Traffic CS System Concept

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Abstract System Concept of ERJU System Pillar Traffic CS domain. It summarises the most important system requirements for Traffic CS and explains in the solution concept how it is foreseen to fulfil these requirements. Furthermore, assumptions and expectations to external systems outside of Traffic CS are stated and roadmap is presented.

Classification Public

Status Approved / To be Decided

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1 Purpose and Scope

1.1 Disclaimer

The present system concept is not part of the final specification deliverables according to the STIP. It is the summary of the current state of design.

[Open, SPT2TRAFFIC-5830 **]**

1.2 Purpose

This System Concept was created to enable an early collaboration about the architecture and functionality of Traffic CS with other SP domains, IP projects and other stakeholders.
The present document summarizes the most important system requirements for Traffic CS and explains in the solution concept how it is foreseen to fulfil these requirements. Furthermore, assumptions and expectations to external systems outside of Traffic CS are stated and roadmap is presented. **[** Open, SPT2TRAFFIC-8822 **]**

1.3 Glossary

Please note: On request by the sector for several reasons, new terms have been defined in the context of the Traffic CS Design in 01/2025. Those terms will be introduced in the SC2.4 deliverables and step-by-step in new or updated Traffic CS Design documents. Following terms are affected:

- **ETPS - European Trackside Protection System** (formerly TPS – Trackside Protection System)
- **PES - Plan Execution System** (formerly EAL – Execution and adaptation layer)
- **DTCC - Dynamic Train-Centric Control** (formerly Moving Block in the context of Traffic CS)

Detailed term definition is given below.

Term	Definition
Application Configuration Data	The Application configuration refers to use case-specific data for the Consuming Systems for a specific application. These can be detailed as SPT2TS-127776 - Infrastructure data i.e., Track edges, Track geometry, Track properties, Segment Profiles, etc. and SPT2TS-127777 - Vehicle data i.e., Braking and Traction efforts, Rolling coefficients, etc.
Area of Control	The Area of Control is the topologically limited extent and the infrastructural Trackside Assets in this geographical extent. The term is used here for defining the technical and operational responsibility of a Trackside Subsystem.
Basic Integrity Level	Integrity attribute for safety-related functions with a TFFR higher than (less demanding) $10^{-5}.h^{-1}$ or for non-safety-related functions.
CCS System	The control command and signalling (CCS) system covers signalling, train control, positioning equipment and telecommunications.
Capacity Management System	System dealing with the long- to short-term planning and allocation of rail infrastructure capacity
Configuration Data	The (CCS/TMS) Configuration Data refers to a conglomerate of different configuration data required for CCS/TMS systems. These can be broadly classified as SPT2TS-127773 - Application Configuration Data and SPT2TS-127774 - System Configuration Data. CCS/TMS Configuration Data is provided via the configuration interface to the CCS/TMS Systems. The configuration data is assumed static within a version and changes occur only when there is a version change or increase, opposite to dynamic data, which may change within a configuration version of the system.

Term	Definition
Connected Driver Advisory System	Realizes a communications link to the Control Centre (or Traffic Management Centre) in each controlled area in which the train operates. This enables the provision of schedule, routing and speed restriction updates to trains in near real time, and also receipt of information from trains to the IM control centre to improve regulation decisions.
Digital Register - Infrastructure	The Digital Register Infrastructure (DR-I) is a database managing and providing static infrastructure data as central service. The data exchange between Traffic CS and this database is based on the EULYNX Standard Maintenance Interface SMI-xx via the subsystem Configuration (MDM).
Dynamic Train-Centric Control	Dynamic Train-Centric Control permits movement **ending at any location on the track** (as long as this movement is allowed by the set of Safety Rules), a capability that is fundamentally restricted under current block-based signalling principles. Dynamic Train-Centric Control combines route protection and train control features. Based on the operational plan obtained from the TMS, Traffic CS will allocate a **Movement Permission for the designated train** and determine the Movement Authority for the designated train. This is different from the current approach where train authorisations are determined for predefined routes that have been set by an IXL.
ERTMS/ATO Trackside	ERTMS/ATO Trackside (ATO-TS) is the ERTMS/ATO trackside subsystem. ERTMS/ATO provides a set of non-safety functions related to speed control, accurate stopping, door opening and closing, and other functions traditionally assigned to a driver, while the safety of operation is still ensured by ETCS with regards to the speed and distance limits and also by other safe systems.
European Railway Traffic Management System	European Railway Traffic Management System (ERTMS) is a single European signalling and speed control system that ensures interoperability of the national railway systems, reducing the purchasing and maintenance costs of the signalling systems as well as increasing the speed of trains, the capacity of infrastructure and the level of safety in rail transport. (ERA definition)
European Trackside Protection System	The Trackside Protection System is the core system of Traffic CS, implementing the safety critical functions. The Trackside Protection System controls all Trackside Assets Control and Supervision (TACS) connected to ETPS, for example points, level crossings, and manages Movement Permissions for trains, whilst maintaining the safety of the railway.
Field Force	The field force *is* the single point of contact with Traffic CS when maintenance activity or construction work is carried out in the field. This actor is responsable for the safety of the staff in the field.
Fixed Block	A block in which the extremities of the block sections are at fixed locations. The signalling allows a train to move from one block to the next, normally only when the block ahead is clear.
Fixed Virtual Block	A Fixed Virtual Block is a Fixed Block where the limits are virtual and do not necessarily correspond to train detection boundaries.
INTERLOCKING	A general term applied to the controlling of the setting and releasing of “signals” and “points” to prevent unsafe conditions arising, and equipment which performs this function.
Infrastructure data	Infrastructure Data is a detailed digital representation of the railway network that contains all infrastructure related information necessary for planning and performing railway operations, such as infrastructure characteristics, location and details of Field Elements, etc. The Infrastructure Data is static and remains unchanged until intended infrastructure updates occur.

Term	Definition
MOVEMENT AUTHORITY	Permission for a train to run to a specific location within the constraints of the infrastructure.
Maintenance and Data Management	Maintenance and Data Management - is the subsystem is which performs the configuration service required for the operation of the TMS and Traffic CS Subsystems, e.g. management and provision of Configuration Data and software updates (e.g. engineering data, security patches).
Movement Permission	Movement Permissions (MPs) are stored within the trackside safety system. A Movement Permission is an extent of track reserved within the trackside safety system for a particular Train Object to move. A Movement Permission includes all conditions under which the movement of the Train Object can be performed safely. A Movement Permission always refers to exactly one Train Object. A Movement Permission is distinct from a Movement Authority, which is sent from the trackside safety system to the ETCS On-Board.
Moving Block	Moving block is a concept where Movement Authorities can end at any location on the track. The Safe Train Extent of each train moves with that train based on its reported position and train integrity status and is not constrained to fixed block locations.
Neighbouring Traffic CS	Neighbouring Traffic CS is located geographically adjacent to current Traffic CS territory. Neighbouring Traffic CS enables handing over or accepting a train going to/coming from current adjacent Traffic CS.
Operational Data	Operational Data refers to real-time information generated from daily operations and activities related to the functioning of railway systems, reflecting the current status of operations (e.g. locked position of a switch). Operational data is exchanged between CCS/TMS systems via Standard Communication Interfaces (SCI-xx). *Note: while Operational Data can be related to infrastructure or vehicle configuration data, it is clearly separated from SPT2TS-127779 - Configuration Data .*
Operational Plan	The Operational Plan is the result of the planning process performed by TMS. An Operational Plan will be issued by the TMS for any operationally relevant activity. This comprises all movements of Physical Train Units incl. shunting operations (Operational Movement), restrictions due to e.g., infrastructure maintenance and construction works, and warning measures during restrictions.
Parameter Data	Parameter Data define the system configuration data required for national and supplier-specific operative environments. A notable example of such data are ETCS national values. ETCS national values may be required for migration purposes and shall be replaced by SERA standardised values in the target system.
Plan Execution System	The Plan Execution System is a subsystem of Traffic CS which is responsible for: • processing the Operational Plans provided by the TMS, which are based on the Operating State of the railway within the Area of Control and • providing the Operating State within the Area of Control received from Trackside Protection System towards the TMS.
RADIO BLOCK CENTRE	A centralised safety unit that receives train position information via radio and sends movement authorities via radio to trains.

Term	Definition
Safe Train Extent	The Safe Train Extent represents the extent of the track that may be occupied by a connected train. It is calculated from train-side information (Confirmed Rear End and Max Safe Front End derived from the ETCS Position Report) and track-side information (track vacancy proving sections like track circuits or axle counters), taking into account the most recent information available from these train- and track-side information sources. Remarks: • The Safe Train Extent for a train will be updated when new information becomes available. • For a moving train, it is likely that the train will move outside the Safe Train Extent between update
Signaller	The Signaller supervises the trains and trackside assets in normal operation and controls them when manual (not automated) interventions are needed (e.g. in degraded situations).
Single European Railway Area	Defining the fundamental design principles and process for adopting a functional architecture for rail as a system, with a focus on CCS, CMS and TMS supporting the implementation of the SERA (Single European Railway Area)
Software Configuration Data	The Software Configuration data refers to executable binary files from suppliers which are usually required to install software on the systems. Software Configuration Data is provided via configuration interface to the CCS/TMS Systems.
Standard Communication Interface	The standardised EULYNX interface for process data information.
Standard Diagnostic Interface	The standardised EULYNX interface for diagnostics to enable communication with the service functions Diagnostics collector and Time synchronisation.
Standard Maintenance Interface	The standardised EULYNX interface for maintenance to enable communication with the service function Loading procedure.
Standard Security Interface	The standardised EULYNX interface for security to enable communication with the service functions for security.
System Configuration Data	The System Configuration data refers to the static data set required to configure systems with primary information before being put into operation. These data are elaborated as SPT2TS-127829 - Parameter Data
TEMPORARY SPEED RESTRICTION	A planned speed restriction imposed for temporary conditions such as track maintenance.

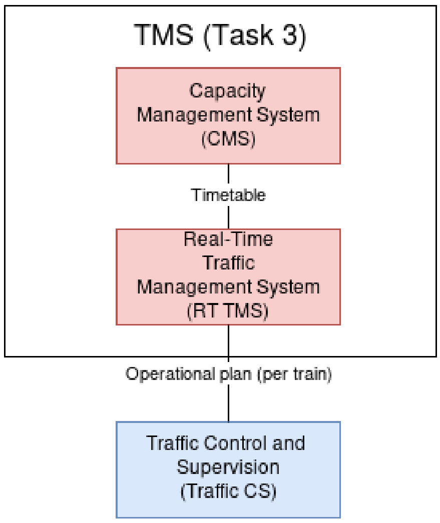
<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>Trackside Asset</td><td>Trackside Assets are elements on or near the track which are used to monitor (using sensors) and/or control (using actuators) the movement of vehicles through the railway network to provide a safe route through the railway network. They can be switchable or non-switchable and are controlled by the actors Trackside Asset Control and Supervision.</td></tr>
<tr><td>Trackside Assets Control and Supervision</td><td>The Trackside Assets Control and Supervision (Trackside Assets CS) with its subsystems (aka Object Controller) controls and supervises the Trackside Assets.</td></tr>
<tr><td>Trackside Train Detection</td><td>The proof of the presence or absence of trains on a defined section of line</td></tr>
<tr><td>Traffic Control and Supervision</td><td>Traffic Control and Supervision is the CSS Trackside System in charge of the control and supervision of the Railways Traffic. It includes ETCS Trackside and ATO Trackside.</td></tr>
<tr><td>Traffic Management System</td><td>According to SPT2TRAFFIC-3312 - CMS TMS System Concept the Traffic Management System (TMS) plans and controls the train runs to be performed. Internally the TMS is split in two parts:


Figure 1 - TMS Scope in System Pillar Architecture
Capacity Management System (CMS)
The CMS plans the timetable (train runs / routes / timings).
Real-Time Traffic Management System (RT TMS)
The RT TMS controls the production (execution) of the timetable. It provides for every train run an Operational Plan to Traffic CS.
RT TMS reacts to deviations (e.g. delays) and defines measures like re-routing or re-periodisation and updates the Operational Plans accordingly.</td></tr>
</table>

Term	Definition
Traffic Management System	Ensemble of applications providing permanent control across the network, automatically sets routes for trains and logs train movements as well as detects and maybe solves potential conflicts.
Train	Train is a set of railway vehicles that are intended to be moved together.
Train Control and Supervision	The Train Control and Supervision (Train CS) contains all CCS/TMS onboard functions, especially for ATO, ATP, radio, localisation, map services, train integrity and train length information, as well as advisory information systems used by the driver for operational reasons.
Train Object	Train Object is the object needed by the Traffic CS to manage the connected trains currently performing their mission. Note: This Train Object could nevertheless correspond to a train not (yet) localised by Traffic CS. If the train is localised by Traffic CS, the Safe Train Extent is the extent of the Train Object.
Transversal CCS	Transversal CCS provides all relevant and necessary supporting systems and service functions that facilitate and secure the operational requirements of multiple CCS and TMS systems in a standardized way. This includes coordination of engineering data, maintenance & diagnostics, and system & product configuration & assurance.
Usage Restriction Area	A Usage Restriction Area (URA) limits or constraints operation on a part within the Area of Control. URAs can be created according to an Operational Plan (e.g. for enabling construction works) or in response to an incident (e.g. as a mitigation measure). There are various limitations possible for a URA, e.g. speed restriction, full track closure or deactivate automatic operation.
Vehicle data	Vehicle Data is a detailed definition of the train/vehicle characteristics i.e., Braking and Traction efforts, rolling coefficients, of the train, wagons, locomotives used for railway operations.
Wayside Monitoring System	Wayside Monitoring Systems are used for diagnostic and maintenance purposes as well as for hazard identification. In this context WMS Systems are applied for monitoring of rolling stock (vehicles) and/or the wayside infrastructure. Some examples include (not exhaustive): Acoustic Bearing Defect Detectors Avalanche detection Hot axle box detection.

1.4 Abbreviations

Abbreviation	Definition
ASTP	Advanced Safe Train Positioning
ATO	Automated Train Operation
ATO-OB	Automatic Train Operation - Onboard (unit)
ATO-TS	ERTMS/ATO Trackside
AoC	Area of Control
BIL	Basic Integrity Level
C-DAS	Connected Driver Advisory System
CMS	Capacity Management System
DAC	Digital Automatic Coupler
DR-I	Digital Register - Infrastructure
DR-V	Digital Register - Vehicle
DTCC	Dynamic Train-Centric Control
ERTMS	European Railway Traffic Management System
ETPS	European Trackside Protection System
FB	Fixed Block

Abbreviation	Definition
FDFTO	Full Digital Freight Train Operations
FRMCS	Future Railway Mobile Communication System
FVB	Fixed Virtual Block
GSM-R	Global System for Mobile Communications — Rail
MA	MOVEMENT AUTHORITY
MB	Moving Block
MDM	Maintenance and Data Management
MP	Movement Permission
O-IF	Operator Interface
PES	Plan Execution System
RBC	RADIO BLOCK CENTRE
RTO	Remote Train Operations
SCI	Standard Communication Interface
SCI-CMD	Standard Communication Interface - Command
SCI-IO	Standard Communication Interface - Input Output
SCI-LC	Standard Communication Interface - Level Crossing
SCI-LS	Standard Communication Interface - Light Signal
SCI-OP	Standard Communication Interface - Operational Plan
SCI-P	Standard Communication Interface - Points
SCI-TDS	Standard Communication Interface - Train Detection System
SCI-TWS	Standard Communication Interface - Trackworker Safety System
SDI	Standard Diagnostic Interface
SERA	Single European Railway Area
SMI	Standard Maintenance Interface
SSI	Standard Security Interface
SSS	Shared Security Service
STE	Safe Train Extent
TA	Trackside Asset
TIMS	Train Integrity Monitoring System
TMS	Traffic Management System
TSR	TEMPORARY SPEED RESTRICTION
TTD	Trackside Train Detection
Traffic CS	Traffic Control and Supervision
URA	Usage Restriction Area
WMS	Wayside Monitoring System

1.5 Scope / System Context

The figure below shows the Traffic CS domain in the SP Environment. All the SP stakeholders are responsible together for a comprehensive SERA Design. A detailed view on the Traffic CS Architecture and the subsystems is given in section: SPT2TRAFFIC-4815 - Architecture.

Please note: The stakeholder Field Force and the respective SP domain do not exist so far. Therefore, assumptions will be taken in terms of the Field Force functional scope and its interface to Traffic CS.

