ERJU SYSTEM PILLAR

T3-CMS TMS Variant Analysis Version 2

T3-CMS TMS Variant Analysis Version 2

Author(s)	Patrick Konix , Peter Šišolák
Abstract	The document deals with possible architectures for CMS and TMS having a EU scope, from a decentralized to a Centralized approach, analysing for every scenario both advantages and drawbacks. It is the basis for the deliverable 09-Cross border TMS & CMS.
Config Item	System Concept
Document ID	30 Deliverables/CMS TMS Variant Analysis Version 2#717098 T3-CMS TMS Variant Analysis Version 2
Classification	Public
Status	In Review by System Pillar
Version	2.3
Revision	717098
Last Change Date	29.09.2025
Copyright	Brussels: Europe's Rail Joint Undertaking, 2025

INFO: History table is not displayed, because this document is in status **doc_contentApproval**.
RULE: History table is not displayed, in statuses: { draft doc_open doc_inprogress doc_contentApproval doc_contentDecision }
CONTACT: For more information contact Administrator

Review Description

Approvals	Knoedl Herbert (INFRA.Netzzugang) : Waiting , NANNI Marco : Waiting , Patrick Konix : Waiting , Bence Jenőfi : Waiting , BO MARCO : Waiting , CANEPA RENZO : Waiting , Peter Šišolák : Waiting , Simone Brezzi : Waiting , Rolf Goßmann : Waiting

Type of Approval	Document Review

Approval Description

Type of Approval	Document Approval

Table of Contents

Table of Figures

1 Preamble

1.1 Scope and intended audience

This document outlines various scenarios (referred to as variants) that illustrate how governance in the business area of “Capacity Management and “Traffic Management” on European level can be conceptually organized and which functions the supporting IT systems should fulfill, and which interfaces between the IT systems must be harmonised. The variants range from a centralized to a decentralized approach. **[**SPT3TMS-16845 **]**

This document is intended for all stakeholders involved in the overall analysis of the European railway system, focusing on the business model of TMS and CMS systems (e.g. Business stakeholders, End users, Assessors, etc.) **[**SPT3TMS-16846 **]**

1.2 Purpose

The goal of this document is the identification and high level description of four scenarios to organize Capacity Management and Traffic Management on a European level to implement the Single European Railway Area (SERA).

A review of the advantages and drawbacks of each of them is done. This document shall be used by relevant stakeholders to take a final decision about which model to adopt.

1.3 Glossary

1.3.1 Terms and definitions

N.A.

1.3.2 Abbreviations

In this document, the abbreviations "IM" for Infrastructure manager" and "RU" for Railway Undertaking are used due to their widespread use in the rail sector. The equivalent terms are "RIM" for Rail Infrastructure Managers" and "ROC" for Railway Operating Company.

CMS	Capacity Management System
CBO	Common Business Objectives
CCS	Command Control Signalling
ETMN	European Traffic Management Network
RIM	Rail Infrastructure Manager
IM	(rail) Infrastructure Manager
ROC, RU	Rail Operating Company, Railway Undertaking
TMS	Traffic Management System
XS - S - M – L - XL	Extra Small - Small – Medium – Large – Extra Large
TCC	(IM) Traffic Control Center
TCR	Temporary Capacity Restriction
ETM Network	European Traffic Management Network
NTCC / RTCC	National Traffic Control Center / Regional Traffic Control Center
short – medium – long	Referring to implementation period in sub-chapter *“Summary Assessment of Feasibility”*

2 History Of Changes

Nr.	Changes	Leaders/Authors
2.0	Draft	
2.1	Comments of TMS	Peter Šišolák 08/01/2025
2.2	Comments of S Brezzi and M Nanni corrected	Patrick Konix on 07/02/2025

3 Introduction

3.1 Governance and processes - variants

The following processes for CM and TM are considered within the scope of this variant analysis:

CMS Operational processes	General capacity allocation (5 years - 1 year)	Create Capacity Strategy	Coordinating and Publishing TCRs
		Create Capacity Model	
		Create Capacity Supply Plan / Plan Capacity	
		Perform Feasibility Study	
	Path allocation (12 months - day of train run)	Handle Annual Requests	
		Handle Late Path Requests	
		Handle Rolling Planning Requests	
		Handle Ad-Hoc / Short Term Requests	
		Handle Capacity Modification Requests	
		Handle Capacity Alteration including Optimisation	
TMS Operational processes		Real-time Monitoring	
		Sense Deviations from the Operational Plan	
		Sense Deviations in Infrastructure Availability	
		Handle Deviation from the Operational Plan	
		Perform Traffic Forecast	
		Sense Operational Conflict between Operational Plans	
		Handle Operational Conflicts + international coordination	
		Log Cause of Deviations and Delays	

These processes are described in the ERJU Task 3 CMS/TMS T3-OperationalProcesses.

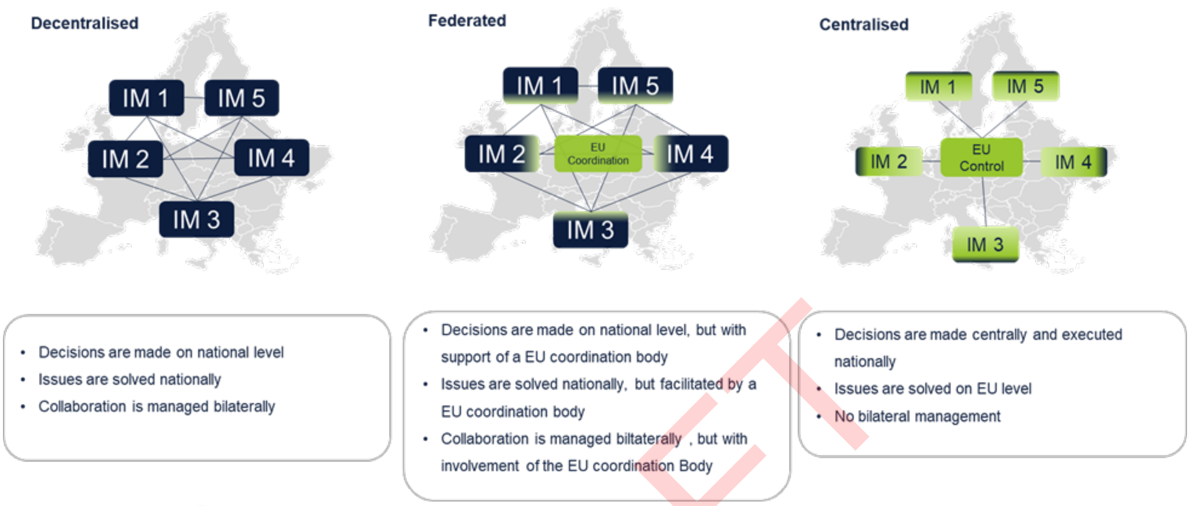
The execution of the harmonized CM and TM processes on European level can be done in a decentralized, a federated and a centralized way.

In a decentralized setup, IMs collaborate bilaterally with the required IMs by exchanging the required information to execute the -harmonized- processes for cross-border traffic.

