ERJU SYSTEM PILLAR

Train CS Baseline 2

Train CS Architecture Baseline 2

Note: the document history shown above is a wrong Polarion artefact and shall not be taken into account.

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Abstract Train CS Architecture Baseline 2 describes the state of discussions as of 2025-09 on architecture of the on-board Control-Command and Signalling subsystem, under the responsibility of the Train Control & Supervision domain of the System Pillar.

The purpose of Train CS Architecture Baseline 2 is twofold. A first section on System Architecture Description is collecting and integrating engineering information related to the CCS-OB. This integration of engineering information feeds the CCS-OB architecture evolution with the functional, logical and physical perspective. A second section is discussing on upgradability and migration recommendations from current CCS definition (as per TSI CCS 2023) towards a CCS on-board up to GoA4.

Train CS Architecture Baseline 2 provides an overview of what the CCS-OB could be. It is to be used as a basis for the System Pillar activities related to pre-assessment and Change Requests towards ERTMS. This document can also be used by external readers of the

	System Pillar, in order to get the current state of art for CCS-OB evolution and integration. This document is descriptive and not prescriptive.
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Document History

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1 Executive Summary

The Train CS domain within the System Pillar is working on the evolution of the on-board Control-Command and Signalling system (CCS-OB). The purpose of Train CS Architecture Baseline 2 is to collect and integrate engineering information related to the CCS-OB.

This integration of engineering information feeds the CCS-OB architecture evolution with the functional, logical and physical perspective, provided in this document. The aim of the Train CS Architecture Baseline 2 is to provide an overview of what the CCS-OB could be, and to be used as a basis for the System Pillar activities related to pre-assessment and Change Requests towards ERTMS. This document can also be used by external readers of the System Pillar, in order to get the current state of art for CCS-OB evolution and integration. This document is therefore descriptive and not prescriptive.

The main structure of this document is based on the migration targets for the overall CCS as published in [Ref.7], with the introduction of new features that must be confirmed by in-depth studies. Concerning the CCS-OB, the novelties identified and subject to studies are the following:

1. Target 1
    a. Evaluation of modularity extensions: CCS consist network, Multi-Display System, Enhancements of the train interface, interface between ETCS-OB and Advanced Safe Train Positioning.
    b. Support of FRMCS medium of communication for the airgap.
2. Target 2
    a. Introduction of the Advanced Safe Train Positioning in the CCS-OB, with associated internal interfaces towards other CCS-OB subsystems, and the airgap in order for the ASTP to get required data from the trackside CCS.
3. Target A
    a. Upgrade of the overall CCS system (both on-board and trackside) to support unattended train operation on the Mainline with ERTMS/ATO up to GoA4.

The document will primarily focus on the CCS-OB architecture for Target 1, and provides an outlook towards Targets 2 and A, in order to secure readiness for future specification activities of the System Pillar towards the foreseen novelties. The document integrates the results coming from the other Train CS tasks as defined by the specific contract for the phase 2.4 [Ref.16].

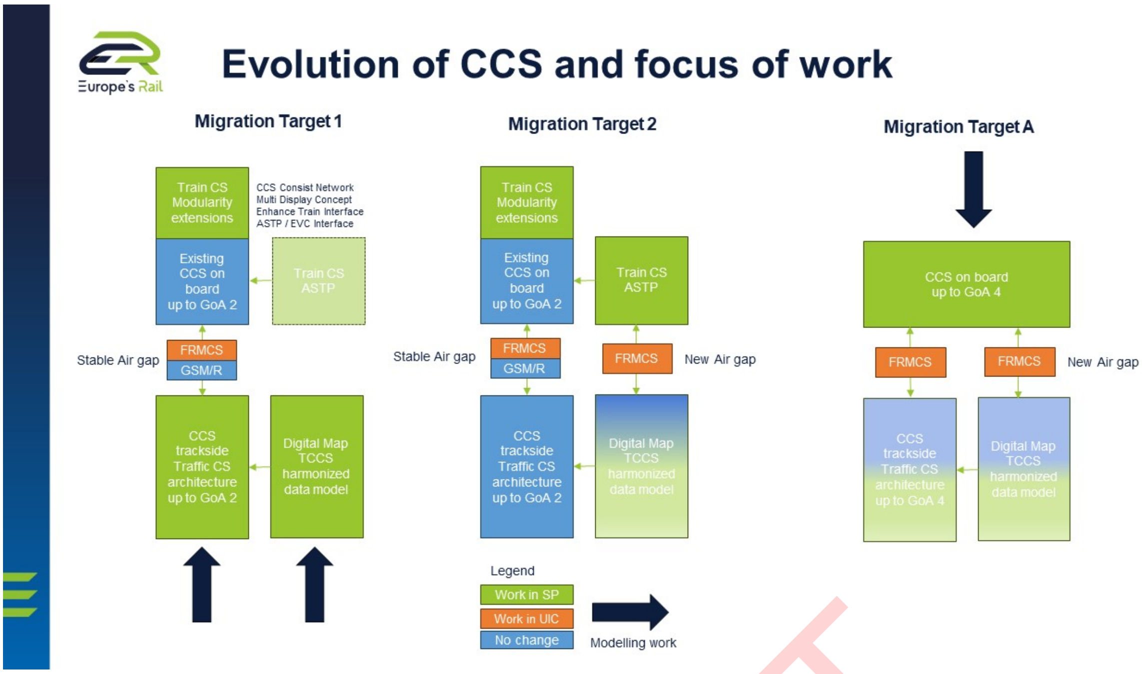


Figure 1 Migration targets for CCS [Ref.7]

These three targets will be elaborated in three sections within the chapter related to System Architecture Description:

1. **CCS-OB Architecture elaboration for Target 1, including results of current Train CS studies**: In this section, the current architecture of the CCS-OB will be extended with the latest results of the current Train CS studies. The main goal of this section is integration and delivering of an updated Logical and Physical Architecture view for the Train CS domain. The primary focus of these architecture views is target 1, but there are also some results coming from the current Train CS studies that give an lookout to future targets (Cybersecurity for CCS-OB, Computing Environment for CCS-OB, Multi Display System, GNSS/EGNOS). The following figure is an architecture view of the system of interest (CCS-OB) alongside neighbouring systems, in the context of Target 1.

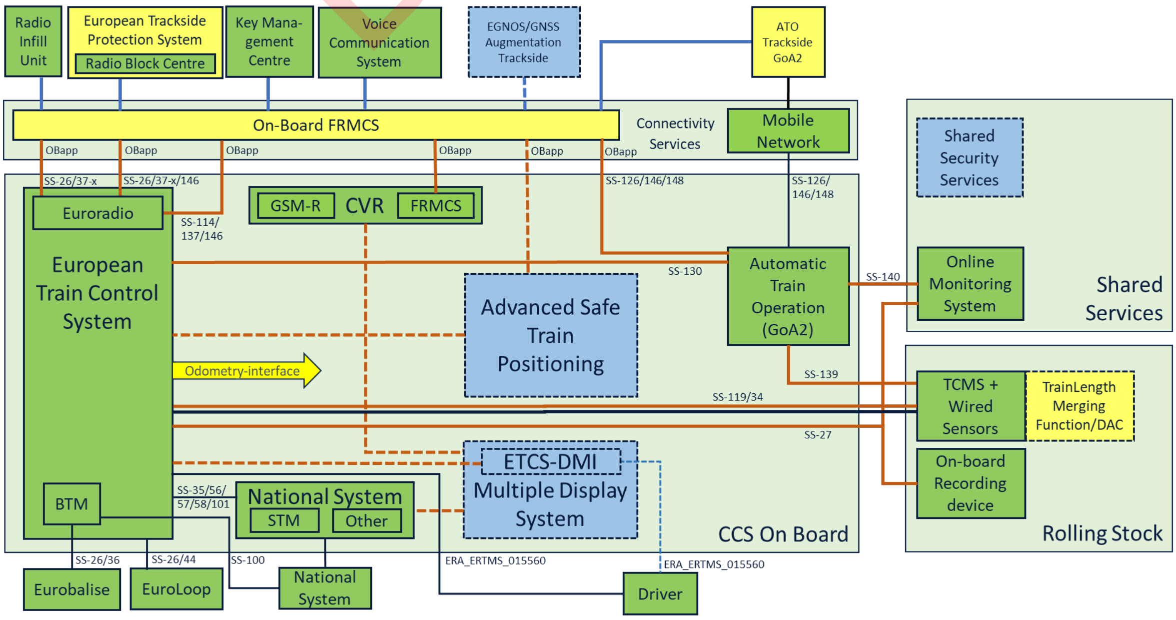


Figure 2 CCS-OB architecture view for Target 1, including results of current Train CS studies

Green: Actors and Logical Components conform current TSI 2023.
Yellow: Actors and Logical Components to be specified/updated for Target 1.
Blue/dashed: Actors, Logical Components currently in study, but meant for later Targets
Black Interfaces: Current Interfaces, conform current TSI 2023.
Red Interfaces: Current Interfaces (striped) and Interfaces in study (dashed) conform CCS Consist Network version 2.
Blue Interfaces: Current Interfaces (striped) and Interfaces in study (dashed) conform FRMCS version 3.
Note on **Train Length Merging Function**: the exact location of the Train Length Merging Function is still discussed.
Notes on the **Advanced Safe Train Positioning** component:

2. The ASTP component is pictured as a separate component, to be specified for later targets (dashed blue).
3. As of 2025-09 no decision is made whether the Full ASTP module will be a separate Interoperability Constituent or not. Information about the current status on ASTP can be found in paragraph 3.2.4.4.
4. For Target 1 a standardised Odometry-interface for testing and enhanced odometry performance and robustness will be specified,
5. The BTM module with its current interfaces is pictured in this figure allocated to the ETCS-OB as is the current situation, but this allocation is still "pending" in the Full ASTP Architecture variants.

1. **CCS-OB Logical Architecture for Targets 2 and A.**
This section is mainly a consolidation of the logical architecture views previously published in the *Train CS Architecture Baseline-1* [Ref.8], and integrating the latest assumptions from the Innovation Pillar. It gives an outlook on the future targets, and secures readiness for future specification activities of the System Pillar towards ERTMS/ATO up to GoA4.
This logical architecture view expresses the migration situations in which current applications (ATO Trackside GoA2 as per SUBSET-125 -126 v1.0.0) may exist next to newer applications (ATO Trackside GoA4), due to the life-cycle of 30 years or more, and reflecting the need for the CCS-OB to remain backward compatible with the trackside.

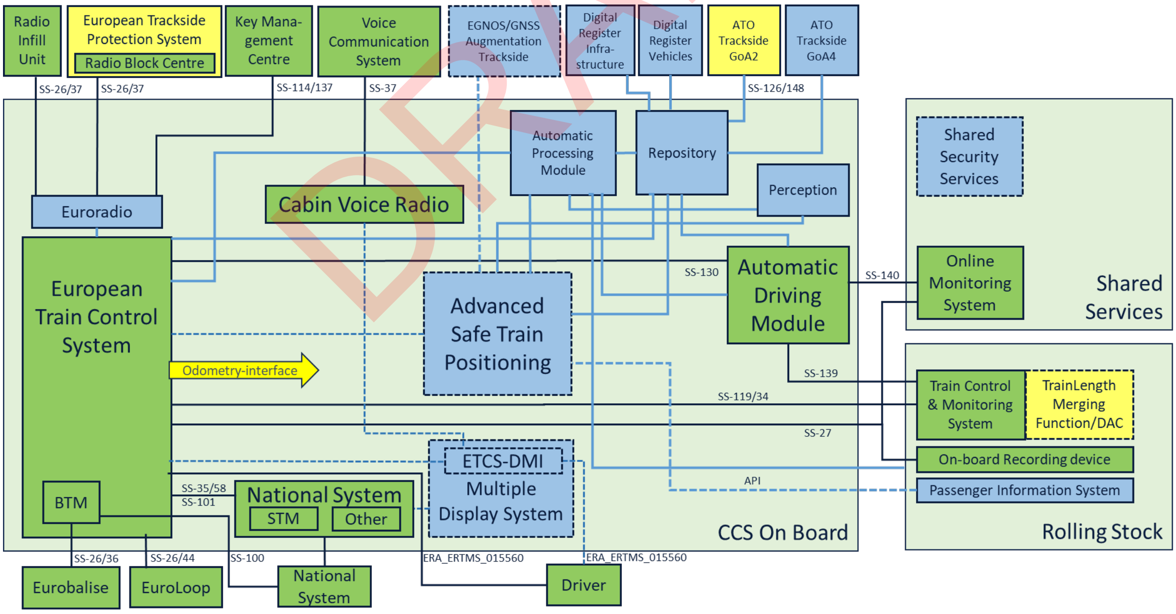


Figure 3 CCS-OB Logical Architecture Targets 2 and A

Green: Actors and Logical Components conform current TSI 2023.
Yellow: Actors and Logical Components to be specified/updated for Target 1.
Blue/dashed: Actors, Logical Components currently in study, but meant for later Targets
Black Interfaces: Current Interfaces, conform current TSI 2023.
Blue Interfaces: Interfaces currently in study (dashed), FRMCS and Interfaces conform previous X2Rail-4- and R2DATO-architectures (striped).
Note on **Train Length Merging Function**: the exact location of the Train Length Merging Function

is still discussed.

2. **CCS-OB Migration.**
While the targets provided by the System Pillar Core Group are an overall guiding principle for the study and evaluation of the integration of novelties within the CCS system, the Train CS domain has elaborated on migration recommendations for the on-board. In this section, the evolution of the CCS-OB architecture, based on the Targets 1, 2 and A, is evaluated. For this evaluation the basic and simplified figure below is used. This figure presents all the key CCS functionalities (enablers) coming from Train CS domain (Yellow) and from others domains (blue), with their respective dependencies to the end-user Features with the Main Benefits for the users.

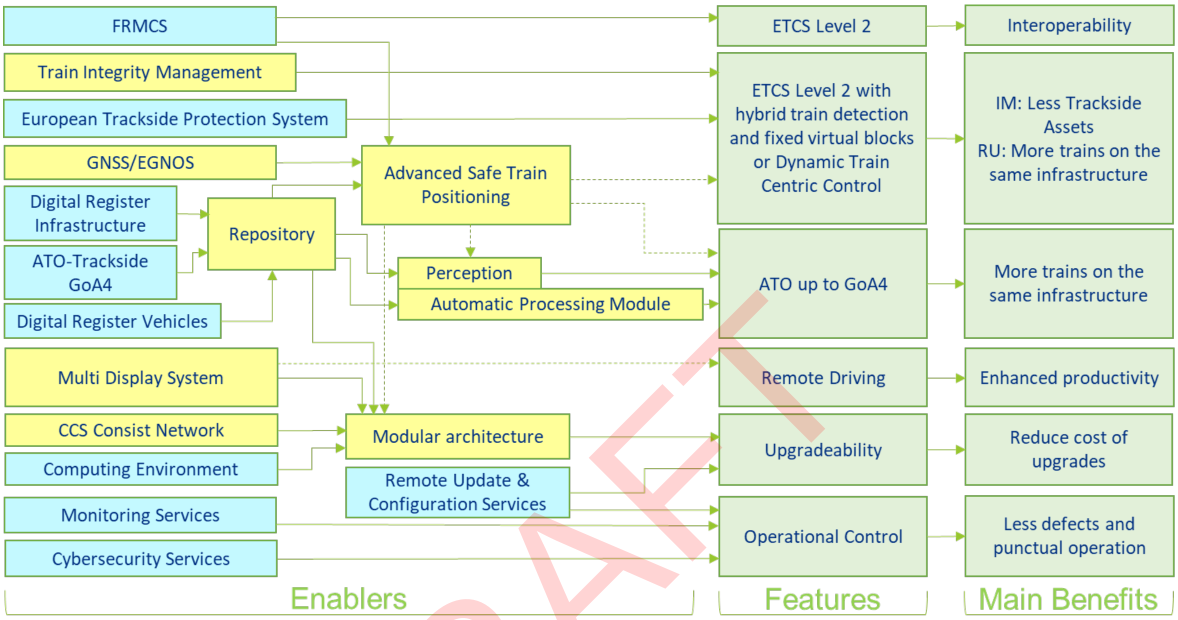


Figure 4 : Contribution of the CCS Key Functionalities to the main benefits for the users

Yellow: Train CS enablers.
Blue: Enablers delivered by other domains.
Green: Features and Main Benefits for the whole of the CCS domain.
Striped line: dependency between enabler(s) towards a feature with end-user benefit.
Dashed line: less strong dependency between enabler(s) towards a feature, which can increase the benefit.

Migration priorities
Given the facts that costs for upgrades and retrofits are increasing and budgets are decreasing, recommendations for the migration to the Command Control & Signalling (CCS) Target A architecture are formulated.
These recommendations are based on the following priorities:
1) Limit the number of upgrades, especially for the existing fleet.
2) Focus the next and future upgrades primarily on:

a. Business continuity:

i. FRMCS, and
ii. Cybersecurity.

b. Achieving the main benefits for the users:

i. ERTMS/ETCS Level 2 with hybrid train detection and fixed virtual blocks -> more trains on the same infrastructure and less trackside assets,
ii. Remote Driving (independent from ERTMS/ATO) -> Higher productivity (in shunting areas, mostly not equipped with ERTMS/ETCS Trackside), and
iii. ATO up to GoA4 -> more trains on the same infrastructure and higher productivity.

Migration recommendations per target

Based on the evaluation of the three targets, the migration recommendations are the following:

Target 1: to only include the following features:

- FRMCS (V3 specifications)
- CCS consist network (namely SS-147)
- Train Integrity Management: to enable ERTMS/ETCS with Hybrid Train Detection with Fixed Virtual Blocks.
- Train interface enhancements
- Cyber security On-board as to ensure compliance to the Cyber Resilience Act.
- Basic ASTP: A standardised odometry-interface for testing and enhanced odometry performance and robustness specification,

Target 2:

- Remote Driving (independent from ERTMS/ATO)
- Full ASTP
- Multi-Display System
- Shared safe and secure computing environment
- Diagnostics

Target A:

- ERTMS/ATO up to GoA4
- Any feature not yet specified in target 1 or 2.

2 Introduction

2.1 Purpose of the Train CS Architecture Baseline 2

The Train CS domain within the System Pillar is working on the evolution of the on-board Control-Command and Signalling system (CCS-OB). The Train CS domain works on this evolution by fulfilling tasks that are required in a yearly specific contract. For this Train CS Architecture Baseline 2, the specific contract is 2.4.

The purpose of this Train CS Architecture Baseline 2 is to collect and integrate engineering information related to the CCS-OB. This information can be available in legal documents (TSI CCS 2023), specifications (SUBSET), deliverables produced by Research & Innovation projects (FP2 R2DATO for example) and deliverables produced by the Train CS domain for specific topics (Advanced Safe Train Positioning for example). This integration of engineering information feeds the CCS-OB architecture evolution with the functional, logical and physical perspective, provided in this document. As a recursive movement, the architecture contained in this document helps in the specification and alignment of the CCS-OB components currently under discussion (Advanced Safe Train Positioning for example). Requirements produced by other System Pillar domains and applicable to Train CS as Cybersecurity and PRAMS are stepwise integrated in this document.

Ultimately, the aim of the Train CS Architecture Baseline 2 is to provide an overview of what the CCS-OB could be, and to be used as a basis for the System Pillar activities related to pre-assessment and Change Requests towards ERTMS. Therefore, this document has to be understood as descriptive, and not prescriptive.

Alongisde the integration of engineering information and the definition of the CCS-OB architecture, the document elaborates on migration recommandations for the on-board. These migration recommandations are preliminary and have to be continued in the next iterations of the document.

The integration of existing engineering information related to the CCS-OB into a consistent and coherent architecture is a long-term task, taking into account that CCS-OB topics can have different levels of maturity, some of the topics even being at concept stage (Multi-Display System for example).

Therefore, the reader is advised that this Train CS Architecture Baseline 2 is a living document, presenting open questions and blind spots that are in the scope of work of the System Pillar Train CS domain for the next years. Ontology, terms and definitions may not be aligned yet.

2.2 Scope of the Train CS Architecture Baseline 2

This Train CS Architecture Baseline 2 has the on-board Control-Command and Signalling (CCS-OB) in its scope of work.

The System Pillar Core Group has defined migration targets for the overall CCS back in 2023 [Ref.7]. The document will primarily focus on the CCS-OB architecture for Target 1, and provides an outlook towards Targets 2 and A, in order to secure readiness for future specification activities of the System Pillar towards the foreseen novelties. The document integrates the results coming from the other Train CS tasks as defined by the specific contract for the phase 2.4 [Ref.16].

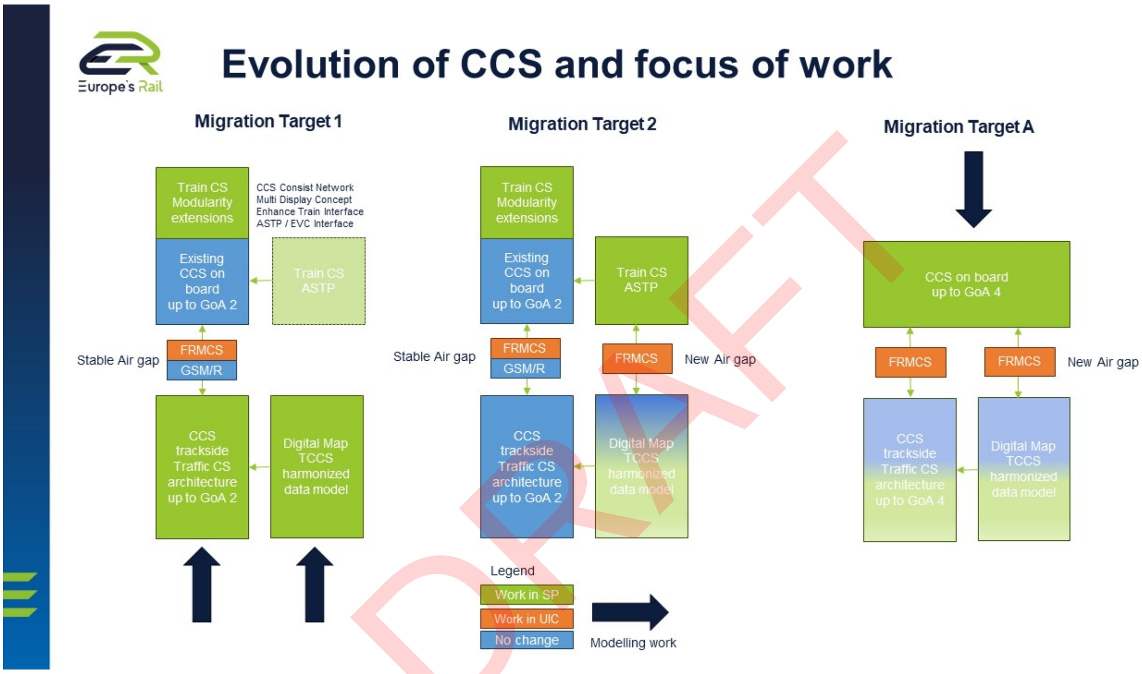


Figure 5 Targets as defined by the System Pillar Core Group [Ref.7]

Within this architecture only the three targets will be used as a basis. In a later phase, the different topics within the targets will be allocated to specific system milestones [Ref.36] and TSI releases with dates.

This Train CS Architecture Baseline 2 is the follow-up on:

- Train CS Architecture Baseline-1 [Ref.8] which was a logical architecture based on the existing architectures coming from OCORA, X2RAIL-4, TSI and Innovation Pillar (ASTP), and
- Summary of the Discussions for a Preliminary Bottom-up On-board CCS Architecture [Ref.3].

The scope in more detail consists of the functionalities for Target 1, including the latest results of the Train CS studies.

1) Functionalities in scope of study for CCS-OB Target 1:

- Advanced Safe Train Positioning in a Basic ASTP version.
- Train Integrity/Train Length,
- CCS Consist Network (SUBSET-147),
- Subset-149 (Online Monitoring System), version 1.2.0., limited to the monitoring of ETCS (via SUBSET-27) and ATO (via SUBSET-140) as explained in the Guide for the application of the TSI 2023 [Ref.37],

- Train Interface enhancements, besides Train Integrity/Train Length (if relevant for the high-level architecture),

2) Functionalities to be studied for use in later CCS-OB targets (2, A):

- Multi Display System Concept (MDS), with a new FFFIS interface ETCS-DMI (to replace SUBSET-121).
  To be decided if the MDS Concept will be used for Target 2 or A.
- Concept architecture for using GNSS with EGNOS, for expected use in Target 2 (Full ASTP).
- Evaluation of the potential use of the Computing Environment, as published by SP CE [Ref.13,14]. The outcome of the evaluation can be used for a Cost Benefit Analysis on the use of the Computing Environment.
- Impact analysis for applying the generic Cybersecurity specifications, as published by the SP Cybersecurity working group, to the CCS-OB subsystems.
- STIP topics and potential ETCS CRs: to be analysed.

In this Train CS Architecture Baseline 2, a snapshot of the current state of art coming from the Train CS task groups is integrated to logical and physical architecture views. Any review comments on this content coming from the task groups should be delivered as review comments in the referenced documents from the related Train CS task groups.

In this Train CS Architecture Baseline 2, for the functionalities in scope, a Logical and Physical Architecture will be presented in chapter 3.

In chapter 4 an outlook of the Logical Architecture for the Targets 2 and A will be provided; this is mainly a reuse of the previous Train CS Architecture Baseline-1 [Ref.8] with some additions coming from the Innovation Pillar.

In chapter 5 the Migration of the CCS-OB functionalities from Target 1 to Target A, the dependencies between functionalities and their contribution to the main benefits is presented. For the evaluation of the contribution of the CCS-OB functionalities to the main benefits, also the dependencies with functionalities coming from other System Pillar domains are taken into account.

In the Appendix the results of migration exercises done within Train CS domain for Target 1, including studies for later targets, can be found.