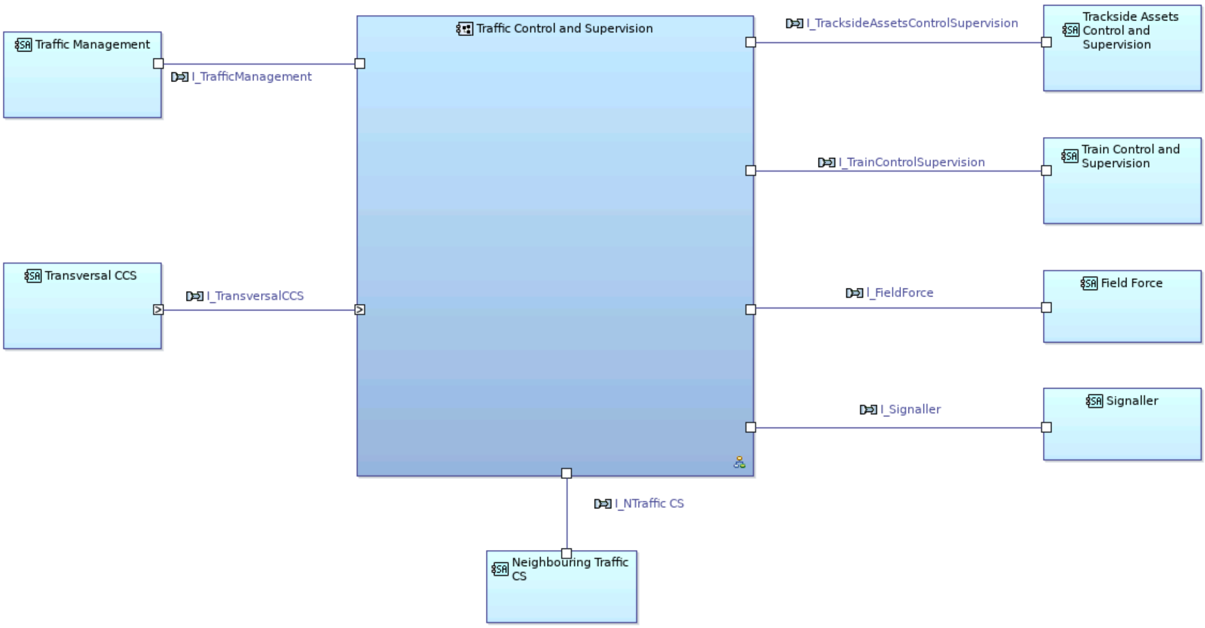


Figure 2 [SAB] Traffic CS [System Context definition]

[Open, SPT2TRAFFIC-8824]

2 SERA Development Targets

2.1 SERA Target

The SERA target is to develop a trackside signalling system for ETCS L2 without lineside signals, based on a harmonised operation concept and harmonised operational rules.

Optionally, ATO GoA2 may also be included, and the SERA target will include this. Later ATO GoA3/4 will become available for use and can then be introduced as an additional option.

Initially, not all trains will be able to provide safe train length and train integrity information. Therefore the SERA target will support a mix of trains with or without the ability to provide train length and train integrity information. As more trains are able to provide train length and train integrity information, via systems such as TIMS and DAC, performance can be increased without further changes to the SERA system.

The upgrade cycle of the ETCS On-Board on trains is slow. Therefore the SERA target will support ETCS On-Board as System Version 2 or higher.

[Open, SPT2TRAFFIC-8827]

2.2 Introduction of harmonized operation concept

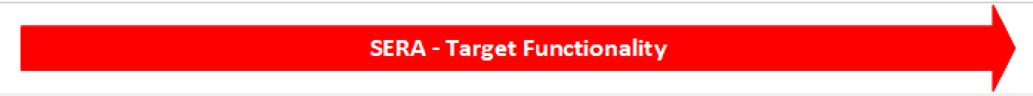
All the development done by Traffic CS is based on the harmonized operation concept defined by System Pillar. Therefore, the SERA functionality can only be introduced together with the harmonized operation concept. [Open, SPT2TRAFFIC-8828]

2.3 SERA Development targets

The SPCG has divided the SERA Phase into three development targets:

1. Harmonized European Rail Operation = entry level based on today's technology
2. Digital European Railway = Enhanced digitalization introducing new technology
3. Automated European Railway = Driverless operation

Accordingly, those development targets are defined as follows:



Development Targets	**1**	**2**	**3**
	Harmonized European Rail Operation	**Digital European Railway**	**Automated European Railway**

Development Targets	1	2	3
	Harmonized European Rail Operation	**Digital European Railway**	**Automated European Railway**
Functions / Technical enablers and features	• Harmonized operation concept ETCS L2 + rules, processes, also for ATO GoA1/2 • ETCS L2 Functionality based on System Version 2.3 or higher • CCS Architecture based on: Harmonized Trackside Protection System ("ETPS", combining a cleaned-up interlocking and RBC functionality specialized on ETCS L2) and Plan Execution System ("PES") • Harmonized "command " interface SCI-CMD between ETPS and PES • Efficient change of topology data (changed track functionality caused by construction or degraded modes) used by the ETPS causing smallest possible interruptions (in time and influenced area) • Safe traffic management for any topology geometry w/o additional site-specific track geometry/functionality safety analysis work steps • Safe traffic control for mixed traffic with trains with or without train integrity/train length information; • Small SIL 4 footprint and generic product safety cases • Supervised manoeuvres and harmonized ETCS shunting signals as implementation option • shared safe and secure computing environment (allowing data centres/clouds for running safe application, harmonized HW or virtualisation abstraction interface) • EULYNX interface to trackside EULYNX object controllers or Multi-OC • Radio communication: GSM-R and FRMCS, dual at both sides • Digital Register Data to ETPS, PES and ATO-TS • FDFTO/ DAC basic package incl. TI / TL • All other interfaces of the System Pillar Target Architecture, which are perhaps agreed and published at this time, can be used for optional implementations	• Digital Register incl. ASTP data • Harmonized RTO functionality as an option • All other interfaces of the System Pillar Target Architecture, which are perhaps agreed and published at this time, can be used for optional implementations	• Digital Register: for all applications, including onboard • Radio communication: FRMCS only • ATO GoA 3/4 (processes, onboard systems, trackside system functionality) • TMS / CMS: Full SP Task 3 architecture • All other interfaces of the System Pillar Target Architecture, which are perhaps agreed and published at this time, can be used for optional implementations
Benefits	• Reduced wayside infrastructure & Reusability of products • Easier and improved engineering, Efficient upgradeability • Better usage of physical track capacity • Shorter deployment time • Energy optimization (by ATO GoA2)	• Further reduced wayside infrastructure • Optimized train driving	• Driverless operation enabling higher flexibility • Further improved deployment

Table 1 - Clustering of SERA Phase in development targets

The current focus of TrafficCS will be on Development Target 1 which includes the harmonized operation concept and architecture. **[** Open, SPT2TRAFFIC-8829 **]**

The specification of the individual Traffic CS Subsystems and interfaces is scheduled in the STIP Plan:
SPPMO-50 - Standardization and TSI Input Plan - Template. **[** Open, SPT2TRAFFIC-11666 **]**

3 System Requirements

The following list represents the most important System Requirements for Traffic CS.

- The requirements in this list have been derived within Traffic CS from consideration of the key requirements for the SERA Phase described above.
- The requirements will be cross-checked against top-down requirements, as part of the on-going work within the Traffic CS Domain.
- The requirements were classified into two categories: those that align with the current specification target and those that exceed these target. The latter are not prioritised for the current specification target and will require further analysis.

Disclaimer:
The following list of requirements is not complete yet and was not derived from the Common Business Objectives or the Railway Requirements. The actual development of the system requirements in accordance with the SEMP is currently being carried within Traffic CS System Requirements. This list here will be completed after the first stage of deriving the system requirements has been finalised. **[** Open, SPT2TRAFFIC-8833 **]**

3.1 Current specification target

Harmonised SERA operational rules.

Traffic CS shall be based on harmonised operational rules, based on a harmonised operational concept, in order support a Single European Railway Area (SERA). **[**SPT2TRAFFIC-4454 **]**

Keep system simple, avoid national variations in functionality. The harmonized o...

Keep system simple, avoid national variations in functionality. The harmonized operational scenarios necessary for train operation in standard and degraded modes form a precondition for lean and cost-efficient system development, implementation and project deployments. This would also lead to simplified operation procedures for the train driver and the signaller.

ETCS L2 only

Traffic CS shall be designed to use ETCS L2 as the only train control system (ETCS L2 only, no L 0/1/NTC) and without Line Side Signalling.

Note: The need for the usage optical shunting signals for specific scenarios is acknoldeged and covered by SPT2TRAFFIC-4467 - Shunting operations with light signals. **[**SPT2TRAFFIC-4967 **]**

Harmonisation of operational processes and operational rules is only possible if...

Harmonisation of operational processes and operational rules is only possible if existing line-side signalling is avoided.

Traffic CS shall support trains equipped with ETCS Baseline 3 and above

Traffic CS will implement ETCS System Version 2 on the trackside. This means that trains equipped with ETCS Baseline 3 and above are supported. The implemented ETCS System versions can be raised over time. [SPT2TRAFFIC-4817]

Harmonisation of operational processes and operational rules is only possible if...
Harmonisation of operational processes and operational rules is only possible if signalling functions based on legacy ATP systems like L0/1/NTC are avoided.

Baseline 2 trains are excluded, since it is assumed that in the time-frame of Tr...
Baseline 2 trains are excluded, since it is assumed that in the time-frame of Traffic CS implementation they will largely have been migrated to Baseline 3 or above. Baseline 2 is not supporting several important features like packet switched radio and level crossing supervision. Many specification errors that have been closed in Baseline 3 require trackside mitigation measures that would make Traffic CS considerably more complex.

This is needed to allow building Traffic CS with current ETCS-equipped trains an...
This is needed to allow building Traffic CS with current ETCS-equipped trains and to allow gradual train migration to newer ETCS versions. It allows to operate trains with different ETCS versions (starting with Baseline 3) in the same area.

EULYNX Standard Communication Interfaces SCI-xx
Traffic CS shall connect to Trackside Assets using the EULYNX/EU-Rail System Pillar standard interfaces (SCI-xx), with at least Baseline 4 Release 2. [SPT2TRAFFIC-4495]

These interfaces are already standardised and in use in legacy system configurat...
These interfaces are already standardised and in use in legacy system configurations. Further harmonisation without national specifics in implementation is advisable.

Shunting operations without light signals
Traffic CS shall allow shunting operations with cab-signalling, not using light signals.
[SPT2TRAFFIC-4455]

This enables removal of all light signals on the track, where trains are eqipped...
This enables removal of all light signals on the track, where trains are eqipped with ETCS Baseline 4 and DAC, if needed. This contributes to safe operation of GoA3/4.

Shunting operations with light signals
Traffic CS shall take into account a configuration for shunting operation using light signals.
[SPT2TRAFFIC-4467]

ERTMS Baseline 3 does not support cab-signalling for all shunting operations (e.g....
ERTMS Baseline 3 does not support cab-signalling for all shunting operations (e.g. pushed movements).

Handling of train and shunting movements in Traffic CS
Traffic CS shall implement only one algorithm (i.e. signalling principle) to permit movements on the railway. Differences in available information (train data, track clearance, …) can lead to different protection levels. [SPT2TRAFFIC-4462]

Simplify the system. All current operations will still be supported. Handling of...
Simplify the system. All current operations will still be supported. Handling of degraded modes can be automated and simplified. It allows partial degradation of supervision instead of going to fully manual operation. The movement allowed by the Traffic CS algorithm can be communicated to train/driver in different ways like ETCS MA, written order or shunting signal.

Improve automation and safety in degraded situations
Traffic CS shall automate as much as possible the operation even in degraded modes. Degradation of supervision level shall only happen as far as needed. [SPT2TRAFFIC-4831]

This increases performance and safety in degraded situations. For example, if a...

This increases performance and safety in degraded situations. For example, if a part of the track is not proven clear, Traffic CS can automatically determine the condition to permit the movement without the need for voice communication. Also flank protection can be provided as much as possible, even for movements that are manually authorised by the signaller.

Usage of FRMCS and GSM-R

Traffic CS shall support use of FRMCS and GSM-R as the radio connection to vehicles. **[**SPT2TRAFFIC-4471 **]**

FRMCS is the target communications system for SERA. It is needed for higher leve...

FRMCS is the target communications system for SERA. It is needed for higher levels of automation. As ETCS System Version 2 is implemented on the trackside, GSM-R is also supported.

Movement from any point to any point

Traffic CS shall allow movements from any starting point to any destination point as long as they can be routed and are safe. **[**SPT2TRAFFIC-4473 **]**

It enables optimised usage of the infrastructure. Note: Marker boards could be u...

It enables optimised usage of the infrastructure. Note: Marker boards could be used for some operational situations.

Operation of mixed fleets

Traffic CS shall support mixed operation of trains with and without train integrity monitoring. **[**SPT2TRAFFIC-4478 **]**

This enables early implementation of Traffic CS without all trains equipped with...

This enables early implementation of Traffic CS without all trains equipped with train integrity (i.e. gradually rollout of trains with TIMS, DAC is supported). It also allows rail operation in degraded situations.

Aggregation of several train localisation sources

Traffic CS shall be able to aggregate different localisation information from train-side (e.g. train position report) and trackside sources (e.g. track occupancy) into one safe representation of the train. **[**SPT2TRAFFIC-4476 **]**

This enables flexible system configurations with any mix of on-board/trackside s...

This enables flexible system configurations with any mix of on-board/trackside sensors depending on the needs of specific lines. It also enables the best performance level and handling of failure of on-board/trackside sensors.

ATO GoA1

Traffic CS shall support manual train operation (GoA 1), optionally with C-DAS as defined in ERTMS/ATO. **[**SPT2TRAFFIC-4481 **]**

This enables scalable ATO based train operation, depending on the operational ne...

This enables scalable ATO based train operation, depending on the operational needs for specific lines and the grade of ATO equipment of the vehicles.

ATO GoA2

Traffic CS shall support automatic train operation in GoA 2 with ERTMS/ATO. **[**SPT2TRAFFIC-4480 **]**

This enables scalable ATO based train operation, depending on the operational ne...

This enables scalable ATO based train operation, depending on the operational needs for specific lines and the grade of ATO equipment of the vehicles.

System configuration data from centralised service

Traffic CS shall acquire system configuration data from a centralised service via a standardised interface, based on EULYNX SMI-xx. Examples for this system configuration data: software updates, configuration values **[**SPT2TRAFFIC-4492 **]**

This shall enable data consistency with other systems (e.g. TMS, Trackside asset...

This shall enable data consistency with other systems (e.g. TMS, Trackside assets) outside Traffic CS which are operated in the same infrastructure area.

Configuration Data update

Traffic CS shall allow updates of Configuration Data during runtime, with minimal impact on railway operation. **[**SPT2TRAFFIC-4494 **]**

This enables to minimise disturbances in operation during a configuration update...

This enables to minimise disturbances in operation during a configuration update. Such feature enables increase of availability, reliability, and performance of rail operations.

Digital Register

Traffic CS shall acquire Configuration Data from a centralized service via a standardised interface based on EULYNX SMI-xx **[**SPT2TRAFFIC-4500 **]**

The implementation of a centralized service for configuration data will ensure c...

The implementation of a centralized service for configuration data will ensure consistent data updates across Traffic CS subsystems and the entire TMS/CSS target system. Additionally, it will reduce the effort required to install and update Traffic CS subsystems and other components of the TMS/CSS target system.

Provide diagnostic information to a centralised diagnostics system in a standardised format,

Traffic CS shall provide diagnostic information to a centralised diagnostics system in a standardised format, based on the generic part of the EULYNX/EU-Rail System Pillar standardised diagnostic interface, called SDI-xx. **[**SPT2TRAFFIC-4490 **]**

This enables better and faster preventive and corrective maintenance of the subs...

This enables better and faster preventive and corrective maintenance of the subsystems belonging to Traffic CS.

Security

Traffic CS shall implement security according to the security-by-design process. Traffic CS shall interface to centralised security services. **[**SPT2TRAFFIC-4497 **]**

The implementation of Security in Traffic CS makes the system less vulnerable fo...

The implementation of Security in Traffic CS makes the system less vulnerable for cyber security threats.

3.2 Beyond current specification target

ATO GoA3/4

Traffic CS shall support automatic train operation in GoA 3/4 with ERTMS/ATO. **[**SPT2TRAFFIC-4483 **]**

This enables the flexible use of ATO based train operation, depending on the ope...

This enables the flexible use of ATO based train operation, depending on the operational needs for specific lines and the grade of ATO equipment of the vehicles.

Remote train operation

Traffic CS shall support remote train operation (RTO). **[**SPT2TRAFFIC-4485 **]**

This enables manual operation of trains without the driver being on-board and ca...