The federated approach differs from the decentralized setup in the existence of a central European body for CM and/or TM which helps to define, coordinates, supports or executes (parts of) the processes, in close collaboration with the involved IMs. This simplifies the harmonisation especially in cases where more then two IMs are to be involved. The bilateral cooperation between IMs is still in place for most of the processes. The IMs remain the responsible bodies for the most important processes such as the planning of the capacity and for the traffic management (commands for the route setting/CCS : TMS will only provide Operational Plan updates to the Plan Execution (PE) function which, as part of the CCS area, forms the requests for securing the Track Path and sends them to the Safety Logic (SL))

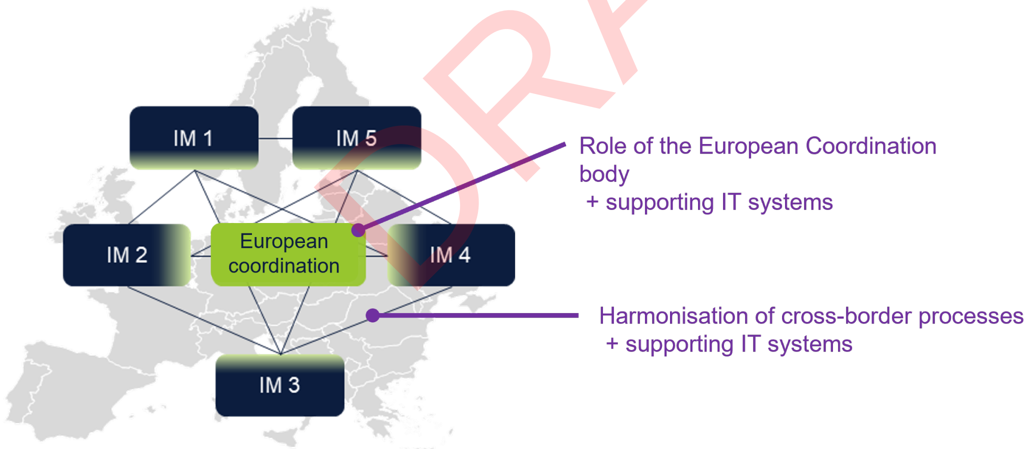
).

In a centralized setup, a single European body executes the processes for CM and TM in a centralized way for the whole of Europe. Some minor parts of the CM and TM processes can remain with the IMs, but the decision-making processes are done on the central level.



[SPT3TMS-16934]

Figure 1: Possible TMS and CMS variants - centralized setup



[SPT3TMS-16938]

Figure 2: Diagrams for possible TMS and CMS variants

3.2 Supporting IT systems - variants

IT systems play a crucial role in supporting the execution of CM and TM processes. Task 3 “CMS/TMS” described the “reference implementation” of such an IT system in the following documents:

· The “System Concept” describes for which processes the systems are used (the scope of the systems)

· The “System Definition” describes the functional requirements and the interfaces with the actors of the system

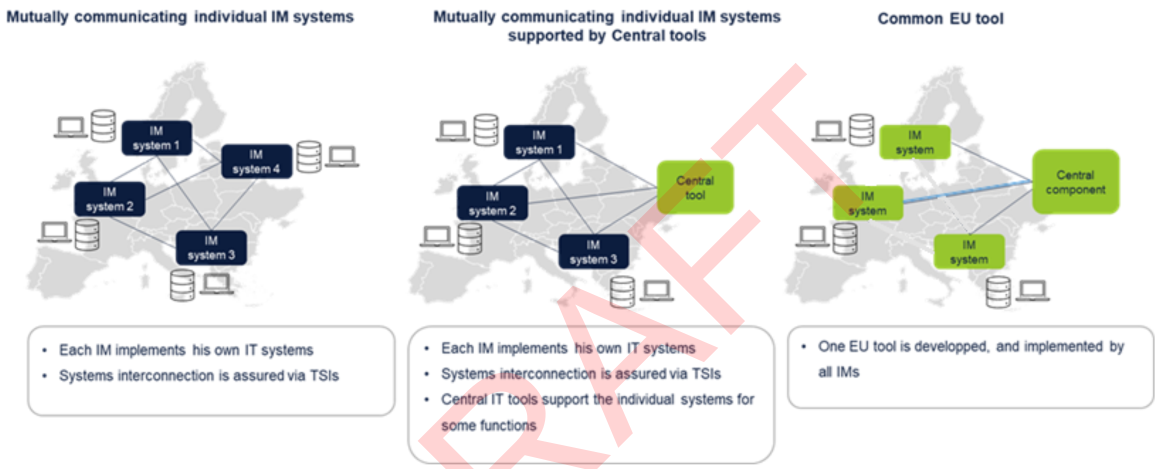
Harmonised interfaces -described is TSI's- which connect the IT systems are an essential component in the setup of the system.

Different variants of governance and processes call for different approaches of IT support. As such, the “reference implementation” of CMS/TMS can be done in several ways on European level.

To support the decentralized variant, IMs implement all systems and functions on their own, while assuring -standardised- connectivity with the systems of other actors on the horizontal level. The IMs have the choice to buy or develop the systems, as well as the responsibility to connect its systems to the other actors’.

The federated one requires a mixed approach for the "reference implementation” where central tools exist to facilitate some of the required functions such as making reference files for network descriptions or rolling stock available, or make available end-to-end operational data for cross-border trains.

In case of a centralised “reference implementation”, the systems are developed centrally on the European level and an instance of this central tool tool is rolled out/installed by all of the IMs individually, or by the central European body (in case of a fully central governance).



[SPT3TMS-16937 **]**

Figure 3: Possible TMS and CMS variants - reference implementation

3.3 Scope of the traffic - variants

The way the processes and supporting IT systems of CM and TM are organized on EU level can also depend on the scope of the traffic. Here we distinguish three types of traffic for which an IM can be responsible: cross-border, national and regional.

[SPT3TMS-16939 **]**

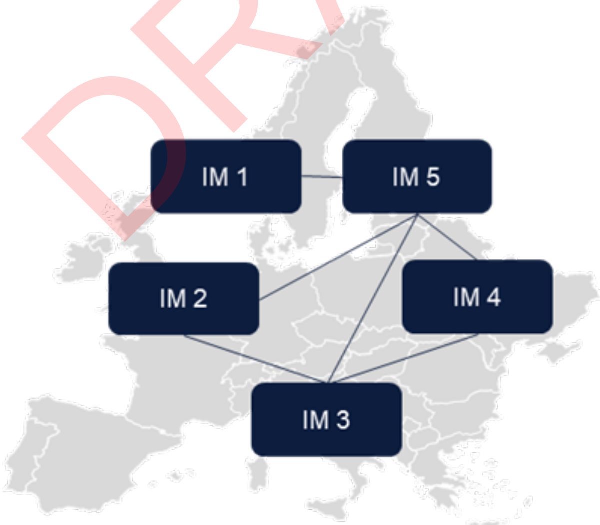
Figure 4: Types of traffic under IM responsibility

4 Four Variants for Capacity Management

4.1 Variant 0 - Decentralized Capacity Management (without central IT support)

4.1.1 Governance and processes

In this variant, every IM is responsible for the capacity management of all train traffic on its network. There is no central entity to actively combine and harmonize requests and offers.

