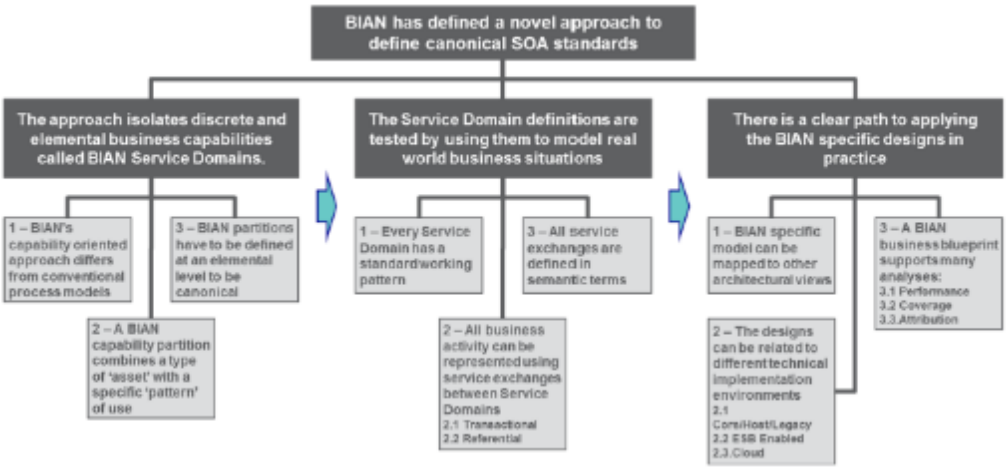

Figure 6 – Design principles and techniques content

The BIAN standards define generic business capability partitions (Service Domains) and their semantic service operations. In order to map these standard designs to a specific organization they need to be selected, adapted and assembled to match the operational scope and structure of organization. BIAN's high level conceptual definitions can then be mapped to more detailed implementation level technical designs to support solution development. The BIAN Service Domains can also be used as the building blocks to assemble an enterprise's business 'blueprint' that can be used for a wide range of planning and analysis uses.

Figure 7 covers the BIAN design principles and techniques, presenting and summarizing guidelines for applying the BIAN design.

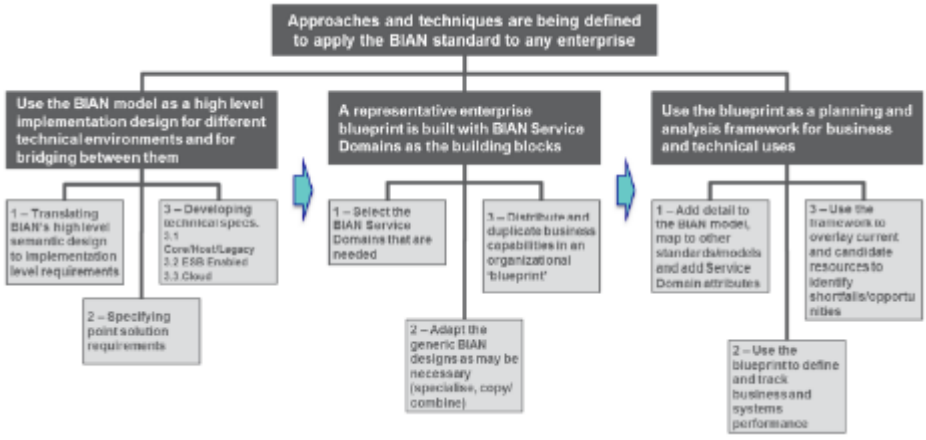

Figure 7 – Applying the BIAN standard

Architecture and database

The BIAN model is a specific type of service oriented architecture applied at the level of business architecture. Using the BIAN model as a high level implementation design – the BIAN business architecture model needs to be related to more detailed systems architecture views for implementation.

The BIAN standard is a business architecture model view that defines a type of service oriented architecture. A SOA captures the business activity as a collection of collaborating operational service centres. It might be expected that the only type of systems architecture that could be linked or derived using the BIAN model would correspondingly be service oriented. Though there are several significant operational advantages in service based systems design, the BIAN business architecture provides valuable insights and design structures for most of the prevailing technical environments found in banks.

The BIAN SOA defines discrete business capability partitions as Service Domains. The Service Domains are usually referred to as service centres – operational capabilities that provide (and consume) business services from other operational capabilities. At the business architecture level the Service Domains can be used as the elemental blocks for building different views of the business enterprise that are then used for different types of planning and analyses.

Interfaces

BIAN members are currently exploring ways to take this use of the BIAN Service Domain acting as a service ‘container’ with a limiting context for access as a way to define standard Application Program Interface (API) access capabilities. The container and its associated service APIs offers constrained access to the bank and the third party can develop differentiated functional capabilities within the container(s). This is an area for future development that will be updated in later releases of the guides.