This enables manual operation of trains without the driver being on-board and can be used in normal operation and for recovery of degraded trains in GoA 3/4.

Driving in relative braking distance

Traffic CS shall support driving in the relative braking distance on track sections where this is possible in terms of safety. The relative braking distance should be controlled on the trackside systems. **[**SPT2TRAFFIC-4475 **]**

This increases line capacity without additional equipment on trains for train-to...

This increases line capacity without additional equipment on trains for train-to-train communication. Train integrity and safe train length is still a pre-condition.

Virtual coupling

Traffic CS shall support virtual coupling of trains, with train-to-train communication. **[**SPT2TRAFFIC-4488 **]**

This improves the performance. It is foreseen on a longer time scale.

This improves the performance. It is foreseen on a longer time scale.

4 Solution Concept

4.1 Architecture

Traffic CS System Architecture

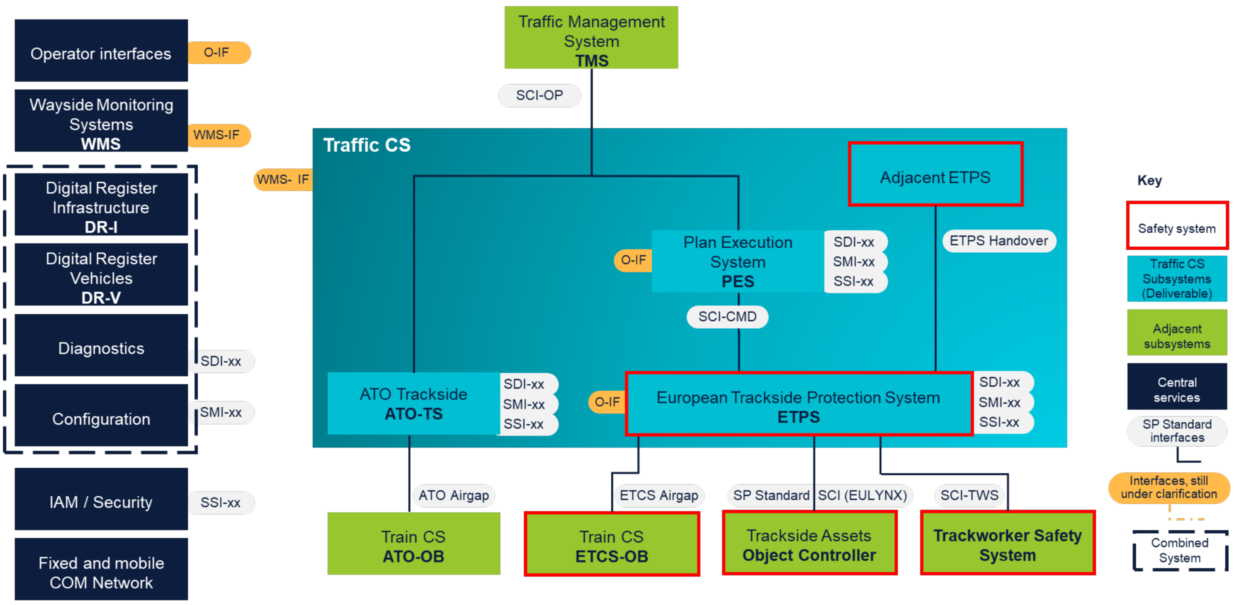


Figure 3 - Traffic CS System Architecture

The figure above shows the proposed Traffic CS System Architecture for the SERA Phase, development target 1. The figure shows the Traffic CS subsystems on conceptual base and their connectivity to internal and external subsystems. Some interfaces (marked orange), which are relevant in the context of the Traffic CS Design are still subject of further clarification and therefore not depicted in detail. More details can be found in the interface and subsystem related chapters.

The requirements beyond specification target 1 have only be analysed on high-level. It is considered that later improvements like ATO GoA 3/4 or Virtual Coupling can be added to the architecture in a compatible way, i.e. without invalidating the specifications for GoA 1/2.

The motivation for the Traffic CS Subsystem split has been as follows:

PES

- functionality requiring only basic integrity will be implemented in PES to keep ETPS lean
- can be used to restrict the flexibility of ETPS - i.e. although ETPS allows safe train movements from anywhere to anywhere, PES can be used to adapt the system behaviour for operational purposes, to realise train movements based on fixed entrance/exit locations

ATO-TS

- Implementation of ATO is an option within Traffic CS. Therefore a separate subsystem is used for ATO-TS, which is only required if ATO is implemented in a particular scheme.

ETPS

- group all safety related and strongly interacting functionality in one single subsystem allowing a stable generic safety case
- limit functionality to mainly safety critical functions and assign basic integrity functionality to other subsystems to allow a lean safety case (small SIL4 footprint)

The safety logic performed within the ETPS will be sufficiently defined so that the PES and ETPS subsystems can evaluate the logic in a consistent way. The PES subsystem should minimise the risk of sending requests to the ETPS subsystem which will be rejected. However, the evaluation by the ETPS subsystem will be definitive, as the ETPS subsystem is the safety critical subsystem. **[** Open, SPT2TRAFFIC-8898 **]**

4.2 Data Flow

The following figure shows the data flow between Traffic CS subsystems and major external subsystems on conceptual basis, from operational perspective (i.e. for ETCS and ATO).

Traffic CS Operational Data Flow:

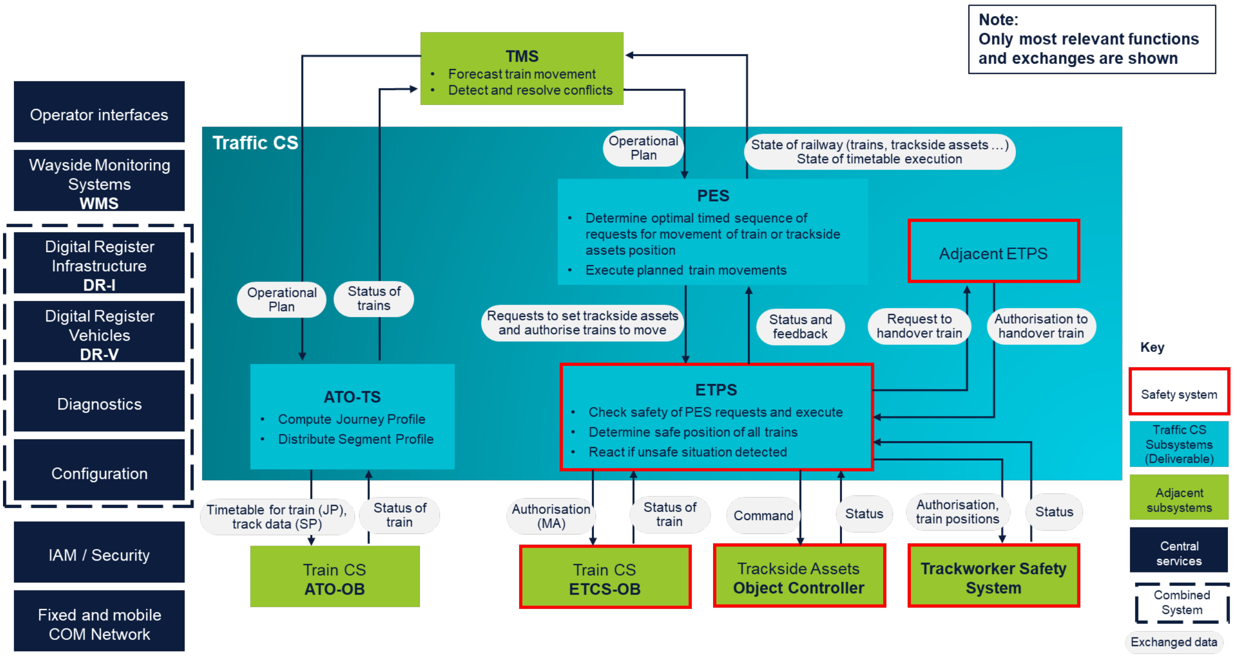


Figure 4 - Traffic CS Operational Data Flow

The data flows to and from the Central Services are not shown in the figure above. There is further information about the interfaces to Central Services in the External Interfaces section [SPT2TRAFFIC-4814 - External Interfaces] and the Assumptions section [SPT2TRAFFIC-5516 - Assumptions to external Systems].

Traffic CS will process data which can be categorised as follows:

1. Static data – these are stable long-term valid data (permanent, seasonable, construction period), which are generated as output from an engineering tool and uploaded from Configuration via SMI to the respective application (e.g. Traffic CS, TMS) via the Digital Register Infrastructure (DR-I) or Digital Register Vehicles (DR-V).
2. Temporary data – these are either pre-configured data from Digital Register Infrastructure which can be activated by command from the operation/incident manager or settings (like TSR) which can be entered directly by the operation/incident manager. Those settings are valid for a short time period (hours, days) and are transmitted via a FFFIS interfaces to the respective application (e.g. ETPS).
3. Dynamic data – Those are rapidly changing data (e.g. in sec, msec) like the monitoring and status data of an object controller.

[Open, SPT2TRAFFIC-8834 **]**

4.3 Subsystems and their main functions

4.3.1 Dynamic Train-Centric Control

Dynamic Train-Centric Control (DTCC) combines route protection and train control features. Based on the operational plan obtained from the TMS, Traffic CS will allocate a **Movement Permission for the designated train** and determine the Movement Authority for the designated train. This is different from the approach where train authorisations are determined for predefined routes that have been set by an IxL.
Dynamic Train-Centric Control permits movement **ending at any location on the track** (as long as this movement is allowed by the set of Safety Rules). I.e. it moves away from traditional block based systems that primarily depend only on signals, track vacancy section occupancy, established routes, and specific national regulations. **[** Open, SPT2TRAFFIC-11716 **]**

Dynamic Train-Centric Control can be implemented in different ways as long as full compliance to the harmonised system specification, harmonised subsystem specifications and harmonised interface specifications is ensured. **[** Open, SPT2TRA FFIC-11717 **]**

4.3.2 Plan Execution System (PES)

4.3.2.1 Description

The main functions of the Plan Execution System (PES) are:

- processing the Operational Plans provided by the TMS, which are based on the Operating State of the railway within the Area of Control and
- provision of the Operating State within the Area of Control received from ETPS towards the TMS.

These are not safety-critical functions.
An Operational Plan can contain:

- An Operational Movement - a timetable for a specific train
  This will include path to be followed, and passing points where required.

There may be additional types of Operational Plan. Only Operational Movement is described below.
For each Operational Movement, this function will need to:

1. Determine if this is a new Operational Movement, or a revision to an existing Operational Movement which is already being processed.
   The following steps are for a new Operational Movement. For a revision to an existing Operational Movement the steps are amended as required.
2. Determine whether the requested operational movement is feasible. The feasibility check could include consistency of the specified path, events, times, and activities as well as basic route compatibility checks (e.g. no stopping point allowed in non-stopping area).
   If the Operational Movement is not feasible, it is rejected.
3. Determine a timed sequence of requests for Movement Permissions and movements of trackside infrastructure, which are needed to achieve the train movement defined in the Operational Plan.
4. Issue requests to the European Trackside Protection System (ETPS) for movements of trackside infrastructure and Movement Permissions in a timely manner, to implement the Operational Plan.
5. Monitor the responses to the requests made to the European Trackside Protection System, and the progress of the train relative to the Operational Plan by examination of the Operating State.
6. Update the TMS with the status of the Operating Plan.
7. Confirm to the TMS when the Operating Plan is completed.

In addition, this function will need to:

- Check internally before issuing requests to the Trackside Protection System that the request should be granted by the Safety Logic.

PES does not ensure the safety logic. Each request to the European Trackside Protection System can be refused. However, PES should nevertheless duplicate some functions also used in the ETPS to minimise the probability that its requests are refused. For example, PES should check whether movement of trackside infrastructure will be possible, before sending a request to move trackside infrastructure. This is “non-provocation”.

Notes:
Changing the position of trackside infrastructure such as points takes time. This function will need to allow time for the changing of position. Requesting a Movement Permission is faster, once the trackside infrastructure is in the correct position, and so can be requested later. **[** Open, SPT2TRAFFIC-8836 **]**

4.3.2.2 Main Inputs

1. Operational Plans from the TMS via interface SCI-OP
   The main purpose of PES is to implement Operational Plans from TMS
2. Infrastructure topology from Digital Register Infrastructure via Configuration SMI-xx interface
   The Operational Plans and the requests to ETPS are in terms of the infrastructure data from the Digital Register Infrastructure.
3. Time Reference
   This is required to provide accurate timing of requests to ETPS, ATO-TS, relative to the requesting timings in the Operational Plan.
4. Operating State of the railway within the Area of Control from ETPS.
   This function does not directly change the Operating State. The Operating State is maintained by ETPS. This function can only indirectly cause changes to the Operating State via requests to ETPS.
5. Operator Requests from O-IF.
   In degraded situations, it may be necessary for the Operator, for example, to request reservation of a path for a train.

[Open, SPT2TRAFFIC-8837 **]**

4.3.2.3 Main Outputs

1. Requests to ETPS via interface SCI-CMD.
   These are requests for movements of trackside infrastructure, and for Movement Permissions.
2. Reports to TMS on progress of Operational Plans based on information from ETPS.
3. Provide current Operating State to the TMS and the O-IF.

[Open, SPT2TRAFFIC-8838 **]**

4.3.3 European Trackside Protection System (ETPS)

The European Trackside Protection System (ETPS) is the core system of Traffic CS, implementing the safety critical functions. The chosen architecture considers that systems existing today show that distributing safety critical functions over several subsystems increases the complexity of the system and inhibits optimization and innovation by increasing at the same time the effort for Standardisation of further interfaces. The internal modules and functional assignments inside ETPS will not be scope for harmonisation and the internal ETPS architecture and design is a supplier choice.

The ETPS provides an interface to the Plan Execution System and offers to execute granular, highly standardised safe commands with a safe envelope supervised by the ETPS.

The ETPS itself works with an internal data representation – boundary components of ETPS will manage the external communication of ETPS using the standardised interfaces and convert the information to and from this data representation if needed (this is a supplier choice).
[Open, SPT2TRAFFIC-8839 **]**

4.3.3.1 Description

The main functions of the European Trackside Protection System (ETPS) are:

1. Maintain an up-to-date Operating State of the railway within the Area of Control.
2. Process requests from PES for movements of trackside infrastructure
3. Process requests from PES for Movement Permissions
4. Process requests from Operator relating to manual operations, for example for Usage Restrictions, including TSRs
5. Release Movement Permissions based on the movement of trains
6. Detect and react to unsafe situations
7. Manage communications to Trackside Assets, Trains and adjacent ETPSs

These are safety-critical functions.
The Operating State includes:

- Status of all Trains currently within the Area of Control
- Status of all Trackside Assets
- Aggregated Track Occupancy information
- All Movement Permissions
- All Usage Restrictions, including TSRs

1. To maintain the Operating State of the railway within the Area of Control, this function will need to:

    1. Process information from trains, for example Train Position Reports.
    2. Process information from Trackside Assets, for example Points, Trackside Train Detection.
    3. Derive Aggregated Track Occupancy from Train Position Reports and information from Trackside Assets.

2. In order to process a request to move a trackside infrastructure element, this function will need to:

    1. Determine the current state of the trackside infrastructure element, to check whether movement is required.
    2. If movement is required, perform a safety check that it is safe to move the trackside infrastructure element.
       For example, the track over the element must not be occupied, and must not be part of a Movement Permission.
    3. If the safety check is successful, issue the command to the Trackside Asset Object Controller to move the infrastructure element.
       If the safety check is not successful, then the request is rejected, and no command will be sent to the Trackside Asset Object Controller.

3. In order to process a request for a Movement Permission, this function will need to:

    1. Perform a safety check that it is safe to allocate the requested Movement Permission.
       For example, that there are no conflicting Movement Permissions already granted, and that any movable infrastructure is in the required position, both within the path of the Movement Permission, and for flank protection.
    2. If the safety check is successful, allocate the Movement Permission within ETPS.
       If the safety check is not successful, then the request is rejected, and the Movement Permission is not allocated within ETPS.
    3. After the Movement Permission is allocated within ETPS, build the Movement Authority message, and transmit it to the specified train.

4. In order to process a request regarding manual operations, this function will need to take corresponding actions. For example, for a request regarding a Usage Restriction, this function will need to:

1. Create / Amend / Activate / Deactivate / Delete a Usage Restriction in accordance with the request.

5. In order to release Movement Permissions based on the movement of trains, this function will need to:

1. Release the portion of the Movement Permission which is behind a train which has moved forward.

6. In order to detect and react to unsafe situations, this function will need to:

1. Monitor the Operating State within ETPS, in order to detect unsafe situations.
   For example, if a point loses detection, check whether the point is within a Movement Permission which is allocated to a train.
2. If an unsafe situation is detected, react to the situation.
   For example, if a point which has lost detection is within a Movement Permission for a train, the reaction could be to send an Emergency Stop message to that train.