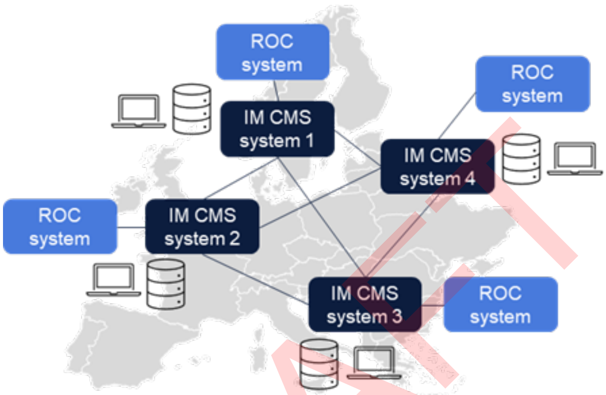


[SPT3TMS-16936 **]**

Figure 5: CMS Variant 0 - Decentralized Capacity Management

4.1.2 Supporting IT systems

This variant describes a direct connection between existing systems. It consists of CMSs, owned and operated individually by each IMs. In absence of a centrally supporting system, every IM is responsible for ensuring exchange of information with their neighbors concerning cross-border capacity management (including advance planning, TCR planning as well as timetabling) by exchanging messages in a commonly agreed format (Telematic TSI messages). RUs request capacity in the individual systems, even for cross-border requests. There is no central entity to actively combine and harmonize requests and offers from an IT perspective either. This variant allows every actor to exchange data through messages from/ to their own system without any need of an extra screen with an extra software. All goes in and out of the existing system. An RU can ask for a path to five IMs from it's own path requesting system. Even if, sometimes, a GUI can be provided to the RU's who needs it.



[SPT3TMS-16935]

Figure 6: CMS Variant 0 - Relationship among actors

4.1.3 Mapping CMS Variant 0 with Common Business Objectives

The main characteristic of variant 0 is the complete lack of a centralized support while decentralized systems are connected to each other as necessary. This implies systems are set up only domestically within one one IM, or systems are connected cross-border between two IMs. It does not specify the technology to be used, but rather the type of interaction. Therefore, the systems can fulfil all objectives. Due to the high complexity and dependency on each system, however, initial implementation also comes with a legacy tech debt, hampering later transition to new technologies.

Variant 0 major benefits – CBO level:

Due to the lack of a centralized system, there are no investment costs on the central level. The introduction of this variant is based on existing decentralized systems, which only require an upgrade to fulfil agreed processes. This variant also allows decentralized systems to develop new technologies, as long as common standards are adhered to.

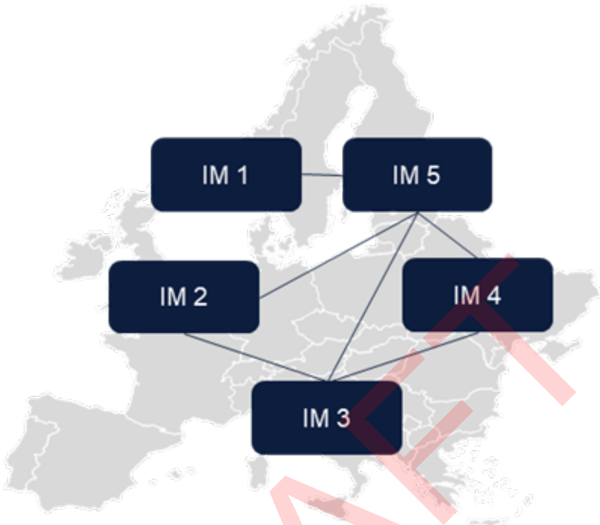
Variant 0 major weaknesses – CBO level:

The lack of a central system requires a high degree of harmonization of processes. This will lead to high harmonization costs for centralization, despite the lack of a central system.
Th

4.2 Variant 1 - Decentralized Capacity Management supported by central IT tools

4.2.1 Governance and processes

In this variant, every IM is responsible for the capacity management of all train traffic on its network. Cross-border path requests are handled through a leading RU, who may assign a leading IM, is in contact with the end customer, and will be responsible for the management of the dossier during the whole timetable process. For advance planning and TCR coordination, no central governance is foreseen in this variant and coordination is done on a bilateral level.

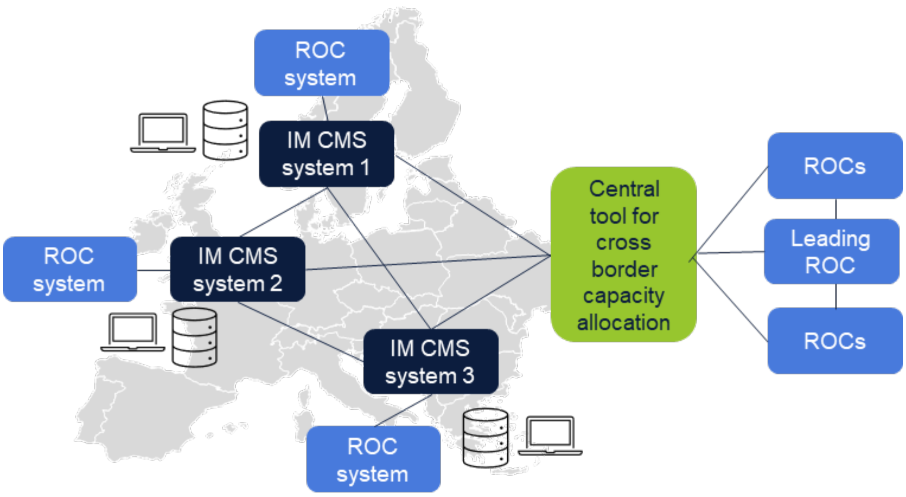


[SPT3TMS-16941 **]**

Figure 7: CMS Variant 1- Decentralized Capacity Management supported by IT tools

4.2.2 Supporting IT systems

Similarly to variant 0, this variant has individual national capacity management systems incl. different IT tools, which exchange information with neighboring countries on advance capacity and TCR planning. National path requests are also handled in the individual national systems. For international path request coordination, however, a central tool is set up. An application optimizes international path coordination by ensuring that path requests and offers are harmonized between all involved parties. Input for international path requests needs to be placed only once into one system – either into the allocation tool in the national system or directly into the central tool. If path requests are placed into the national system, the central tool is updated via TAF/TAP TSI interface. If there is no interface between the national system and central tool, a graphical user interface (GUI) enables information provision manually or via excel upload directly into the web application. The central tool allows harmonization of international path requests with partners and all involved stakeholders, with transparent workflows and processing status. Cross-border path requests are handled through a leading RU, who is in contact with the end customer and will be responsible for the management of the dossier during the whole timetable process.



[SPT3TMS-16946 **]**

Figure 8: CMS Variant 1- Relationship among actors

4.2.3 Mapping CMS Variant 1 with Common Business Objectives

Variant 1 connects only a limited number of systems, particularly for requesting and allocating international paths, with a central system. All other connections between systems are still directly between decentralized systems. This allows to combine only the process with the highest cross-border relevance. Similar to variant 0, increasing the rate of newest technology is limited.

Variant 1 major benefits – CBO level:

Due to the lack of a complete centralized system, there are little investment costs on central level. The introduction of this variant is based on existing decentralized systems, which only require an upgrade to fulfil agreed processes. This variant also allows decentralized systems to develop new technologies, as long as common standards are being kept.