2.3 Methodology

2.3.1 Introduction

As already introduced in the purpose section, the CCS-OB is specified by many engineering information available in different documents (i.e. TSI CCS and Appendix A documents). Following a strict top-down engineering approach is not appropriate nor relevant, as it would imply a complete re-work of the existing documentation related to the CCS-OB. It has been decided and agreed with System Pillar Core Group that Train CS domain follows an iterative approach based on existing documentation.

2.3.2 Engineering work items handled in this document

The Train CS Architecture Baseline 2 calls enginnering work items to describe the architecture of the CCS-OB. These engineering work items are the following:

Actor
An actor is an entity external to the system under consideration, which can be either a human or a

technical system. Actors interact with the system through interfaces.

This definition is applicable to system actor, logical actor, and physical actor.

Function

A function is a transformation of inputs into outputs which is purpose-oriented and pays towards a higher goal of a system. All possible input and output values are defined by the exchange items allocated to the functional exchanges of the function. Consequently, when the inputs to the system change, the transformations within the system modify the outputs accordingly. They can be available in a range of system states and therefore change its behaviour based on the current state of inputs.

The structure of functions does not have to reflect any possible implementation and does not have to follow an object decomposition paradigm, as would be followed normally by software engineers implementing one or more systems. In addition, each function is continuously performed by the system or system actors. They are not created, called and terminated.

Functions are allocated to the system or to the system actors. Each function is allocated to one or multiple functional requirements, defining “what” the function is doing. The expected characteristics of functions are then specified via non-functional requirements, which define the “how” (how safe, how accurate, how fast, how reliable, etc.) the function is performing the transformation.

Logical Function

A SPPR-2598 - Function derived during logical architecture by splitting a system function.

Logical Component

An abstraction of a system that performs the system functions without imposing restrictions on implementation.

Logical components are also only connected via FIS and not via FFFIS interfaces.

Sub-system (sometimes called “Building Block”)

Sub-systems are along ARCADIA systems on System Level 5. Not to be confused with sub-systems in the TSI / interoperability directive. In the TSI / interoperability directive context a sub-system shall be regarded as a interoperability constituent

A sub-system is a part of a system, which is not split into smaller entities. It represents a leaf element in the hierarchy of systems-of-systems.

Physically speaking, a sub-system is either a piece of hardware plus software, or just a piece of software.

A sub-system is a source able unit of the CCS system, in particular:

- a sub-system can be individually tendered to a supplier,
- a sub-system can be built individually by a supplier,
- a sub-system must be integrated into a system, which includes all necessary test, verification, certification and validation activities depending on the level of harmonisation.

The harmonisation of the sub-system’s features is to be defined according to the requested level:

- Functional Apportionment,
- Interoperability,
- Exchangeability, or
- Interchangeability.

Interface
An interface is the link between different building blocks. Inside a building block there can be only "proprietary interfaces". With an interface the sub-systems of different suppliers can be combined.

2.3.3 Document development

This document has been developed based on work items as Functions, Interfaces, Actors, Logical Components and Subsystems coming from the current TSIs and SUBSETs, which might be modified for Target 1 by the inputs coming from Innovation Pillar and from the Train CS task groups.

The step by step methodological approach for this document is as follows:

1. Identification of CCS-OB actors and external interfaces.
2. Start of a functional breakdown structure for the Logical Functions, derived from the current documentation as TSIs (paragraph 3.4.1.2) and SUBSETs.
3. Refinement of the sub-functions which are a candidate for change according to the current Train CS tasks.
   For example: Refinement of the Localisation function into Logical sub-functions, which are a candidate for re-allocation from the Logical Component European Train Control System (ETCS) to the new Logical Component Advanced Safe Train Positioning (ASTP). The level of detail of the refinement should align with the level of detail of the sub-functions in the architecture variants as discussed in the Train CS task groups.
4. Allocation of Logical Functions to the Logical Components. The result will be Logical Components with Logical (sub-)Functions. Logical Components can:
   a. stay as-is, conform the current TSI (for example: ATO-OB as per SUBSET-125),
   b. change, in line with a re-allocation of sub-functions (for example: European Train Control System, in case of re-allocation of the ETCS-DMI to the new Logical Component Multi Display System (MDS)), or
   c. be new, in line with a re-allocation of current subfunctions or addition of new subfunctions to new Logical Components (for example: ASTP and MDS).
5. Depending on the (re-)allocation of Logical Functions to Logical Components:
   a. Logical Interfaces may stay as-is conform with current interface-TSIs or be new or changed due to a re-allocation of Logical Functions, and/or
   b. Logical Components may stay as-is conform the current TSIs or be new or changed.
6. At this point the result will be a Logical Architecture with Logical Components (including subfunctions) and Logical Interfaces.
7. The Logical Components can now be allocated to subsystems.
   At this point the analysis of the future use of a standardised Computing Environment, as published by the SP Task 2 Computing Environment team, is carried out and integrated into this document.
8. The Logical Interfaces can be allocated to Physical Components like communication network services.
   For Target 1, the allocation of Logical Interfaces to CCS-Network (SUBSET-147) and FRMCS is developed.
   For future use, an analysis of the impact of the Security requirements, as published by the SP workgroup for Security is carried out.
9. After all the foregoing steps are done for Target 1, including the current Train CS studies, the future Targets 2 and A for the logical architecture are described, and an evaluation of the contribution of all the functionalities to the main benefits is provided in the Migration chapter.

The methodology and overall spirit of the activity done to deliver this document is evolution instead of revolution, by:

1. Consolidating the existing information describing the CCS-OB spread into several documents, into this single CCS-OB Train CS Architecture Baseline 2,
2. Describing the possible evolutions with the introduction of the topics dealt by the current Train CS task groups.

3. Feeding the System Pillar pre-assessment activities and identifying the Change Requests to be drafted in the next phases in order to confirm the evolutions of the CCS-OB.

2.4 Glossary

For the elaboration of this chapter it has been followed the Glossary Usage Guidelines

2.4.1 Abbreviations

Acronym (abbreviation)	Full text (title)
3GPP	Third Generation Partnership Project
ADM	Automatic Driving Module
API	Application Programming Interface
APM	Automatic Processing Module
ASTP	Advanced Safe Train Positioning
ATO	Automatic Train Operation
BTM	Balise Transmission Module
CCS	Control-Command and Signalling
CVR-OB	Cabin Voice Radio On-Board
DMI	Driver Machine Interface
DNS	Domain Name System
E-2-E	End-to-End
ERA	European Railway Agency
EECT	ERA Extended Core Team
COTS	Commercial Off-the-Shelf
ETCS	European Train Control System
ETPS	European Trackside Protection System
ETSI	European Telecommunications Standards Institute
EWAN	EGNOS Wide Area Network
FBS	Functional Breakdown Structure
FIS	Functional Interface Specification
FFFS	Form-Fit Functional Specification
FRMCS	Future Railway Mobile Communication System
FRS	Functional Requirement Specification
GA-OB	GNSS Augmentation On-Board
GA-TS	GNSS Augmentation TrackSide
GAD	GNSS Augmentation Dissemination system
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
GSM-R	Global System for Mobile Communications — Rail
GW	Gateway
IAM	Identity Access Management
JP	Journey Profile
KM	KEY MANAGEMENT
MCC	Mission Control Centre
MCX	Mission Critical Services
MDS	Multi Display System
NAC	Network Access Control
NLES	Navigation Land Earth Station
NTC	National Train Control
OB	On-board

Acronym (abbreviation)	Full text (title)
O&M	Operation and Maintenance
OCORA	Open CCS On-board Reference Architecture
PER	Perception
PKI	Public key infrastructure
RA	Registration Authority
RAT	Radio Access Technology
RIMS	Ranging and Integrity Monitoring Stations
RMR	Railway Mobile Radio
SCS	Shared Cybersecurity Services
SERA	Single European Railway Area
SIEM	Security Information and Event Management
SIS	Signal In Space
SESAR	Single European Sky ATM Research
SOC	Security Operation Centre
SP	Segment Profile (ATO/C-DAS)
SRS	System Requirements Specification
SSI	Standard Security Interface
STIP	Standardisation and TSI Input Plan
STM	Specific Transmission Module
STS	Secure Time Synchronisation
TAF	Telematic Applications for Freight
TAP	Telematic Applications for Passenger
TCCS	Transversal CCS domain
TCMS	Train Control & Management System
TD	Technical Document
TDS	Train Display System
TLMF	Train Length Merging Function
TOBA	Telecom On-Board Architecture
TSI	Technical Specifications for Interoperability
TTLS	Train Time Location Service
UAS	User Authentication Service
UIC	International Union of Railways (Union Internationale des Chemins de fer)
VCS	Voice Communication System
VNC	Virtual Network Computing
ESS	Enterprise Security Services
CA	Certificate Authority
BKP	Backup and restore

2.4.2 Relevant terms and definitions

Term	Status	Definition
SPT2TRAIN-8136 - Commercial Off-the-Shelf	Open	Commercial Off The Shelf (COTS) components and modules are assemblies, modules or parts designed for commercial applications for which the item manufacturer or vendor solely establishes and controls the specifications for performance, configuration, and reliability (including design, materials,

Term	Status	Definition
		processes, and testing) without additional requirements imposed by users and external organisations. Referenced by: SPT2TRAIN-8567
SPT2TRAFFIC-11319 - Single European Railway Area	Open	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) Referenced by: SPT2TRAIN-8567
SPLI-1849 - Standardisation and TSI Input Plan	Done / To be decided	The Europe's Rail (EU-Rail) Standardisation and TSI Input Plan (STIP) is a collection of all outputs from EU-Rail (Innovation and System Pillar) which contribute to the goal of harmonisation of the railway system. The harmonisation topics are categorised in technical domains and described by the foreseen harmonisation channel (TSI, EN standards, SP document), the time horizon as well as dependencies with existing regulations, standards, and R&I activities. Referenced by: SPT2TRAIN-8567
SPLI-624 - Repository	Done / To be decided	A repository is similar to a database and data dictionary; however, it usually encompasses a comprehensive information management system environment. It must include not only descriptions of data structures (i.e. entities and elements), but also metadata of interest to the enterprise, data screens, reports, programs, and systems. Typically, it includes and internal set of software tools, a DBMS, a metamodel, populated metadata, and loading and retrieval software for accessing repository data. Referenced by: SPT2TRAIN-8567
SPLI-973 - ON-BOARD RECORDING DEVICE	Done / To be decided	A device (outside the ERTMS/ETCS on-board equipment) that records and stores data for subsequent analysis (e.g. further to a train accident). Referenced by: SPT2TRAIN-8567
SPT2TRAFFIC-8367 - European Trackside Protection System	In Progress	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. Referenced by: SPT2TRAIN-8567

2.5 Referenced documents

This table lists the documents used as reference inside this deliverable.

Reference	Document name	Version	Link
1	Granularity concept and principles	3	ARC-D2.3 Granularity Concepts and Principles < 30 Deliverables < Documents & Pages < SPT2ARC (europa.eu)
2	Common Business Objectives	Unknown	Common Business Objectives < Common Business Objectives < Documents & Pages < SPT1RailwaySystem (europa.eu)
3	Summary of the discussions for a preliminary bottom-up on-board CCS architecture	1.0	Summary of the Discussions for a Preliminary Bottom-up On-board CCS Architecture
4	D21.1 - Operational needs and system capabilities of an ASTP system (Use Cases)	1.1	D21.1 Operational needs and system capabilities of an AST system
5	Guide for the application of the CCS TSI 2023	1.1.0	Guide for the application of the CCS TSI 2023/1695
6	TSI CCS	2023	TSI CCS 2023
7	The CCS Migration to SERA, ERA Conference	23 April 2024	The CCS Migration to SERA, ERA Conference
8	Train CS Architecture Baseline-1	1.1	Train CS Architecture Baseline 1 Version 1.1
9	Secure Component Specification	1.0	20 Secure Component Specification
10	Secure Communication Specification	1.0	21 Secure Communication Specification
11	Shared Cybersecurity Services Specification	1.0	22 Shared Cybersecurity Services Specification
12	Security Program Requirements	1.0	23 Security Program Requirements
13	Computing Environment: Recommendation on Interfaces to be standardised	0.8	Recommendation on Interfaces to be standardised
14	Computing Environment: System Concept including operational analysis	0.1	System Concept including operational analysis
15	D3.3.1.1. - GNSS augmentation dissemination architecture evaluation	0.20	E4R_D3.3.1.1_20
16	Deleted		
17	ASTP Architecture Variants	3 Sept 2025	System architecture description - Basic ASTP

Reference	Document name	Version	Link
18	TSI 2027 Cybersecurity	v0a	CR-07681-TSI 2027 Cybersecurity
19	FRMCS FFFIS	2.0.0	https://uic.org/IMG/pdf/frmcs_fffis_fffis-7950_v2.pdf
20	SUBSET-147	1.0	SUBSET-147, version 1.0
21	FRMCS SRS	2.0.0	https://uic.org/IMG/pdf/frmcs_srs_at-7800_v2.pdf
22	Traffic CS System Concept	1.5	Traffic CS System Concept
23	Multi Display Concept	11 June 2025	System_Concept_TrainCS_MultiDisplay
24	System Pillar Glossary: Definitions		Definitions
25	API for other applications		SPPMO-2877 - STIP_72 - API for other applications
26	CR Ethernet CCS Consist Network	19 Dec 2024	CR-11913-Ethernet_CCS_Consist_Network
27	Minutes of Meeting On Board Modularity and Upgradeability	19 Mrt 2025	MoM R5 OBM 20250319
28	Cost Driver Analysis, EC	March 2025	
29	CR-07702 Train Length Information (Par. 2.1.1)		CR-07689-Strategic_Train interface enhancements
30	SRS, EUG Solution for Enhanced Onboard Localisation Change Request (CR1368) - GNSS Augmentation for ERTMS/ETCS	0g	SRS, EUG Solution for Enhanced Onboard Localisation Change Request (CR1368) - GNSS Augmentation for ERTMS/ETCS
31	Specification for Authorisation, Integration and Upgradeability of modular Train CS system including train interface	1.0	Specification for Authorisation, Integration and Upgradeability of modular train CS system including train interface
32	Train Interface enhancements	14 Dec 2024	CR-16092-CCS on-board Modularity
33	Assessment Target 1	April 2025	Assessment Target 1
34	Report on FRMCS V2 and V3 Scope and Planning, Version 2.0 (March 2025)	March 2025	Draft FRMCS Report V2
35	EUG, Hybrid Train Detection		https://ertms.be/activities/hybrid-train-detection
36	ARC Roadmap and release plan - system milestones	0.4	Document and Release Plan - System milestones
37	Guide for the application of the CCS TSI 2023	2.0	Guide for the application of the CCS TSI 2023/1695
38	Train Display System Concept	4.0	

Reference	Document name	Version	Link
			TWS01-201_Train_Display_System_TDS_concept
39	Task 7A and 7B - MoM 02/09/2025		ASTP Taskgroup 7 MoM 02-09-2025

CCS-OB System Architecture Description

In this section, the System Architecture Description of the CCS-OB is discussed. It focuses primarily on Target 1, that was the main expectation of Train CS for this release. An outlook of Targets 2 and A is provided, based on current output and assumptions of Innovation Pillar.

3 CCS-OB architecture - Target 1

3.1 Introduction

In this chapter the CCS-OB architecture overview will be presented in two steps:

1. The CCS-OB Logical architecture described by:
    a. The CCS-OB perimeter, defined by the external actors and the external interfaces and presented as an external logical view,
    b. The CCS-OB functions, defined by the functional breakdown structure and its distribution,
    c. The CCS-OB logical architecture view, the Logical Components, Interfaces and Actors.

2. The Physical CCS-OB architecture described by:
    a. The CCS-OB physical architecture view for Target 1,
    b. The CCS-OB physical architecture view for Target 1, including the Cybersecurity requirements,
    c. The analysis of the future use of a standard Computing Environment for the CCS-OB subsystems.

3.2 CCS-OB Logical Architecture

3.2.1 CCS-OB external view

The CCS-OB perimeter definition follows a step-wise approach, analyzing reference architectures (e.g. from TSI CCS 2023), input architecture documents (e.g. from Innovation Pillar), and neighboring SP domain architecture models. Primary sources establish the foundation, while preliminary and cross-checked actor and interface lists refine the scope. Completeness and traceability checks ensure alignment with the overall System Pillar CCS architecture model.

3.2.1.1 CCS-OB Logical architecture external view

The CCS-OB Logical architecture external view below shows all relations between external actors and internal logical components within the scope of CCS-On Board. Logical interfaces already defined as subsets in the TSI or the Application Guide are shown.

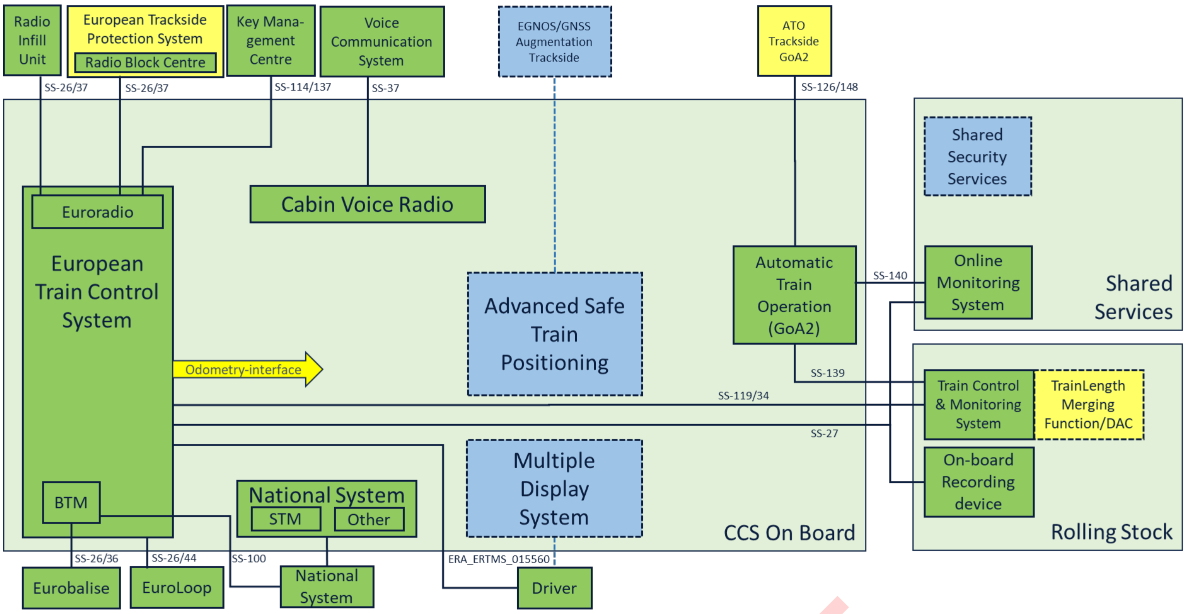


Figure 6 CCS-OB Logical Architecture external view

Explanation of the figure above:

- **Green:** Actors and Logical Components conform current TSI 2023.
  Yellow: Actors and Logical Components to be specified/updated for Target 1.
  Blue/dashed: Actors, Logical Components and external Interfaces in study, but meant for later Targets
  Black Interfaces: Current Interfaces, conform current TSI 2023.
- Naming: the extension "On Board" for the Logical Components within the scope of CCS-On Board is left behind for the sake of simplifying texts and lay-outs.
- Note on **Train Length Merging Function**: the exact location of the Train Length Merging Function is still discussed.
- Notes on the **Advanced Safe Train Positioning** component:
  - The ASTP component is pictured as a separate component, to be specified for later targets (dashed blue).
  - As of 2025-09 no decision is made whether the Full ASTP module will be separate Interoperability Constituent or not.
    Information about the current status on ASTP can be found in paragraph 3.2.4.4.
  - For Target 1 a standardised Odometry-interface for testing and enhanced odometry performance and robustness will be specified,
  - The BTM module with its current interfaces is pictured in this figure allocated to the ETCS-OB as is the current situation, but this allocation is still "pending" in the Full ASTP Architecture variants [Ref.17].
- **Automatic Train Operation** (ATO Trackside and ATO-On Board) is limited to ATO up to GoA2 in Target 1.
- The interpretation of SUBSET-149 **Online Monitoring System** that has been used in this Logical Architecture is:
  - that SUBSET-149 defines three types of interfaces:
    - Re-use of the existing SUBSET-27 for monitoring of ETCS-OB.
    - Use of SUBSET-140 for monitoring of ATO-OB.
    - A generic interface definition for exchanging monitoring messages.
  - Only the first two of these interfaces are mentioned in this logical architecture.
    This is in accordance with the explanation given by the CCS TSI Application guide [Ref.5]:
    " *The current version of SUBSET-149 identifies monitoring data generated by ERTMS/ETCS and*

ERTMS/ATO on-boards. The SUBSET-149 does not cover all monitoring data, so future evolutions can include additional data (i.e. related to RST-functionality) as well as information generated by other devices. For the ETCS application, SUBSET-027 is used as the main set of monitoring data to be used within the OMS. For the ATO application, SUBSET-140 is used as the main set of recording and monitoring data to be used for the OMS".

3.2.1.2 CCS-OB Actors and External Interfaces overview

The actors of the CCS-OB are listed below as work items. Each actor is listed with its name, a description, reference interfaces and associated specifications, when these are available.

Note: a harmonised set of components and actors has to be established at CCS level, in order to converge on ontology. The list of actors below is a proposal of Train CS domain, to be discussed further at System Pillar level.

Voice Communication System

The Voice Communication System (VCS) is the trackside counterpart to the Cabin Voice Radio (CVR) and provides all required functionalities on trackside to establish and answer voice calls between On-Board staff and trackside staff

Reference interface:

TSI CCS 2023 - 4.2.4.2

Train Control & Monitoring System (TCMS)

Reference interfaces:
TSI CCS 2023 - 4.3.2 - Interface to the Rolling Stock Subsystem:
SUBSET-034/119
SUBSET-139

Note: sometimes additional proprietary interfaces to TCMS can be needed.

System Pillar specifications :
System Concept_Train Integrity and Train Length - Part A WP3_1

Shared Cyber-Security Services

A collection of standard security interfaces (SSIs) of central security functions accessible for all Secure Components in the automation solution. The realisation of the Shared Cybersecurity Services (SCS) implements the requirements of the Secure Component Specification as they are considered as Secure Components as well.

The interfaces from Secure Components to Shared Cybersecurity Service are identified by SSI-<service name>.

The Shared Cybersecurity Services implementations are identified by SCS-<service name>.

Reference interfaces:
ERTMS End-to-End Security:
SUBSET-146

System Pillar Cybsersecurity specifications :
21 Secure Communication Specification
22 Shared Cybersecurity Services Specification

Radio In-fill Unit
A unit which provides a semi-continuous infill function via GSM-R.

Reference interfaces:
TSI CCS 2023 - 4.2.5 - ETCS Interoperability Airgap:
SUBSET-026
SUBSET-037

European Trackside Protection System / Radio Block Centre
Definition of European Trackside Protection System: SPT2TRAFFIC-8839
Definition of Radio Block Centre: A centralised safety unit that receives train position information via radio and sends movements authorities via radio to trains.

Reference interface:
TSI CCS 2023 - 4.2.5 - ETCS Interoperability Airgap:
SUBSET-026
SUBSET-037
SUBSET-146

Online Monitoring System on-board
The On Board part of the Online Monitoring System as defined in SUBSET-149

Reference interfaces:
TSI CCS 2023 - Application guide:
SUBSET-149
SUBSET-027
SUBSET-140

On-board Recording Device (ORD)
A device (outside the ERTMS/ETCS on-board equipment) that records and stores data for subsequent analysis (e.g. further to a train accident).

Reference interfaces:
TSI CCS 2023 - 4.2.14 - Interface to Data Recording for Regulatory Purposes :
SUBSET-027

National System trackside
Trackside components of the National System as provided in SUBSET-026 §2.5.3 ERTMS/ETCS reference architecture.

Interfaces between on-board and trackside national systems are specific and out of scope of harmonization.

Key Management Centre
The entity responsible for key management functions in a KM domain.

Reference interfaces:
TSI CCS 2023 - 4.2.8 - Key Management:
SUBSET-114
SUBSET-137
SUBSET-146

Euroloop
Loop compliant with the ERTMS/ETCS specification

Reference interfaces:
TSI CCS 2023 - 4.2.5 - ETCS Interoperability Airgap:
SUBSET-026
SUBSET-044

Eurobalise
Balise compliant with the ERTMS/ETCS specification

Reference interfaces:
TSI CCS 2023 - 4.2.5 - ETCS Interoperability Airgap:
SUBSET-026
SUBSET-036

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.

Reference interfaces:
TSI CCS 2023 - 4.2.5 - ATO Interoperability Airgap:
SUBSET-126
SUBSET-146
SUBSET-148

Driver
As defined in Article 3 of Directive 2007/59/EC.

Reference interfaces:
TSI CCS 2023 - 4.2.12 - ERA Driver Machine Interface:
ERA_ERTMS_015560

3.2.2 CCS-OB functions

3.2.2.1 Introduction

The definition of the CCS-OB functions and their breakdown into sub-functions, have been done in a stepwise approach, taking into account state-of-art applicable information (TSI CCS 2023 and Appendix A), as well as novelties produced within Innovation Pillar.

The goal of Train CS domain is to propose a first set of functions for the CCS-OB, with Target 1 as main focus, by consolidating the existing Automatic Train Control functions distributed within TSI CCS 2023, SUBSET-026 and SUBSET-125, while identifying the functions for which a potential re-allocation will be necessary in the future, in the context of on-board modularity. This functional breakdown structure will facilitate the future arbitration of the re-allocation of the functions, it's impacts on existing documents, and preparation work of Change Requests.