7. In order to manage communications, this function will need to:

- Manage connections to trains within the Area of Control
- Manage connections to Trackside Assets within the Area of Control
- Manage connections to Adjacent ETPS systems

Notes:

- The Movement Permissions allocated to trains are part of the Operating State.
- Usage Restrictions, including TSRs, are part of the Operating State.
- When deriving the Aggregated Track Occupancy, ETPS must retain track occupancy corresponding to trains which are no longer communicating with the trackside.
- The safety logic required within ETPS in order to perform the safety checks above needs to be specified sufficiently to enable the PES subsystem to send requests with a low risk that a request is rejected by ETPS.

[Open, SPT2TRAFFIC-8845 **]**

4.3.3.2 Main Inputs

1. Infrastructure topology from Digital Register Infrastructure via Configuration SMI-xx Interface
   The Operating State and Requests to ETPS are based on the infrastructure data from the Digital Register Infrastructure.
2. Requests from PES via interface SCI-CMD.
   These are requests for movements of trackside infrastructure, and for Movement Permissions.
3. Requests from the Operator via the O-IF.
   These are requests related to manual operations for a specific train(s) in a specific area or related to usage restrictions (e.g. TSR).
4. Information from Trains, for example Train Position Reports, via ETCS Airgap.
5. Information from Trackside Asset Object Controllers, for example from Object Controllers for Points, and Trackside Train Detection devices, via EULYNX/EU-Rail System Pillar SCI protocols.
6. Requests to receive trains from Adjacent ETPS systems via ETPS HO interface.

7. Safety inputs from Wayside Monitoring Systems.
   This is only applicable for the subset of Wayside Monitoring Systems providing safety inputs to ETPS and would likely be implemented via Object Controllers.

[Open, SPT2TRAFFIC-8840 **]**

4.3.3.3 Main Outputs

1. The Operating State of the railway within the Area of Control
2. Information to Trains, for example Movement Permissions, complete with profile data, via ETCS Airgap.
3. Outputs to Trackside Asset Object Controllers to control movable trackside infrastructure, for example Points, via EULYNX/EU-Rail System Pillar SCI protocols.
4. Outputs to Adjacent ETPS systems to send a train to the Adjacent ETPS system via ETPS HO interface.

[Open, SPT2TRAFFIC-8841 **]**

4.3.4 ATO Trackside (ATO-TS)

The ATO Trackside subsystem implements the adaptation function between TMS and ATO OBU. i.e.

- it receives the Operational Plan and translates it to the Journey Profile which is sent by ATO-TS to ATO-OB
- it translates the infrastructure topology from Digital Register Infrastructure to Segment Profiles which are sent by ATO-TS to ATO-OB on request of the ATO-OB

In addition, for each train within the area, the ATO Trackside subsystem will:

- manage communications to ATO-OB
- process ATO status information sent by the train

[Open, SPT2TRAFFIC-5669 **]**

4.3.4.1 Main Inputs

1. Infrastructure topology from Digital Register Infrastructure via Configuration SMI-xx Interface to be able to provide Segment Profiles to ATO-OB
2. Vehicle data from Digital Register Vehicles
3. Operational plan from TMS containing detailed information about passing and stopping points.
4. Journey Profile Requests from ATO-OB, if required
5. Segment Profile Requests from ATO-OB, if required

[Open, SPT2TRAFFIC-5667 **]**

4.3.4.2 Main Outputs

1. Provide static infrastructure data as Segment Profiles to ATO-OB
2. The operational plan for specific trains as Journey Profiles to ATO-OB
3. ATO Status Report to TMS

[Open, SPT2TRAFFIC-5673]

4.4 Internal Interfaces

This section contains descriptions of the main content for the Traffic CS internal interfaces.

Overview Traffic CS Interfaces - Internal

Interface designation	Connectivity	Maturity class	Interface spec base	Reference section
SCI-CMD	PES – ETPS	Low	RCA	SPT2TRAFFIC-5525
ETPS HO	ETPS - Adjacent ETPS	Medium	Subset-039	SPT2TRAFFIC-5527

Table 2 - Overview Traffic CS Internal interfaces

Maturity classes

- **Harmonisation to be agreed** - Specific need for harmonisation based on SPT2ARC-545 - GRANULARITY CONCEPTS AND PRINCIPLES to be determined
- **Low** – currently no specification exists or generic base only or high-level specification only (w/o proven use) but at least need for harmonisation confirmed – e.g. SCI-OP
- **Medium** – already in use, modification/optimization expected (e.g. for harmonization purposes) – e.g. SCI-P
- **High** – already in proven use, less/no modifications expected – e.g. SS-026

[Open, SPT2TRAFFIC-8848]

4.4.1 SCI-CMD

Information relating to infrastructure or trackside assets which is transferred via this interface is presented in terms of the data received from Digital Register Infrastructure.
Main information from ETPS to PES:

1. Operating State of the railway within the Area of Control

The Operating State includes:

- Status of all Trains currently within the Area of Control
- Status of all Trackside Assets
- Aggregated Track Occupancy information
- All Movement Permissions
- All Usage Restrictions, including TSRs

Main information from PES to ETPS:

1. Requests to move trackside assets to required positions
2. Requests for Movement Permissions for trains

3. Requests for control of non-safety relevant Usage Restrictions.

[Open, SPT2TRAFFIC-8853 **]**

4.4.2 ETPS Handover - ETPS HO

ETPS connects with adjacent ETPSs to allow a safe handover of trains from one Area of Control to another one. Handover to legacy safety systems is foreseen via the same interface with an additional adapter on the legacy side.

The interface is for trains travelling in both directions across the TPS Area of Control boundary. From the point of view of a single ETPS, the interface can be used to:

- Handover a train from this ETPS to an adjacent ETPS
- Receive a train from an adjacent ETPS into this ETPS

If the interface is to a legacy signalling system, it is assumed that there will be an interface adapter, so that the standard interface can be used within the ETPS.

It is likely that the interface will be defined based on ETCS Subset-039 (FIS for the RBC/RBC handover).

Definition of the standard interface is within Traffic CS scope.
[Open, SPT2TRAFFIC-8852 **]**

The interface adapter required for any legacy signalling system may need to be bespoke to that system.
Definition of the bespoke interfaces, and the various interface adapters required for legacy signalling systems, is not within Traffic CS scope. **[** Open, SPT2TRAFFIC-11722 **]**

4.5 External Interfaces

This section contains descriptions of the main content for the Traffic CS external interfaces.

Overview Traffic CS Interfaces - External

Interface designation	Connectivity	Maturity class	Interface spec base	Reference section
SCI-OP	PES – TMS	Low	RCA	SPT2TRAFFIC-5042
SCI-OP	ATO-TS - TMS	Low	RCA	SPT2TRAFFIC-5042
SCI-TWS	ETPS - TSS	Low	EULYNX SCI-xx based	SPT2TRAFFIC-5659
SCI-WMS	ETPS - WMS	Low	EULYNX SCI-IO based	SPT2TRAFFIC-5059
ATO Airgap	ATO-TS - ATO-OB	High	TSI	SPT2TRAFFIC-5045
ETCS Airgap	ETPS - ETCS-OB	High	TSI	SPT2TRAFFIC-5435
SCI-P	ETPS - OC Point	Medium	EULYNX/EU-Rail SP	SPT2TRAFFIC-5043
SCI-TDS	ETPS - OC TDS	Medium	EULYNX/EU-Rail SP	SPT2TRAFFIC-5043
SCI-IO	ETPS - OC IO	Medium	EULYNX/EU-Rail SP	SPT2TRAFFIC-5043
SCI-LC	ETPS - OC LC	Medium	EULYNX/EU-Rail SP	SPT2TRAFFIC-5043
SCI-LS	ETPS - OC LS	Medium	EULYNX/EU-Rail SP	SPT2TRAFFIC-5043

Interface designation	Connectivity	Maturity class	Interface spec base	Reference section
SMI-xx	Configuration (MDM) - Traffic CS Subsystems	Low	EULYNX/EU-Rail SP	SPT2TRAFFIC-5533
SDI	Diagnostics - Traffic CS Subsystems	Medium	EULYNX/EU-Rail SP	SPT2TRAFFIC-5534
SSS	SSS - Traffic CS Subsystems	Medium	EU-Rail SP	SPT2TRAFFIC-5586
O-IF	Operator Workplace - ETPS	Low	-	SPT2TRAFFIC-5777
O-IF	Operator Workplace - PES	Low	-	SPT2TRAFFIC-5777

Table 3 - Overview Traffic CS External interfaces

Maturity classes - see definition in section SPT2TRAFFIC-5526 **[** Open, SPT2TRAFFIC-8850 **]**

4.5.1 SCI-OP

The interface between TMS and CCS is named SCI-OP.
Traffic Control and Supervision executes the operational plan received from the Traffic Management System. The execution of the plan is performed with control of infrastructure users and infrastructure states in a compatible and safe way to fulfil the commands inside of plan at the right time. Infrastructure usages (traffic, stabling, possessions, etc.) is controlled and reported to TMS. **[** Open, SPT2TRAFFIC-5657 **]**

PES splits incoming plans into single commands for the control level ETPS, ETPS checks the compatibility of the commands from a safety point of view and sends them to the actors of the physical field level (trains, trackworkers, trackside assets, etc.). ETPS supervises and aggregates the status of all “physical field level” actors as logical object information and events and reports them to Traffic Management System via PES over SCI-OP to give the status of traffic and Infrastructure usages. **[** Open, SPT2TRAFFIC-11730 **]**

ATO-TS receives the Operational Plan and translates it to the Journey Profile which is sent by ATO-TS to ATO-OB. Vice versa ATO-TS provides the ATO status report from the ATO-OB to the TMS. **[** Open, SPT2TRAFFIC-11727 **]**

4.5.2 ATO airgap

ATO-OB receives from ATO-TS the timetable for the specific train movement.

ATO-OB provides to ATO-TS the ATO Status Report containing information about the train status as well as estimated time to arrive at the next timing point giving TMS the possibility to adapt the operational plan if necessary and possible.

For GoA2, the communication is based on the specification contained in CCS TSI, i.e. Subset-126. Some additional use cases for GoA2 are already under discussion and could impact Subset-126. A future extension will be required for GoA3/4. **[** Open, SPT2TRAFFIC-5672 **]**

4.5.3 ETCS airgap

ETPS sends authorisations to Train CS (ETCS-OB), including all required additional data like speed profiles or track conditions and receives back status information from the trains, which include Train Position Reports.

This uses Subset-026 from TSI CCS.

In order to satisfy the requirement to support Baseline 3, GSM-R circuit switched communication will be required. However, this is expected to be replaced by packet switched communication, for example based on FRMCS. **[** Open, SPT2TRAFFIC-8849 **]**

4.5.4 SCI-WMS

The interface SCI-WMS is foreseen to connect WMS Systems to Traffic CS. A context diagram containing WMS and Traffic CS is given in: SPT2TRAFFIC-5789 - The figure below shows a concept proposal how the context of Traffic CS and WMS...

PES receives commands from Wayside Monitoring Systems which may trigger limitation like a speed limit due to wind conditions or a track closure due to fire detected. The direct interface from WMS to ETPS is only needed to execute for immediate safety reactions. The full monitoring data is to be handled elsewhere, in the diagnostics system.

Simple safety relevant Wayside Monitoring Systems are connected to ETPS via a common generic interface based on e.g. EULYNX SCI-IO transferring an enumeration attribute for the status.
Different status values will be mapped via Traffic CS configuration to different standardised, parameterized reaction(s)
This has the following advantages:

- simple, straight forward generic interface ETPS - Wayside Monitoring System supporting several states
- Wayside Monitoring System is completely decoupled from behaviour of Traffic CS
- more "simple" Wayside Monitoring System
- new simple Wayside Monitoring System types can be introduced without impacting Traffic CS (except for adapted configuration of Traffic CS)

The following preliminary configurable reactions of ETPS (combinations possible) have already been identified:

- stop immediately affected trains in a configurable area
- stop trains approaching a configurable area at a configurable location
- introduction of a configurable usage restriction in a configurable area
- configurable text message to the driver of trains in a configurable area
- evacuation request for affected trains in a configurable area

The interface SCI-WMS shall be of generic type (i.e. independent of the specific WMS System type - see SPT2TRAFFIC-5787) on ETPS side allowing limited configurability in terms of Traffic CS system reactions as stated above. **[** Open, SPT2TRAFFIC-8851 **]**

4.5.5 SCI-TWS

Currently the functional scope of the subsystem TWS is not specified in the SP Environment and for SERA, and there is no specification for a technical interface between TWS and ETPS.

In the shorter term, trackworker safety will be managed via manual procedures, and the use of Usage Restrictions within ETPS.

The Traffic CS domain assumes that later there will be a technical connection between TWS and ETPS, based on SCI-xx. This can only be defined once the functional scope of TWS is known.

It is expected that the interface will include Authorisations and Train Positions sent from ETPS to TWS, and Requests sent from TWS to ETPS.

The interface shall be of generic type and specified as SP Standard. **[** Open, SPT2TRAFFIC-8855 **]**

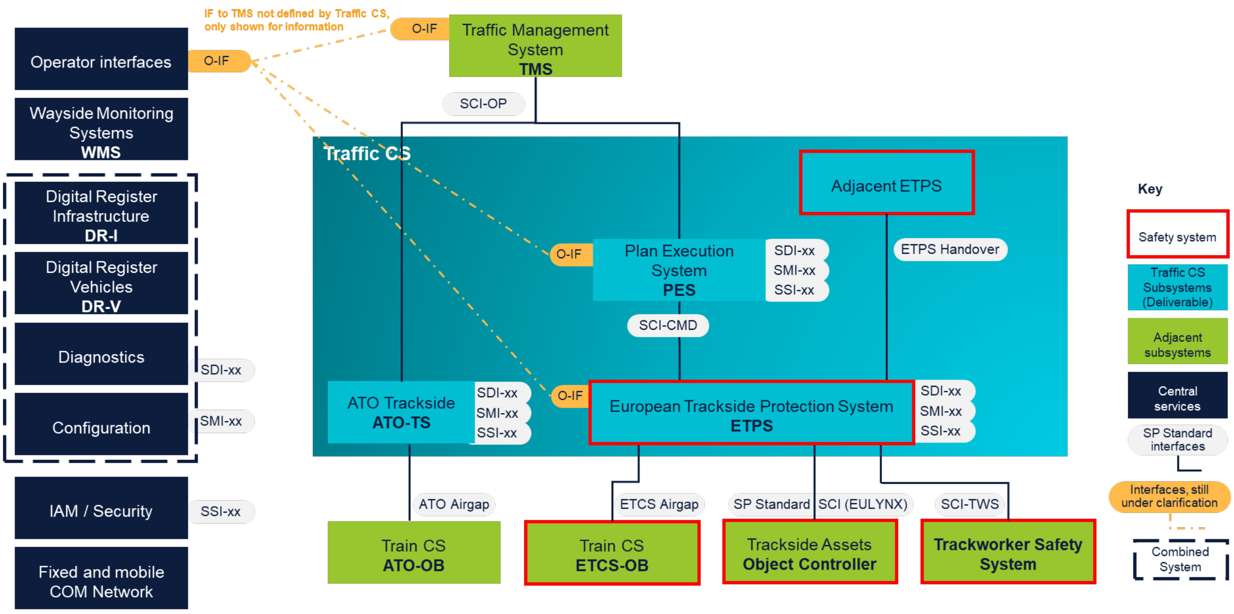
4.5.6 O-IF

The figure below shows operator interface O-IF in the Traffic CS Context. The operator interface (and related workplace) is required for managing situations and operational needs, which are not part of the Operational Plan (OP; standard procedures).

This interface will be subject of clarification in next design stages. Among others there is clarification needed on the functiona l scope, interface connectivity and safety, e.g.:

- Which actions are needed in degraded modes, emergency situations, for maintenance (auxiliary operations)?
- How actions are triggered manual, automatic or semi-automatic?
- Which subsystems are to be connected? - PES, ETPS
- Is there an external connection to TMS?
- The safety level and procedure needs to be determined. Today certain actions require higher safety than SIL0.

[Open, SPT2TRAFFIC-11721 **]**



[Open, SPT2TRAFFIC-11723 **]**

Figure 5 - Operator interface connectivity

There are different types of interaction with the Operator Interface:

1. Operator Requests to Move Points, or to reserve a Path for a train in some degraded situations.
   For these, the safety checks will still be performed within ETPS.
   The assumption is that these requests will be routed via PES, and be processed within ETPS in the same way as other requests from PES.