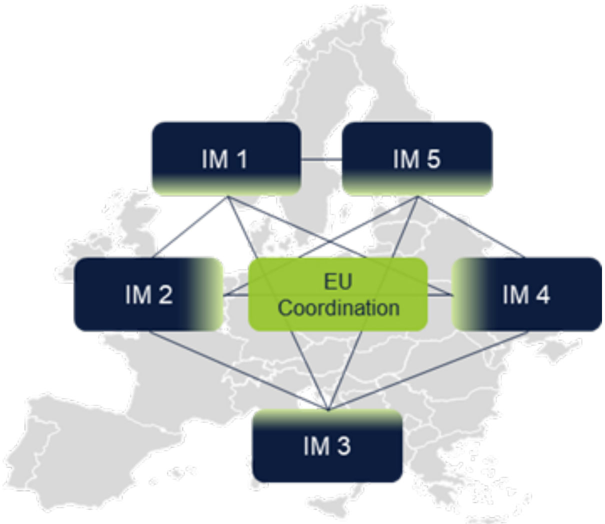
Variant 1 major weaknesses – CBO level:

The lack of a complete central system requires a high degree of harmonization of processes. This will lead to high harmonization costs for centralization, despite the lack of a central system.
Also, the development of new technologies, improvements and automatization might be hampered by the need for common standards and processes.

4.3 Variant 2 – Federated Capacity Management supported by a roof CMS

4.3.1 Governance and processes

In this variant, coordination and harmonization processes as well as central IT systems are provided by central entity appointed and commonly governed by IMs. IMs are responsible for local and national development of capacity products in the advance planning, TCR and timetabling phases and to follow the harmonization procedures as laid out by the appointed central entity.



[SPT3TMS-16944]

Figure 9: CMS Variant 2- Federated Capacity Management with a roof CMS

4.3.2 Supporting IT systems

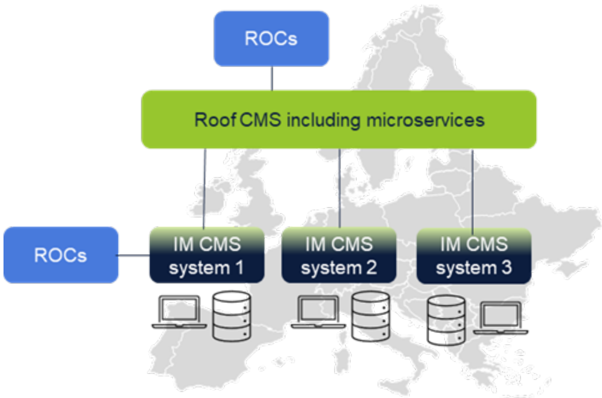
Variant 2 consists of national systems handling capacity planning and allocation that are connected to a central system which combines and analyses national CMS inputs. The central system -which manages international traffic capacity- is a platform with different central tools and functions to:

- manage Temporary Capacity Restrictions as negative (i.e. non-bookable) capacity,

- manage and visualise all capacity combining positive as well as negative capacity and

- manage capacity requests and providing offers to applicants.

A “Messaging Module” enables communication between all national and central systems, enabling interfaces between them and access to common central databases. All capacity management process steps are done in the national systems by the IMs, which then are updated and combined in the central system. Mandatory standards for communication are required, which shall be used for data exchange between the national IM and RU systems, but also between the central modules.



[SPT3TMS-16951]

Figure 10: CMS Variant 2- Relationship among actors

4.3.3 Mapping CMS Variant 2 with Common Business Objectives

A main feature of this variant 2 is the provision of a central set of tools with which national systems are connected. Prerequisites are the use of same processes and standards for communication as well as common databases.

Variant 2 major benefits – CBO level:

Variant 2 combines national systems with a central component. This variant is the most cost-effective way of cooperating between national systems without replacing existing ones. This way, costs are low, harmonization rates are high, innovation can be achieved on decentralized level and customers' needs can be dealt with in one architecture. Innovative approaches can be piloted and scaled up.

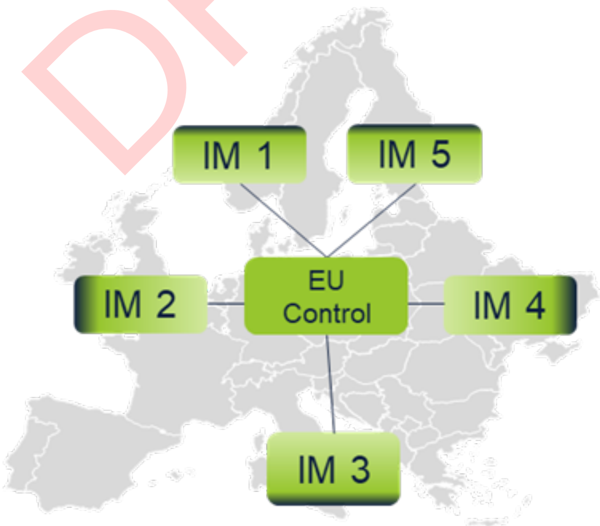
Variant 2 major weaknesses – CBO level:

Innovation might be slowed by the agreement on the lowest possible denominator between stakeholders. Bringing all players to the same level might be time-consuming, hampering progressing speeds.

4.4 Variant 3 - Centralized Capacity Management

4.4.1 Governance and processes

In this variant, an EU body responsible for capacity management executes all CM processes for all trains. IMs have very little/no responsibilities on the level of capacity management.

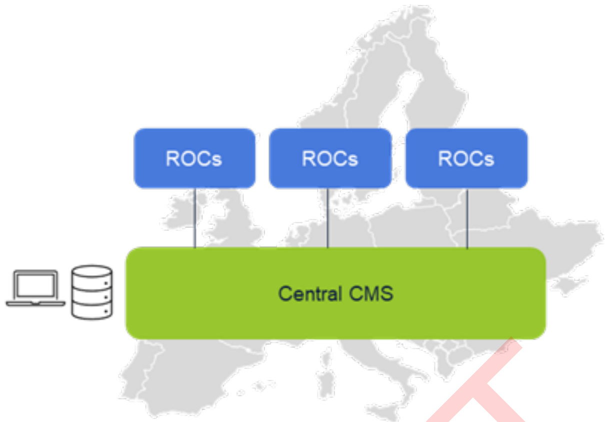


[SPT3TMS-16950 **]**

Figure 11: CMS Variant 3- Centralized Capacity Management

4.4.2 Supporting IT systems

Variant 3 consists of only a fully European CMS, where the IMs feed all data related to capacity management information directly into the central EU system. All capacity management phases are planned in the central system for both national and international traffic. National systems in any way do not exist in this variant.



[SPT3TMS-16949 **]**

Figure 12: CMS Variant 3- Relationship among actors

4.4.3 Mapping CMS Variant 3 with Common Business Objectives

In this variant, no relevant decentralized systems are used. The central system provides workstations on national level.

Variant 3 major benefits – CBO level:

This variant requires the lowest rate of harmonization of systems and processes due to a lack of decentralized systems. New technologies can be implemented rather immediately. Costs can be reduced to a minimum.

Variant 3 major weaknesses – CBO level:

The use of one single tool hampers innovation due to a lack of individual testing areas with one single tool. It also creates a single point of failure.

It requires a high degree of harmonization of national rules for capacity planning and publication.