The approach followed to produce this Functional Breakdown Structure (FBS) consists in multiple iterations in order to:

1. Converge on existing CCS-OB functions, traced to either TSI CCS 2023 legal document, or SUBSETs,
2. Derive these functions into sub-functions,
3. Identify leaf functions : functions that are no more decomposable in the CCS-OB perimeter, and therefore allocatable to a logical component of the CCS-OB,
4. Discuss the possible logical allocation of the leaf functions, in particular the ones in the focus for Target 1, and identify the pros and cons of possible allocations leading to logical architecture variants proposed in this document.

NOTE: some non leaf functions can already be allocated to logical components when these functions are traced to a SUBSET for which there is no ambiguity in terms of logical allocation (SUBSET-125 for example).

3.2.2.2 Functional Breakdown structure

The CCS-OB functions are provided in the breakdown structure below, including the source of the function (TSI CCS, SUBSETs, Innovation Pillar documents), and it's allocation to a logical component. For some functions, the allocation is still under analysis and is therefore mentioned as "pending".

Note to System Pillar Polarion users: This table contains implicit engineering information, as the numbering of the functions implicitely providing the breakdown, or the column allocating a function to a logical component. This implicit information has been made explicit for all work items of this table, by adding the logical links between the work items (e.g. parent and child function in the context of functional allocation).

Number	Logical Function	Source	Allocated to
1	SPT2TRAIN-5597 - Provide Automatic Train Protection and cab signalling	TSI CCS 2023 4.2.2	SPT2TRAIN-6368 - CCS On-board
1.1	SPT2TRAIN-6371 - Set the train characteristics (e.g. maximum train speed, braking performance)	TSI CCS 2023 4.2.2 (1)	SPT2TRAIN-6367 - ETCS-OB
1.2	SPT2TRAIN-6372 - Select the supervision mode on the basis of information from trackside	TSI CCS 2023 4.2.2 (2)	SPT2TRAIN-6367 - ETCS-OB
1.3			Pending

Number	Logical Function	Source	Allocated to
	SPT2TRAIN-6373 - Perform odometry functions	TSI CCS 2023 4.2.2 (3)	
1.3.1	SPT2TRAIN-6374 - Provide safe train speed	FP2 R2DATO D21.1	Pending
1.3.2	SPT2TRAIN-6375 - Provide safe train acceleration	FP2 R2DATO D21.1	Pending
1.3.3	SPT2TRAIN-6376 - Provide odometry information	FP2 R2DATO D21.1	Pending
1.4	SPT2TRAIN-6377 - Locate the train in a coordinate system based on Eurobalise locations	TSI CCS 2023 4.2.2 (4)	Pending
1.5	SPT2TRAIN-6378 - Calculate the dynamic speed profile for its mission on the basis of train characteristics and of info from trackside	TSI CCS 2023 4.2.2 (5)	SPT2TRAIN-6367 - ETCS-OB
1.6	SPT2TRAIN-6379 - Supervise the dynamic speed during the mission	TSI CCS 2023 4.2.2 (6)	SPT2TRAIN-6367 - ETCS-OB
1.7	SPT2TRAIN-6380 - Provide the intervention function	TSI CCS 2023 4.2.2 (7)	SPT2TRAIN-6367 - ETCS-OB
1.8	SPT2TRAIN-6381 - Manage information of completeness of the train (Train integrity and safe consist length information)	TSI CCS 2023 4.2.2 (4') (a)	SPT2TRAIN-6367 - ETCS-OB
1.9	SPT2TRAIN-6382 - Manage information about Cold movement detection	TSI CCS 2023 4.2.2 (4') (b)	Pending
2	SPT2TRAIN-5598 - Provide Automatic Driving up to GoA2 over ETCS	TSI CCS 2023 4.2.18	SPT2TRAIN-6366 - ATO-OB
2.1	SPT2TRAIN-6383 - Provide the driving function	SUBSET-125 7.1	SPT2TRAIN-6366 - ATO-OB
2.2	SPT2TRAIN-6384 - Manage Timing Points	SUBSET-125 7.2	SPT2TRAIN-6366 - ATO-OB
2.3	SPT2TRAIN-6385 - Add/skip stopping point	SUBSET-125 7.3	SPT2TRAIN-6366 - ATO-OB
2.4	SPT2TRAIN-6386 - Hold train at a stopping point	SUBSET-125 7.4	SPT2TRAIN-6366 - ATO-OB
2.5	SPT2TRAIN-6387 - Manage low adhesion	SUBSET-125 7.5	SPT2TRAIN-6366 - ATO-OB
2.6	SPT2TRAIN-6388 - Manage time	SUBSET-125 7.6	SPT2TRAIN-6366 - ATO-OB
2.7	SPT2TRAIN-6389 - Manage reporting	SUBSET-125 7.7	SPT2TRAIN-6366 - ATO-OB

Number	Logical Function	Source	Allocated to
2.8	SPT2TRAIN-6390 - Manage data consistency	SUBSET-125 7.8	SPT2TRAIN-6366 - ATO-OB
2.9	SPT2TRAIN-6391 - Manage ATO system version	SUBSET-125 7.9	SPT2TRAIN-6366 - ATO-OB
2.10	SPT2TRAIN-6392 - Determine ATO-OB train position	SUBSET-125 7.10	SPT2TRAIN-6366 - ATO-OB
2.11	SPT2TRAIN-6393 - Perform Driving Advisory System functions	SUBSET-125 7.11	SPT2TRAIN-6366 - ATO-OB
2.12	SPT2TRAIN-6394 - Perform ATO-OB self-test	SUBSET-125 7.12	SPT2TRAIN-6366 - ATO-OB
2.13	SPT2TRAIN-6395 - ATO-OB Data acquisition	SUBSET-125 7.13	SPT2TRAIN-6366 - ATO-OB
3	SPT2TRAIN-5599 - Communicate with the CCS Trackside Subsystem	TSI CCS 2023 4.2.2	SPT2TRAIN-6368 - CCS On-board
3.1	SPT2TRAIN-6396 - Eurobalise data transmission	TSI CCS 2023 4.2.2 (1')(a)	Pending
3.2	SPT2TRAIN-6397 - Euroloop data transmission	TSI CCS 2023 4.2.2 (1')(b)	SPT2TRAIN-6367 - ETCS-OB
3.3	SPT2TRAIN-6398 - Radio data transmission for radio infill	TSI CCS 2023 4.2.2 (1')(c)	SPT2TRAIN-6367 - ETCS-OB
3.4	SPT2TRAIN-6399 - Radio data transmission	TSI CCS 2023 4.2.2 (1')(d), 4.2.18 (1)	SPT2TRAIN-6368 - CCS On-board
3.5	SPT2TRAIN-6400 - KER balise data transmission	TSI CCS 2023 4.2.6.1, SUBSET-101	Pending
3.6	SPT2TRAIN-6401 - Key Management	TSI CCS 2023 4.2.8	SPT2TRAIN-6367 - ETCS-OB
4	SPT2TRAIN-5600 - Communicate with the driver	TSI CCS 2023 4.2.2	SPT2TRAIN-6369 - Multi-Display System
4.1	SPT2TRAIN-6402 - Enter ETCS and ATO information into the on-board by the driver	TSI CCS 2023 4.2.12	SPT2TRAIN-6369 - Multi-Display System
4.2	SPT2TRAIN-6403 - Enter Railway Mobile Radio (RMR) information into the on-board by the driver	TSI CCS 2023 4.2.13	SPT2TRAIN-6369 - Multi-Display System

Number	Logical Function	Source	Allocated to
4.3	SPT2TRAIN-6404 - Provide ETCS information to the driver	TSI CCS 2023 4.2.12	SPT2TRAIN-6369 - Multi-Display System
4.4	SPT2TRAIN-6405 - Provide ATO information to the driver	TSI CCS 2023 4.2.12	SPT2TRAIN-6369 - Multi-Display System
4.5	SPT2TRAIN-6406 - Provide NTC information to the driver	ERA_ERTMS_015560	SPT2TRAIN-6369 - Multi-Display System
4.6	SPT2TRAIN-6407 - Provide Railway Mobile Radio (RMR) information to the driver	TSI CCS 2023 4.2.13	SPT2TRAIN-6369 - Multi-Display System
5	SPT2TRAIN-5601 - Communicate with the STM	TSI CCS 2023 4.2.2 (3')	SPT2TRAIN-6367 - ETCS-OB
5.1	SPT2TRAIN-6408 - Manage the STM output	CCS TSI 2023: 4,2,2,(3'),(a)	SPT2TRAIN-6367 - ETCS-OB
5.2	SPT2TRAIN-6409 - Providing data to be used by the STM	CCS TSI 2023: 4,2,2,(3'),(b)	SPT2TRAIN-6367 - ETCS-OB
5.3	SPT2TRAIN-6410 - Managing STM transitions	CCS TSI 2023: 4,2,2,(3'),(c)	SPT2TRAIN-6367 - ETCS-OB
6	SPT2TRAIN-6106 - Monitor health equipment and provide degraded mode support	TSI CCS 2023 4.2.2 (5')	SPT2TRAIN-6368 - CCS On-board
6.1	SPT2TRAIN-6411 - Initialise the on-board ETCS functionality	CCS TSI 2023: 4,2,2,(5'),(a)	SPT2TRAIN-6367 - ETCS-OB
6.2	SPT2TRAIN-6412 - Provide degraded mode support	CCS TSI 2023: 4,2,2,(5'),(b)	SPT2TRAIN-6367 - ETCS-OB
6.3	SPT2TRAIN-6413 - Isolate the on-board ETCS functionality	CCS TSI 2023: 4,2,2,(5'),(c)	SPT2TRAIN-6367 - ETCS-OB
7	SPT2TRAIN-6107 - Support data recording for regulatory purposes	TSI CCS 2023 4.2.2 (6')	SPT2TRAIN-6367 - ETCS-OB
7.1	SPT2TRAIN-6414 - Record juridical data to the on-board recording device	SUBSET-026 3.20.1.2; SUBSET-027	SPT2TRAIN-6367 - ETCS-OB
8	SPT2TRAIN-6108 - Forward information/orders and receiving state information from rolling stock	TSI CCS 2023 4.2.2 (7'), 4.2.18	SPT2TRAIN-6368 - CCS On-board
8.1			

Number	Logical Function	Source	Allocated to
	SPT2TRAIN-6415 - Communication between ETCS and rolling stock	TSI CCS 2023 4.2.2 (7) ,4.2.18.(3)	SPT2TRAIN-6367 - ETCS-OB
8.2	SPT2TRAIN-6416 - Communication between ATO and rolling stock	TSI CCS 2023 4.2.18 (3), 4.2.18.(4)	SPT2TRAIN-6366 - ATO-OB
9	SPT2TRAIN-6109 - Support Shared-services		SPT2TRAIN-6368 - CCS On-board
9.1	SPT2TRAIN-6417 - Online Monitoring Functions	SUBSET-149	SPT2TRAIN-6368 - CCS On-board
9.1.1	SPT2TRAIN-6418 - Monitoring for ETCS	SUBSET-27	SPT2TRAIN-6367 - ETCS-OB
9.1.2	SPT2TRAIN-6419 - Monitoring for ATO	SUBSET-140	SPT2TRAIN-6366 - ATO-OB
9.2	SPT2TRAIN-6420 - Security Services	SP PRAMSS Shared Cybersecurity Services	Pending
9.3	SPT2TRAIN-6421 - Train Time and Location Service (TTLS)	SUBSET-147	Pending
10	SPT2TRAIN-6110 - Locate the train in a 3D coordinate system		SPT2TRAIN-6368 - CCS On-board
10.1	SPT2TRAIN-6422 - Provide 3D position and uncertainty	FP2 R2DATO D21.1	Pending
10.2	SPT2TRAIN-6423 - Provide 3D velocity and uncertainty	FP2 R2DATO D21.1	Pending
10.3	SPT2TRAIN-6424 - Provide 3D acceleration and uncertainty	FP2 R2DATO D21.1	Pending
10.4	SPT2TRAIN-6425 - Provide 3D attitude and uncertainty	FP2 R2DATO D21.1	Pending
10.5	SPT2TRAIN-6426 - Provide virtual reference location information	FP2 R2DATO D21.1	Pending

3.2.3 CCS-OB Logical Architecture view

In the figure below the previous logical architecture external view is extended with the internal CCS-OB logical components and interfaces, including results of current studies.

Note: the scope of the Logical Architecture view is conform with the scope as mentioned in the introduction, so Target 1 specifications, including results of the current studies which might be studies for later targets (ASTP, MDS, EGNOS, etc.).

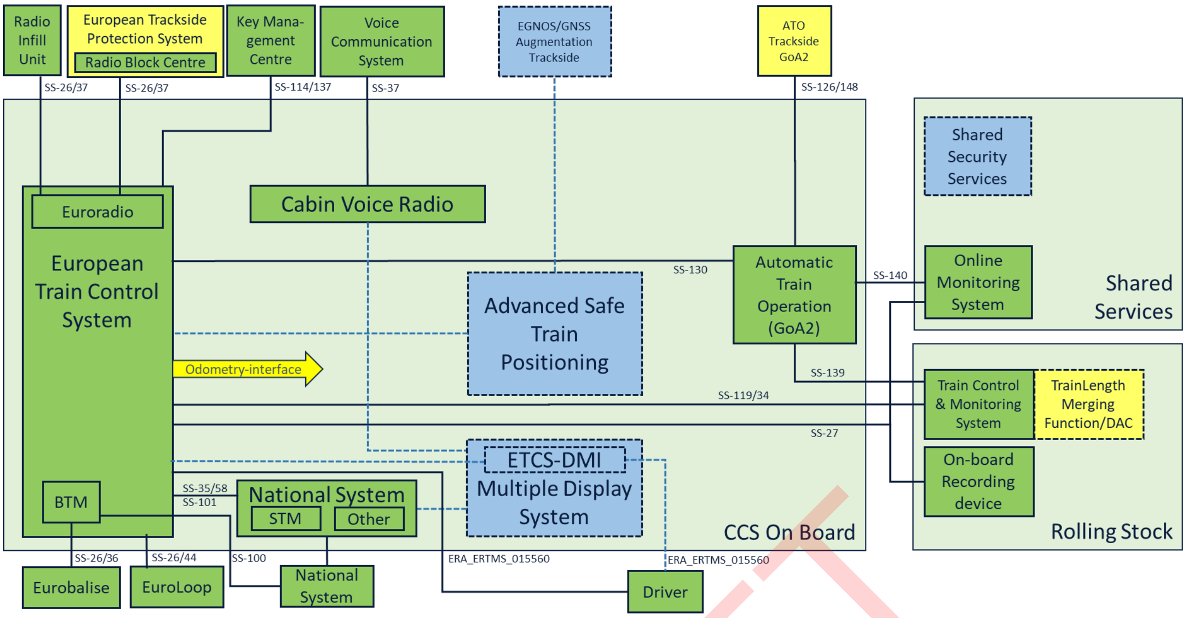


Figure 7 Logical Architecture view Target 1, including current studies

Explanations of the elements in the Logical Architecture view:

- **Green:** Actors and Logical Components conform current TSI 2023.
  Black Interfaces: Current Interfaces, conform current TSI 2023.
  Yellow: Actors and Logical Components to be specified/updated for Target 1.
  Blue/dashed: Actors, Logical Components and Interfaces in study, as part of the current studies, but meant for later Targets.
- Note on **Train Length Merging Function**: the exact location of the Train Length Merging Function is still discussed.
- Notes on the **Advanced Safe Train Positioning** component:
  - The ASTP component is pictured as a separate component, to be specified for later targets (dashed blue).
  - As of 2025-09 no decision is made whether the Full ASTP module will be a separate Interoperability Constituent or not. Information about the current status on ASTP can be found in paragraph 3.2.4.4.
  - For Target 1 a standardised Odometry-interface for testing and enhanced odometry performance and robustness will be specified,
  - The BTM module with its current interfaces is pictured in this figure allocated to the ETCS-OB as is the current situation, but this allocation is still "pending" in the Full ASTP Architecture variants [Ref.17].
- **Train Integrity Management**: the current concept [Ref.29] is showing a Train Length Merging Function (TLMF) that merges two independent Length Measurements coming from the Rolling Stock with the TLMF as a new functionality within the Rolling Stock scope and a change of the SUBSET-119 application interface.
- **Multi Display System**: the current concept [Ref.23] is showing a re-allocation of the ETCS-DMI (including National System- and ATO-DMI) and a re-allocation of the Cabin Voice Radio-DMI to a new Multi Display System. In a later stage all applications used on the cabin desk, like TCMS and others, might be integrated to this new flexible concept.
  The Multi Display System is a new concept for flexible configuring of an extending amount of cabin-applications over a limited set of display-devices with more possibilities for fail-over and standardising display-devices.

- **EGNOS/GNSS Augmentation**: this can become a new interface in a future target and the concept advice from the current study on EGNOS is to connect via FRMCS [Ref.15].
- Naming: the extension "On Board" for the Logical Components within the scope of CCS-On Board is left away for the sake of simplifying texts and lay-outs.

3.2.4 CCS-OB logical components

In this section, logical components of the CCS-OB are discussed. The logical components are listed as work items, with a definition, and functional apportionment.

Note: although the section 3 is discussing on the CCS-OB Target 1, some logical components studied by Train CS tasks are looking ahead of Target 1. Therefore, the reader is advised that content at logical component level in this section (especially on ASTP and MDS) is not limited to Target 1.

3.2.4.1 Granularity principles

The logical components follow the guiding principles of the System Concept_CCS - Granularity Concepts and Principles - Main.

The current level of details that this document is providing is the functional apportionment. For some logical component, several variants of functional apportionment are proposed. These are results coming from the different Train CS task groups.

Functional apportionment
Functional apportionment is the clear assignment of functions to subsystems. It is an architectural choice supporting the ability to replace a subsystem of supplier A by a subsystem of supplier B both compliant with a given FIS.

3.2.4.2 European Train Control System On-board (ETCS-OB)

European Train Control System on-board (ETCS-OB)

As per SUBSET-023, ETCS is the control command part of ERTMS.

The potential re-allocations of the current ETCS-OB functions for the Odometry, the Balise transmission Module (BTM) and the Driver Machine Interface function are discussed in the paragraphs on the Logical Components for:

- Advanced Safe Train Positioning (potential re-allocation of Odometry and BTM), and
- Multi Display System (potential re-allocation of the the Driver Machine Interface function).

3.2.4.3 Automatic Train Operation On-board (ATO-OB)

ATO-OB is the on-board component of ERTMS/ATO defined in the clause 5.1.1.2 of SUBSET-125 v1.0.0:

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.

SUBSET-125 version 1.0.0

No reallocations of functions for ATO-OB are foreseen for Target 1.

3.2.4.4 Advanced Safe Train Positioning (ASTP)

3.2.4.4.1 Status

For the development of the Advanced Safe Train Positioning (ASTP) several architecture variants for Basic and Full ASTP have been discussed [Ref.17].

The current status coming from the Train CS task group on ASTP [Ref.39] is:

- For Target 1 the architecture variant 2 for Basic ASTP, including a generic interface with Odometry information for testing and external users, is agreed.
- For Target 2 no decision on the architecture variant for Full ASTP is made, which means that all Full ASTP architecture variants as described in [Ref.17] are still open for further investigation.

3.2.4.4.2 Basic ASTP for Target 1

A technical comparison of the different variants in [Ref.17] was performed in 2025 by a group of experts of Train CS domain. The aim was to determine whether the increased complexity resulting from the introduction of a new Interoperability Constituent was offset by a clear added value.

The main conclusions of this study were:

- Introducing a new ASTP Interoperability Constituent at the Basic ASTP stage is not deemed beneficial considering that all major suppliers already have existing certified EVCs. Introducing new IC would mean to modify existing EVCs without improvement of performance or major technical benefit.
- The permission to use grouping does not alleviate the impact of creating new Interoperability Constituents (e.g. ASTP) from existing ones (e.g. ETCS-OB).
- The transition from a monolithic approach to a distributed approach will also raise the question of integration responsibility that may be transferred to the integrator.

It has been concluded that the logical architecture identified as variant 2 for the Basic ASTP step (figure below) is preferred from a technical standpoint regarding the Basic ASTP step in the next TSI release.

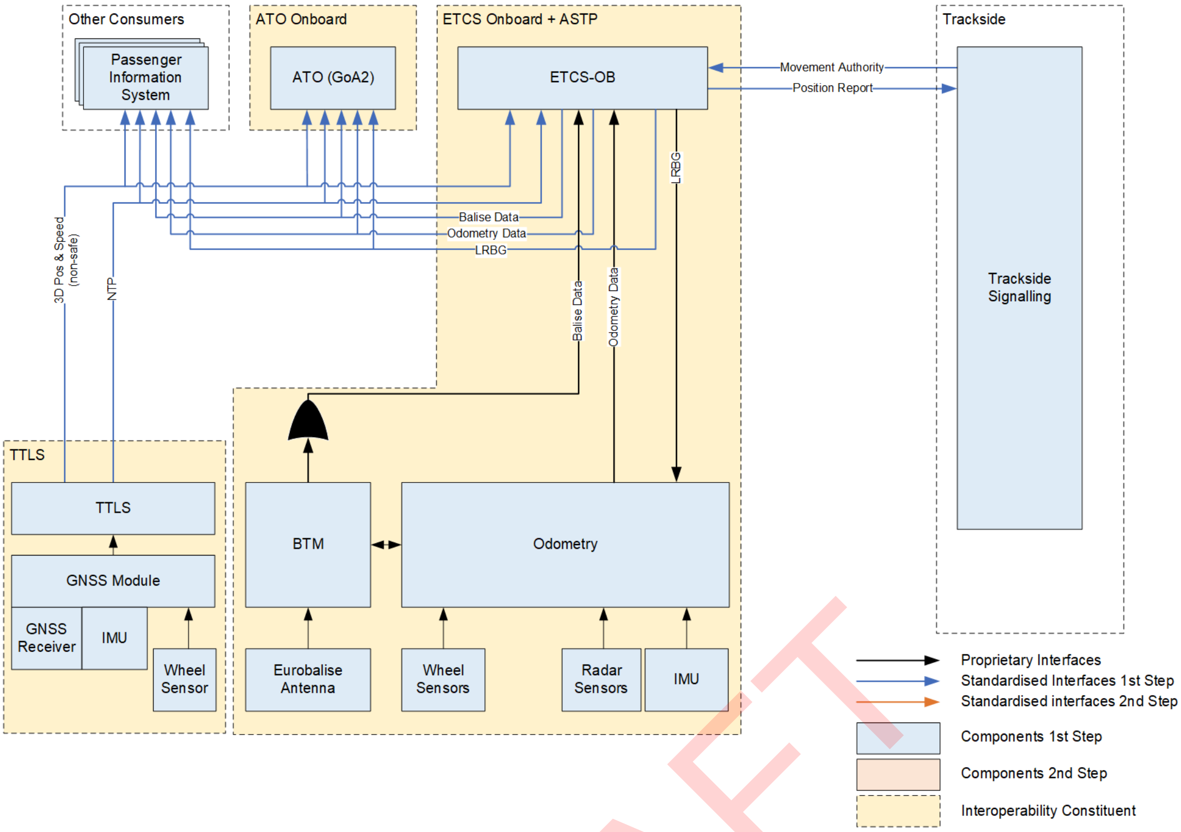


Figure 8 Basic ASTP for Target 1

For a full description of the figure above, see [Ref.17].

Not represented in this figure is the Odometry-interface for testing and external users. This interface needs to be specified in the coming period and will be added in a new version of the CCS-OB architecture.

3.2.4.4.3 Full ASTP for Target 2

For Target 2 no decision on the architecture variant for Full ASTP is made, which means that all Full ASTP architecture variants as described in [Ref.17] are still open for further investigation.

Four of the most characteristic Full ASTP architecture variants are shown below to give an impression of the variants discussed. For more information on the details of these variants, see [Ref.17].

Full ASTP, variant 1
The Full ASTP variant 1 is the baseline scenario. In this variant the odometry/ASTP function as well as BTM function is allocated to the ETCS-OB interoperability constituent with proprietary interfaces in between.

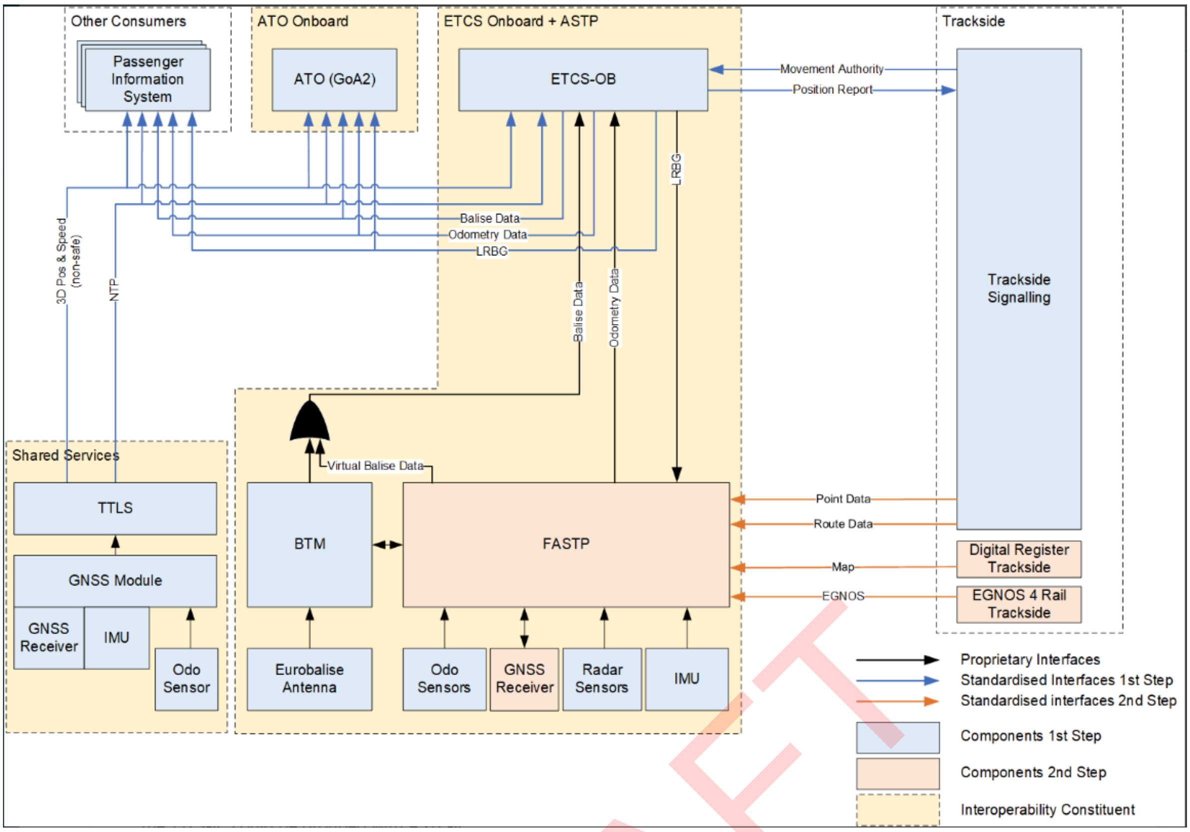


Figure 9 Full ASTP for Target 2, variant 1 [Ref.17]

Full ASTP, variant 2

In the Full ASTP variant 2 the odometry/ASTP function is a separate Interoperability Constituent, while the BTM function is allocated to the ETCS-OB interoperability constituent with proprietary interfaces in between. These separate interoperability constituents can however be grouped as one interoperability constituent, which means that they can still be deployed on the same hardware platform(s) but with standardised interfaces to improve upgradeability.