2. Operator Commands, for example: Override points, Axle counter resets, TSR management.
   For these, the safety check is by the Operator.
   The assumption is that or these requests, there will be a direct interface between the Operator and ETPS, and that a safety protocol between the Operator and ETPS is required.

3. Operator Emergency Commands, for example to stop a train or all trains within an area.
   These commands make the railway more restrictive.
   For these, the requirement is that the implementation is fast, as they are in response to an emergency.
   The assumption is that for these commands, these will be a direct interface between the Operator and ETPS, and that the commands will be processed by ETPS.

4. Provide Operating State to Operator Interface
   ETPS will be required to provide the complete Operating State to the Operator Interface.
   In order to perform the safety checks required for the Operator Commands, the Operator will need up to date information about the current Operating State.
   The assumption is that the Operator Interface will provide some technical measure to ensure that the Operating State provided on the Operator Interface is up to date.

The above is an outline. A full safety assessment of the requirements related to the Operator Interface will be required.

Work within Traffic CS will focus on the information to be exchanged between Traffic CS and Operator Interfaces, but will not include the presentation or User Interfaces. **[** Open, SPT2TRAFFIC-8856 **]**

4.5.7 EULYNX/EU-Rail System Pillar SCI

ETPS requests Trackside Assets Objects Controllers to set a trackside asset to a specific position and to receive safe status information from these Trackside Assets Object Controllers. Trackside assets are typically points, level crossings, axle counters, in some cases light signals (for System Pillar scope only optionally shunting signals) and Generic IO based systems.
These use the already standardised EULYNX/EU-Rail System Pillar Trackside Assets Control and Supervision domain SCI interfaces:

- Eu.Doc.80 SCI-P Standardised interface for safe communication to Subsystem Point
- Eu.Doc.109 SCI-LC Standardised interface for safe communication to Subsystem Level Crossing
- Eu.Doc.44 SCI-TDS Standardised interface for safe communication to Train Detection System
- Eu.Doc.33 SCI-LS Standardised interface for safe communication to Light Signal
  - Please be aware that the scope of SCI-LS will be reduced to System Pillar scope (i.e. shunting signals)
- Eu.Doc.46 SCI-IO Standardised interface for safe communication to Generic IO

For Generic IO based systems ETPS provides the configurability of a set of well defined, parameterizable functions which can be configured for each interface towards a Generic IO based system. [Open, SPT2TRAFFIC-5606]

4.5.8 EULYNX/EU-Rail System Pillar SDI

All Traffic CS subsystems provide diagnostic information based on the Standard Diagnostic Interface (SDI) specified by EULYNX/EU-Rail System Pillar Transversal and Trackside Assets Control and Supervision domain which were published mid 2024 in the context of the System Pillar (also known as EULYNX Baseline 4 Release 3).

Each Traffic CS subsystem utilises the generic diagnostic classes specified in Eu.Doc.94 (SDI-XX) according to its supplier specific architecture and design.

A specific Traffic CS subsystem SDI specification based on harmonised needs for diagnostic information from the specific Traffic CS subsystem will be created in the future and utilised by the suppliers of the specific Traffic CS subsystem. [Open , SPT2TRAFFIC-5601]

4.5.9 EULYNX/EU-Rail System Pillar SMI

All Traffic CS subsystems provide a maintenance interface as it will be specified by Rail System Pillar Transversal Control and Supervision domain.

This maintenance interface will be based on the Standard Maintenance Interface (SMI) specified by EULYNX/EU-Rail System Pillar Transversal Control and Supervision domain which was published mid 2024 in the context of the System Pillar (also known as EULYNX Baseline 4 Release 3) with all necessary adaptations to apply this SMI interface in the complete System Pillar context.

Since the necessary adaptations are currently discussed in the Transversal CS domain of the System Pillar, the maturity level of the available specifications is only low up to medium.

The SMI interface will be used to transfer and activate a System Configuration for specific subsystems. The System Configuration can include software as well as configuration data. The receiving subsystem of Traffic CS will be able to check integrity and authenticity of the received data.

Harmonisation of the detailed data format to be transmitted via SMI to the specific subsystems still needs to be agreed. [O pen, SPT2TRAFFIC-5603]

4.5.10 Shared Security Services

All Traffic CS subsystems are compliant to the System Pillar Secure Component specification SPPRAMSS-1473 - Secure Component Specification and are using the services specified in SPPRAMSS-1495 - Shared Cybersecurity Services Specification .

The following table shortly list for what purposes Traffic CS subsystem is using the specific Shared Security Service.

SEC IF Term	SEC Interface	Content
SSI-STS	**Secure Time Synchronisation**	This service is used by all Traffic CS subsystems for validating certificates and allowing Traffic CS subsystems to use synchronised time stamps for diagnosis. Furthermore, the Plan Execution System (PES) and ATO-TS subsystems are using the synchronised time to derive actions from the operational plan received from the TMS at the right time.

SSI-PKI	**Public Key Infrastructure Interface**	This service is used by all Traffic CS subsystems to receive/update certificates and to query the status of specific certificates.
SSI-IAM	**Identity and Access Management Interface**	This service is used by all Traffic CS subsystems to manage roles for authorisation. This covers access to diagnosis information, functions at the maintenance interface but also management of emergency user accounts to directly access Traffic CS subsystems.
SSI-UAS	**User Authentication Service**	This service enables authentication of human users.
SSI-LOG	**Security Logging Interface**	This service is used by all Traffic CS subsystems to log security related events
SSI-BKP	**Backup Interface**	This service can be used by Traffic CS subsystems to create and restore backups. Further analysis is needed to determine the specific needs of each Traffic CS subsystem related to this service. Current concepts include that usage restrictions are received from TMS via the operational plan or that Traffic CS introduces usage restrictions itself and informs TMS about this. If TMS is anyway aware of usage restrictions related to the operational plan as well as the usage restrictions received from ETPS, TMS could be used as backup
SSI-NAC	**Network Access Control Interface**	This service is used by all Traffic CS subsystems to identify and authenticate themselves towards the network to receive network access authorisation

[Open, SPT2TRAFFIC-5587 **]**

5 Assumptions to external Systems

This section summarizes Traffic CS Assumptions and expectations on system level to external systems, as far as they are known in this early design stage without having top-down and clause-by-clause requirement tracing. Furthermore, questions and assumptions to those external systems are collected.

The aim of this section is an early alignment of the parallel working domains on significant system design aspects avoiding delays in the work of affected domains and preventing later huge reworks. **[** Open, SPT2TRAFFIC-8862 **]**

5.1 Transversal - Configuration (MDM)

Configuration (MDM) will control the transmission of data to Traffic CS.
This will include:

1. Infrastructure Data from Digital Register Infrastructure
2. Configuration Data for Traffic CS

Infrastructure Data is described in section below.
Configuration Data will include data such as:

- Addressing data, for example for Trackside Asset Object Controllers, Adjacent ETPSs
- Other configuration data required within Traffic CS
- Executable software binaries

Configuration (MDM) provides a mechanism for the transmission of Configuration Data from Digital Register Infrastructure.

The data is safety critical, but the transmission is not a safety system, as the data is protected. [Open, SPT2TRAFFIC-8864]

5.2 Transversal - Digital Register Infrastructure

Traffic CS assumes there will be a database managing and providing static infrastructure data as central service for connected systems like Traffic CS. This database is Digital Register Infrastructure (DR-I).

The data exchange between Traffic CS and this database shall be based on the EULYNX Standard Maintenance Interface SMI-xx via the subsystem Configuration (MDM). [Open, SPT2TRAFFIC-8863]

5.2.1 Data Management

Infrastructure data will be transmitted to Traffic CS via Configuration (MDM).

Traffic CS components can request infrastructure data for a particular instance of a particular component. This is required if a Traffic CS component is replaced or reset.

Configuration (MDM) can transmit a new version of infrastructure data to a particular instance of a particular component. This is required if there is an updated version of the infrastructure data.

The process of accepting a new version of data is separate from the process of activating the new version of the data. This is required in order to coordinate update of data across Traffic CS subsystems and connected systems such as TMS. This is also required in order to coordinate update of data with railway operations. [Open, SPT2TRAFFIC-8866]

5.2.2 Data Assumptions

The key assumptions regarding the infrastructure data are:

1. The infrastructure data is validated to comply with data preparation rules, and to be consistent with the physical railway. This is required for Traffic CS components to trust the data for implementing safety functions.
2. The infrastructure sent to different Traffic CS components and connected systems such as TMS is consistent. This is required because the communications will be in terms of the infrastructure data from DR-I. For example, this applies to external interface SCI-OP for TMS to PES interface, and internal interface SCI-CMD for PES to ETPS interface.

[Open, SPT2TRAFFIC-8865]

5.2.3 Data Content

The infrastructure data transmitted from Configuration (MDM) to the Traffic CS components will contain Static Infrastructure Data.

Static Infrastructure Data will comprise:

- A Node-Edge map for the complete Area of Control, plus additional adjoining data where this is required, for example for handover to adjacent systems.
- Items located on the Node-Edge map, together with attributes for those items.
  For example: Balises.
- Areas located on the Node-Edge map, together with attributes for those items.
  For example: Gradients, Permanent Speed Restrictions

The DR-I data only includes static infrastructure data. Therefore, the DR-I data does not include:

- Dynamic data such as track occupancy.
- Temporary data such as Temporary Speed Restrictions created via the Operator Interface.

These are part of the Operating State stored within Traffic CS. **[** Open, SPT2TRAFFIC-8867 **]**

5.3 Transversal - Digital Register Vehicle

Traffic CS assumes there will be a database managing and providing vehicle data as central service for connected systems like Traffic CS. This database is Digital Register Vehicles.

The existence of a direct interface between DR-V and Traffic CS requires clarification. Another option is that Traffic CS receives all vehicle data from TMS in the Operational plan. **[** Open, SPT2TRAFFIC-8869 **]**

5.3.1 Data Management

Traffic CS components can request vehicle data for a particular vehicle. This is required when a vehicle arrives within the Area of Control.

It may be possible for Traffic CS components to store data for vehicles. In this case, Traffic CS components could request to check the validity of their data stored for a particular vehicle with the Digital Register Vehicle. If it is required, how such an interface could work will need to be defined. **[** Open, SPT2TRAFFIC-8868 **]**

5.3.2 Data Assumptions

The key assumption regarding the vehicle data is:

1. The vehicle data is validated to comply with data preparation rules, and to be consistent with the railway vehicles. This is required for Traffic CS components to trust the data for implementing safety functions.

There may be additional assumptions if further data is added to the list below. **[** Open, SPT2TRAFFIC-8871 **]**

5.3.3 Data Content

The vehicle data transmitted from DR-V to the Traffic CS components will contain:

- Vehicle parameters

There may be further data added to this list, in particular data required for ATO GoA3/4. **[** Open, SPT2TRAFFIC-8870 **]**

5.4 Wayside Monitoring Systems (WMS)

Wayside Monitoring Systems (WMS) are used for diagnostic and maintenance purposes as well as for hazard identification. In this context WMS Systems are applied for monitoring of rolling stock (vehicles) and/or the wayside infrastructure. Depending on the specific monitoring purpose there is a variety of WMS Types available, for example:

Acoustic Bearing Defect Detectors	Hot Axle Box Detectors
Automatic Vehicle Inspection Systems	Hot Wheel Detectors
Avalanche detection	Pantograph Monitoring System
Bogie Performance Detectors	Rail Temperature Monitoring
Brake Pad Inspection Systems	Tread Condition Monitoring Detectors
Broken Rail Detection	Tunnel Monitoring System
Dragging Equipment Device	Video Monitoring Systems
Earthquake detection	Weigh in Motion
Falling Objects	Wheel Impact Detector Systems
Flood Doors	Wheel Profile Measurement
Gauge Profile Monitoring	Fire alarm systems wayside

Table 4 - Types of Wayside Monitoring Systems

Each of those WMS Systems consists of sensors and evaluation units. Today the various WMS Evaluation units provide their output in different format to the different information receivers. Such receiver could be either an operation/incident manager and/or the vital signalling system (e.g. IxL) taking further processing and action.

The integration of WMS in the future SP and Traffic CS Environment needs to be clarified. For this an WMS owner should be appointed by the SP, who is responsible for:

- coordination of the various WMS types
- generic specification of operational scenarios or rules related with various WMS Systems
- handling of hazardous and non-hazardous events (either on wayside or vehicle)
- generic specification of WMS connectivity to vital systems like ETPS and to other non-vital systems (e.g. PES, operation/incident manager).

The figure below shows a concept proposal how the context of Traffic CS and WMS could look like. In terms of connectivity to Traffic CS there might be a distinction necessary between:

- hazardous events - directly connected ETPS via SCI-WMS for immediate safe system reaction
- non-hazardous events - connected to PES or other subsystems.

The shown connections are subject of further clarification inside Traffic CS (functional scope of PES and split to TMS) and with other domains like TMS and Transversal. In this context the foreseen functional scope of the affected subsystems and logical sequences in case of on an WMS event needs to be clarified.
Please note: Beside forwarding hazardous events directly to ETPS they will be forwarded also to PES or other subsystems - like the non-hazardous events.
Further assumptions regarding connectivity are given in: SPT2TRAFFIC-5059 .

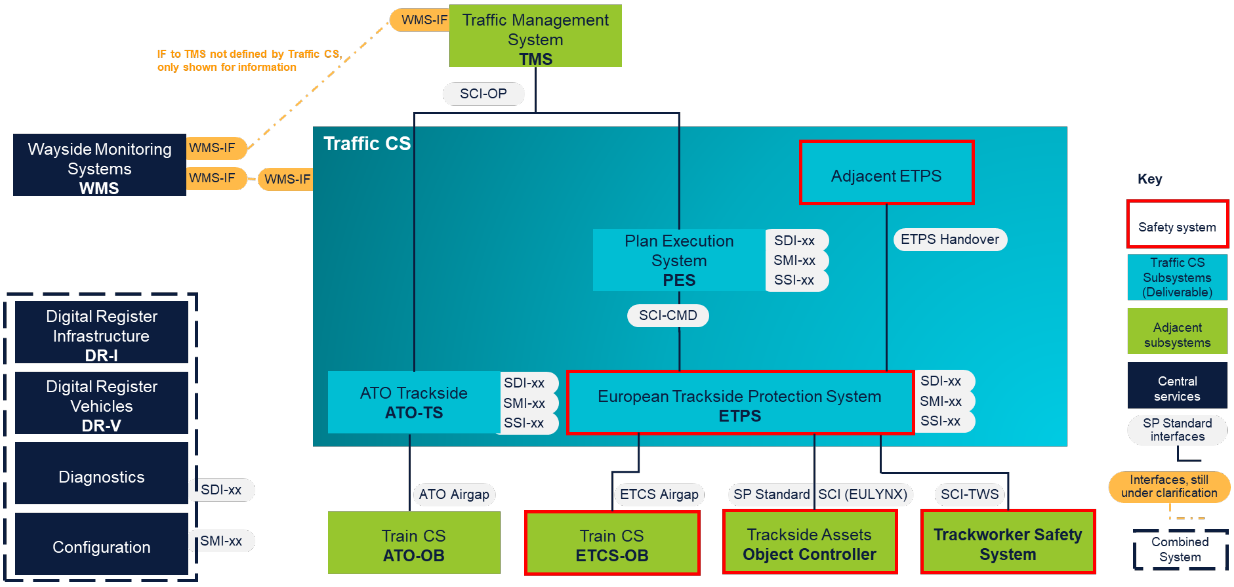


Figure 6 - System context of Traffic CS and WMS Systems

[Open, SPT2TRAFFIC-5787]

5.5 Trackside Assets - Object Controllers

The ETPS Subsystem inside Traffic CS provides connectivity to the trackside object controllers based on the EULYNX/EU-Rail System Pillar Standard Communication Interface SCI-xx.

Further harmonisation of trackside object controllers and related required functionality of the system is expected.

Interface to Generic IO systems will be further harmonised allowing to connect different Generic IO Systems to ETPS and to configure standardised configurable reactions of ETPS in ETPS as described in **SPT2TRAFFIC-5059**. [Open, SPT2TRAFFIC-5823]

5.6 Train CS - ETCS-OB

The key assumptions regarding the ETCS OB are:

1. ETCS OB is compliant with the TSI CCS, and particular with Subset 026.
2. ETCS OB can communicate via radio with trackside.