Communication protocols

As BIAN’s focus is on improving application to application interoperability, the focus of the service operation definition is on the specific content related to the exchange of structured information. The use of the term ‘structured’ here is intentionally vague given the ever increasing ability of technology to infer structure from different information sources. In this context the structured semantic service operation content should usually be mapped to underlying systems message definitions. Messages here refer to standard machine to machine data structures that have been defined to support specific application to application exchanges. Standard messages have been published by a number of standards bodies. Of particular interest at this time is the ISO 20022 financial services message specifications and the IFX Forum messaging standard. It is important to note that published industry standard message specifications are only available for a small subset of the business activities covered by the BIAN Service Landscape.

It is intended that by showing how the mapping is done to available standard messages that the same approach can be amended and applied to other messages groups. This includes new messages that may be developed, messages that may already be available in proprietary

solutions or messages that may be developed from scratch as required in specific solution developments.

INTEREST OF USING SOA FOR THIS SYSTEM

BIAN and its members believe that SOA is the best technology for internal and external interfaces to produce consistent definitions, levels of detail and boundaries through collaboration. When combined with industry-agreed IT standards, SOA will ensure interoperability, whereby different IT systems within a bank can work together as seamlessly as possible, without additional time or cost requirements for integration.

The value proposition for SOA derives from:

- Agility — Improving the ability of the organization to make changes to systems, mostly by separating portions of the systems that can evolve independently.
- Asset leverage — Improving the use of assets reduces or eliminates the development and implementation of redundant business logic.
- Standardization and quality — Creating standardized services enables best practices to be replicated. It also increases the efficiency and facilitates the improvement of development processes.

8.2.5 Smart grids - Standard IEC 62357-1

SOURCE INFORMATION

Website: https://webstore.iec.ch/publication/6918 (preview - full version has to be purchased)

Document: IEC Technical Committee 57, Edition 1.0 2012-10 - Power systems management and associated information exchange – Part 1: Reference architecture.

DOMAIN OF APPLICATION OF THE SYSTEM

Power systems, smart grids

GENERAL INFORMATION ON THE SYSTEM

Partners involved: International Electrotechnical Commission, IEC Technical Committee 57

Network / Country concerned: Global network

Level of development of the system: The second edition of IEC 62357-1 currently being prepared will reflect the progress recently achieved from the international Smart Grid (SG) initiatives and the CIGRE D2.24 large system architecture vision. This second edition will also reflect the most recent editions of the TC 57 standards including IEC 61850 series and IEC 61968 series, IEC 61970 series, and IEC 62325 series.

Date of creation of the system (or last update): 2012

SYSTEM DESCRIPTION

Purpose

IEC/TR 62357-1 provides updates and defines a layered reference architecture to help direct longer term goals and activities, specifically to ensure compatibility of all new standards developed in TC 57 by benefitting from lessons learned during development of the current standards and their application on actual utility projects as well as through application of other internationally recognized architecture standards, such as the UN/CEFACT Core Components Technical Specification.

IEC TC 57 is chartered with developing standards for electric power system management and associated information exchange in the areas of generation, transmission and distribution real-time operations and planning as well as information exchange to support wholesale energy market operations. IEC/TR 62357-1 "Power systems management and associated information exchange – Part 1: Reference architecture" has three objectives with respect to TC 57's current and future work. It also has a fourth objective regarding the role of TC 57 standards in development and implementation of the Smart Grid.

Business requirements and services descriptions

The business functions embraced by the new TC 57 charter, includes:

- energy management,
- SCADA and network operation,
- substation protection, monitoring, and control,
- distribution automation,
- distributed energy resources (DER),
- demand response and load control,
- meter reading and control,
- customers,
- work,
- network expansion planning,
- operational planning and optimization,
- maintenance and construction,
- records and asset management,
- market operations,
- reservations,
- financial,
- energy scheduling.

Architecture and database:

The architecture described in the standard IEC 62357-1 is a reference architecture for power system information exchange, defined to describe all the existing object models, services and protocols within TC 57 and how they relate to each other. Then, to meet the objective of identifying areas where harmonization between TC 57 standards is needed and to suggest possible approaches to achieve it in order to facilitate a single, comprehensive, optimal plan for deployment of these standards in product development and system implementations, a strategy is developed to show where harmonization is needed, and if possible, to recommend how to achieve a common model. Where changes cannot be made due to maturity of standards, then recommendations for adapters to make the necessary transformations between models are made. The third objective of the architecture technical report, i.e. to define a vision for the future reference architecture that will help direct longer term goals and activities, is achieved by defining a new future reference architecture that recognizes the importance of a single, internally consistent semantic layer to avoid unnecessary seams (i.e., the concept of a seamless architecture), while facilitating information exchange over a variety of industry standard transport infrastructures. This new reference architecture provides a framework for growth and

incorporation of new, evolving technologies without invalidating the existing standards developed by TC 57.