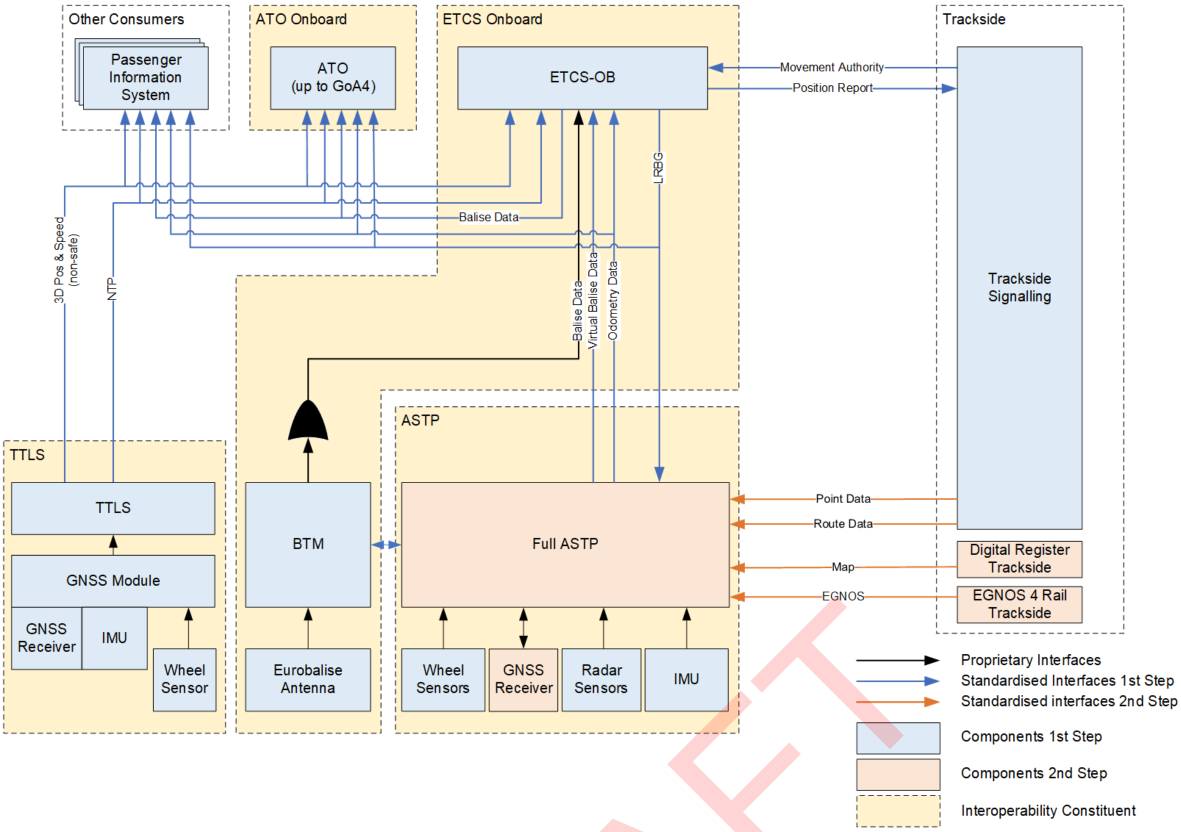


Figure 10 Full ASTP for Target 2, variant 2[Ref.17]

Full ASTP, variant 4

In the Full ASTP variant 4 both the odometry function and the BTM function are combined in a separate Interoperability Constituent. These separate interoperability constituents can however be grouped as one interoperability constituent, which means that they can still be deployed on the same hardware platform(s) but with standardised interfaces to improve upgradeability.

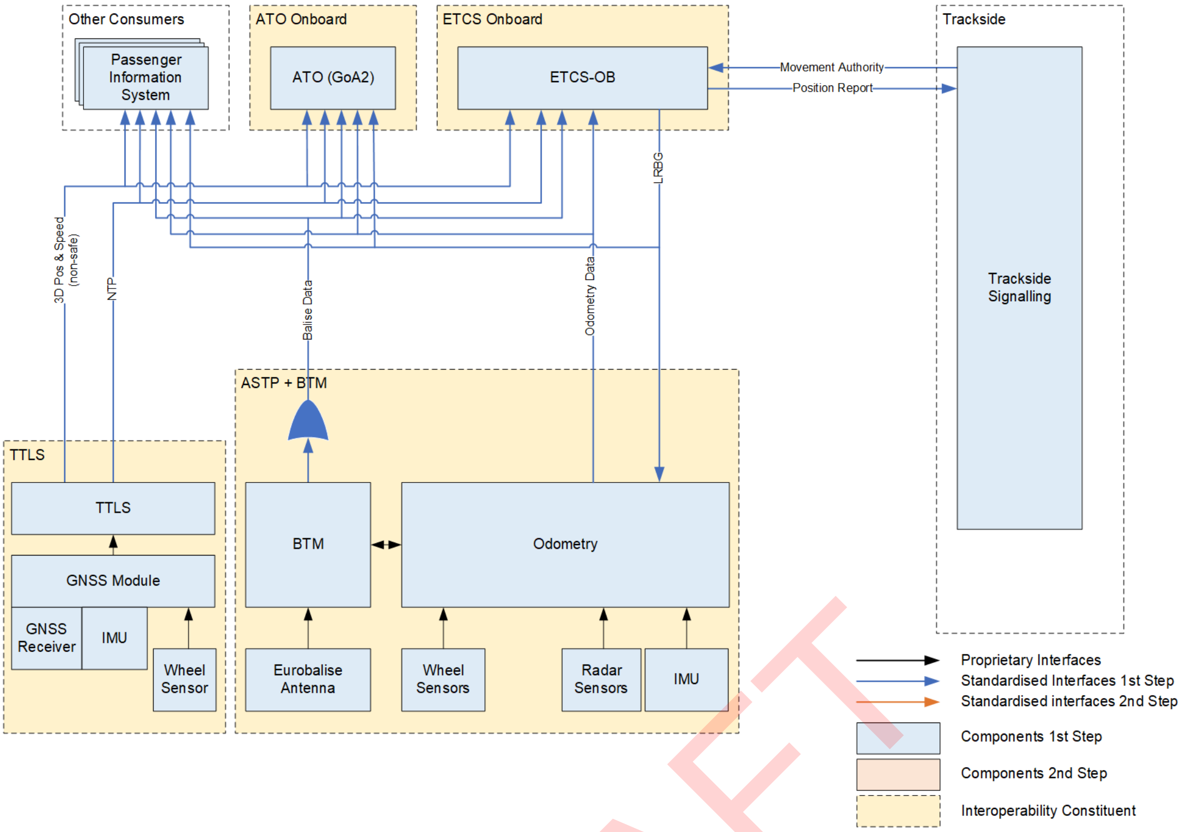


Figure 11 Full ASTP for Target 2, variant 4 [Ref.17]

Full ASTP, variant 6

In the full modular variant 6 the current Odometry as well as the current BTM function that are now in the ETCS interoperability constituent are re-allocated to separate interoperability constituents. These separate interoperability constituents can however be grouped as one interoperability constituent, which means that they can still be deployed on the same hardware platform(s) but with standardised interfaces to improve upgradeability.

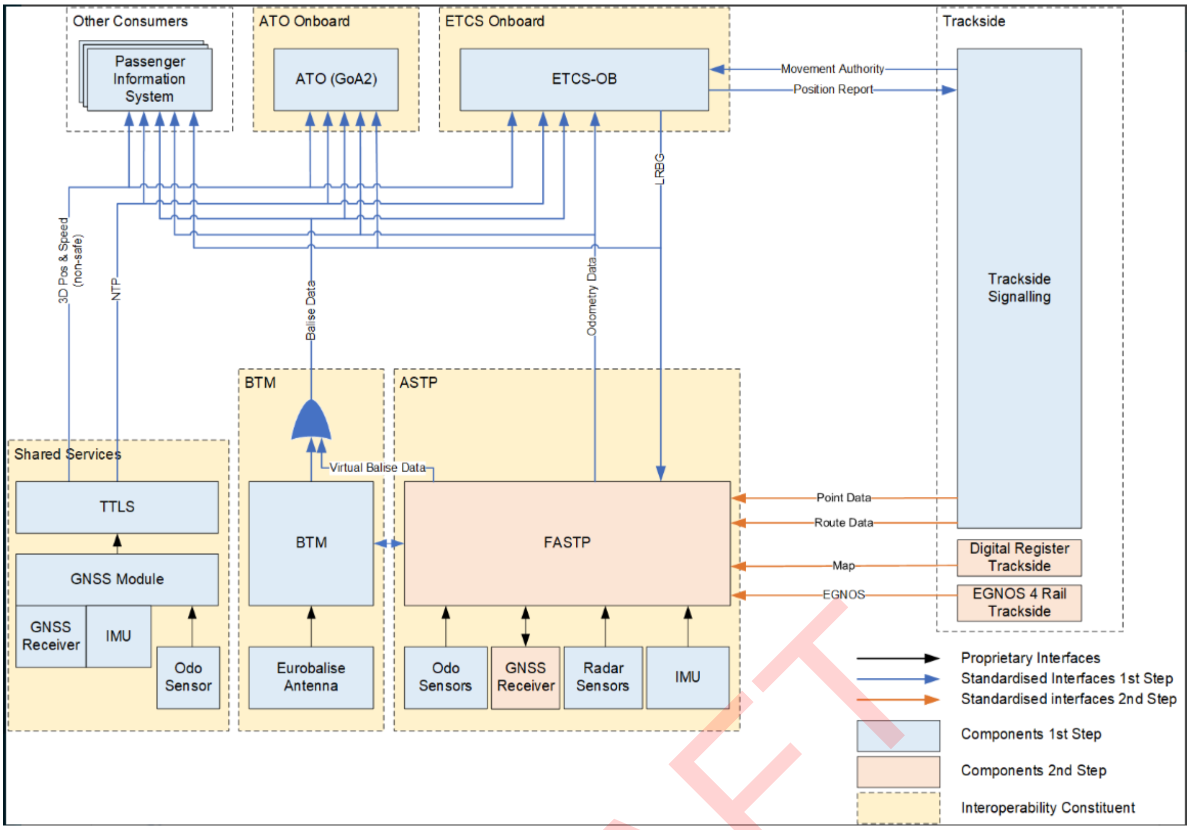


Figure 12 Full ASTP for Target 2, variant 6 [Ref.17]

3.2.4.4.4 GNSS Augmentation (On Board)

One of the functions within the Full ASTP (Target 2) will most probably be the GNSS Augmentation On Board (GA-OB).

GNSS Augmentation is to be considered a vital service when GNSS is used by full ASTP to bound the odometry error and to re-calibrate the train confidence interval.
The GNSS Augmentation dissemination architecture [Ref.30] has been published for review by the Train CS task group on EGNOS4Rail and the current status is that the preferred option for the GNSS Augmentation dissemination architecture is option 2.

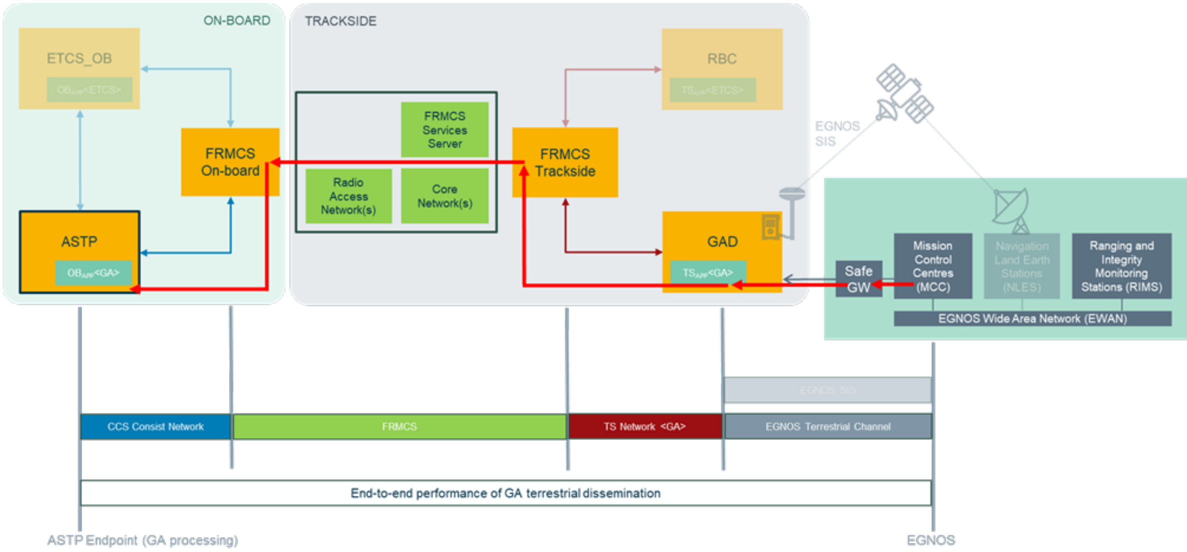


Figure 13 GNSS Augmentation, preferred option 2

For the scope of CCS-OB architecture this means that the GNSS Augmentation data will be coming from the Logical Actor GNSS Augmentation - Trackside (GA-TS) via FRMCS to the GNSS Augmentation - On Board (GA-OB) as a Logical Function within ASTP.

The Logical Function GA-OB (within ASTP) and the Logical Interface between GA-TS (within GAD) and GA-OB (within ASTP) are described in the SRS, EUG Solution for Enhanced Onboard Localisation Change Request (CR1368) [Ref.31] and is used for further development on EGNOS4Rail.

The logical information which are exchanged between trackside and On Board are mainly related to navigation info such as satellite ephemeris, clock correction, ionospheric correction, signal in space health and data validity status. This in addition to the protocol ensuring session management and navigation data request.

3.2.4.5 Multi Display System (MDS)

The Multi Display System is aiming to:

- Provide a more flexible way to add new applications to the limited set of display devices in the cabin,
- Provide fail-over functionalities in case of display failures, and
- Standardise the display devices for easier maintenance and upgrades

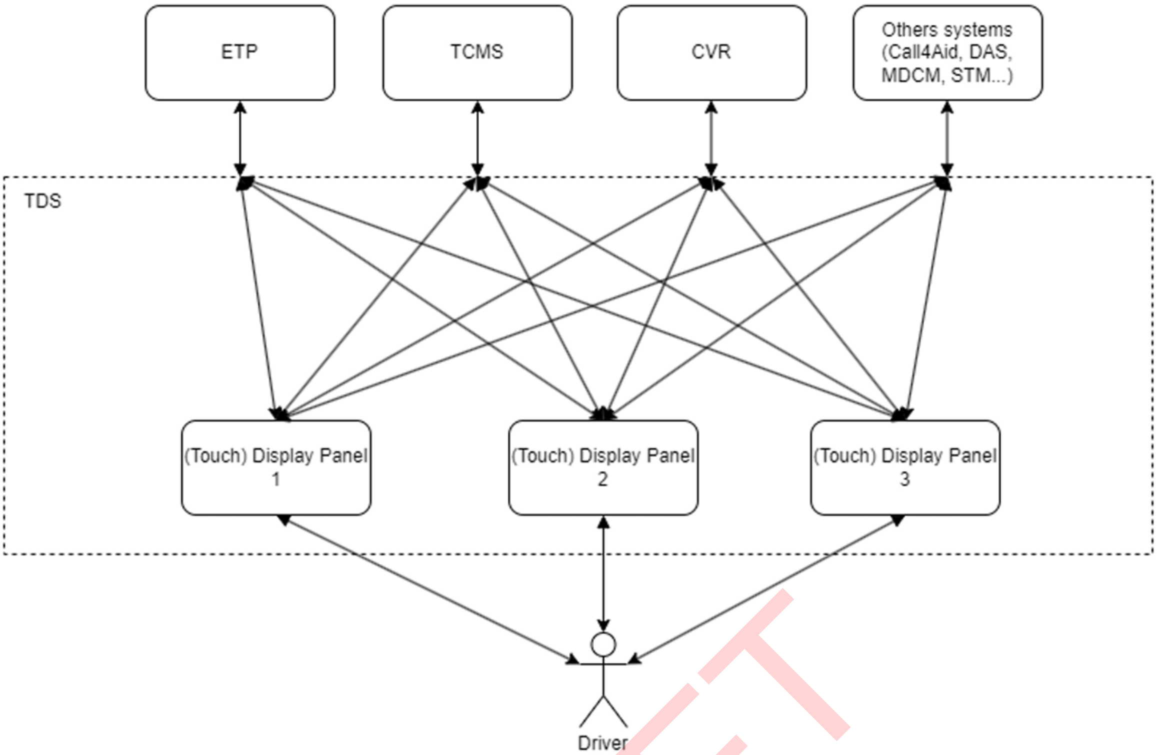


Figure 14 Multi Display System Concept [Ref.23]

Explanation of the figure on the MDS concept:

- Terms used in the figure come from OCORA Train Display System Concept {Ref.38]:
    - TDS (OCORA) is synonym for MDS (System Pillar)
    - ETP (OCORA) is synonym for ETCS-OB (TSI/System pillar)
- The figure shows mainly the principle of the flexible distribution of applications over a limited set of (standardised) display devices.
  The number of Display Panels shown as well as the number of cabin applications shown is not representative for the future implementations.

3.2.4.5.1 Allocated functions

The allocated functions are all subfunctions as mentioned in SF SPT2TRAIN-5600 - Communicate with the driver

3.2.4.5.2 Current status of the MDS concept coming from the Train CS task group on MDS

To achieve the goals as mentioned in the description, two functional allocations have been considered [Ref.23]:

1. Functional allocation with the presentation logic kept within the kernel system and the lay-out engine and display manager within the Multi Display System. As for Cabin Voice Radio, TCMS and NTC in the figure below.

2. Functional allocation with the presentation logic, lay-out engine and the display manager within the Multi Display System. As for ETCS-OB (ETP) in the figure below.

The Logical and Physical Architecture for the MDS System Concept document [Ref.23] is shown in the figure below:

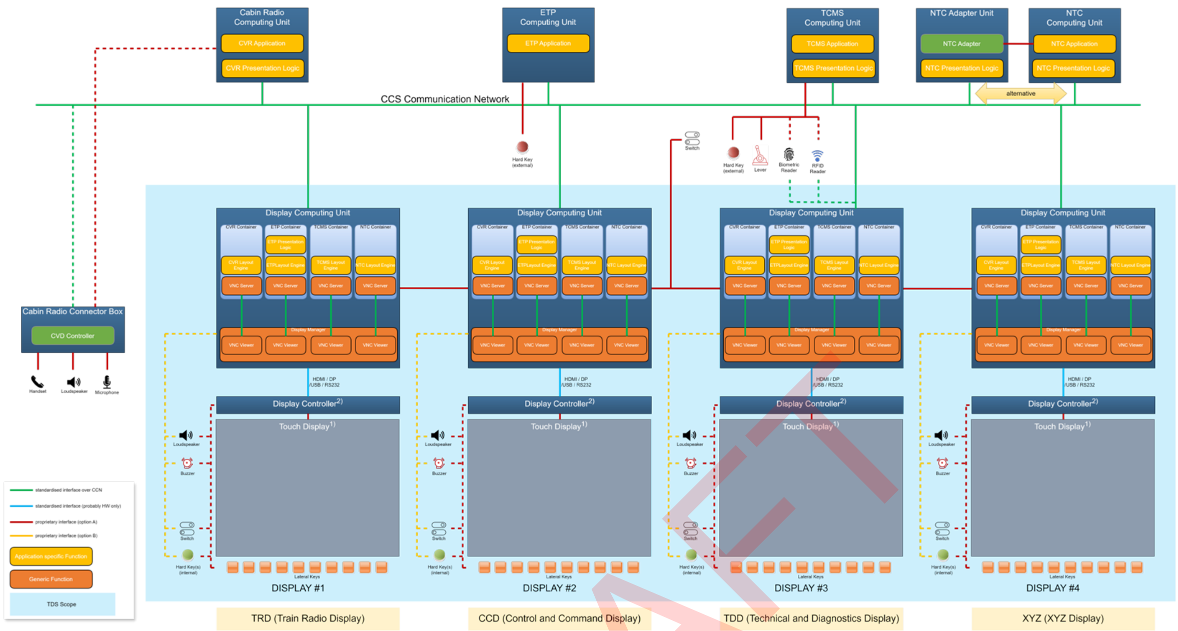


Figure 15 Logical and Physical Architecture Multi Display System Concept [Ref.23]

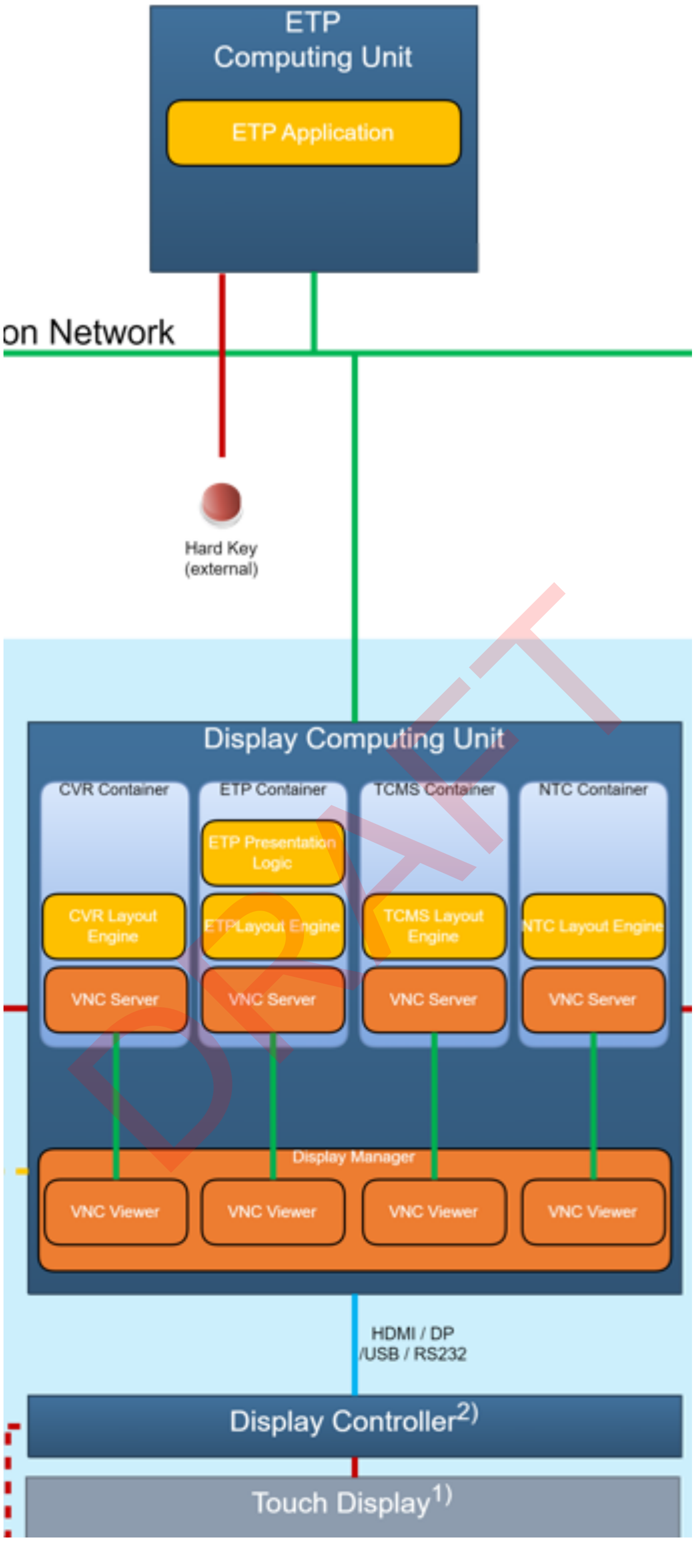


Figure 16 Example for the re-allocation of the ETCS-DMI to the Multi Display System [Ref.23]

Explanation:

- The figure shows the split between the ETCS-OB (ETP) kernel application and the ETCS-Driver Machine Interface (DMI).
- The ETCS-DMI is divided into the Presentation Logic, the Lay-out Engine, and the Viewer.

- The Display Manager arranges the different Views of the possible parallel applications over the available display devices in the cabin.