4.5 Overview of the Core Business Objectives with CMS relevance

CBO	V0	V1	V2	V3	Short description
4.1 Meeting evolving customer requirements					
Strengthen the ability to sustain a given service quality, punctuality, and safe operation	(X)	(X)	X	X	Variants 0 and 1 still rely on national planning with high risks of non-matching plans for cross-border
	(x)	(X)	X	X	

Leverage on real-time information and data sharing to provide accurate status within the full transport system (end-to-end) and allow an overall optimization of the transport offer					Variants 1, 2 and 3 provide permanent and cross-border overviews of allocated and available capacity. Variant 2 and 3 add a centralized coordination body
Enable railways to deploy digital solutions by simplifying the access to information available in the standardized architectures	(X)	X	X	X	Variants 1, 2 and 3 enable easier access due to central system being used.
4.2 Improved performance and capacity					
Increase capacity utilisation of the rail	(X)	(X)	X	X	International capacity is better facilitated and optimized with central systems as displayed in variants 2 and 3
Increase transport capacity agility	(X)	(X)	X	X	International capacity availability on short notice can be achieved with variants 2 and 3
Reduce the dwelling time between trains	-	-	-	-	
Reduce the travelling and transit time	(X)	(X)	X	X	Optimization of timetables can be done integrated in European capacity management
Better predict capacity needs of infrastructure	X	X	X	X	Capacity Management Systems in all variants require thorough pre-planning of capacity based on data availability

5 Four Variants for Traffic Management

5.1 Variant 0 - Decentralized Traffic Management

5.1.1 Governance and processes

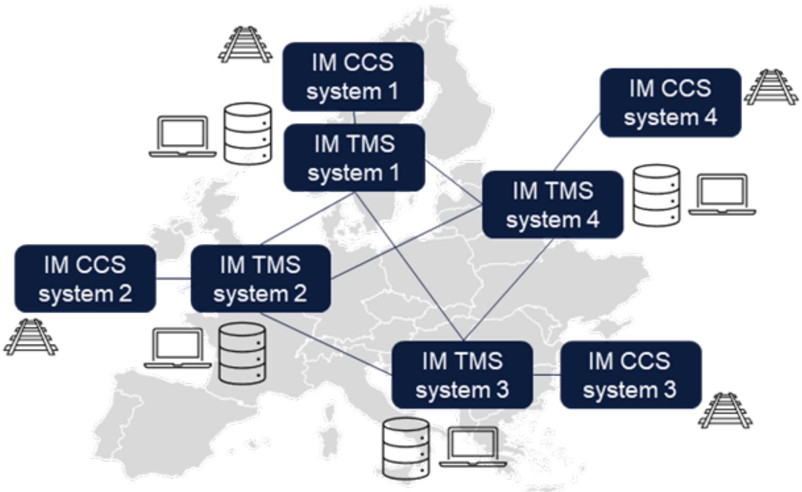
In this variant, every IM is responsible for the traffic management on its network. Harmonised processes (defined by legislation and/or by sector collaboration) assure the collaboration between IMs for cross border traffic operations

[SPT3TMS-16948 **]**

Figure 13: TMS Variant 0 - Decentralized Capacity Management

5.1.2 Supporting IT systems

Variant 0 standardizes the exchange of operational data such as plans, real-time updates, forecasts, and deviations between interconnected Traffic Management Systems. This ensures that each Infrastructure Manager can both send and receive data with neighboring systems using common formats and messages, in line with the Telematics TSI requirements.
The approach is based on integration rather than centralization. Multi-network traffic is managed using the same tools as domestic traffic, which eliminates the need for separate data sources or manual reconciliation. This model allows traffic managers to maintain a unified view of multi-network operations, with each TMS functioning as a transparent node within the broader network. The effectiveness of this approach depends on how well local systems can handle and integrate multi-network data. The variant does not include a centralized “overall” view of a train’s journey as it moves from one TMS’s area of control to the next. The system is focused on the national view of the trains. Management of international train is done with national focus. Instead, individual TMSs can be thought of as a series of neighboring “cells”, with each managing what happens within it but taking into consideration information exchanged with predecessor and successor cells. As such, the provision of information to RUs (e.g., real-time data affecting their trains, …) must equally be provided by the individual TMSs managing part of a cross-border journey.



[SPT3TMS-16953 **]**

Figure 14: TMS Variant 0 - Relationship among actors

5.1.3 Mapping TMS Variant 0 with Common Business Objectives

The major difference between variant 0 and the other variants is the lack of any "centralised system" in the overall architecture. There is no complete international train view, all trains are handled as national ones. The international trains are handed over at the borders without any sophisticated approach to optimize the complete international train run from origin to destination. The variant doesn't work with international train delta to optimize the train arrival to the destination on time. The limited view, in case of incidents, of the international trains is another disadvantage of this variant. In principle, variant 0 is capable of fulfilling almost all of the CBOs defined.
Due to the decentralized approach, harmonized processes will be more complex to achieve. The synchronization of a "peer to peer" bilateral data-exchange becomes more difficult when the volume of message-traffic increases.

Variant 0 major benefits – CBO level:

- Changeability and upgradeability(3), simplified integration

  On a central EU level, no system needs to be developed and no central operational organization needs to be set up and financed. Once all -cross border relevant- processes are defined and data connections are set up between the systems (in a standardized way), the OPEX cost will be relatively low as well.

Variant 0 major weaknesses – CBO level:

· or a central governance/setup via -for example- a linked data concept

, the CBO "Reducing the impact of disturbances - intelligent incident handling as well as process and functional assistance of works enabling a smooth operation" is difficult to achieve

· Due to the lack of consolidated data in one place or a central governance/setup via -for example- a linked data concept

, the CBO "Provide to customer rapid alerts of traffic congestion, including rerouting options" is difficult to achieve

· Since there are no central IT tools with the consolidated data in place or a central governance/setup via -for example- a linked data concept

, the CBO "Develop tools for public administrations which can be leveraged by different stakeholders to stimulate new types of services" is hard to achieve

· Since there are no central IT tools with the consolidated data in place or a central governance/setup via -for example- a linked data concept, the CBO "Coordinate international train run over the entire journey to arrive on time" is difficult

· Since there are no central IT tools in place (including one with the topology description) or a central governance/setup via -for example- a linked data concept

, the CBO "Provide reference data which is highly reliable, updated automatically, that can be used by the whole sector and accessed by its systems" is difficult to achieve

· Enable railways to deploy digital solutions by simplifying the access to information available in the standardized architectures... generate large amounts of information that shall be organized and exchanged to deliver customer value

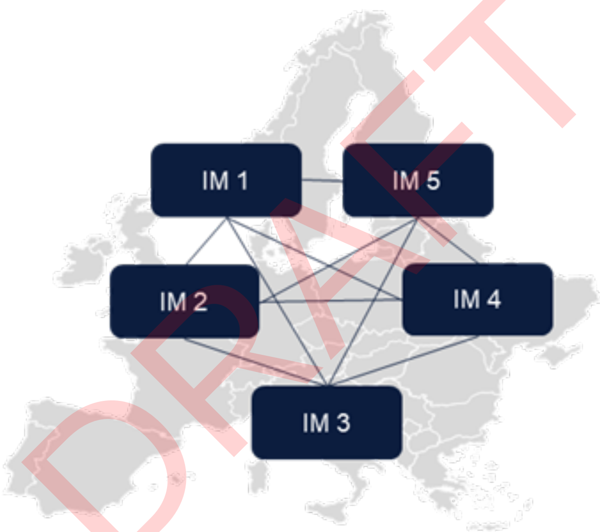
· Train routing diagrams still on the national level not taking into account the neighboring actual available capacity

A lot of the CBOs related to customer requirements require access to all available data linked to the TMS systems of several IMs, RUs, and other stakeholders. Since there is no "central data source" available, the system architecture needs to access data from several sources, and compile the data in order to create an "end-to-end" view. This compilation is complicated -especially for "real time" cases such as incident handling and information to travelers- on a system level: it requires that all data sources are available with the same data quality level, and have implemented similar technical stands (versioning).