There will be changes to the TSI CCS. These will be managed through the CCM process. [Open, SPT2TRAFFIC-8874]

5.7 Train CS - ATO-OB

The key assumptions regarding the ATO OB data are:

1. ATO OB is compliant with the TSI CCS, particularly Subset 126.
2. ATO OB can communicate via radio with trackside.

There will be changes to the TSI CCS, in particular relating to ATO GoA3/4. [Open, SPT2TRAFFIC-8873]

5.8 TMS - Traffic Management System

The Traffic Management System (TMS) covers the planning and specific management functions for railway operations. Traffic CS includes the supervision and control of the railway operations. TMS is responsible for all planning activities including producing an Operational Plan, based upon the Operating State and operational events.
The key assumptions regarding TMS are:

1. The TMS will provide Operational Plans to Traffic CS. These are based on the Operating State of the railway within an Area of Control provided by Traffic CS to TMS.
2. Updates to the Operational Plan if required would be completed by the TMS, and not by Traffic CS.

[Open, SPT2TRAFFIC-8872 **]**

5.9 Trackworker Safety System (TWS)

Currently the functional scope of the subsystem TWS (also called Field Forces) is not specified in the SP Environment and for SERA. But there will be a future need for TWS for protection of track workers and enabling maintenance of the wayside infrastructure.

Therefore, Traffic CS will take assumptions in the current design phase in terms of:

- TWS Core functions
- expected different ETPS System reactions on different TWS Inputs
- TWS connectivity to the vital ETPS Subsystem - see SPT2TRAFFIC-5659 - SCI-TWS .

[Open, SPT2TRAFFIC-8887 **]**

5.10 Communication Network

So far, the ERJU has not appointed a domain "Communication" dealing with the connectivity requirements between SP Subsystems (except the FRMCS part for radio communication between wayside and onboard).

In the EULYNX Environment the connectivity between EULYNX Subsystems has been specified in the document:

- Eu.Doc.100 - Specification of Point of Service - Signalling.

A similar approach is needed to manage the connectivity of the Subsystems within Traffic CS as well to external subsystems in a coordinated way. Therefore, an action by the SPCG on this subject is needed. **[** Open, SPT2TRAFFIC-8885 **]**

5.11 Computing Platform

Traffics CS will be defined without reference to a specific computing platform.

The key assumption regarding the Computing Platform is:

- The Computing Platform will meet requirements for safety, availability and the scalability

The Computing Platform is to be defined by the System Pillar Computing Environment domain. **[** Open, SPT2TRAFFIC-8882 **]**

6 Migration to SERA Target

6.1 Why is Migration needed?

The SERA Target to be achieved by Traffic CS is defined in section SPT2TRAFFIC-4460 - SERA Development Targets .

The acceptance of the harmonized Traffic CS Target architecture by the railway sector is largely determined by a proper migration concept describing the path how to come from the variety of legacy signalling systems towards a system containing finally the complete SERA Target functionality.

The elaboration of a detailed migration concept top-down from the SERA Target system is part of the Traffic CS domain work in the next design stages. This work is done by the Migration Group based on the remit tasks. The Migration Group analyzes and recommends feature specifications that could be integrated already in tenders in the SERA Pre-phase period ("specifications ready to use"). Furthermore, based on an analysis of typical legacy situations and typical migration scenarios, the Migration Group will elaborate blueprints for adapter solutions for integrating Traffic CS components in a legacy environment.

Therefore, here in the present System Concept a short outlook on the migration topic is given only.

A change from a conventional signalling system to a harmonized Traffic CS (with SERA Target functionality) requires a migration strategy to enable the most shock-free transformation possible, i.e. to continue continuous high-performance train operation in the transition period and at the same time making optimal use of available so-called "SERA Enablers" with focus also on protection of investment of existing assets.

The huge variety of legacy national systems (e.g. IxL, RBC, ATP; being part of SERA Pre-Phase) makes it impossible to define one generic e.g. European migration plan that can be applied by each of the Railways for their specific situation in a specific area of control.

Therefore, the aim of migration activities inside Traffic CS is to provide guidance and criteria for deployment of so called "**SE RA Enablers**". The Migration Group inside Traffic CS provides also recommendations for deployment of SERA Enablers. **SERA Enablers** are features/specifications (or data models) like EULYNX Equipped object controllers, which have the matur ity "ready for use" in projects still based on legacy ETCS L2 FB/FVB. **[** Open, SPT2TRAFFIC-11733 **]**

In general, national migration plans shall base on the local alignment and a comprehensive business case of IM's and RU's in terms of, e.g. on:

- Optimum time
- Protection of investment
- Optimized performance
- Cost efficiency
- Backward compatibility
- Short deployment time
- Low complexity
- Technical and non-technical migration criteria
- Technology gap to be closed towards SERA Target.

[Open, SPT2TRAFFIC-11732 **]**

6.2 SERA Deployment

6.2.1 Overview

The development of the SERA Target functionality is a long-term process. In this process standalone functional units so-called "SERA Enablers" are developed belonging to the SERA Target system. In this context a migration strategy is needed to benefit early from their advantages and to ensure protection of investment. Once all SERA Enablers are "ready for use", the so-called "SERA Phase" starts, i.e. the entire SERA target system is available.

The design activities and the initial rollout of certain early SERA Enablers ("ready for use") before the SERA Phase are belonging to a so-called "SERA Pre-phase". The early integration of SERA Enablers during the SERA Pre-phase into projects still using national specifications and legacy systems forms a significant part of the overall migration strategy towards SERA.

The *Figure below* represents a high-level qualitative view on the SERA Deployment phases - the SERA Pre-phase and the SERA Phase.

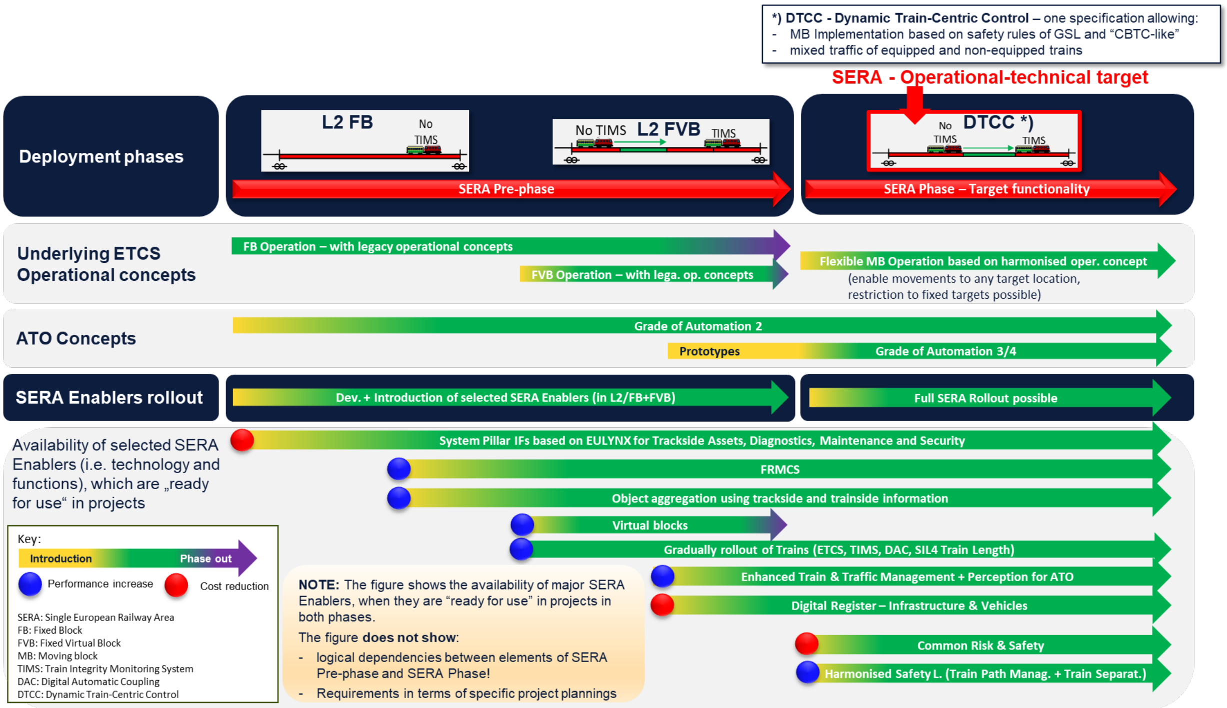


Figure 7 - SERA Deployment Phases

[Open, SPT2TRAFFIC-8830]

The upper part of the figure shows the underlying operation concepts for ETCS and ATO (optional) for both deployment phases.

The deployment phase - **SERA Phase** - is based on the harmonized operation concept for ETCS L2 and using the safety principles called "DTCC"! This is the SERA Target functionality to be specified by Traffic CS.

The deployment phase - **SERA Pre-phase** - is characterized by project implementations still with national ETCS L2 Operation concepts based on FB or FVB.

The lower part of of the figure contains a rough overview of SERA Enablers, when they are available for project implementations either already in the SERA Pre-phase or later in the SERA Phase.

Please note:

- The SERA Enablers in the *Figure* are shown at the time when they should be available and "ready for use" (i.e. mature and certified/approved products) in both deployment phases to be applied in projects.

- Of course the development of SERA Enablers must start earlier e.g., in the SERA Pre-Phase and before (not shown here).
- The figure contains development steps and deployment phases only in the context of SERA (not for projects).
- The figure does not show specific project-related plannings, which are subject of the individual railways (when shall which technology be introduced) - i.e. there will be a longer coexistence of legacy and SERA equipped systems in the Railway infrastructure. Even if the SERA Target system is available, for some reasons still legacy projects and solutions might be deployed (IM/RU decision).
- The figure does not show logical dependencies between elements of SERA Pre-phase and SERA Phase.

[Open, SPT2TRAFFIC-11731 **]**

6.2.2 SERA Pre-Phase

The SERA Pre-Phase contains the period until the SERA Target is ready for implementation (i.e. SERA Phase begins). The i ntroduction of certain SERA Enablers (e.g. EULYNX interfaces) in combination with legacy L2/FB/FVB principles and ATO GoA2 is expected during this deployment phase. This will lead to performance increase and cost reduction already. The gradual rollout of those SERA enablers shall be part of the migration path towards the later SERA Phase with the target system.
SERA Enablers in this pre-phase must be functional units of reasonable size and standalone testable - e.g. like an object controller with EULYNX Interfaces. **[** Open, SPT2TRAFFIC-8826 **]**

6.2.3 SERA Phase

The SERA Phase starts when the SERA Target - i.e. moving block with the safety principle DTCC e.g. implemented with GSL or CBTC - is ready for deployment in projects. For this all SERA Enablers - see figure 7 - must be ready for use. Core elements for DTCC are the subsystems ETPS and PES plus related interfaces.
Additionally also related tools (e.g. for engineering, testing, simulation) and adjacent systems and interfaces outside of the Traffic CS Design scope must be available as well. For instance these are:

- TMS via SCI-OP interface
- Central services for configuration, digital register, diagnostics, security via SMI, SDI, SSI interface - see figure 3.

[Open, SPT2TRAFFIC-11736 **]**

6.2.4 Comparison of both deployment phases - SERA Pre-Phase and SERA Phase

The following table contains a comparison of the deployment phases - the SERA Pre-phase and the SERA Phase. The table shows how projects could be equipped in those phases, based on available SERA Enablers. The SERA Pre-phase is mainly characterized by the usage of national and legacy solutions added by early introduction of few SERA Enablers.
Please note, the table does not show project phases or mandatory project implementations!

deployment Phases	**SERA Pre-Phase**	**SERA Phase - Target 1 (refer to SPT2TRAFFIC-4460 - SERA Development Targets)**
Definitions	Standalone SERA Enablers – being part of the SERA Target - are already availble for usage in legacy projects	All SERA Enablers for DTCC are available Trackside infrastructure is equipped for MB Enabling degraded modes and mixed fleets (with reduced TDD)
Feature & Functions		

deployment Phases	SERA Pre-Phase	SERA Phase - Target 1 (refer to SPT2TRAFFIC-4460 - SERA Development Targets)
Operation Concept	Legacy national operation concepts for signalling and ETCS deployment Legacy national L2 implementations, either based on FB or FVB; FVB/HTD allows operation of mixed fleets – i.e. trains with and without TIMS in parallel on the same network	Harmonized operation concept, in standard and degraded mode. MB implementation as DTCC, allowing performant and flexible train operation; mixed fleets are supported in parallel in the same network No distinction between train and shunting routes Shunting: - allow shunting without light signals by using cab signalling - Allow shunting with light signals if cab signalling is not possible
Operational Rules	National Operational Rules	Harmonised Operational Rules, as far as not contradicting to national laws
RAMSS	National risk analysis and safety assessment procedures	Common European risk analysis and safety assessment procedures, e.g. allowing cross-acceptance
Train path and route protection & Movement authority management	- Train path and route protection by IxL - MA Management by RBC - Legacy functional scope of IxL+RBC is very different per IM and Supplier - ETCS L2 based on FB or FVB/HTD - No legacy ATP and no L0/1 for new installations	- Digital ETPS (enabling path/route protection and MA generation); black box view - ETCS L2 without signals - Moving block (MB) as DTCC - one specification of ETPS allowing freedom of implementation - e.g. Geometric safety logic (GSL) - or CBTC-like safety rules
ATO	GoA1/2 Operation possible	GoA1/2 Operation possible
Communication	- GSM-R and Transition to FRMCS - IP based networks	- FRMCS - IP based networks - Public networks if required
Central systems for Cross functions and interfaces: **Diagnosis / Configuration / Security**	- EULYNX/EU-Rail System Pillar based interfaces SDI-xx, SMI-xx, SSI-xx - Coexistence of legacy solutions	EULYNX/EU-Rail System Pillar interfaces SDI-xx, SMI-xx (e.g. for connection of Central Services - Config, Diag, Maintenance, Security), SSI-xx
Standardized external operational interfaces to Trackside Assets	- EULYNX/EU-Rail System Pillar based interfaces SC I-xx to Trackside Assets - Coexistence of legacy solutions	EULYNX/EU-Rail System Pillar based interfaces SCI-xx to Trackside Assets
Standardized external operational interfaces to other systems	- EULYNX SCI-xx (but low harmonization and maturity) - Coexistence of legacy solutions	New standardized interfaces (e.g. FIS, FFFIS based)
Technical Enablers for SERA	- SIL4 Train length (incl. TIMS) - Fixed block-based Object aggregation - Digital Register	- SIL4 Train length (incl. TIMS) - Moving block-based object aggregation - Digital Register

deployment Phases	SERA Pre-Phase	SERA Phase - Target 1 (refer to SPT2TRAFFIC-4460 - SERA Development Targets)
Trackside assets	Slight reduction of TTD – Trackside train detection device - depending on trains being fitted with TIMS Reduction or no use of light signals	Significant TTD reduction by gradual equipment of fleet with TIMS based trains, depending on the level of support required for degraded situations. No light signals, except probably shunting signals, where supervised manoeuvres are not available
Standards, Guidelines and Tool base	CENELEC, TSI 2023 --> TSI xx EULYNX	CENELEC, TSI xx EULYNX as SP Standard MBSE, top-down design SP Standard specifications

Table 5 - Deployment phases towards SERA Traffic CS Target functionality

[Open, SPT2TRAFFIC-8831]

6.3 Migration Opportunities

Traffic CS proposes the following migration opportunities (see figures below) based on the planned availability of SERA Enablers being part of the SERA Target. The given proposals form a recommendation only, to ensure protection of investment and make early use of the benefits from available SERA Enablers. A concrete planning and decision about introduction (migration) of SERA Enablers is always part of the specific project (to be done by RU/IM).