In the Logical Architecture view, the MDS concept is shown as a Logical Component MDS (dashed lines, because concept for target 1) with a re-allocation of the ETCS-DMI with a first Logical Interface to be specified.

3.2.4.6 National System

As stated in TSI CCS 2023 §4.1.2 requirements for National System on-board and for Specific Transmission Module (which enable the Class A on-board system to operate on Class B infrastructure) are the responsibility of the relevant Member State. The documents that can be used as reference for the harmonised STMs FFFIS are SUBSET-035, SUBSET-058, SUBSET-056, SUBSET-057, SUBSET-059 in version 4.0.0.

3.2.5 CCS-OB Interfaces

3.2.5.1 Introduction

In this section, the interfaces of the CCS-OB Target 1 are provided.

3.2.5.2 External interfaces

The external interfaces of the CCS-OB Target 1 are listed alongside the actors in the external view.

3.2.5.2.1 Train interface ETCS-Rolling Stock

For the train interface there are several enhancements provided in current Change Requests [Ref.32].

3.2.5.2.2 Train Length Merging Function (Train Integrity Management) for freight trains

For Train Integrity Management a Design Decision is in preparation [Ref.29], based on a Train Integrity Management concept coming from SP Task 4 (figure below).

This concept is based on:

- Two independent (SIL-2) Train Length measuring functions (Train Length Master A and Train Length Master B), and
- One Train Length Merging Function (SIL-4), which delivers the final result to the ETCS-OB for the Train Control Report.

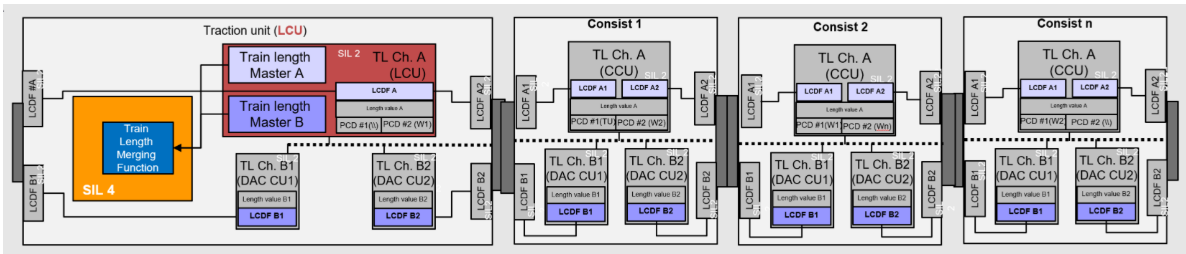


Figure 17 Train Integrity management physical view

3.2.5.3 Internal interfaces

The internal interfaces of the CCS-OB Target 1 are the following:

Automatic Train Operation (GoA2) / ETCS on-board (Subset-130)

ETCS on-board / STM (SS-035, SS-056, SS-057, SS-058, SS-101, SS-147)

3.3 CCS-OB Physical Architecture

3.3.1 Introduction

This paragraph on the CCS-OB Physical Architecture contains:

- An introduction of the two main architectural changes for Target 1:
  - Command-Control & Signalling Consist Network for CCS-OB (SUBSET-147, [Ref.20]), as developed for internal CCS-OB-interfaces and external Interfaces to the Rolling Stock unit.
  - Future Railway Mobile Communication System (FRMCS, [Ref.19]) for Train-Trackside communication, to replace all GSM-R-based communication in the future.
- A CCS-OB Physical Architecture view for Target 1 will be given, based on the current TSIs and the two main specification changes for Target 1 (CCS Consist Network and FRMCS).
- An analysis on the potential use of the standardised Computing Environment, coming from the System Pillar Computing Environment domain is done.
- An analysis on the application of the (generic) Cybersecurity specifications, coming from the System Pillar Cybersecurity domain, to the Train CS domain is done.

In this chapter related to the physical architecture, the logical components are now subsystems as per the definition provided in the Methodology section.

3.3.2 Command-Control & Signalling Consist Network (SUBSET-147)

The current Control-Command & Signalling Network for CCS-OB, version 1.0 (SUBSET-147, [Ref.20]), as developed for internal CCS-OB-interfaces and external Interfaces to the Rolling Stock unit, will be changed with a further standardisation over the lower 6 OSI-layers.

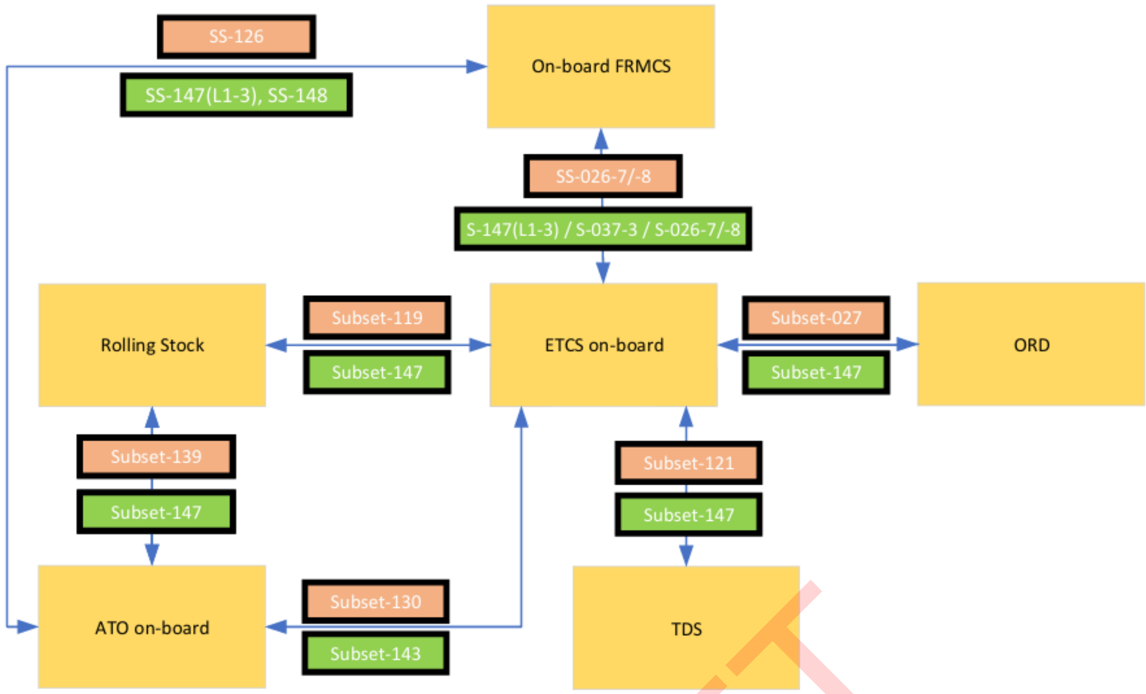


Figure 18 CCS Consist Network Interfaces according to SUBSET-147, version 1.0 [Ref.20]

Note: the interface with On Board FRMCS is only applicable for newly developed vehicles, according to [Ref.6], paragraph 4.2.6.5.1.

According to the CR on CCS Consist Network [Ref.26] the following SUBSETs are impacted:

SUBSET-147: CCS Consist Network Communication Layers FFFIS
SUBSET-119: Train Interface FFFIS
SUBSET-130: ATO-OB / ETCS-OB FFFIS Application Layer
SUBSET-139: ATO-OB / Rolling Stock FFFIS Application Layer
SUBSET-140: ATO-OB / Recording-Monitoring devices FFFIS Application Layer
SUBSET-027: FIS Juridical Recording
SUBSET-149: Online Monitoring System
SUBSET-xxx: FFFIS STM Application Layer Ethernet CCS Consist Network

3.3.3 Future Railway Mobile Communication System (FRMCS)

This paragraph is introducing the specifications and architecture of the FRMCS, to be integrated in the CCS-OB Architecture for Target 1.

The FRMCS specifications as mentioned in [Ref.19]:

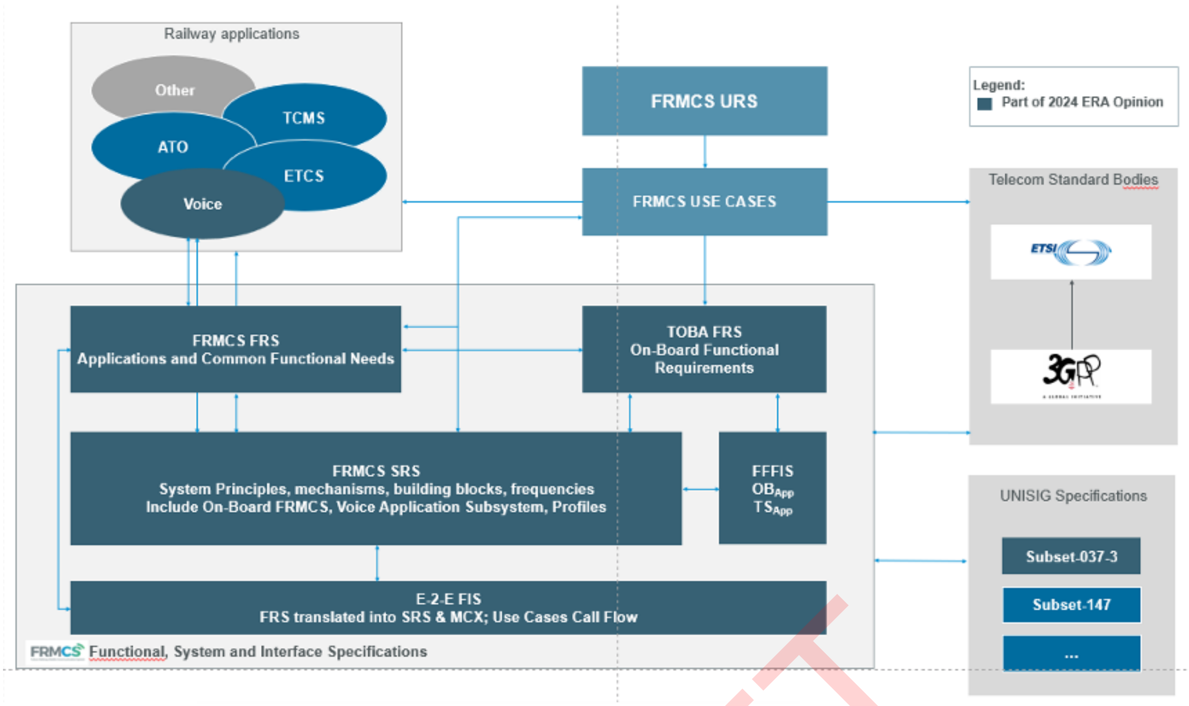


Figure 19 FRMCS specifications version 2.0.0 [Ref.19]

The high-level view of the functional blocks for FRMCS [Ref.19]:

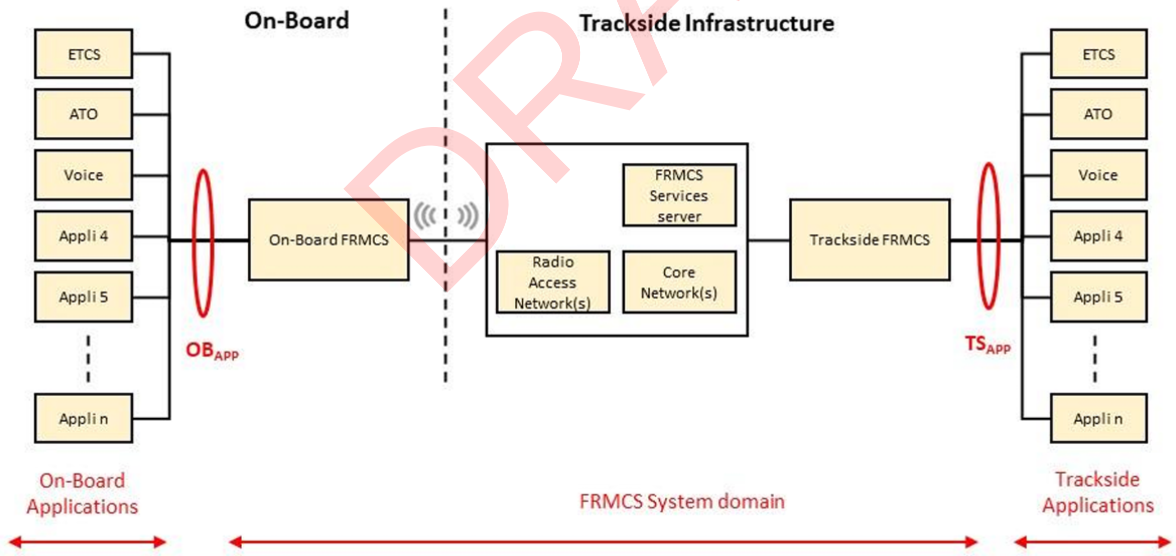


Figure 20 High-level view FRMCS [Ref.19]

With OBapp being the interface as specified in the FRMCS-SRS [Ref.21].

Architecture of On-Board FRMCS [Ref.21]:

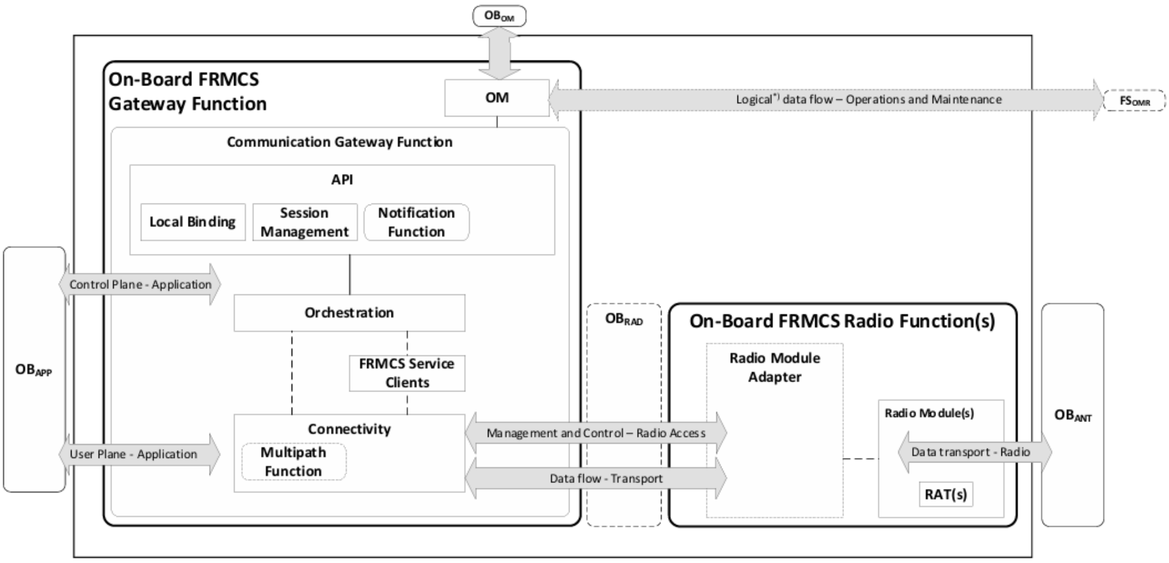


Figure 21 Architecture On-Board FRMCS [Ref.21]

3.3.4 CCS-OB Physical Architecture view Target 1

The next figure shows the physical allocations of all logical interfaces as defined in the logical architecture view.

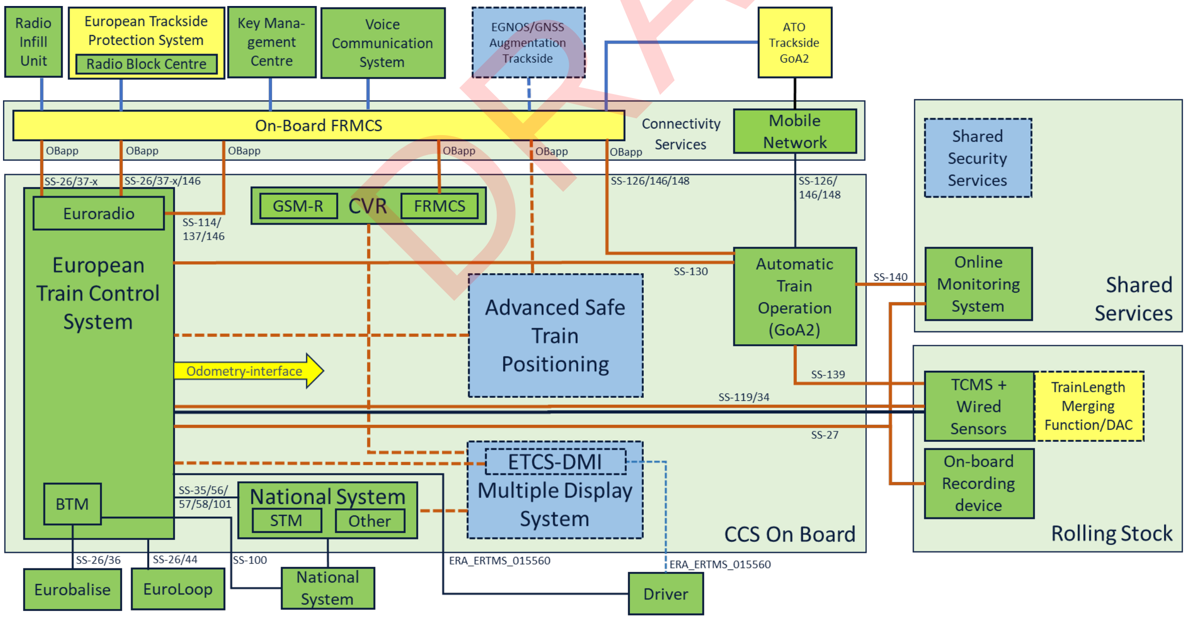


Figure 22 Physical Architecture view Target 1, including current studies

Explanations of the elements in the Physical Architecture view:

- **Green**: Actors and Logical Components conform current TSI 2023.
  Yellow: Actors and Logical Components to be specified/updated for Target 1.
  Blue/dashed: Actors, Logical Components in study, but meant for later Targets
  Black Interfaces: Current Interfaces, conform current TSI 2023.
  Red Interfaces: Current Interfaces (striped) and Interfaces in study (dashed) conform CCS Consist Network version 2.

- **Blue Interfaces**: Current Interfaces (striped) and Interfaces in study (dashed) conform FRMCS version 3.
- Current GSM-R communication channels for ETCS, CVR and ATO are not shown, but still remain in the transition period.
- The interface between Automatic Train Operation and ATO Trackside can be realised via:
    - CCS Consist Network (red) and FRMCS (dark blue), or
    - can still be done via Mobile Network and is colored light blue.
- EGNOS/GNSS Augmentation: this can become a new interface in a future target and the concept advice from the Train CS task group on EGNOS is to connect via FRMCS [Ref.15] (dark blue, dashed).
- All Connectivity Services via FRMCS and Mobile Network Operators are allocated to a separate zone for security zoning.
- MDS: In a later stage all applications used on the cabin desk, like TCMS and others, could be integrated to this new flexible concept.
- All interfaces and subsystems presented by dashed lines are still under discussion within the Train CS task groups.
- Naming: the extension "On Board" for the subsystems within the scope of CCS-On Board is left away for the sake of simplifying texts and lay-outs.

Open question:

- Automatic exchange of the Operational Train Number between ETCS-OB and the Cabin Voice Radio (GSM-R and/or FRMCS). The Operational Train Number is needed for both Start of Mission (ETCS-OB) as for the safety communication between the traffic controller/signaller and the driver via the Cabin Voice Radio (GSM-R and/or OB-FRMCS).
  Automatic exchange between ETCS-OB and Cabin Voice Radio is needed to avoid double inputs from the driver (error prone).

3.3.5 CCS-OB Physical Architecture view, including Computing Environment

The paragraph discusses on:

- Introducing the Computing Environment specifications,
- Applying the (generic) Computing Environment specifications to the specific CCS-OB subsystems, and
- Evaluating the potential use of the standardised Computing Environment for the CCS-OB subsystems.

The evaluation of the potential use of the standardised Computing Environment for the CCS-OB subsystems can be used as inputs for the Cost Benefit Analysis.

3.3.5.1 Computing Environment specifications

The Computing Environment as presented by SP Computing Environment [Ref.13] is based on the following model:

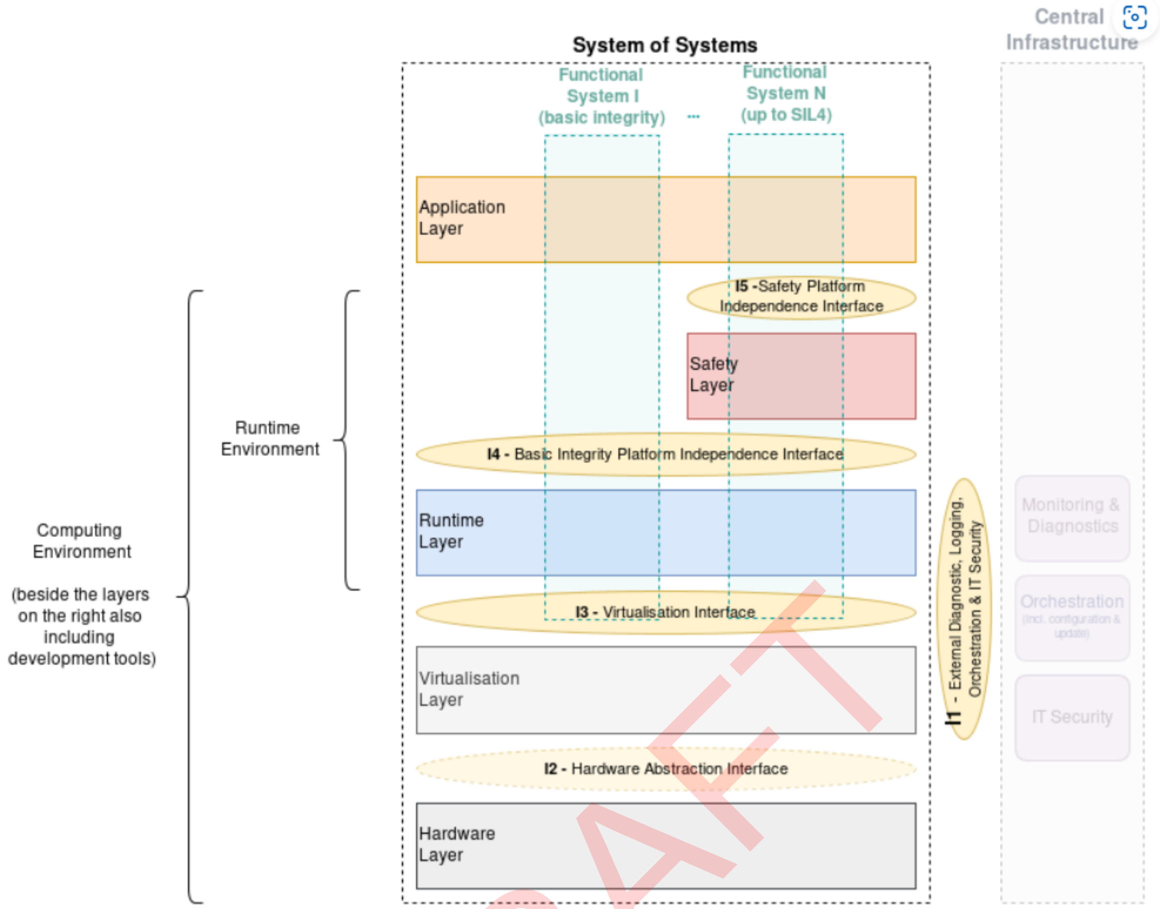


Figure 23 Computing Environment model [Ref.13]

- **Application Layer**: Contains Functional Applications
- **Safety Layer**: The Safety Layer implements all the technical safety principles related to fulfilling the requirements of EN50126, EN 50716 (formerly 50128), EN 50129, EN 50159 (e.g., composite fail safety, fault tolerance, voting mechanisms, redundancy mechanisms for availability, safety communication layers etc.) that are needed to enable the execution of Functional Applications up to SIL4.
- **Runtime Layer**: The Runtime Layer refers to the system services (e.g., application and computing resource orchestration, monitoring of the Functional Applications and the Application Execution Environment, tracing and logging, communication services that are not related to safety, security means incl. authentication, encryption, key storage, etc.) and the communication stack for information exchange between Functional Applications running on the same Computing Environment and with external entities. It may also include an operating system.
- **Virtualisation Layer**: Contains mechanisms that are able to provide Virtual Computing Elements needed to run multiple Compartments on a single physical hardware underneath.
- **Hardware Layer**: Contains the actual Physical Computing Elements providing the compute resources to the platform.

The conclusions on the interface assessments as published [Ref.13]:

- **External Diagnostic, Logging, Orchestration and IT Security Interface(s) (I1)**: The costs incurred by the standardisation of this interface are considered similar to the case where it is not standardised, while the need to standardise is seen as high. As there is broad consensus in the SP Computing Environment domain, this should definitely be standardised.
- **Hardware Abstraction Interface (I2)**: Here, the need is only medium, as it is not strictly mandatory for most user stories that this interface is standardised, but the cost related to standardization are even considered lower than if the interface were not standardised. As there is broad consensus in the SP Computing Environment domain, this should also definitely be standardised.

- **Virtualisation Interface (I3)**: Here, the analysis indicates that the cost incurred by the standardisation of this interface is slightly higher than if this were not standardised, but this aspect is outweighed by a high need. As there is broad consensus in the SP Computing Environment domain, this should also definitely be standardised.
- **Basic Integrity Platform Independence Interface (I4)**: Here, the cost evaluation has led to a similar result as for I3. It would hence be beneficial to standardise this, but at slightly lower priority compared to the previous interfaces. In general, there is controversy in the SP Computing Environment domain on the feasibility and business case associated to the standardisation of I4, hence it is recommended that this is further investigated and prototyped in FA2 R2DATO (as ongoing), before a decision on standardisation is taken.
- **Safe Platform Independence Interface (I5)**: Here, the cost analysis has indicated that standardisation would incur higher cost compared to the case where (only) proprietary variants of this interface are further pursued. In general, there is a strong controversy in the SP Computing Environment domain on the feasibility and business case associated to the standardisation of this interface. It is hence recommended that I5 is further investigated and prototyped in FA2 R2DATO (as ongoing).