5.2 Variant 1 - Decentralized Traffic Management supported by central IT tools

5.2.1 Governance and processes

In this variant, every IM is responsible for the management of all train traffic on its network. Harmonised processes (defined by legislation or by sector collaboration) assure the collaboration between IMs for cross border traffic operations.



[SPT3TMS-16952 **]**

Figure 15: TMS Variant 1- Decentralized Capacity Management supported by IT tools

5.2.2 Supporting IT systems

Variant 1, while still envisaging independent, individual IM operated nationally (or regionally) owned and operated traffic management systems (TMS), includes European level “Central TMS Cooperation and Reporting systems” that centralise the collection and distribution of data. The “Roof systems” in this variant largely act as information brokers capable of consolidating different IMs’ data and thus compiling an overarching view that transcends the boundaries of individual systems’ areas of control, and also include functionalities focused on coordination of processes. As such, the “Roof systems” are also capable of disseminating consolidated, end-to-end cross-border journey information directly to RUs, Terminals, or other users requiring this type of information.

Data can be consumed by users or systems according to the applicable European rules and regulations: in this sense, the “Central systems” as per this variant may be viewed as less of a “Traffic Management” and more of a “Traffic Information Brokering” system; any actions taken in response to the increased information transparency would be subject to agreement between affected IMs in this variant. The “Central system” mostly gathers information from the connected stakeholders such as train timetables, train running information, train delay causes, incident information, train composition information, train running forecast information, referential data such as topology data, company lists, country list, rolling stock referentials.

The functionalities of the “Central system” are:

· contains and shares actual train timetables, train running and incident information

· presents delay causes and provided train composition information

· contains necessary reporting data to prepare performance reports and dashboards

· provide additional train running forecasts covering the complete European railway network

· serves with a filtering option to select the preferred group of trains

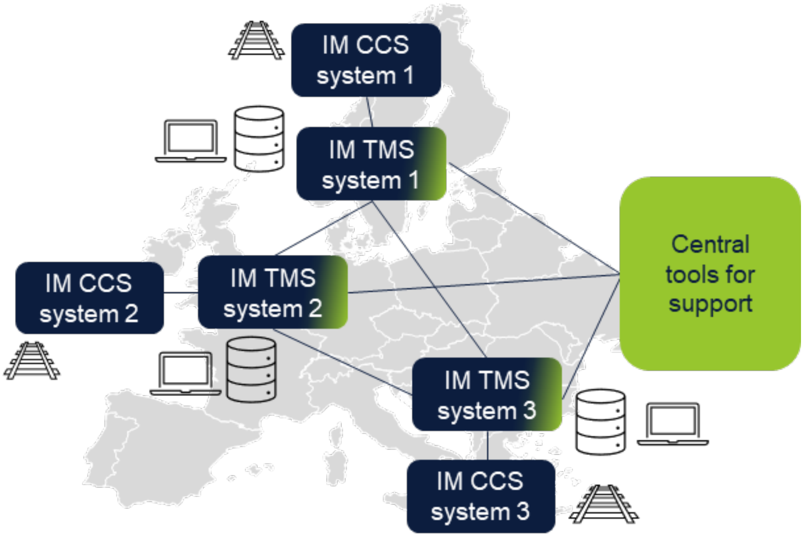
· display the European network condition with an expected view

· informs about capacity utilisation of the adjacent lines to the region of traffic managers responsibility

· is a platform for enhanced international contingency management

· ensures communication and cooperation of the European railway network national traffic control centers

Central systems developed by the sector are currently existing already (or are foreseen to be developed) and serve a number of purposes. Their biggest benefit is to make the exchange of EU cross-border relevant data easier, in parallel to bilateral data exchange, by serving as a data hub and as such by supporting cross-border processes and concepts such as the "ETM Network" which focuses on the cooperation and coordination between the Traffic Control Centers (TCCs). The goal is to define how the IMs can contribute to the EU Strategy aiming to improve traffic management processes, especially in regard to the management of international trains from origin to destination. The train run is influenced by all levels of traffic management, starting on a local level via regional to the national level as top of the process. The goal of the proposed concept is to strengthen current practices and solutions on a more harmonised and developed level. The starting point is in the usage of experiences of the already functioning relationships and working practices that are built upon the regional and national level of TCCs. The systematic establishment of virtual interconnections of NTCCs/RTCCs should be the cornerstone of ETM, with direct support from other levels of traffic control centers. This approach reflects the existing vertical and horizontal structure and its roles and responsibilities. The new network is focused on national traffic control centers in synergy with regional centers involved in cross border cooperation of neighboring areas.



[SPT3TMS-16940 **]**

Figure 16: TMS Variant 1- Relationship among actors

5.2.3 Mapping TMS Variant 1 with Common Business Objectives

The major difference between variant 1 and the other variant 0 is the addition of "centralised systems" in the overall architecture. These centralised systems allow to achieve some CBO's in a much easier way (with less technical complexity thanks to the availability of the data in one central place and the possibility to develop functionalities in a central system.

Variant 1 major benefits – CBO level:

· Reducing the impact of disturbances - intelligent incident handling as well as process and functional assistance of works enabling a smooth operation

· Provide to customer rapid alerts of traffic congestion, including rerouting options

· Develop tools for public administrations which can be leveraged by different stakeholders to stimulate new types of services

· Provide reference data which is highly reliable, updated automatically, that can be used by the whole sector and accessed by its systems

· Serve with centralised train running data hub for train tracking and reporting, especially for international trains, from origin to destination

· Enable railways to deploy digital solutions by simplifying the access to information available in the standardized architectures... generate large amounts of information that shall be organized and exchanged to deliver customer value

A lot of the CBOs related to customer requirements require access to all available data linked to the TMS systems of several IMs, RUs, and other stakeholders. Since there is no "central data source" available, the system architecture needs to access data from several sources and compile the data in order to create an "end-to-end" view. This compilation is complicated -especially for "real time" cases such as incident handling and information to travelers- on a system level: it requires that all data sources are available with the same data quality level and have implemented similar technical stands (versioning).

Variant 1 major weaknesses – CBO level:

· Continuous supervision and detection of conflicts and resolution potentially leveraging on data sharing.

· Missing real-time coordination of international trains (in case of abnormal high scale disrupted situations)

with aim to ensure punctual arrival to the destination

· Train routing diagrams still on the national level not taking into account the neighboring actual available capacity

* Conflict resolution for cross-border trains in case of abnormal high scale disrupted situations

is easier manageable from a centralized EU traffic control.