Interfaces

IEC 61968 (all parts), Application integration at electric utilities – System interfaces for distribution management

IEC 61970 (all parts), Energy management system application program interface (EMS-API)

Communication protocols

IEC 61850 (all parts), Communication networks and systems for power utility automation

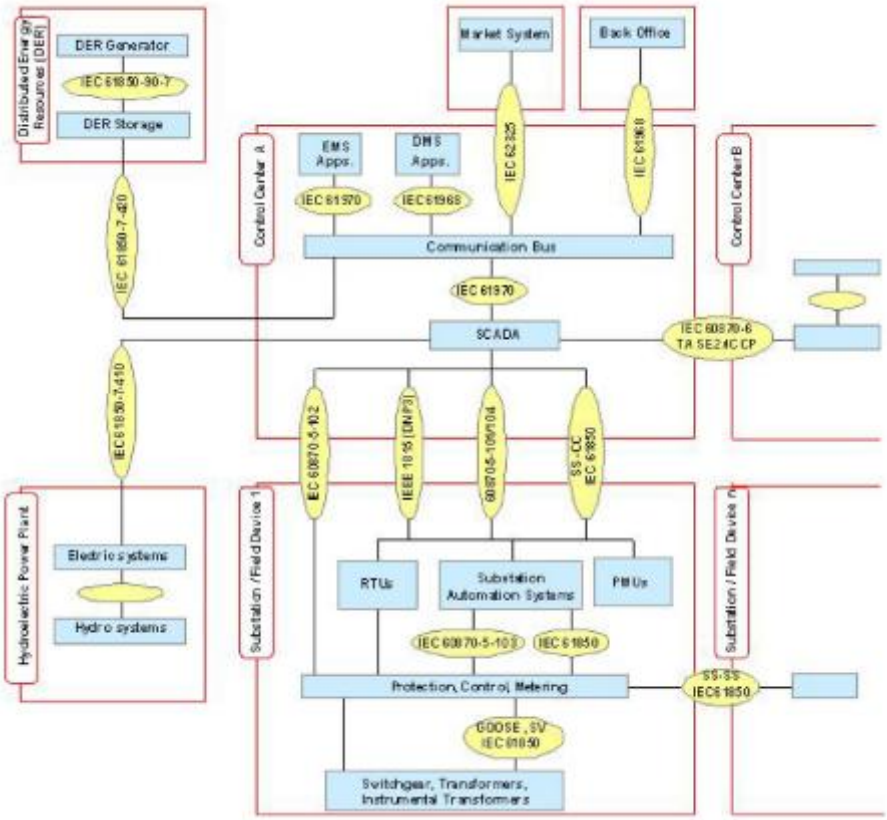

Figure 8 – Application of TC 57 standards to a power system

INTEREST OF USING SOA FOR THIS SYSTEM

A common data model and a few generic data-driven interface patterns can be used for all information exchange independent of the underlying protocols selected for a given system implementation. This new architecture is known as a Model-Driven Architecture (MDA), or when applied to integration of systems and applications, as Model-Driven Integration (MDI). Actual implementations can then take advantage of the current industry architectural trends, such as Service Oriented Architectures and the use of Web services.

8.2.6 Other useful sources

Tony C Shan, Winnie W Hua, "Solution Architecture for N-Tier Applications", SCC, 2006, 2013 IEEE International Conference on Services Computing, 2013 IEEE International Conference on Services Computing 2006

C. Matthew MacKenzie, Ken Laskey, Francis McCabe, Peter F Brown, Rebekah Metz, Booz Allen Hamilton, Reference Model for Service Oriented Architecture 1.0 OASIS Standard, 12 October 2006

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Wada, H. ; Dept. of Comput. Sci., Massachusetts Univ., Boston, MA ; Suzuki, J. ; Oba, K., A Service-Oriented Design Framework for Secure Network Applications, Computer Software and Applications Conference, 2006. COMPSAC '06. 30th Annual International, 2006

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Van Haren, Open Group SOA Source Book, April 2006

Service-Oriented Solution Framework for Internet Banking (Tony Chao Shan, Wachovia Corporation, USA, Winnie Wei Hua, CTS Inc., USA) International Journal of Web Services Research Vol. 3, Issue 1 edited by Liang-Jie Zhang © 2005, Idea Group Inc.