The operational scenarios as specified in the System Concept including operational scenarios [Ref.14]:

ID	Scenario
Integration	
SPT2CE-1411	Integration of Functional System FS2 beside Functional System FS1 on already existing physical Computing Element
SPT2CE-1406	Integration of Functional System FS2 with Functional System FS1, interacting with each other
SPT2CE-1405	Integration of Virtualisation Environment on a new version/type of a Physical Computing Element
Deployment	
SPT2CE-1420	Prepare Physical Computing Element(s)
SPT2CE-1421	Install Virtualisation Environment on Physical Computing Element(s)
SPT2CE-1428	Configure Virtual Computing Elements required for first Functional System
SPT2CE-1431	Deploy Functional System Compartments on Virtual Computing Elements
SPT2CE-1439	Uninstall Functional System deployed on Virtual Computing Element(s)
Update	
SPT2CE-1448	Replace physical computing element
SPT2CE-1446	Update Virtualization Environment while Functional System is Running (Compatible Update)
SPT2CE-1456	Update Functional System while it is Running (Compatible Update)
SPT2CE-1458	Update Functional System including Stopping of FS (Incompatible Update)
Recovery	
SPT2CE-1483	Total SW Failure of one FS Compartment
SPT2CE-1499	Failure of all external communication channels regarding I0
SPT2CE-1485	Total SW Failure of all FS Compartments
SPT2CE-1482	Individual SW failure of one virtual computing element
SPT2CE-1489	SW Failure of one complete VE Instance
SPT2CE-1487	SW Failure of all VE Instances
SPT2CE-1496	Individual HW failure within one physical Computing Element
SPT2CE-1490	Total HW failure of one complete physical computing element.
SPT2CE-1492	Disaster scenario - failure of all computing elements
SPT2CE-1501	Failure of one external communication channel regarding I0

3.3.5.2 Application of the Computing Environment specifications to CCS-OB subsystems

This paragraph elaborates on the potential use of a standardised Computing Environment as specified in the current (draft) specifications for Computing Environment [Ref.13], which are summarised in the previous paragraph.

Five statements about the potential use of a standard Computing Environment as coming from the Question & Answer session on March 19th, 2025 [Ref.27] :

1. The use of the standardised Computing Environment is limited to the use of standard (COTS) hardware in combination with IP based ethernet communication between systems.
   This means for example that if the wish is to run the ETCS application on standard hardware, then the modules like BTM and Odometry must be splitted because they need specific hardware and they need to be connected via IP-communication.
2. The standardised Computing Environment can be used for both safe and non-safe application.
   As of 2025-09, the Computing Platform only considers composite fail-safety as safety principle, e.g. 2oo2 or 2oo3. This is an adequate principle to run SIL4 functions, but to run a SIL2 function, there are also other safety principles possible that use less resources, e.g. single channel with self-tests and supervision. These other safety principles are currently not considered in the Computing Platform, i.e. any SIL2 function that runs on the computing platform also has to use composite fail-safety, e.g. run as 2oo2 or 2oo3 system.
3. If you update or add one of the systems certified to operate for the Computing Environment, then you don't need to recertify the safety system(s) running on the same Computing Environment only because they are running on the same Computing Environment (i.e. recertification remains only necessary for subsystems that directly interface to the new or changed subsystem).
   Virtualisation will provide isolation of systems. In the computing environment you would not need to split the hardware between safe and non safe, running the virtual machines in the same hardware.
4. The Computing Environment can be used for remote update and remote configuration as described by the operational scenarios in [Ref.14].
5. The alignment of the Computing Environment specifications with the specifications for CCS Consist Network (SUBSET-147) and the Cybersecurity specification [Ref. 9, 10, 11 and 12] is to be done.

Applying the first two statements to the Physical Architecture view for Target 1 leads to the Physical Architecture view in the figure below.

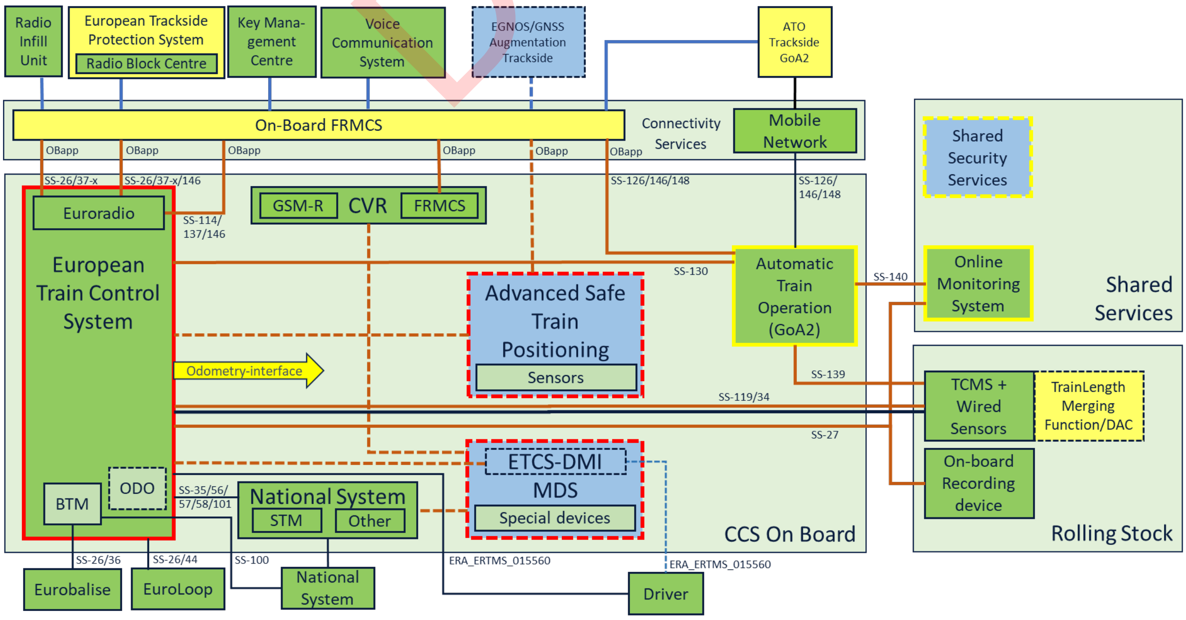


Figure 24 Physical Architecture view Target 1, including the potential use of the Computing Environment

Explanations on the elements in the Physical Architecture view, including Computing Environment:

- Note: for the analysis of the potential use of the Computing Environment for the Train CS domain, the CCS-OB Physical Architecture view for Target 1 is used as a basis, but this does not imply that the Computing Environment will be in scope for the CCS-OB Target 1. Only the analysis is currently in scope for Train CS.
- **Green:** Actors and Logical Components conform current TSI 2023.
  Yellow: Actors and Logical Components to be specified/updated for Target 1.
  Blue/dashed: Actors, Logical Components currently in study, but meant for later Targets
  Black Interfaces: Current Interfaces, conform current TSI 2023.
  Red Interfaces: Current Interfaces (striped) and Interfaces in study (dashed) conform CCS Consist Network version 2.
  Blue Interfaces: Current Interfaces (striped) and Interfaces in study (dashed) conform FRMCS version 3.
- **Red contour**: For the use of a standard Computing Environment for SIL-4 (ETCS, ASTP) and SIL-2 (MDS) applications we need:
    - a 2oo2 or 2oo3 deployment of the kernel on the Computing Environment hardware (like the current deployments on proprietary hardware), and
    - a separate deployment of sensor-modules (for example BTM) and special devices on specific hardware with an IP based ethernet communication to the kernel of these applications.
- **Yellow contour**: For the use of a standard Computing Environment for non-safe applications, like Automatic Train Operation (ATO-OB) and also for the systems in the Shared Services zone, a single deployment on the standard Computing Environment is possible.
  The ATO-OB contains the ATO odometry according to the current allocation of functions. Therefore, it also has specific
  sensors and cannot be fully allocated to the computing platform.
- For a National System On Board connected via Profibus, a deployment on the standard Computing Environment is unlikely because of the use of Profibus instead of IP based ethernet communication. For a National System On Board that is connected through a proprietary interface (which is also an allowed solution in the ETCS reference architecture), this might be possible. But note: an National System On Board usually also has special interfaces (similar to the BTM and the ODO for ETCS).
- For the Cabin Voice Radio (CVR) a deployment is uncertain or unlikely because of:
    - the use of special devices (audio, hardkeys, etc),
    - the separate development of specifications outside of the System Pillar, in case of FRMCS.

3.3.5.3 Evaluation of the use of a standard Computing Environment for CCS-OB

The main restriction coming from the Computing Environment specifications is the mandatory use of IP based ethernet communication between subsystems.

For CCS-OB subsystems with embedded sensors and/or special devices on special hardware (ETCS, ASTP and MDS), this will imply that these sensors and/or special devices on specific hardware will have to be split as a separate module and will need to use IP based ethernet communication with the kernel system.

The first candidates for the use of the standard Computing Environment would be the Automatic Train Operation (ATO-OB), the Online Monitoring System and the Shared Security Services as CCS-OB/Shared Services systems without any sensors or special devices.

For the subsystems Cabin Voice Radio and National System the use of the standard Computing Environment is unlikely for various reasons as stated in the previous paragraph.

This evaluation of the potential use of the standardised Computing Environment for the CCS-OB subsystems can be used as inputs for the Cost Benefit Analysis on the potential use of the standard Computing Environment for CCS-OB and Shared Services systems.

3.3.6 Physical Architecture view Target 1, including Cybersecurity

In this analysis we will apply the generic cybersecurity specifications as published by SP Cybersecurity to the specific CCS-OB subsystem and we will evaluate the impact on the CCS-OB subsystem as well as the dependencies from the connected Shared Security Services on board the Rolling Stock and on the trackside of the Railway Undertaking.

3.3.6.1 Cybersecurity specifications

The Cyber Security requirements as published by SP PRAMSS consist of four specifications [Ref. 9, 10, 11 and 12] as shown in the figure below.

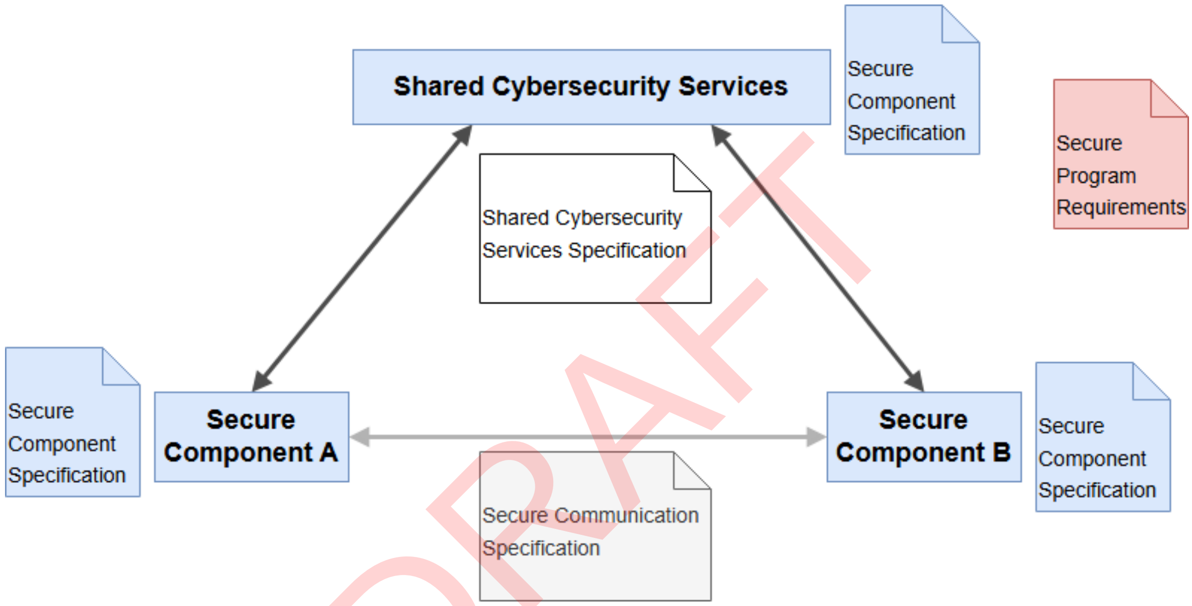


Figure 25 Cybersecurity Specifications as published by SP PRAMSS [Ref.9]

The Shared Security Services as published in the Shared Cybersecurity Services Specification [Ref.11]:

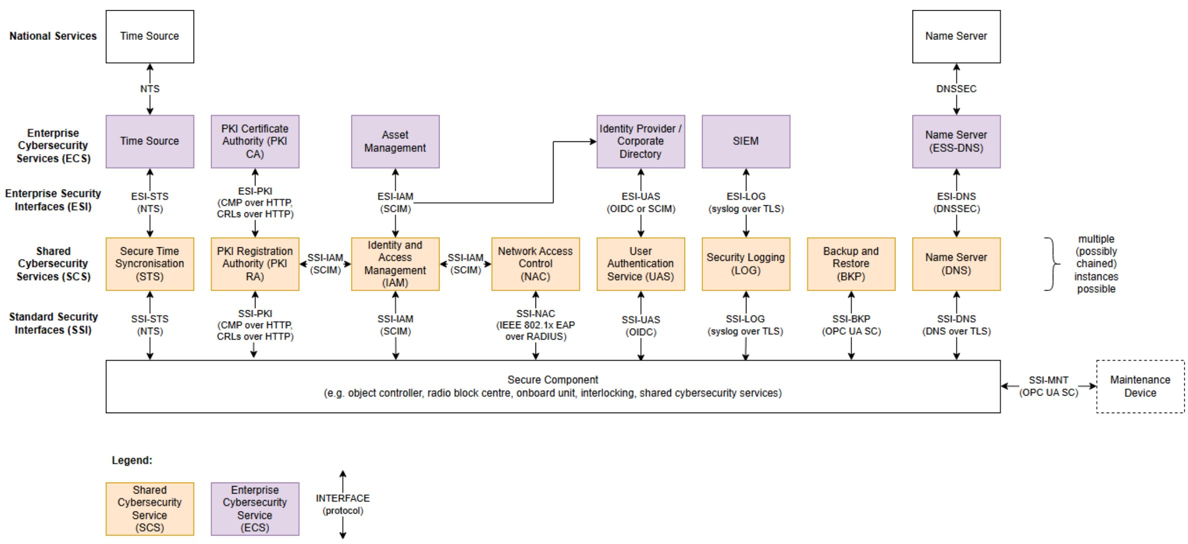


Figure 26 Shared Security Services [Ref.11]

A first allocation of the Shared Cybersecurity Services over onboard, trackside (Railway Undertaking) and centralized Enterprise Cybersecurity Services (Railway Undertaking) as presented in [Ref.11]:

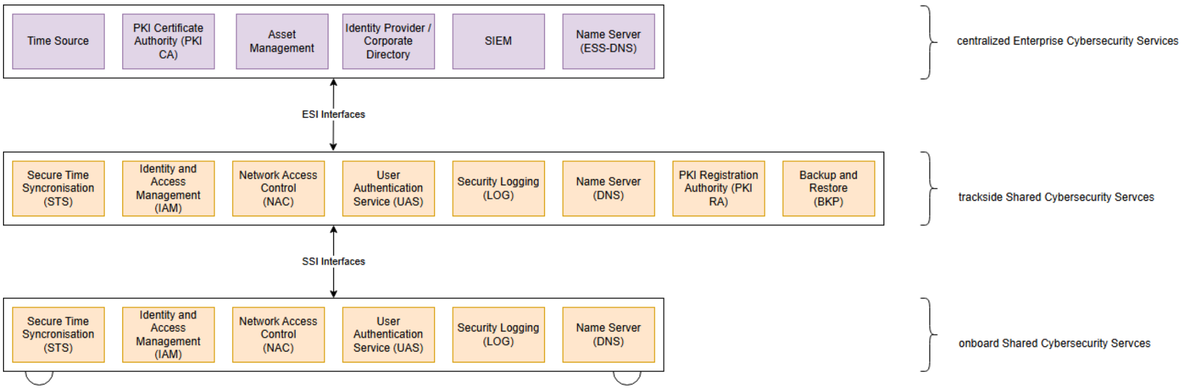


Figure 27 Allocation of Shared Cybersecurity Services to on board, trackside and enterprise [Ref.11]

3.3.6.2 Physical Architecture view Target 1, including Cybersecurity specifications

Looking at the onboard cyber security services as shown in the previous figure and making some assumptions, the application of these cybersecurity requirements can lead to the following architecture view (changes introduced by Cybersecurity in orange).

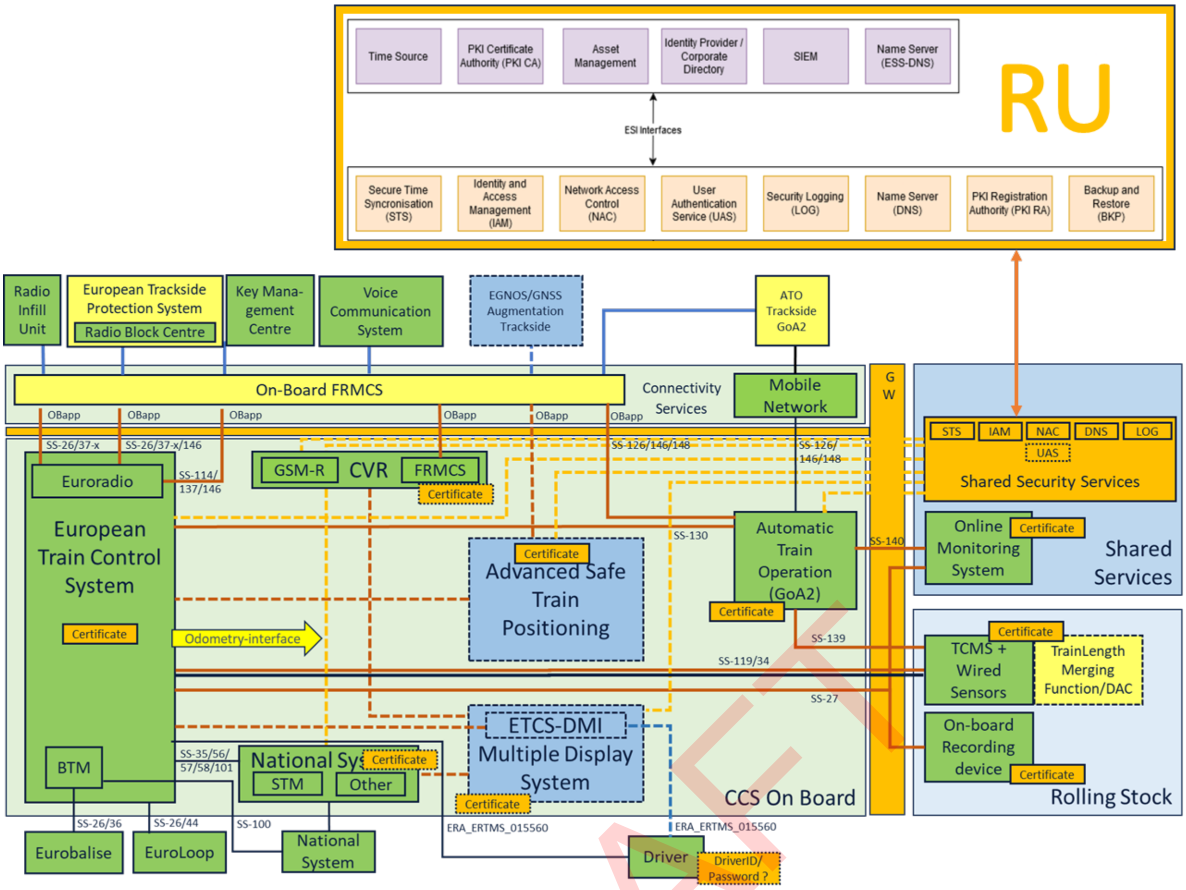


Figure 28 CCS-OB Physical Architecture Target 1 view, including Cybersecurity

- **Green:** Actors and Logical Components conform current TSI 2023.
  Yellow: Actors and Logical Components to be specified/updated for Target 1.
  Blue/dashed: Actors, Logical Components currently in study, but meant for later Targets
  Black Interfaces: Current Interfaces, conform current TSI 2023.
  Red Interfaces: Current Interfaces (striped) and Interfaces in study (dashed) conform CCS Consist Network version 2.
  Blue Interfaces: Current Interfaces (striped) and Interfaces in study (dashed) conform FRMCS version 3.
  Orange/dashed Interfaces: Potential interfaces between Shared Security Services and CCS-OB-subsystems for the exchange of certificates, security event logging, etc.
- Note: for the analysis of the potential application of the Cybersecurity specifications to the Train CS domain, the CCS-OB Physical Architecture view for Target 1 is used as a basis, but this does not imply that the Cybersecurity specifications will be in scope for the CCS-OB Target 1. Only the analysis is currently in scope for the Train CS.

Assumptions and open questions for the application of the Cybersecurity on CCS-OB:

1. Assumption 1: If every CCS-OB subsystem has to be a Secure Component, then the implications are:
   a. All CCS-OB subsystems will need certificates as a basis for authentication and authorisation (Note: NTCs will most probably be excluded)
   b. All internal and external communications between systems will be controlled via IAM, NAC and DNS.
   c. If prioritization is needed, then all data-communication connections between the CCS-OB systems and the external trackside and on board rolling stock systems have the highest priority. This includes all connections from ETCS-OB, ASTP and ATO-OB to the connected trackside and on board rolling stock systems.

2. Assumption 2: Every CCS-OB subsystem will log security events and send them to the LOG collector within the Shared Security Services on board the Rolling Stock.
3. Assumption 3: A gateway is needed to separate the CCS-OB zone from the Rolling Stock & Connectivity Services zones.
4. Assumption 4: Connectivity Services will be separated via a specific zone.
5. Open Question: User Access Control is possible for the driver, but needs to be decided.

3.3.6.3 Alignment between the current SUBSET-147 and the Cybersecurity specifications

For the TSI 2027 Cybersecurity it is foreseen in [Ref.18] that "*It is planned to update the existing TSIs by adding references to sections in System Pillar cybersecurity specifications to achieve compliance to EU cybersecurity acts and directives, as well as international standards*".

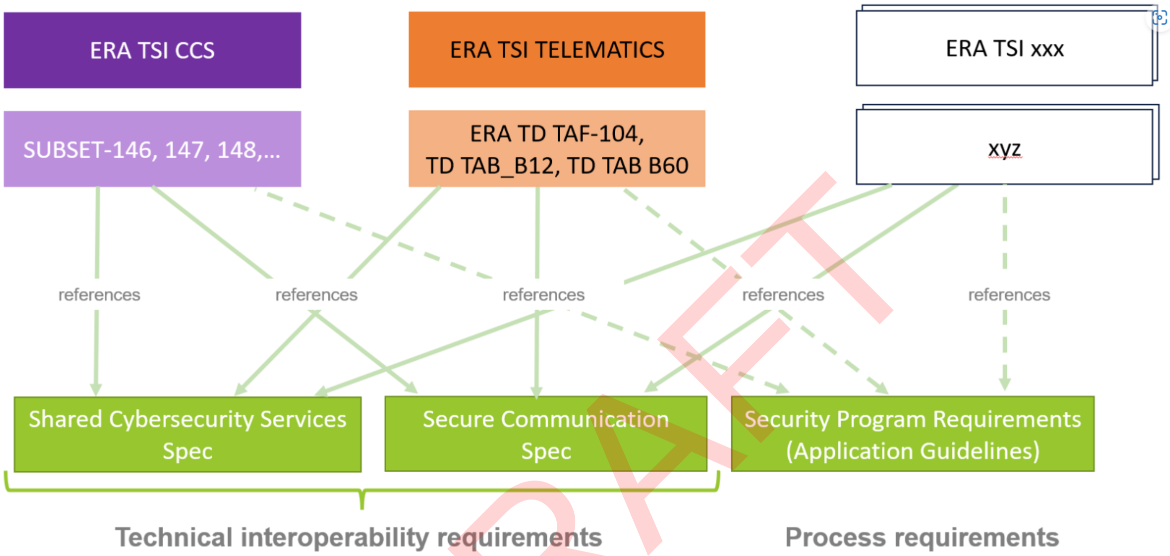


Figure 29 Planned alignment between SUBSET-147 and Cybersecurity Specifications [Ref.18]

3.3.6.4 Evaluation on applying Cybersecurity specifications to CCS-OB

The previous CCS-OB Physical Architecture view Target 1, including Cybersecurity shows the full application of all cybersecurity specifications on all CCS-OB subsystems.

From the discussions so far, the current proposal for the application of the cybersecurity specifications to the CCS-OB subsystems and the Shared Services is:

- To use certificates for Identity and Access Management for at least the CCS-OB subsystems that exchange data to the trackside systems (ETCS, ASTP and ATO).
- Every CCS-OB subsystem will have to log security events and send them to the LOG collector within the Shared Security Services.
- A gateway and zoning is needed to separate the CCS-OB zone from the Rolling Stock, Shared Security Services and Connectivity Services zones.

Optional and/or to be discussed:

- The use of certificates for Identity and Access Management for the systems in the other zones on board (Rolling Stock and Shared Security zones).
- The use of certificates for Identity and Access Management for the other CCS-OB subsystems within the CCS-OB zone (National System and Multi Display System).
- User Authentication Service. Open point: is this really needed for Driver-ETCS-connection ?

3.4 CCS-OB PRAMS requirements

This section will integrate in further releases the requirements provided by System Pillar PRAMS domain applicable to Train CS.

4 CCS-OB architecture - Targets 2 and A

This section is providing an outlook of what the CCS-OB could be for later targets.