5.3 Variant 2 – Federated Traffic Management supported by central IT tools

5.3.1 Governance and processes

In this variant, every IM is responsible for the management of all train traffic on its network. A "EU supporting and monitoring body" facilitates/supports the following processes:

- support operational coordination between infrastructure managers

- identify rules, procedures and tools which solve obstacles for multi-network rail services

- establish a platform for simple and direct cooperation of neighbouring and over neighbouring traffic control centres

- Supports and leads to having the same level of dispatcher competence over Europe for effective cooperation and performance

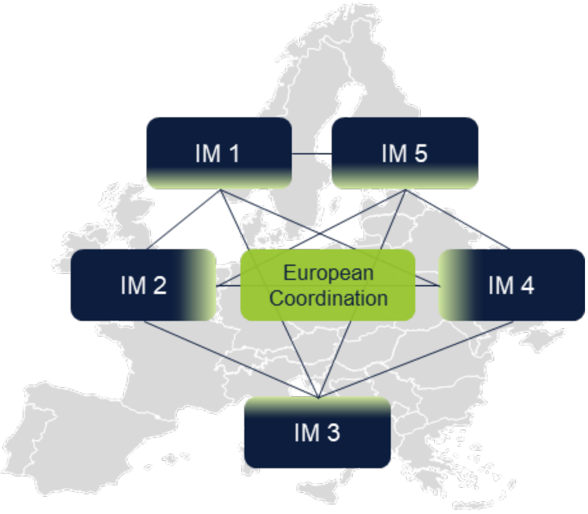
- support monitoring disruptions, and propose measures to increase overall traffic and resource management efficiency

- support balancing priority rules over the European railway network respecting national particularities

- Support NTCCs or RTCCs in coordinating consequence management of unexpected temporary capacity restrictions

- act as a first point of contact - if the RU requires it- for stakeholders outside the rail sector interested in using rail services, providing contacts to relevant actors at infrastructure managers and other operational stakeholders

The Network coordinator does not perform any Traffic Management commando's. Harmonised processes (defined by legislation or by sector collaboration) assure the collaboration between IMs for cross-border traffic operations.



[SPT3TMS-16947 **]**

Figure 17: TMS Variant 2- Federated Traffic Management supported by IT tools

5.3.2 Supporting IT systems

Variant 2, while still envisaging independent, individual IM operated nationally (or regionally) owned and operated traffic management systems (TMS), includes European level "Centralised TM Supporting and Reporting systems" (to merge data) that centralise the collection and distribution of data. The "Roof systems" in this variant largely acts as an information broker capable of consolidating different IMs' data and thus of compiling an overarching view that transcends the boundaries of individual systems' area of control. As such, the "Roof system" is also capable of disseminating consolidated, end-to-end cross-border journey information directly to RUs, Terminals or other users requiring this type of information. Data can be consumed by users or systems according to the applicable European rules and regulations: in this sense, the "Central systems" as per this variant may be viewed as less of a "Traffic Management" and more of a "Traffic Information Brokering" system; any actions taken in response to the increased information transparency would be subject to agreement between affected IMs in this variant. The "Central system" mostly gathers information from the connected stakeholders, such as train timetables, train running information, train delay causes, incident information, train composition information, train running forecast information, referential data such as topology data, company lists, country list, and rolling stock referentials.

From the above listed information and implemented functionalities the "Central system":

· contains and shares actual train timetables, train running and incident information

· contains necessary reporting data to prepare performance reports and dashboards

· provide additional train running forecasts covering the complete European railway network

· presents delay causes and provided train composition information

· serves with a filtering option to select the preferred group of trains

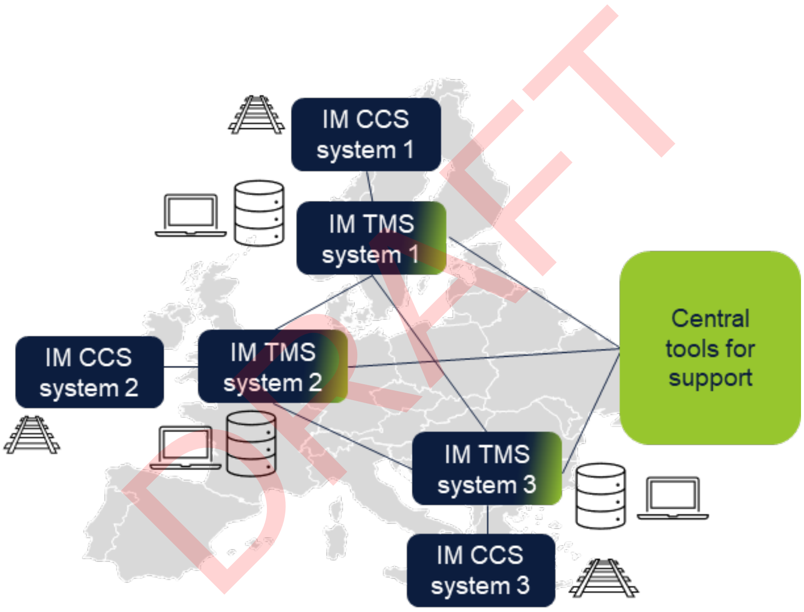
· display the European network condition with an expected view

· informs about capacity utilisation of the adjacent lines to the region of traffic manager responsibility

· is a platform for enhanced international contingency management

· ensure communication and cooperation of the European railway network national traffic control centers

Central systems developed by the sector are currently existing already (or are foreseen to be developed) and serve a number of purposes. Their biggest benefit is to make the exchange of EU cross-border relevant data easier by serving as a data hub and as such by supporting cross-border processes and concepts such as the "ETM Network" which focuses on the cooperation and support between the Traffic Control Centres (TCCs). The goal is to define how the IMs can contribute to the EU Strategy aiming to improve traffic management processes, especially in regard to international trains. The train run is influenced by all levels of traffic management, starting on a local level via regional to the national level as top of the process. The goal of the proposed concept is to strengthen current practices and solutions on a more harmonised and developed level. The starting point is in the usage of experiences of the already functioning relationships and working practices that are built upon the regional and national level of TCCs. The systematic establishment of virtual interconnections of NTCCs should be the cornerstone of the ETM Network concept, with direct support from other levels of traffic control centres. This approach reflects the existing vertical and horizontal structure and its roles and responsibilities. The new network is focused on national traffic control centres in synergy with regional centres involved in cross-border cooperation of neighbouring areas.



[SPT3TMS-16945]

Figure 18: TMS Variant 2- Relationship among actors

5.3.3 Mapping TMS Variant 2 with Common Business Objectives

The major difference between variant 1 and the other variant 0 is the addition of "centralised systems" in the overall architecture. These centralised systems allow achieving some CBO's in a much easier way (with less technical complexity thanks to the availability of the data in one central place and the possibility to develop functionalities in a central system.

Variant 2 major benefits – CBO level:

· improved efficiency of international train management from origin to destination

· Corrective measures for international trains to reach their destination on time

· More efficient resource management of operational stakeholders

· Coordinate approach for international contingency management

· Reducing the impact of disturbances - intelligent incident handling as well as process and functional assistance of works enabling a smooth operation

· Provide to customer rapid alerts of traffic congestion, including rerouting options

· Develop tools for public administrations which can be leveraged by different stakeholders to stimulate new types of services

· Provide reference data which is highly reliable, updated automatically, that can be used by the whole sector and accessed by its systems, the bilateral data exchange still remain according to the Telematic TSI

· Improved operational and post operational reporting about traffic performance and incident management

· Enable railways to deploy digital solutions by simplifying the access to information available in the standardized architectures... generate large amounts of information that shall be organized and exchanged to deliver customer value

* Improved real-time coordination of international trains (in case of abnormal high scale disrupted situations)

with aim to ensure punctual arrival to the destination

A lot of the CBOs related to customer requirements require access to all available data linked to the TMS systems of several IMs, RUs, and other stakeholders. Since there is no "central data source" available, the system architecture needs to access data from several sources and compile the data in order to create an "end-to-end" view. This compilation is complicated -especially for "real time" cases such as incident handling and information to travelers- on a system level: it requires that all data sources are available with the same data quality level and have implemented similar technical stands (versioning).