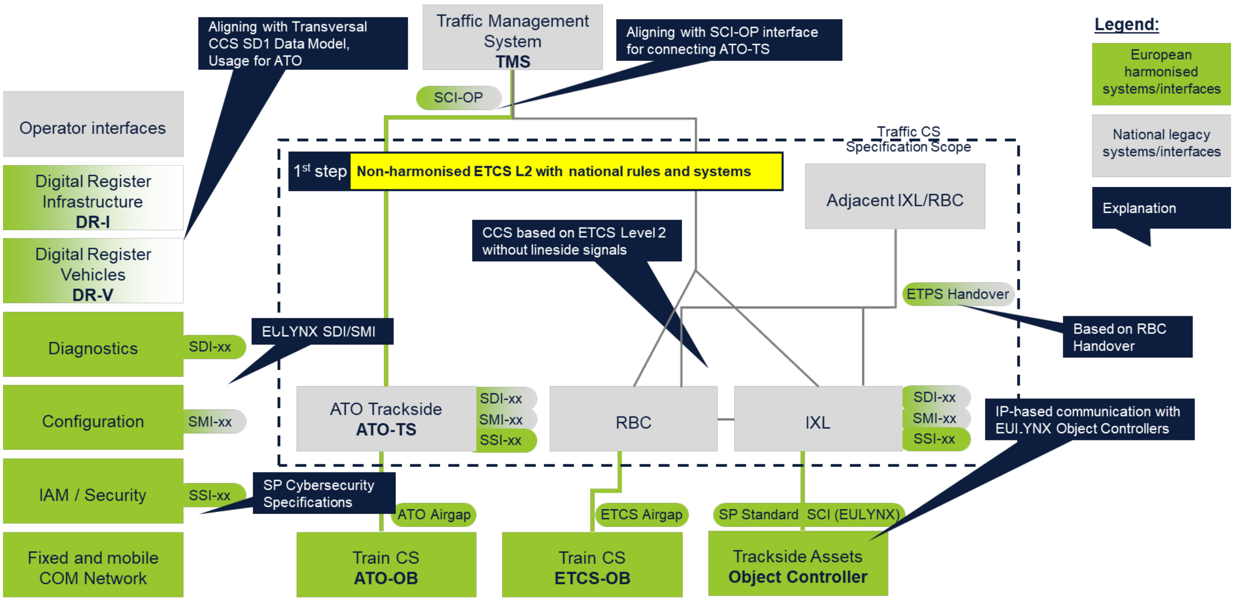


Figure 8 - Migration sample for early available SERA Enablers

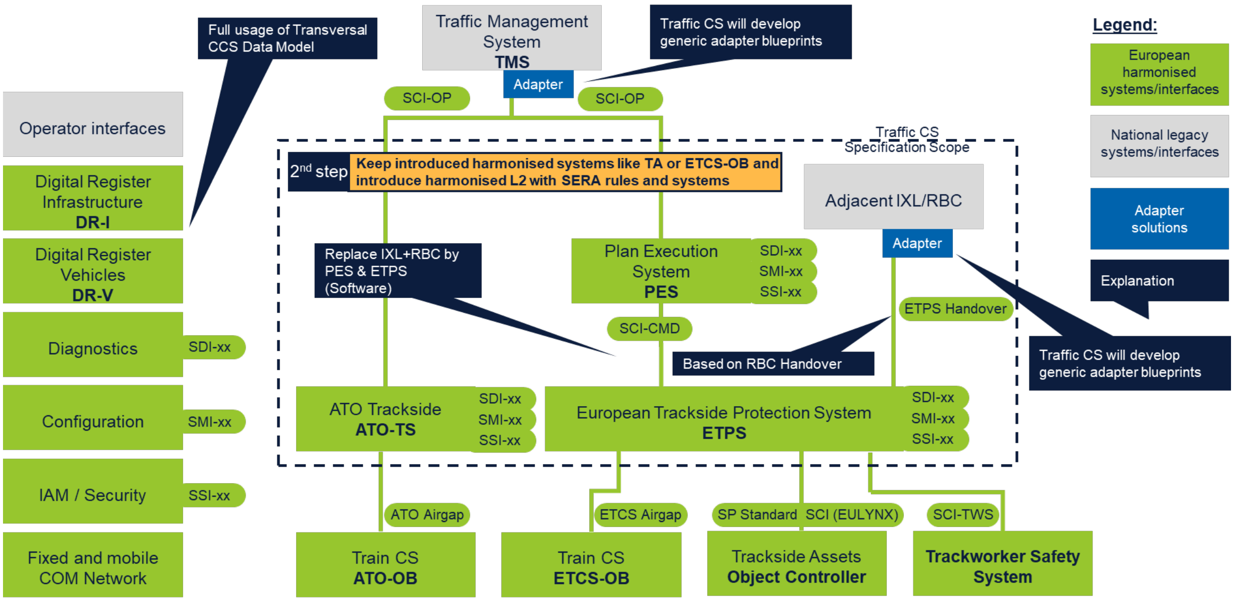


Figure 9 - Migration sample comprising Traffic CS Components.
[Open, SPT2TRAFFIC-11735]

6.4 Adapters for Migration

The smooth transition for continuous train operation between SERA and Non-SERA Equipped areas (legacy area) is a core requirement and substantial part of migration work (see figure 11).
For this, the work will start to analyze which interface functions are required for coupling of two adjacent SERA Areas on a lean and generic base (see figure 10). Afterwards it needs to be checked which additional interface functions might be required to connect a SERA Area to a Non-SERA Equipped area (see figure 11), which might be equipped with a:

- L2 – IxL+RBC Combination
- Level NTC - IxL.

For both variants the content of existing interface specifications like SS-39 (RBC Handover) and SCI-ILS (EULYNX Interlocking block interface) will be evaluated and if needed additional data defined in a generic way.

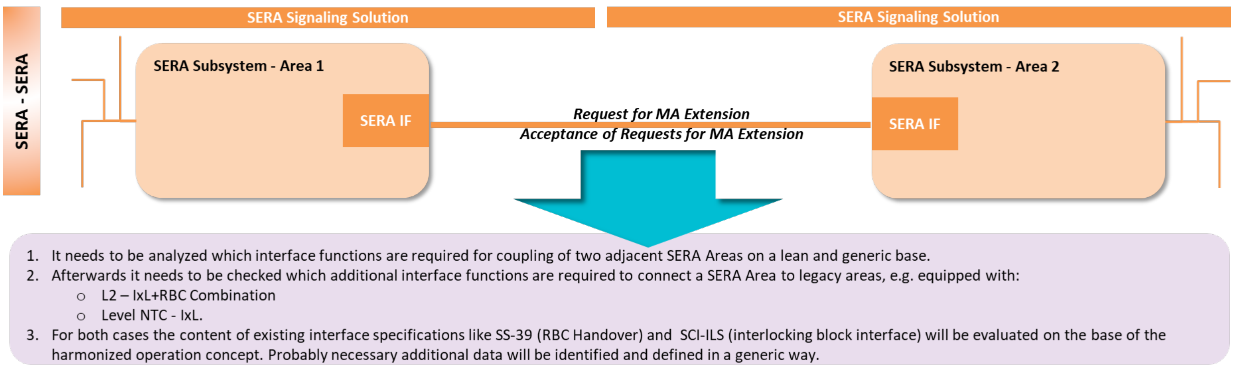


Figure 10 - Required Functionality for SERA-SERA Coupling
[Open, SPT2TRAFFIC-11734]

The adapter functionality for coupling SERA Area to a Non-SERA Equipped area will be derived from the SERA Standard interface functionality (marked orange) as shown in the figure below.

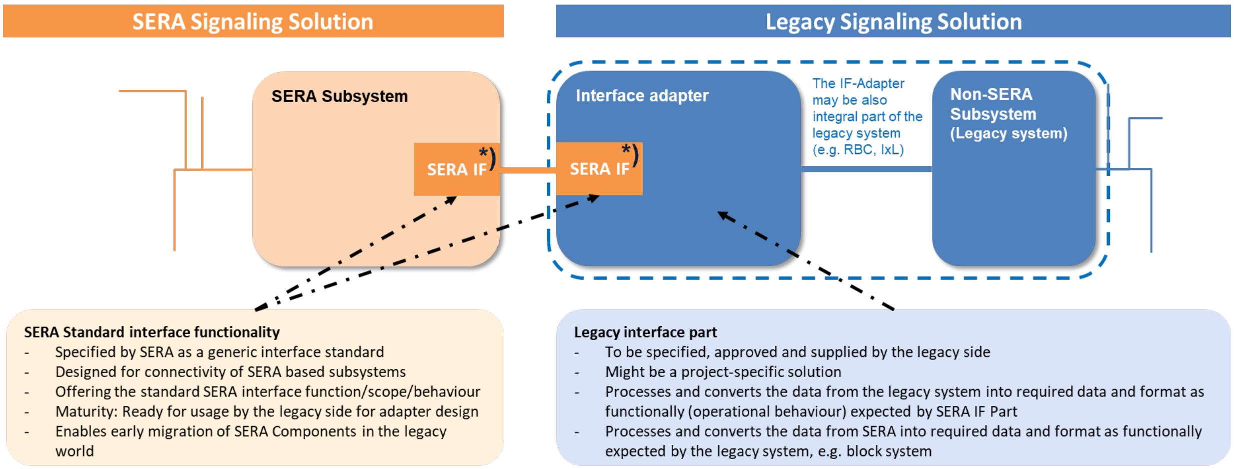


Figure 11 - Adapter between SERA and Non-SERA

[Open, SPT2TRAFFIC-11741]

The migration work inside Traffic CS in terms of coupling SERA and Non-SERA Equipped areas will focus on the scenarios shown in the figure below. For this the Migration Group will elaborate blueprints for adapter solutions based on the SERA Standard interface which need to be on the legacy side for a specific project to the legacy technology (marked blue). Due to the huge variety of legacy systems the SP cannot develop project specific adapters.

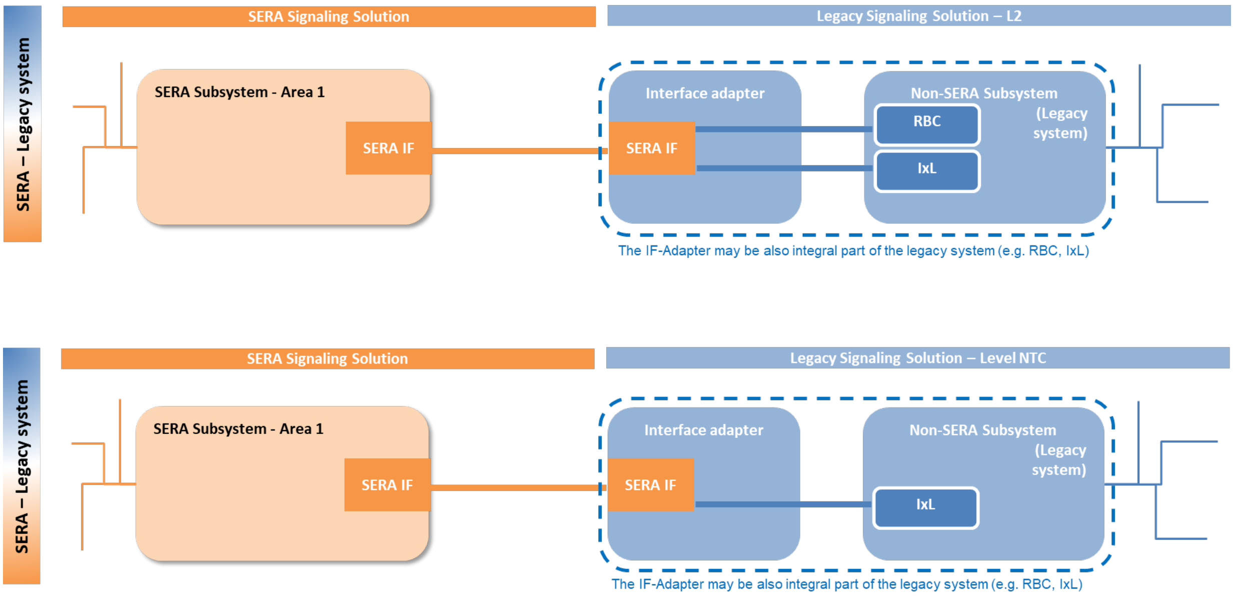


Figure 12 - Typical Samples for Connection of SERA and Legacy equipped Areas

[Open, SPT2TRAFFIC-11740]

Among other, the further analysis of the adapter design shall include the following issues and pre-conditions:

Specification of standard SERA interface adapter

- Specification based on harmonized operation concept for bi-directional transition between two SERA Areas
- Connectivity between two SERA Areas should base on:
- Request for MA extension to adjacent area
- Acceptance of MA Requests from adjacent area
- Specification of a SERA Interface as a generic interface standard in terms of functionality, set of data, interface behaviour

- Maturity: Ready for use to define the legacy side of a project specific adapter (to be done by the respective project)

Specification of legacy SERA Adapter part

- To be supported by an appropriate design of the SERA Interface part
- Enabling a generic connectivity of Non-SERA Areas supporting typical configurations (e.g. L2, IxL only)
- Processes and converts the data from the legacy system into required data and format as functionally (operational behaviour) expected by SERA Interface part
- Processes and converts the data from SERA into required data and format as functionally expected by the legacy system, e.g. block system

[Open, SPT2TRAFFIC-11739]

6.5 Transition Area

The smooth transition between SERA and Non-SERA Equipped areas requires - beside the signalling interface, described in the previous section - an equivalent operational scenario and corresponding trackside installations in the transition area. A possible trackside situation is shown in the figure below.

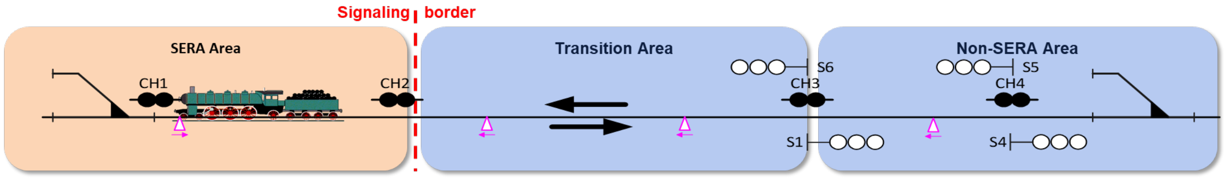


Figure 13 - Sample Layout for smooth Transition

[Open, SPT2TRAFFIC-11738]

The transition area shall be equipped in a way not affecting SERA Area in terms of L2 operation without signals. Like for the adapter, this requirement requires further analysis to design a generic solution how to equip the transition area. Some issues and pre-conditions to be investigated are given in the following:

Harmonized operation concept for transition

- Harmonized operational scenarios for entry and exit of/to SERA Area
- Safe handling of degraded scenarios
- Generic transition scenarios for few typical legacy equipped areas (e.g. L2, IxL only)
- Enabling smooth transition in both directions

Equipment and control of transition area

- Location of the signalling border
- Generic layout of a transition area from SERA to typical Non-SERA Areas
- Identification and allocation of necessary active (e.g. signals,) and passive (e.g. fix balises) wayside elements
- Handling of existing elements in a brownfield transition area
- Control of active wayside elements shall be done by the legacy side only
- There shall be NO control of active wayside elements in the transition area from the SERA Side

[Open, SPT2TRAFFIC-11737]

7 Frequently Asked Questions

This section contains answers to questions which have frequently come up in presentations of Traffic CS. The content is only a short summary and the main document text contains more details for many points.

7.1 What will be the output of Traffic CS?

The main deliverables of the Traffic CS domain are a specifications for all defined subsystems. The specifications will contain interfaces, functional and non-functional requirements and a precise behaviour description (linking inputs and outputs depending on the system state). This will be accompanied by safety assessment documentation and engineering rules. **[** Open, SPT2TRAFFIC-11695 **]**

7.2 Will Traffic CS be enforced by TSI?

The deliverables will be published as System Pillar Standards and are not intended for publication in a Technical Specification for Interoperability (TSI). Traffic CS will only affect TSI CCS if the need for changing interoperable interfaces is identified. This would be handled through the established ERA Change Control Management. **[** Open, SPT2TRAFFIC-8879 **]**

7.3 Is it allowed to make adaptations?

Since Traffic CS won't be legally required by TSI it will be possible to make adaptations, but this will lead to variants/configurations which increase cost and are in contrast to the Common Business Objectives. **[** Open, SPT2TRAFFIC-8892 **]**

7.4 Is it possible to use existing implementations to fulfil the Traffic CS requirements?

Traffic CS aims to specify in a way that allows numerous ways of implementation. This can also include the reuse of existing implementations or products, possibly with adaptations to fulfil the harmonised requirements. **[** Open, SPT2TRAFFIC-11697 **]**

7.5 Is Moving Block covered by Traffic CS?

Yes. We try to move away from the concept of blocks and routes. Based on the requirements, the solution is driven more towards what typically would be considered Moving Block. However, it is not the intention of Traffic CS to block the use of fixed blocks. If the Traffic CS requirements can be fulfilled, any solution should be allowed. **[** Open, SPT2TRAFFIC-8880 **]**

7.6 Is train integrity needed for Traffic CS?

No, Traffic CS will support the operation of mixed fleets, i.e. running trains with and without train integrity monitoring in parallel.
Availability of safe train length information in Traffic CS (e.g. via TIMS and notified by Train CS to Traffic CS) will allow to increase the performance and reduction of trackside equipment needed for trackside train detection (axle counters and track circuits). **[** Open, SPT2TRAFFIC-8877 **]**

7.7 Will Traffic CS support Hybrid L3 (now HTD)?

HTD is the EUG concept to merge information from physical track sections and safe rear end reported by ETCS on-board into occupation status of virtual track sections. The aim to improve capacity while keeping fixed block technology and operations.