The reader is advised that:

1. The content in this section does not differentiate Target 2 from Target A, i.e. only Target A is described.,
2. The content is based on Innovation Pillar knowledge that is to be further consolidated in next iterations,
3. Technical transitions between Targets 1, 2 and A have not been discussed within Train CS so far and must be elaborated in the future.

4.1 CCS-OB logical architecture view - Targets 2 and A

The figure below shows the Logical Architecture view for the future targets 2 and A, previously published in the Train CS Architecture Baseline-1 [Ref.8], and integrating latest assumptions from Innovation Pillar. This logical architecture view expresses the migration situations in which current applications may exist next to newer applications, due to the life-cycle of 30 years or more.

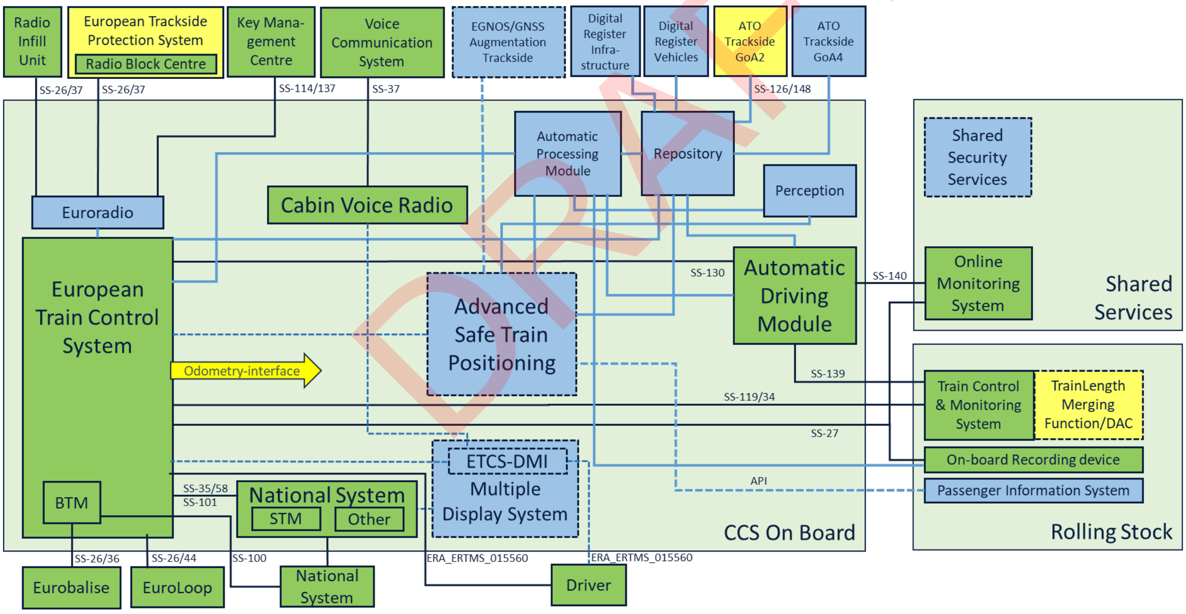


Figure 30 Logical Architecture view for Targets 2 and A

Explanations of the figure:

- **Green:** Actors and Logical Components conform current TSI 2023.
  Yellow: Actors and Logical Components to be specified/updated for Target 1.
  Blue/dashed: Actors, Logical Components currently in study, but meant for later Targets
  Black Interfaces: Current Interfaces, conform current TSI 2023.
  Blue Interfaces: Interfaces currently in study (dashed), FRMCS and Interfaces conform previous X2Rail-4- and R2DATO-architectures (striped).
- **European Trackside Protection System**, Digital Register Infrastructure, Digital Register Vehicles and ATO Trackside (GoA2) are external actors as also defined in the Traffic CS System Concept [Ref.22].

- **Euroradio** can be split from ETCS-OB after the phase out of GSM-R. Rationale is that it is a separate, non-safe functionality that can be split to improve modularity.
- **API from ASTP to Passenger Information System**, as defined by [Ref.25] will most likely (dashed line) be part of the Full ASTP architecture. The assumptions on this API as of 2025-09 is that the API is mainly aiming to deliver Train Time and Location information to Passenger Information Systems, which might come from the Full ASTP-module in Target 2. Other relevant information for the Passenger Information System as open/closed doors and other, will come from TCMS (outside the scope of Train CS domain).
- Assumption on the current **interface ATO Trackside - ATO-On Board** (SUBSET-126) is that a new version of SUBSET-126 will manage the airgap via the Repository, to serve on-board data customers as ASTP, ADM and APM. The rationale is that Repository will be the only on-board component managing the track/train communication (ERTMS/ETCS SUBSET-026 excepted), in order to avoid having multiple on-board components managing their own airgap and version compatibility checks with the trackside. This assumption is currently discussed within Innovation Pillar and must be further elaborated.
- ATO GoA4-Trackside will deliver Mission data, Operational Execution data and Incident Solving data as defined by the ATO GoA4 architecture.
- Note on **Train Length Merging Function**: the exact location of the Train Length Merging Function is still discussed.

4.2 Logical components

4.2.1 Introduction

In this section, the foreseen logical components for the evolution of the CCS-OB targets 2 and A are discussed. These logical components and their description are integrated in this document on the basis of the research and innovation currently performed within the Innovation Pillar. Further specification and consolidation is expected in the next iterations of the Innovation Pillar.

4.2.2 Repository

The description of Repository has been taken from [FP2 R2DATO D6.5 v03 Annex 1 SRS ATO up to GoA3/4] and adapted to the System Architecture Description.
Repository filters all data received from Digital Register Infrastructure (segment profile static data), Digital Register Vehicles (train data and train data sets), ATO Trackside GoA2 (providing journey profile data and segment profile data according to SUBSET-126 version 1.0.0), ATO Trackside GoA4 (providing mission profile data and journey profile data according to a new version of SUBSET-126) according to the needs of the on-board logical components and forwards them through the relevant interfaces.
Rationale: new module dedicated to communication and sharing of information with all on-board modules including safety related data received from Digital Registers. Interoperable/interchangeable module active in all GoA levels and interfacing with ATO Trackside GoA2 in GoA2 and with Digital Registers and ATO Trackside GoA4 in GoA3/4.
For keeping compatibility with GoA2, REP has 2 modes for communication with trackside: one working with SUBSET-126 structure for GoA2 trackside and one working with SP static data (interface with Digital Register Infrastructure) and JP/SP dynamic data (interface with ATO Trackside GoA4) for GoA3/4 trackside.

4.2.3 Automatic Driving Module

The description of Automatic Driving Module has been taken from [FP2 R2DATO D6.5 v03 Annex 1 SRS ATO up to GoA3/4] and adapted to the System Architecture Description.
The Automatic Driving Module (ADM) component is in the train and drives a train automatically.
Rationale: re-use of SUBSET-125 ATO-OB core functions. Interoperable/interchangeable module active in all GoA levels.

4.2.4 Automatic Processing Module

The description of Automatic Processing Module has been taken from [FP2 R2DATO D6.5 v03 Annex 1 SRS ATO up to GoA3/4] and adapted to the System Architecture Description.
The Automatic Processing Module (APM) component is in the train and should substitute driver and train attendant responsibilities for reacting in case of incident. It manages mission execution, safe reflexive reactions, evaluated reactions and safety procedures in cooperation with the trackside.
Rationale: new module emulating the driver in GoA3/4. Interoperable/interchangeable module active in all GoA levels (GoA2 will be selected by default if there is no Mission Profile).

4.2.5 Perception

The description of Perception has been taken from [FP2 R2DATO D6.5 v03 Annex 1 SRS ATO up to GoA3/4] and adapted to the System Architecture Description.
The Perception (PER) component is in the train and senses the Physical Railway Environment in place of a driver.
Rationale: new module dedicated to perception with a possible synergy with other sectors like automotive one. Interoperable/interchangeable module active in GoA3/4. Upgradability is possible with technology evolution.

4.3 Internal interfaces

The foreseen internal interfaces of the CCS-OB for Targets 2 and A are listed as work items below:

Automatic Driving Module / On-board Repository

Automatic Processing Module / On-board Repository

Automatic Processing Module / Perception On-board

Automatic Processing Module / ETCS on-board

Full Advanced Safe Train Positioning / Repository

Advanced Safe Train Positioning / Automatic Driving Module

Advanced Safe Train Positioning / Automatic Processing Module

On-board Repository / ETCS On-board

Advanced Safe Train Positioning / Perception

Logical exchange between National System and MDS

API for other applications [Ref.25]: ASTP / Passenger Information System

CCS-OB Upgradability, Evolutivity and Migration recommendations

In this section, the document discusses on upgradability and evolution of the CCS-OB. Migration aspects are elaborated and key recommendations for programming are provided.

5 CCS-OB migration

In this chapter, the contribution of the Train CS domain key functionalities to the main benefits for users in the Command Control & Signalling domain, will be evaluated.

5.1 Introduction

Based on the current targets 1, 2 and A, as given by the SP Core Group [Ref.7], this chapter describes how the key functionalities developed by the Train CS domain will stepwise contribute to the benefits for the users in the Command Control & Signalling domain.

To illustrate this stepwise contribution to the users benefits, the following illustration of the dependencies between functionalities and benefits will be used.

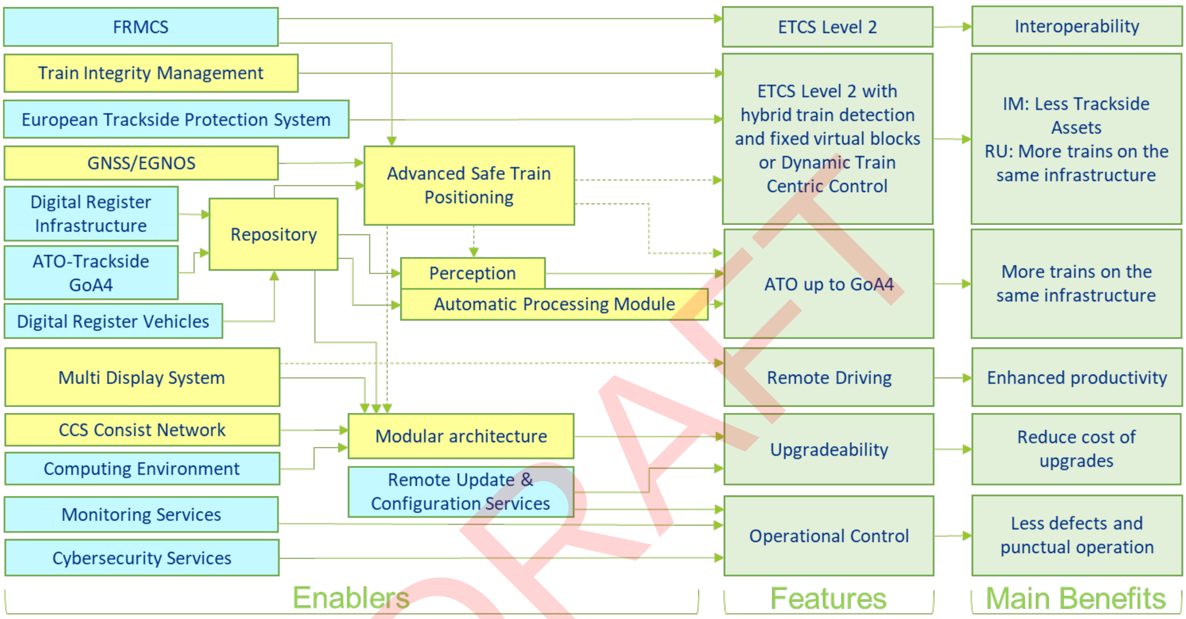


Figure 31 Dependencies between key CCS functionalities and main benefits

In this illustration key functionalities are split in:

- Enablers: Functionalities which "enable" Features.
- Features: End-user functionalities with a main benefit for the business of Railway Undertaking and/or Infra Managers. These are the main features, but not all.
- Main benefits: the foreseen main benefits for Railway Undertakings and/or Infra Managers.
- Colors:
  Yellow: Train CS enablers.
  Blue: Enablers delivered by other domains.
  Green: Features and Main Benefits for the whole of the CCS domain.
  Striped line: dependency between enabler(s) towards a feature with end-user benefit.
  Dashed line: less strong dependency between enabler(s) towards a feature, which can increase the benefit.

In general this figure focuses on the dependencies between the key CCS functionalities and the main benefits for the users in the CCS domain. This figure will be used in the next paragraphs to describe the migration steps from the current CCS-OB architecture to the target CCS-OB architecture for the Single European Railway Area (SERA), including the associated benefits for the users in the CCS domain. Note that also the dependencies to the key functionalities from other System Pillar domains are included, because all considered benefits require key functionalities from other System Pillar domains and will be evaluated per target. Dependencies presented by **dashed lines** are not strict dependencies, but can improve the benefit.

More specific explanations of some dependencies are listed below:

- The **Future Railway Mobile Communication System (FRMCS)** will replace GSM-R, which will be phased out in the 2030-ies, and is needed for the continuation of railway operation in general and with ETCS Level 2. FRMCS will also support new functionalities like e.g. ETCS level 2 with hybrid train detection up to functionalities like ATO GoA4.
- **ETCS Level 2 with hybrid train detection and fixed virtual block or with Dynamic Train-Centric Control**:
    - DTCC allows movements from any point to any point, and targets for additional improvements. DTCC can be introduced independently from onboard functionality, this synergy can grow stepwise over time and in parallel..
    - To achieve the main benefit of more trains on the same infrastructure via reduced headways there is a dependency to the use of the Train Integrity Management function. The more trains that have a Train Integrity Management function, the bigger the benefit.
    - The reduction of trackside assets will be only possible if all trains are equipped with Train Integrity Management.
    - Advanced Safe Train Positioning: not mandatory for this feature, but can improve the reduction of headways in certain areas, due to providing location information with a higher accuracy.
- **ATO up to GoA4** also includes the upgrade of the current ATO GoA2 module to the Automatic Driving Module (ADM) and can also include improvements on energy-efficiency of the automatic driving. Optimising energy consumption and train schedules is not mentioned as a main benefit, because certain RUs already make use of Driver Advisory Systems which have already achieved a lot of these benefits and, more important, also work for non-ERTMS-trajectories.
- If the **Multi Display System** concept has proven to be useful and feasible in the train cabin, then we might consider to use a remote version of the MDS in the control center for Remote Driving, together with remote controlling of traction and brakes and cameras for the cabin view. This is shown as a dashed line for dependency between MDS and Remote Driving. In particular, the remoted use of the MDS will be necessary to perform the ERTMS/ETCS start of mission, and the use of the CCS-OB by the remote driving in general.
- **Remote Driving** as it is used here means: driving a train from a remote control center, not including Remote Preparation of a train. Remote driving might have several potential benefits depending on the use case.
  For Remote Driving independent from ERTMS/ATO, it might increase productivity, because there is no need for a driver on the train for certain activities (for example: remote shunting, without the needed transfer times).
  Remote Driving is also identified as a fall-back for ATO up to GoA4.
- The **Modular Architecture** is added as a non-functional enabler in this figure because of the special attention that is asked for upgradeability and the reduction of costs for upgrades.
- Both **Cybersecurity Services** (including Security monitoring) and **Monitoring Services** (monitoring and diagnosis of subsystems) are Shared Services that support the Operational Control and help to prevent disruptions of the train service due to rolling stock unit failures.
- **Remote Update & Configuration Services** will help the upgradeability in cases where there is no need to send technicians to the rolling stock units for updates and/or configuration changes and thus enlighten the current scarcity on technicians in combination with an increase of IT systems on modern trains.
- The goal and benefit of the **CCS Consist Network** is to ease integration and to save integration and certification/authorisation costs.

In the next paragraphs the contribution of the CCS-Onboard functionalities to the main benefits for users in the CCS domain will be elaborated in the following steps:

1. An evaluation of the Target 1, including current Train CS studies as mentioned in the Scope (ASTP/EGNOS, Train Integrity/Train Length, MDS and FRMCS), with their contribution to the main benefits for the users in the CCS domain.
   This evaluation also includes the dependencies to functionalities coming from other System Pillar domains, like Traffic CS and Transversal, which are needed to reach the main benefits.
2. Evaluations for Target 2 and Target A like mentioned for Target 1.

3. Evaluation of the functionalities contributing to the On Board Modularity and Upgradeability with their main benefits.
4. Recommendations coming out of the evaluations of the foregoing steps.

5.2 CCS-OB Migration step to Target 1

5.2.1 Introduction

In this paragraph, an overview of the dependencies between the CCS-OB functionalities for target 1, and their contribution to the key functionalities and main benefits for users, is provided.

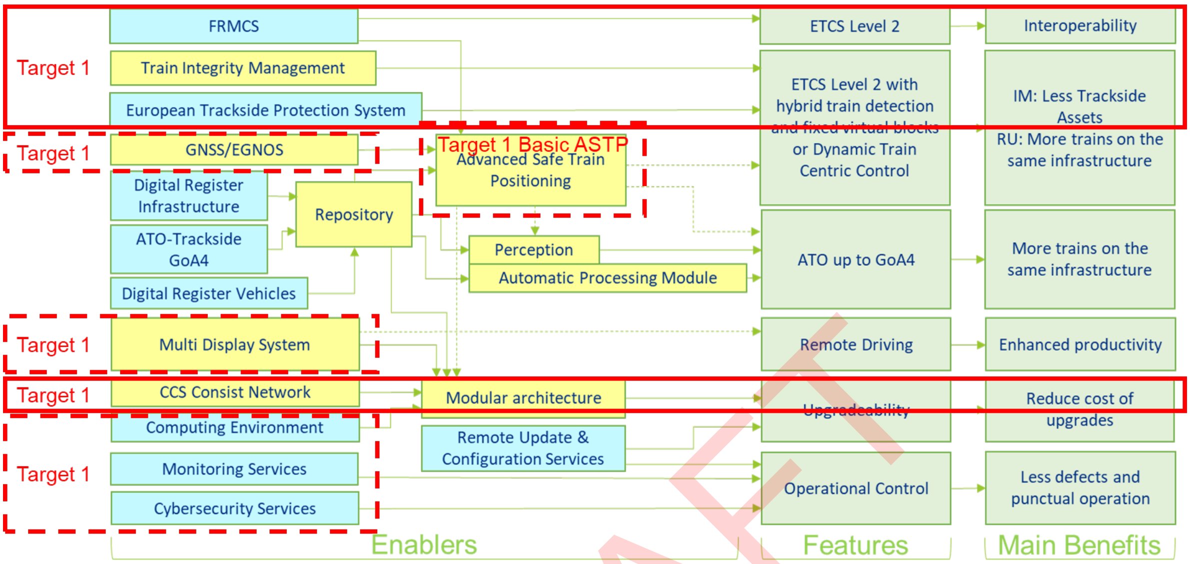


Figure 32 Dependencies between key CCS functionalities and main benefits in scope for Target 1, including current Train CS studies

All functionalities to be delivered for target 1 are enablers of which only FRMCS has a direct link with an end-user functionality (ETCS Level 2). The introduction of FRMCS is the most important for the business continuity, because of the obsolescence and phase-out of GSM-R foreseen in the 2030-ies. For newly developed vehicles the connections on board to On Board FRMCS via the CCS Consist Network is foreseen.

The functionalities which are shown within dotted boxes are first specification steps or analysis towards future targets.

Functionalities in scope for Target 1:

- The **Future Railway Mobile Communication System (FRMCS)** will replace GSM-R, which will be phased out in the 2030-ies, and is needed for the continuation of railway operation in general and with ETCS Level 2. FRMCS will also support new functionalities like e.g. ETCS level 2 with hybrid train detection up to functionalities like ATO GoA4.
- **Train Integrity Management**: the new Train Length Merging Function for Train Integrity Management will be delivered as part of Target 1 and will be an important enabler for ETCS Level 2 with hybrid train detection and fixed virtual block.
- **European Train Protection System**: Traffic CS will deliver a specification for a harmonised European Train Protection System.
- **ETCS Level 2 with hybrid train detection and fixed virtual block or with Dynamic Train-Centric Control:**
  - DTCC allows movements from any point to any point, and targets for additional improvements. DTCC can be introduced independently from onboard functionality, this synergy can grow stepwise over time and in parallel..
  - To achieve the main benefit of more trains on the same infrastructure via reduced headways there is a dependency to the use of the Train Integrity Management function. The more trains that have a Train Integrity Management function, the bigger the benefit.

  - The reduction of trackside assets will be only possible if all trains are equipped with Train Integrity Management.
  - Advanced Safe Train Positioning: not mandatory for this feature, but can improve the reduction of headways in certain areas, due to providing location information with a higher accuracy.
- **Basic ASTP**: The current status on ASTP as explained in paragraph 3.2.4.4 is that Basic ASTP (for Target 1) will consist of an Odometry interface for testing and data-collection, and specification of enhanced odometry performance and robustness.
- **GNSS/EGNOS**: Study for the dissemination architecture for the use of EGNOS correction data on GNSS-data, for later use by Full ASTP in Target 2.
- **Multi Display System**: Concept for the use of a more standardised and flexible display system in the cabin of a train, which allows to add more applications than there are devices in the cabin, lower costs of upgrades through the use of standard display devices and the possibilities of fail-over between the displays of cabin applications.
- **CCS Consist Network:** will be delivering a final specification for Target 1 and can thus be a first improvement towards a Modular Architecture and can contribute to a reduction of the cost for future software upgrades for systems connected to the CCS Consist Network.
- **Computing Environment**: An analysis on the potential use of the generic System Pillar specifications for computing environment on board of the train.
- **Cybersecurity Services**: Impact analysis on the use of the generic System Pillar specifications for cybersecurity on board of the train.

Dependencies on other System Pillar domains for Target 1

To reach the Features with Main benefits for users there is the following dependency to CCS-Trackside functionalities:

- FRMCS, as developed by UIC/EECT RMR, which consists of:
  - Trackside-FRMCS, and
  - On Board FRMCS.
  Both described in the Physical Architecture view for Target 1.

The CCS-OB Architecture for Target 1 with the main changes after TSI 2023 in yellow:

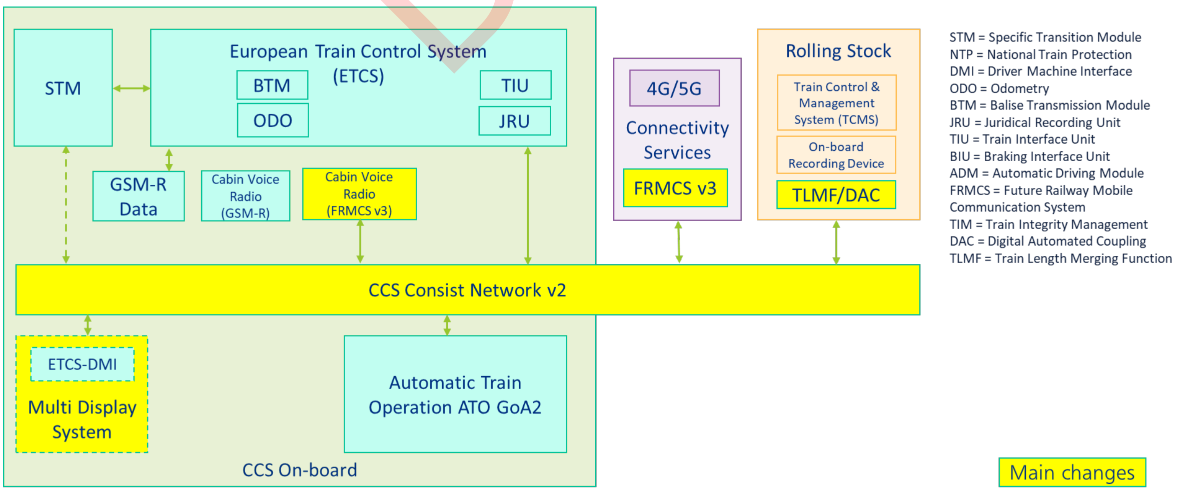


Figure 33 Simplified Architecture view for Target 1, illustrating the main changes

In the next paragraphs the possible migration steps to get to the target architecture are elaborated.

5.2.2 Evaluation on Target 1

The evolution of architectures as described in previous chapters is not related to specific implementation dates.

However, we need to take the timeline into account when the objective is to reduce the burden of upgrading onboard equipment for railway undertakings, lessors and keepers of rolling stock (contractual request 10.3.5). Hence **we need to assess the impact of migration steps as recommended by the Core Group**:

- ***Migration Target 1*** *= first set of solutions largely based on today's technology (specifications for some elements are already ready, completion of specifications for all elements of target* ***estimated around 2027****, products sequentially delivered but with the full set in the early 2030s).*
- ***Migration Target 2*** *= Enhanced digitalization introducing new technology (specifications progressively developed, completion* ***estimated around 2030,*** *and products delivered following that).*
- ***Migration Target A*** *= Automated European Railway.*

According to ERJU (EU-Rail response to CER/EIM position paper: Railway System Architecture: Railway System Architecture; SPG-STG-D-SPG-137-01_-_2024020_DRAFT_response_to_CER-EIM_paper_of_Railway_System_Architecture.pdf), ***"Migration Target" means the availability of harmonized solutions as a subset of the System Pillar target architecture at a certain point in time.*** *The definition of the migration targets below is based on the expected availability of solutions and the readiness of the rail environment for such a step, and also the potential benefits for the overall performance of the European Rail System and / or the benefits for the involved stakeholders.*

An **assessment process with assessment criteria** has been defined in deliverable D2 of MIG SC2.3 activity.