Variant 2 major weaknesses – CBO level:

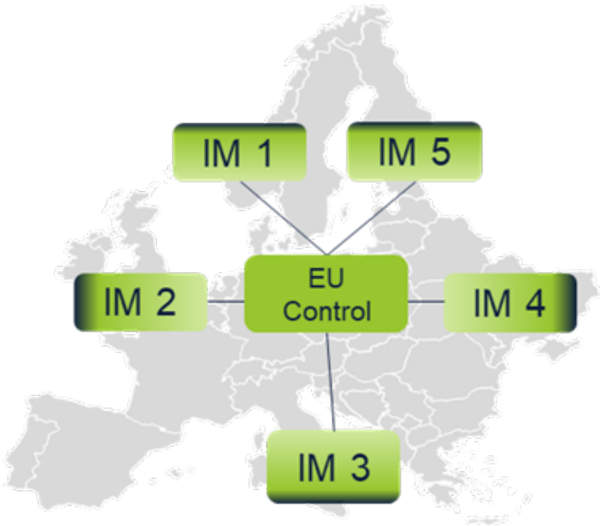
· Train routing diagrams still on the national level not taking into account the neighboring actual available capacity

* Conflict resolution in case of abnormal high scale disrupted situations for cross-border trains is more easily managed from a centralised EU traffic support and monitoring system.

5.4 Variant 3 - Centralized Traffic Management

5.4.1 Governance and processes

In this variant, all trains are managed by the central European body. National or regional IMs remain responsible for supplying relevant information (e.g. incidents)

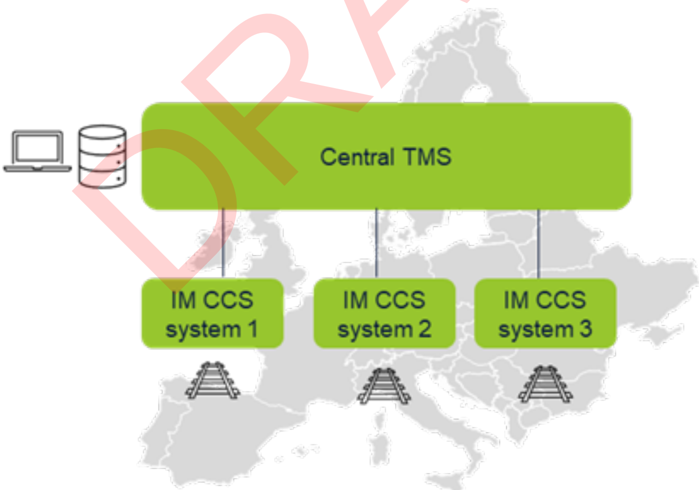


[SPT3TMS-16943]

Figure 19: TMS Variant 3- Centralized Traffic Management

5.4.2 Supporting IT systems

This variant envisages abolishing national / regional TMSs altogether and replacing them with a single, Europe-wide system that plans and controls both cross-border and nationally/locally operated traffic. National or regional IMs remain responsible for local planning (timetables, construction works, ...) as well as for supplying relevant information (e.g. incidents), but are not in control of the integrated timetable planning on a European level as well as for traffic control operations.



[SPT3TMS-16942]

Figure 20: TMS Variant 3- Relationship among actors

5.4.3 Mapping TMS Variant 3 with Common Business Objectives

The "Euro Control Entity" will manage all trains within Europe.

Variant 3 major benefits – CBO level:

· Overall OPEX optimization

· Simplified integration

· Improved European network traffic management

Variant 3 has the advantage of the simplest integration (as in variant 3) plus a fully harmonized way of managing trains within Europe.

Variant 3 major weaknesses – CBO level:

· CAPEX

· Implementation period

· induced investments in the railway infrastructure

* not relevant for usual day to day decisions, due to lack of relevant information details

* overall European harmonization of national traffic management rules, if not all operational rules, is required

The migration towards one "Euro Control Entity" will have huge costs.

5.5 Overview of the Core Business Objectives with TMS relevance

CBO						
4.1 Meeting evolving customer requirements		V 0	V1	V2	V3	
Continuous supervision	Continuous supervision and detection of conflicts and resolution potentially leveraging on data sharing	(x)	x	X	**X**	Cross-border conflict resolution is easier with a central IT system in place and with an EU level supervision which decides upon priorities
Smart/assisted incident handling	Reducing the impact of disturbances - intelligent incident handling as well as process and functional assistance of works enabling a smooth operation	x	X	**X**	**X**	Cross-border conflict resolution is easier with a central system in place and with an EU level supervision which decides upon priorities
Rapid deviation information/solution	Provide to customer rapid alerts of traffic congestion, including rerouting options	(x)	**X**	**X**	**X**	Is technically easier to achieve with a central data-hub (style European Mobility

						Data Space) in place
Tools support new services	Develop tools for public administrations which can be leveraged by different stakeholders to stimulate new types of services	(x)	**X**	**X**	**X**	Is technically easier to achieve with a central data-hub (style European Mobility Data Space) in place
Analytical information for passenger flow/ incident(1)	Provides valuable information to optimize the layout of stations + Provides valuable information to refine the procedures for incidents +	(x)	**X**	**X**	**X**	Is technically easier to achieve with a central data-hub (style European Mobility Data Space) in place
Reliable European reference data	Provide reference data which is highly reliable, updated automatically, that can be used by the whole sector and accessed by its systems	(x)	**X**	**X**	**X**	Is technically easier to achieve with a central data-hub (style RINF) in place to assure quality
Enable railways to deploy digital solutions by simplifying the access to information available in the standardized architectures	... generate large amounts of information that shall be organized and exchanged to deliver customer value.	(x)	**X**	**X**	**X**	Is technically easier to achieve with a central data-hub (style RINF) in place to assure quality
4.2 Improved performance and capacity						
New technologies, harmonized processes	...development of cutting-edge technologies and improved and harmonised operational processes and rules designed to be implemented across the whole EU rail system, capacity and performance can be significantly improved, and interoperability strengthened	**X**	**X**	**X**	**X**	Cutting-edge technologies and improved/harmonised processes will bring benefits in each variant
Deep/optimized plan	TMS/CMS (Capacity Management System) to enable more efficient infrastructure usage	(x)	**X**	**X**	**X**	Is technically easier to achieve with a central data-hub (style European Mobility Data Space) in place

Automatic Train Operations optimisation. {ATO}	Unmanned train operation on, at least selected, sections of heavy rail networks, especially high traffic density lines, or for specific transportation functions like shunting					
Predict capacity needs	Better prediction of demand needs to support future investment	(x)	**X**	**X**	**X**	Is technically easier to achieve with a central data-hub (style European Mobility Data Space) in place
4.3 Reduced costs						
Changeability and upgradeability(3), simplified integration	Simplified integration	(x)	x	x	X	The presence of central components facilitates integration. A central TMS is very costly to implement, but integration is easier afterwards
Overall CAPEX/OPEX optimisation(1)	The economic viability has to consider the full lifecycle cost considering both Capex + Opex from railways and suppliers' points of view	x	x	x	X	A connection between a central TM system with controlling possibilities and all european CCS systems is the most expensive to set up.
4.5 Harmonised approach to evolution and greater adaptability						
Operational harmonisation, unique requirements	Deliver a common and sufficiently detailed set of operational rules – enabling the use of based on radio-based ERTMS alone systems – to support a much greater degree of operational harmonisation...	(X)	(X)	X	X	Operational rules must be harmonised in all variants. The supervision of the rules is easier with a central governance body in place