Traffic CS will take the principles and operational scenarios described in HTD into account for the specification of how to merge input from different localisation sources into one „true“ representation of track occupation. The proposed way to specify this mechanism is described in SPT2TRAFFIC-7631 - Safe Train Extent based on Sensor Fusion. If required, it will be possible to derive the occupation status of fixed virtual blocks from this one "true" representation of track occupation. **[** Open, SPT2TRAFFIC-8875 **]**

7.8 Can fixed block be used with Traffic CS?

There are different aspects in relation with fixed block:

- Trackside train detection systems:
  - Provide status (clear/occupied) of fixed pre-configured sections
  - Typically axle counters or track circuits
  - --> Can and will be integrated in ETPS design
- Safety logic based on fixed block or fixed routes:
  - Safety principles for fixed block describe which conditions need to be fulfilled to allow the entry into a pre-configured section (note: this section is not necessarily the same as the TTD sections)
  - Traditionally, the authorisation to enter a section is transmitted from track to train (driver) by a lineside signal
  - With cab signalling like ETCS L2, the (virtual) signal aspect needs to be mapped to a specific train, which is not always obvious and requires substantial additional safety logic
  - --> Safety principles for ETPS won't rely on fixed block but directly specify the conditions to process a request for train movement and generate an ETCS Movement Authority
- TMS/Scheduling:
  - Timetable and scheduling is normally based on trains, but detailed train time calculation can be based on occupation of fixed block sections
  - Automatic route setting is often based on translation of train timetable to request pre-configured routes
  - --> Not needed by Traffic CS, but adaptation can be done beyond SCI-OP (adapter or in TMS)
- Operation
  - Operational concepts often assume existence of fixed blocks and procedures contain rules based on fixed blocks
  - --> Harmonised operational rules can be simpler by always referring to specific trains instead of signals or blocks
  - In degraded situations, fixed locations are needed for communication between driver and signaller (marker boards)
  - --> degraded situations are still supported by the use of marker boards where needed; a marker board does not

imply a fixed block but is just a geographic reference

[Open, SPT2TRAFFIC-8878]

7.9 Scalable solutions: Is Traffic CS designed only for new high-speed lines?

The specification is intended to allow development of scalable products that can be applied on all types of railway lines fulfilling different customer needs

- Rural, high-density, high-speed, suburban, freight-only, …
- Adaptation to specific application only through configuration
- On high-density with mixed traffic: train integrity improves capacity, many axle counters for performance
- Rural: only intermittent radio coverage, almost no costly trackside equipment, still same safety level, same operations, same vehicle equipment

[Open, SPT2TRAFFIC-8883]

7.10 Is satellite positioning needed for Traffic CS?

In principle, we assume that the location method used by Train CS is transparent to Traffic CS and that the relative location to a reference position in the track principles introduced by ETCS (position report) will be kept. Improved location accuracy (i.e. reduced confidence interval) is of course welcome. [Open, SPT2TRAFFIC-8889]

7.11 How is manual operation foreseen?

Manual operation can have different aspects:

The manual request of a train movement can be performed on TMS level by creating an Operational Plan for this movement (also for immediate movement). Traffic CS would then receive this Operational Plan and there is no difference in Traffic CS to an automatically created Operational Plan. This also allows to have ATO working with a manually created Operational Plans.

The manual request of changing a Trackside Assets state (e.g. change point position or close level crossing) can be performed via the operator interface towards PES, keeping the safety checks in ETPS active.

The manual permission of moving a train depends on the operational situation. An operator interface from ETPS to the signaller is foreseen for actions with safety implication. Further details will follow once the corresponding operational scenarios and technical solution have been developed in detail. [Open, SPT2TRAFFIC-8890]

7.12 Will Traffic CS still work if there is a TMS failure?

Traffic CS can continue the operation as long as there are Operational Plans for the train movements. If TMS fails, the existing Operational Plans can still be executed. In this case, Traffic CS would not receive updates from TMS when deviations from the timetable occur to resolve conflicts. [Open, SPT2TRAFFIC-11699]

7.13 Is usage of Public Networks supported?

ATO-TS - ATO-OB could in principle be implemented using public communication networks. Within Traffic CS, the assumption is that there is communication between trackside and train. **[** Open, SPT2TRAFFIC-8891 **]**

7.14 How is safety regarding rolling away parked train (parts) ensured? How can it be detected in a system with very reduced trackside train detection?

Trains equipped with ETCS are normally protected against rolling away, even when powered off. Even there, it is possible in rare cases that these trains move. Parking vehicles without any ETCS-equipped part don't have rollaway protection by ETCS. Normally, measures are taken to prevent rollaway (e.g. brake shoes). It can still not be excluded that these parked vehicles roll away.
It is clear that measures have to be implemented to protect train movements on tracks close to tracks with parked vehicles against the parked vehicles rolling into the path of the on-going train movements. It is possible to use physical protection with derailers or points for flank protection. This can be combined with the usage of trackside train detection where needed to detect rollaway movements and trigger safety reactions accordingly. **[** Open, SPT2TRAFFIC-8893 **]**

7.15 How will transitions to and from non-SERA areas work?

There will be a standard interface used between adjacent Traffic CS systems. It is foreseen that the same standard interface can be used for the interface with an adjacent non-SERA area, by using an interface adapter. The specification of the various interface adapters required is not within the scope of Traffic CS. **[** Open, SPT2TRAFFIC-8876 **]**

7.16 Why are is shunting with signals part of the Traffic CS design when the goal is ETCS L2 without signals?

Two goals are behind the shunting requirements:

- Allow shunting without light signals by using cab signalling, if possible
- Allow shunting with light signals, if cab signalling is not possible

In many operational situations, cab signalling can already be used today for shunting (e.g. run in FS if train set has train data available and track is clear). Traffic CS design aims at always using the best possible supervision and only degrade as far as needed, also keeping as much as possible automation active. Lower supervision modes can be used if some data is not available (e.g. OS with missing track clearance).

Some scenarios (especially pushed movements) are not possible to cover by ETCS cab signalling without System Version 3 and DAC introduction and require another way of authoring the movement. Options can be a process with voice communication driver-signaller or to use a light signal. Since voice communication takes considerable time and is error-prone, Traffic CS proposes to define a harmonised shunting process with signals.

Traffic CS allows both ways of shunting (with cab signalling and with light signal) via engineering configuration. It is assumed that many locations won't require equipment of shunting signals, e.g. when no pushed movements with wagons are performed without SV 3 and DAC.

It is recommended to define a harmonised signal aspect for the described authorisation with light signal. This could also be used in degraded situations without radio communication. Keeping existing national shunting signals can be investigated in individual projects taking into account questions of interoperability and safety (one signal aspect for different operational processes).

[Open, SPT2TRAFFIC-11702 **]**

7.17 Is an upgrade of all trains needed (higher SV, train integrity)?

No, ETCS with System Version 2 will be the current base for the development.
Train integrity will reduce cost for capacity but is optional. Traffic CS can also be used completely without train integrity. **[** Open, SPT2TRAFFIC-11709 **]**

7.18 Are track layout changes needed?

No, the safety rules for Traffic CS can work on any physical track layout. **[** Open, SPT2TRAFFIC-11708 **]**

7.19 Will there be different sets of operational rules in one network?

Yes, this in unavoidable when going to harmonised operations.
It is however not a new situation in many countries (e.g. when lines with L2 only are introduced the operation will be different to lineside signalling). **[** Open, SPT2TRAFFIC-11707 **]**

7.20 Is it possible to combine Traffic CS subsystems with existing safety systems in one area of control?

No, ETPS will be the sole safety system in one are of control (AoC). An AoC can be compared with the coverage of an RBC of today. The size is not determined by the Traffic CS specification and will more depend on the concrete product implementation and project specific engineering.
A combination of Traffic CS subsystems with existing non-harmonised systems would lead to enormous complexity and is not economically viable.
To ease migration, it can be investigated to keep existing trackside assets in place and only replace the centralised components of RBC and interlocking by Traffic CS. To give recommendations for this topic is part of the work in the migration group. **[** Open, SPT2TRAFFIC-11706 **]**

7.21 Is the Traffic CS approach safe and accepted by all stakeholders?

Is this new approach safe and accepted by all stakeholders?

Routes are not simply a mechanism by which RBCs and interlocking share information. They are, fundamentally, a definition of the train movements that are required to be supported by the signalling system. By removing routes, we are moving from a signalling system that is designed specifically to support a limited set of operational moves, to a signalling system where all movements on the layout are theoretically possible. This is a very different approach to the way we do railway signalling and potentially has far reaching implications that need to be fully analysed and understood. E.g. although it brings additional operational flexibility, it potentially also means that the safety system will allow movements that would be excluded by default by current signalling approaches (possibly for safety reasons). For instance, opposite movements on a single track in plain line are usually prevented by the interlocking. The new approach would prevent overlapping movements to guarantee safety but the question whether opposite movements are planned operationally is done in the TMS.
How can it be ensured that this new approach is safe and accepted by all stakeholders?

Safety Evaluation of Architecture

A thorough evaluation of the removal of routes from the Generic Safety Logic will be performed to ensure that the transfer of exclusion for unexpected operational scenarios, currently managed under Safety Integrity Level 4 (SIL4), can be effectively managed under Basic Integrity Level systems, such as PES.
Risk assessments will be conducted to determine if the Basic Integrity Level systems possess adequate safety measures and controls to handle these scenarios. This will include the documentation of the rationale for this transfer must be prepared, including any adjustments to the safety management processes and compliance with relevant safety standards.

Engaging with Relevant Stakeholders

Safety experts and stakeholders will be engaged throughout this process to validate the approach and ensure alignment with safety objectives. Furthermore, it is anticipated that most National Safety Authorities (NSAs) will require evidence that the implementation of Generic Safety Logic will not compromise existing safety levels.
This necessitates a proactive approach to defining and adhering to safety objectives from the outset.

7.22 How are the development efforts managed?

How are the development efforts managed?

The establishment of a market utilizing Generic Safety Logic involves significant time and financial investment.
Developing and implementing such systems requires extensive research and development, along with rigorous testing to ensure compliance with safety standards.
Additionally, market acceptance hinges on building trust in the technology, as well as demonstrating its reliability and effectiveness in enhancing safety.

Development efforts to be demonstrated by Business cases

Development efforts will be showcased through comprehensive business cases.

7.23 Will reduction of safety functions make it harder to create a safety case?

Will reduction of safety functions make it harder to create a safety case?

Compared with typical signalling systems today (interlockings), the Design Decision proposed removes functionality from the safety system (ETPS), with these functions placed within the non-safety systems (TMS, PES). This is in order to minimise the safety functionality. This particularly applies to the removal of Routes from the safety system.
This makes it harder to present the proposed system as an evolution from present signalling.
This in turn may make it harder to achieve a Safety Case for the proposed new system, requiring more work and deeper analysis.

Early work on Safety Case

In order to de-risk the approval process, an evaluation of how to present the generic safety case for the safety system (ETPS) will be performed. This will take account of the similarities to and differences from the safety cases made for signalling systems today. This safety work is included in the System Pillar process.

Option for Route-Based system

The work within Traffic CS will consider alternative options for implementation of Moving Block signalling, including an option which retains more of the functions within the safety system, by maintaining the concept of Routes. This is referred to as "Moving Block with Pre-Defined Routes".

7.24 Will a new approach be required for testing?

Will a new approach for checking and testing project-specific data be required?

Yes. Basing the safety system (ETPS) on topology data is a change from typical present day systems, where interlockings are supplied with logical data, rather than full topology data. Topology data will be presented as in a Node-Edge model, with locations and areas specified relative to the Nodes and Edges.
Today interlocking systems are either supplied with a logical connection of objects, or with route tables.
The function to derive the logical requirements for the safety system is therefore moved from an off-line activity, with due process, to become an on-line real-time activity within ETPS.
This will need a new process for the checking, integration and testing of the safety system, compared with today. The challenge will be to minimise the activities required, whilst remaining compliant with e.g. CENELEC requirements.

Defining a new process for the checking and testing project-specific data

A new process for checking and testing of project-specific data will be defined, both for new installations, and for installations where the topology data has been updated.

7.25 Will it be necessary to duplicate Safety Logic in EAL, to avoid rejected requests?

Will it be necessary to duplicate Safety Logic in PES, to avoid rejected requests?

Frequent rejection of requests by the safety system could stress the safety system. We should avoid a system where requests from PES to ETPS are frequently rejected. This could be prevented by evaluation equivalent to the safety logic with PES, before sending the request to ETPS.

Pre-evaluation of requests from PES to ETPS

In order to avoid requests from PES to ETPS being rejected, it is likely that PES will need to perform some pre-evaluation of requests equivalent to the safety logic based on the Operating State from ETPS, before the request is sent to ETPS. This would be some level of duplication of the safety logic, although any pre-evaluation within PES will not need to be considered as a safety function. This increases the coupling between PES and ETPS. This will require precise definition of the safety logic.

7.26 How will the system function in areas without Trackside Train Detection?

How will the system function in areas without TTD?

The derivation of Safe Train Extents as described is based on use of both trackside and on-board inputs.
However, there are today low traffic lines without full trackside train detection.
Will it be possible to use the concept of Safe Train Extents even if there is no trackside train detection present on parts of a railway?

The data fusion algorithm will be specified to cope with areas of railway without TTDs

Yes. The data fusion algorithm will be specified to cope with areas of railway without trackside train detection.
However, the combination of railway without trackside train detection, and ETCS On-Boards without safe train length would result in long Safe Train Extents. This may be acceptable on low traffic lines. The need of TTD has to be assessed within each project, depending on requirements for mixed traffic (e.g. during migration), depending on requirements for recovery from degraded situations.

7.27 What is the impact of using Safe Train Extents on other parts of the system?

What is the impact of track occupancy as collection of Safe Train Extents on other parts of the system?

Presenting track occupancy as a collection of Safe Train Extents specified relative to the railway topology is a change from present day signalling, where track occupancy is presented as fixed block occupancy.
This is required to achieve the benefit of greater precision of track occupancy by trains.
However, in order to realise the capacity benefits, this change will necessarily have an impact on other parts of the signalling system (TMS, PES), which will need to consider Safe Train Extents received from ETPS.

Adapt other parts of the system

The other parts of the signalling system could be adapted to use the topologically defined Safe Train Extents.
This would realise the maximum benefit of using Safe Train Extents, but is a large impact on other parts of the system.

Implement a "Fixed Virtual Block" through adaptation

Alternatively, it may be decided to implement a “Fixed Virtual Block” towards TMS through adaptation. This does not imply to add fixed block in the safety logic
This would in turn require additional data in the Digital Register – Infrastructure, to define the virtual blocks.

Collaborate with others on the definition of the interface from Traffic CS to TMS

Traffic CS will collaborate with other domains within System Pillar on the definition of the interface between Traffic CS and

TMS, to understand the most pragmatic approach.

7.28 How might stakeholders resist changes to established engineering processes and systems?

How might stakeholders resist changes to established processes and systems?

Stakeholders may exhibit resistance to changing established engineering processes and systems due to concerns about disruptions to current operations or the effort required to adapt to new methodologies.

Optimising Engineering Processes for TMC/CSS Systems and ETCS Level 2 Rollout

Infrastructure Managers need to optimize today's engineering processes for TMC/CSS systems anyhow. The goal is not to overhaul the engineering processes for all existing systems, but rather to establish new engineering processes for new test tracks and single lines, while expanding the scope alongside the ongoing rollout of ETCS Level 2 with the TMS/CSS target system. In addition, the standardisation supports IM and supplier digitisation and optimisation strategies through a standardised data model and engineering/validation rules.

7.29 4. What risks does reliance on a centralized service pose for system operations?

What risks does reliance on a centralized service pose for system operations?

Reliance on a centralized service could create a single point of failure, potentially impacting system operations if the service experiences outages or technical issues.

Ensuring reliable Configuration Data Management

The Digital Register - Infrastructure (DR-I), Digital Register - Vehicle (DR-V), and Configuration Management System (MDM) are not intended to serve as data hubs for publishing and subscribing of Operational Data. Instead, their purpose is to provide a reliable, consistent and versioned datasets of Configuration Data. Updates to Configuration Data will not occur within seconds or minutes, but rather over hours or days. Therefore, a system failure does not have direct impact on the railway operation. Additionaly a procedure with two decoupled phases for preloading and activation of the Configuration Data is planned to address risks during updates and ensure that all systems are synchronously updated.

8 References

- [RCADocuments] The RCA documents were previously available from EUG and EULYNX web site. However, they have now been removed.
- [X2R5Documents] All X2Rail-5 public deliverables are available on-line here: https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-5

[Open, SPT2TRAFFIC-8884 **]**