There are the following criteria:

- STIP date
- Current specification maturity (Rate from VERY LOW to VERY HIGH (1-5) 5: TSI ready)
- Probable date of availability
- Timeframe needed for developing products (0,5 years - 5 years)
- BENEFITS / ADDED VALUE : Rate from VERY LOW to VERY HIGH (1-5)
  - Improved customer performance e.g., improve service quality, punctuality...
  - Improved performance and capacity e.g., increase capacity, harmonized processes, reduce travelling and transit times
  - Reduced costs e.g., life-cycle cost, changeability, upgradability, CAPEX/OPEX optimisation, increase market size
  - More sustainable and resilient transport e.g., efficient energy use, increase system robustness, improve maintenance, cybersecurity
  - Harmonised approach to evolution and greater adaptability e.g., operational harmonization, standardized architecture, increase flexibility, adaptability, optimize safety, address workforce shortage
  - Reinforced role for rail in European transport and mobility e.g., improvement of methods and tooling, reducing complexity by design, enable fast migration, efficiency
  - Improved EU rail supply industry competitiveness e.g., increase attractiveness of railway for different actors, leverage rail technical expertise for other areas
- EFFORTS / IMPACT Rate from VERY LOW to VERY HIGH (1-5)
  - Change of operational/organizational procedures

    - Changes of regulatory framework
    - Capacity/Needed ressources for development & implementation (and for migration issues)
    - Impact on authorization

- Just enabler or real objective
- Railway use case (passenger, freight, HS, ...)
- Dependencies (trackside, innovation pillar, etc.)

Should we follow this process, this would mean the assessment of around 38 features according around 18 criteria, thus 684 assessments to be made. Such assessment would require knowledge coming from experts not always available in TrainCS, time consuming discussions in order to agree inside TrainCS Domain and possible time consuming discussions with experts and groups outside TrainCS Domain.

We therefore decided to **simplify the methodology** and only keep the following important criteria:

- Is it just an enabler or a feature with immediate benefits for the end user (end user being the vehicle owner, keeper or maintainer and/or the Driver of the train or any other end user for which this functionality is of added value)?
- When will the specification be ready for input to TSI or standard?
- Is there a dependency with other features (onboard or trackside)?
- Should the feature be applicable for Newly built vehicles (in accordance with TSI CCS 7.4.2.1) (**hereafter New Vehicles**) and/or for Existing vehicles (in accordance with TSI CCS 7.4.2.2) (**hereafter Existing Vehicles**).

This leads to the following **assessment table Assessment Target 1 [Ref.33], where**:

- N1 (meaning New Vehicles Target 1) and N2 (meaning New Vehicles Target 2) are targets for New vehicles
- E1 (meaning Existing Vehicles Target 1) and E2 (meaning Existing Vehicles Target 2) are targets for Existing vehicles

In case of any inconsistency between the assessment table (xls) and the Polarion text, Polarion shall prevail. The assessment table also classifies features as "Mandatory" or "Optional"with “mandatory” meaning a specification which is part of a TSI and applicable in a mandatory way, and “optional” meaning a specification which is not in a TSI (for example a standard not referred to) or a text in the TSI which is applicable only if the applicant decides to install a specific feature onboard (for example ATO). This classification, which was initially part of our assessment, has not been taken into account in the recommendation here-under because it would require more discussion and a detailed CBA.

Based on this assessment our recommendation is to include in target 1 only the following features:

- **FRMCS (V3 specifications)**
- **Cyber security On Board*,** as to ensure compliance to the Cyber Resilience Act.
- **CCS consist network (namely SS-147)**
- **Train interface enhancements**
- **Train Integrity/Train Length**
- **Multi Display System concept**
- **Basic ASTP**

We recommend to include in target 1 technologies that in order of priority;

(i) ensure business continuity for railways

(ii) reduce costs and improve the viability of railways

(iii) pave the way for further needed improvements (via next targets)

FRMCS is the main priority for target 1. The availability of FRMCS specifications is critical for ensuring business continuity of Railways on the short term, as GSM-R will become obsolete in the relative near future. **The availability and implementation of FRMCS should not be hindered / delayed by any other foreseen functionality, other then what will be required related to Cyber Security.** FRMCS in addition will further support future CCS functionalities such as ETCS Level 2 with hybrid train detection and ATO up to GoA4.
For New vehicles FRMCS is foreseen to have an interface to the (full stack) CCS Consist network ensuring improved modularity and future upgradability. Train interface enhancements (see SPP-4828) will create a more generic product, avoiding additional costs due to project specific interface requests and thus ease integration and updates of ETCS on-board in future. Train Integrity / Train Length is an important enabler for ETCS Level 2 with hybrid train detection and fixed virtual block, which can improve the efficiency and thus viability of Railways. The Multi Display System allows to reduce future costs for upgrades and operation, through the use of standard display devices and the possibilities of fail-over between the displays of cabin applications. The Basic ASTP, which consists of a standardised odometry-interface for testing and enhanced odometry performance and robustness specification, can ease the implementation of a potentially separated ASTP interoperability constituent in a subsequent next step, of which its benefits still will need to be justified.

*Note on Cyber security; The Cyber Resilience act (REGULATION (EU) 2024/2847 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2024 on horizontal cybersecurity requirements for products with digital elements and amending Regulations (EU) No 168/2013 and (EU) No 2019/1020 and Directive (EU) 2020/1828) shall apply from 11 December 2027, cybersecurity specifications developed for CCS (Application of the Cybersecurity specifications version 1.0 to the CCS-OB and TCMS Shared Services (PKI,LOG,DNS,TTLS) will have to be applied and should then be part of target 1 as well.

5.3 CCS-OB Migration step to Target 2

5.3.1 Introduction

The CCS-OB Architecture as now proposed for Target 2 with the main changes in yellow:

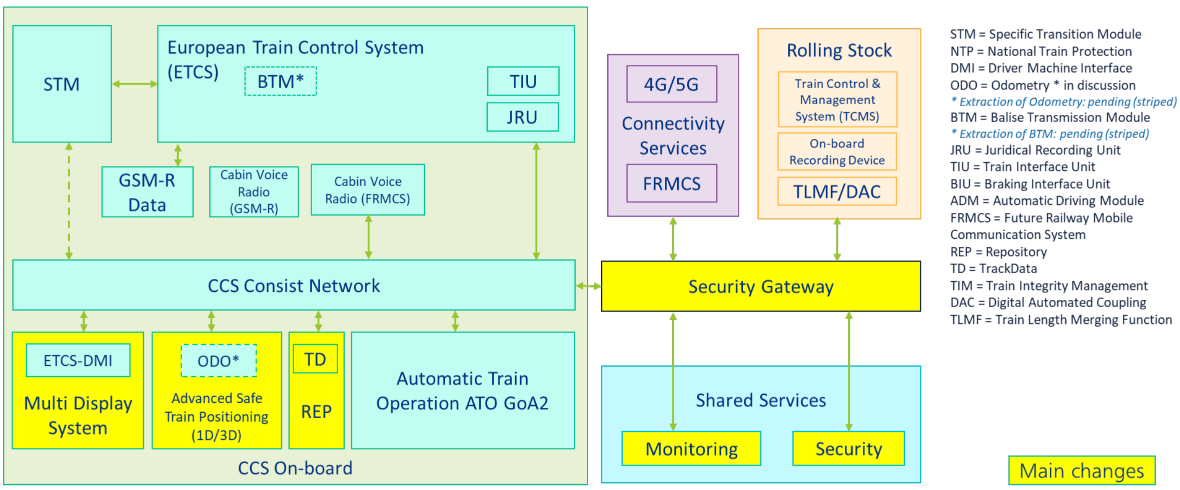


Figure 34 Simplified Architecture view for Target 2, illustrating the main changes

The contribution of the CCS-OB Target 2 functionalities to the Main Benefits for users:

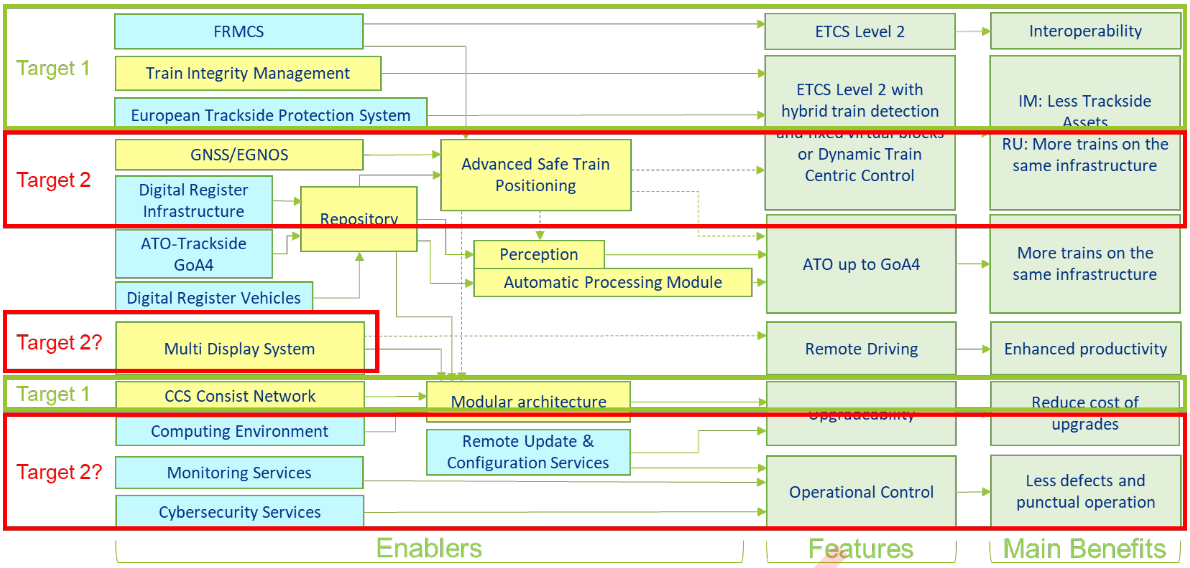


Figure 35 Dependencies between key CCS functionalities and main benefits in scope for Target 2

The figure above shows the contribution of Target 2 CCS-functionalities (red), including the corresponding main benefits for users.

Functionalities in scope for Target 2:

- **GNSS/EGNOS**: in study as of 2025-09, and a potential enabler to improve the Odometry and deliver a 3D Position for ATO GoA4 in Target A.
- **Digital Register Infrastructure (digital map)** is needed for the version of Full ASTP. This data will be exchanged via the Repository on board. In Target 2 the data from the Repository will only be used by the Full ASTP module.
- **Full Advanced Safe Train Positioning**: this can improve the reduction of headways in certain areas, due to providing location information with a higher accuracy.
- **Multi Display System concept**, as to be part of Target 1.
- **Computing Environment**, **Monitoring Services** and **Cybersecurity Services** are potential Target 2 functionalities which are still to be decided.

Dependencies from other System Pillar domains for Target 2

To reach the Features with Benefits for users there are also dependencies to CCS-Trackside functionalities:

- To reach ETCS Level 2 with hybrid train detection and virtual blocks we need from the SP Traffic CS:
  - European Trackside Protection System for dividing fixed blocks into virtual blocks to decrease headways.
  - Digital Register (Railway) Infrastructure to be used for a more accurate Advanced Safe Train Positioning (ASTP).
- To prevent cyber attacks and reach a higher grade of Operational Control and a punctual operation we need Shared Security Services On Board (out of scope for CCS-OB) and Security Information and Event Management / Security Operating Centre at the trackside (out of scope for ERJU).

5.3.2 Evaluation on Target 2

Further to the evaluation of target 1 (see section 4.2.3), target 2 should include:

- **Remote Driving** (independent from ERTMS/ATO)
- **Full ASTP**
- **Multi Display System**: ETCS for first use case, ready to integrate other use cases / applications
- **Shared Security Services**: needs to be compliant with the Cyber Resilience Act
- **Shared safe and secure computing environment**, as described under SPT2TRAIN-7463 - Evaluation of the use of a standard Computing Environment for CCS-OB
- **Monitoring and Diagnostic Services** of CCS-OB components

5.4 CCS-OB Migration step to Target A

5.4.1 Introduction

The CCS-OB Architecture as now defined for Target A with the main changes in yellow:

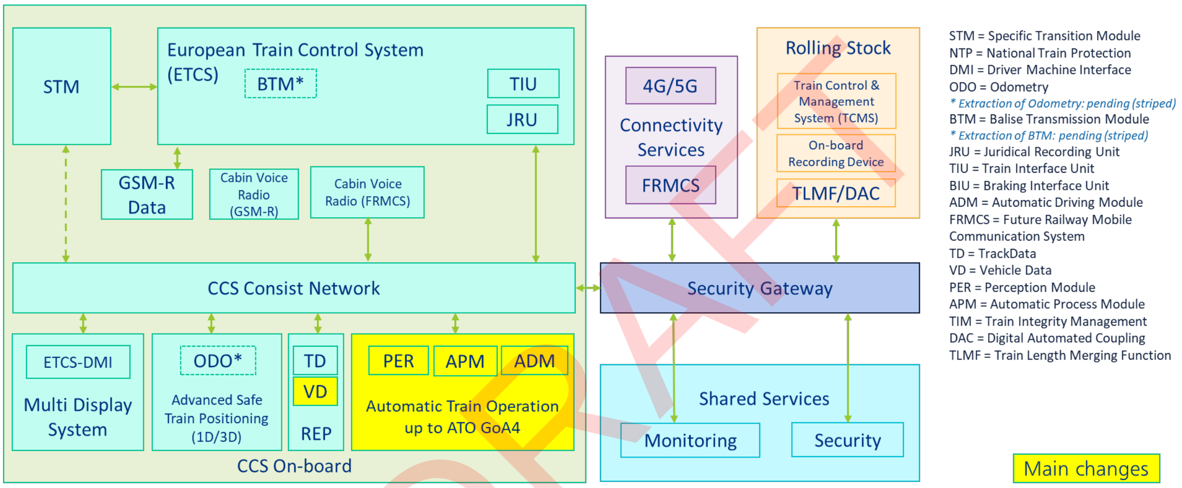


Figure 36 Simplified Architecture view for Target A, illustrating the main changes

The contribution of the CCS-OB Target A functionalities to the Main Benefits for users:

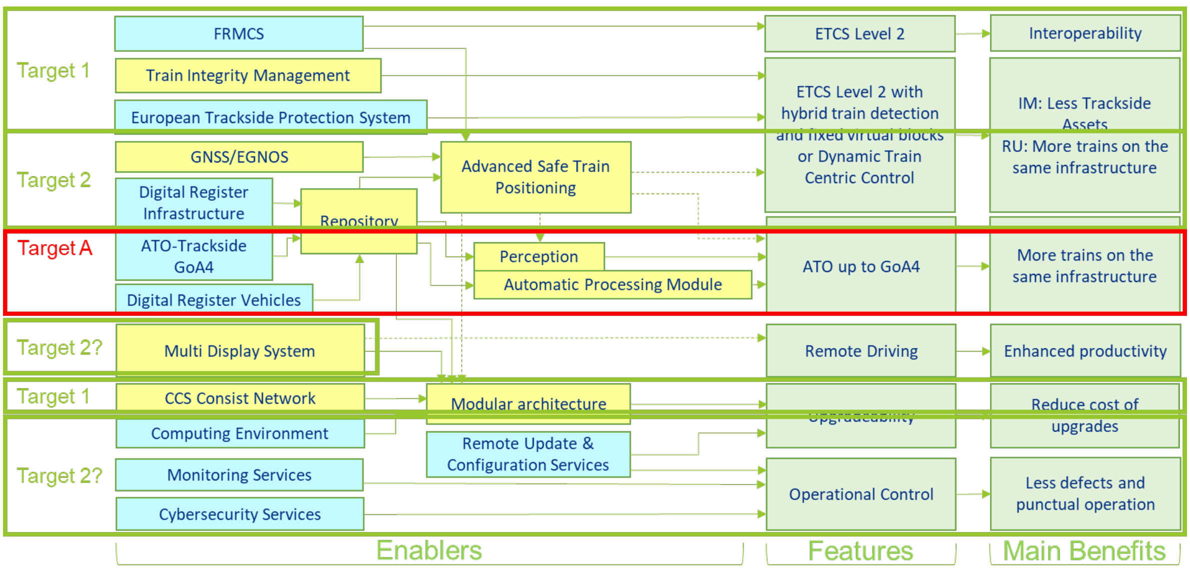


Figure 37 Dependencies between key CCS functionalities and main benefits in scope for Target A

Functionalities in scope for Target A:

- **ATO Trackside GoA4** and **Digital Register Vehicles** are needed as inputs for the Automatic Processing Module.
- **Repository**: all data coming from the Trackside will be exchanged via the Repository on board.
- Note: **Remote Driving** is mentioned as a possible fall-back functionality in *[ref FP2 R2DATO D6.5 v03 Annex 1 SRS ATO up to GoA3/4]*. Remote Driving can also be independent from ERTMS/ATO, to enhance productivity for certain driver activities (e.g. shunting movements). Remote Driving is investigated by the Innovation Pillar, but not yet in the System Pillar. The main reason why it is mentioned here is the future possibility to use a remote version of the Multi Display System as a building block for Remote Driving.

Dependencies from other System Pillar domains for Target A

To reach the Features with Benefits for users there are also dependencies to:

- Trackside components:
    - Digital Register Vehicles to be used for ATO up to GoA4, and
    - ATO-Trackside GoA4 for ATO up to GoA4.

5.4.2 Evaluation on Target A

Any feature not yet specified in target 1 or 2 would be part of target A and make ATO possible up to GoA4.

5.5 CCS-OB Modularity and Upgradeability

5.5.1 Introduction

The modularisation of the CCS-OB is one of the topics of the Train CS domain in the System Pillar, to determine the right granularity in order to identify the best balance between facilitated upgradability and reduction of cost while keeping the integration complexity at an appropriate level.
Challenges in terms of architecture development on this topic are:

- The railway system, and the CCS-OB specifically, is not a green field, but is composed of existing systems. This means that creating modularity often requires redesigning current systems. This costs of redesign has to be beneficial in terms of total cost of ownership.
- Modularising systems improves upgradeability but will also increase the effort of integration.

These challenges have to be taken into account to find the balance between the optimum granularity in a modular architecture.

Without a detailed answer coming from a cost benefit analysis this paragraph summarises the functionalities, in scope of Train CS domain, that contribute to a modular architecture and have the possibility to improve the upgradeability and may lead to a reduction of the cost for upgrades of the CCS-OB subsystems:

- The CCS Consist Network with FFFIS interfaces to all connected subsystems.
  This will make it possible to upgrade connected subsystems, in case there is no change on the interface, without recertification of connected subsystems and by that improve the upgradeability of the connected subsystems and reduce the cost of upgrades.
- A standardised Computing Environment. If sufficiently applicable for CCS-OB subsystems, then this may lead to the following benefits:
    - Use of Commercial Of The Shelf (COTS) hardware and easy upgrade of COTS hardware.
    - Remote update and configuration of software by using standard interfaces to the application on the COTS hardware.

- The Multi Display System for cabin applications.
  The Multi Display System improves the upgradeability for cabin applications by using standard display devices and making it easier to upgrade or add cabin applications to the drivers desk.
- The Repository on-board to manage the acquisition of information coming from the Digital Registers on the trackside.
- The Remote Update & Configuration Services will help the upgradeability in cases where we don't need to send technicians to the rolling stock units for updates and/or configuration changes and thus enlighten the current scarcity on technicians in combination with an increase of IT systems on modern trains.
- Modularising Odometry and BTM as subsystems as part of the development of Advanced Safe Train Positioning to create a modular architecture with the possibility to improve on upgradeability and reduce costs of future upgrades, as studied in the ASTP task group.

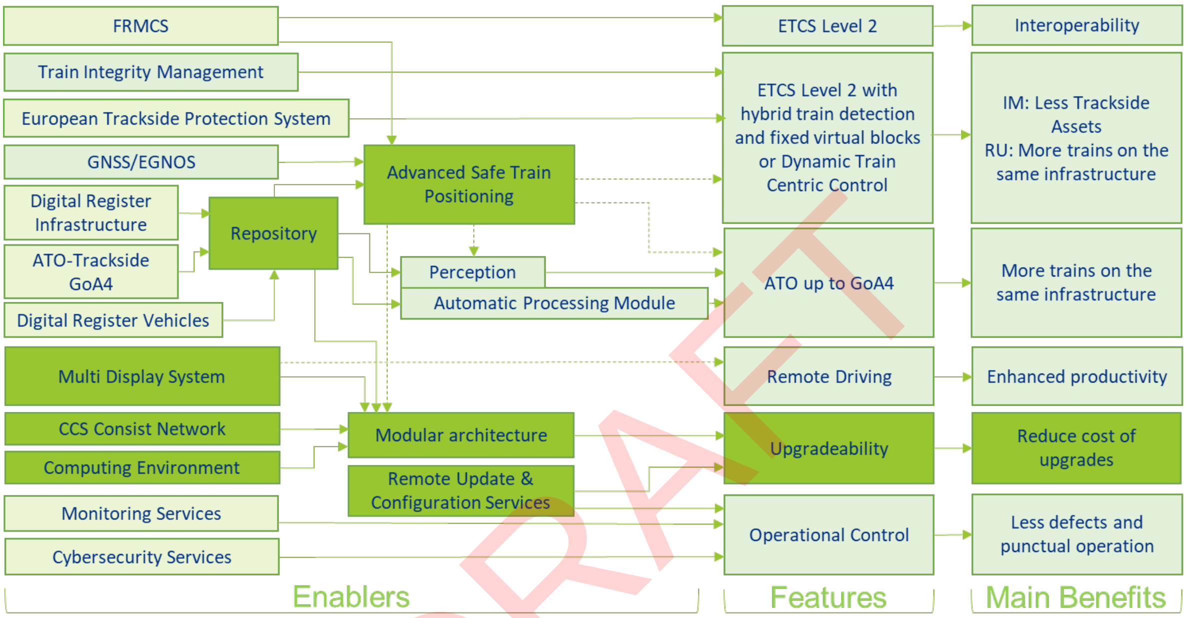


Figure 38 Dependencies between key CCS functionalities and main benefits for On Board Modularity and Upgradeability

5.5.2 Evaluation of CCS On-board modularity and upgradeability

This section is discussing the use of CCS On-board modularity and upgradability analysis in order to identify how cost reduction can be achieved.

Reducing the cost of upgrades and retrofits is very important given:

- the lifecycle of rolling stock units of around 30 to 40 years,
- the amount of rolling stock units to be upgraded of around 30.000 in the SERA,
- the increasing amount and frequencies of upgrades/retrofits with new functionalities and/or corrections,
- the cost of an upgrade/retrofit per rolling stock unit of 400k for upgrades or 900k for retrofits [Ref.28], and
- the needed extraction of a rolling stock unit out of the daily operation.

The costs per rolling stock unit are coming from the EC Cost Driver Analysis [Ref.28]:

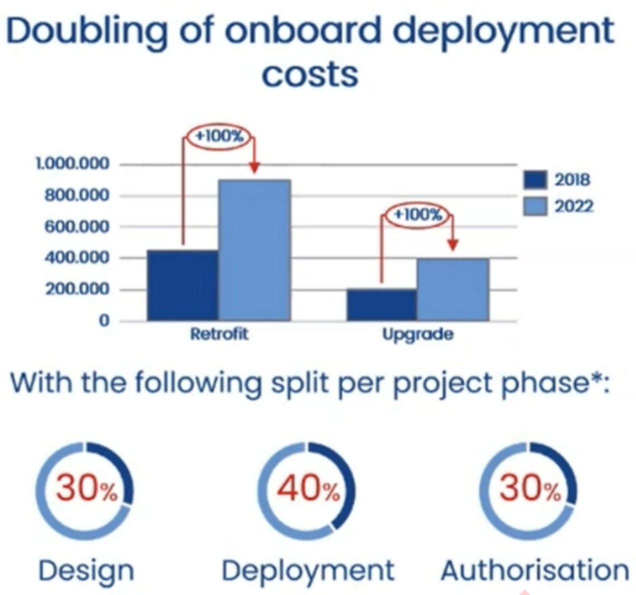


Figure 39 Onboard deployment cost per rolling stock unit [Ref.28]

With the most impactful cost drivers:

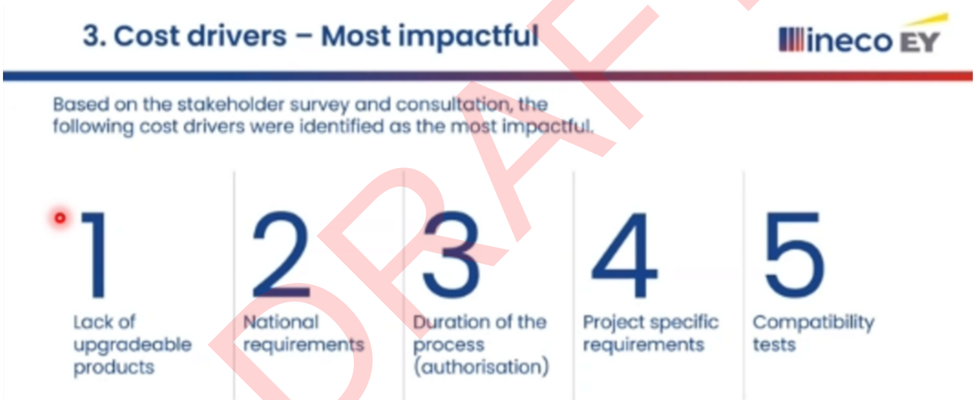


Figure 40 Most impactful cost drivers [Ref.28]

Looking at the Onboard deployment cost per rolling stock unit in the figures above, the following CCS-OB functionalities are linked as possibilities to reduce the cost:

1. Design (30%)/Lack of upgradeable products.
   Within the scope of CCS-OB the following functionalities can contribute to the modularity and have the possibility to reduce the cost of upgrades and/or retrofits:
   a. CCS Consist Network,
   b. Computing Environment
   c. Multi Display System
   d. Repository
   e. Advanced Safe Train Positioning
   f. Euroradio (after the phase out of GSM-R)
2. Deployment (40%).
   Within the scope of CCS-OB the Remote Update and Configuration of software might contribute to optimize the time and cost needed for deployment of software updates by reducing the number of times that technician have to visit / work on the rolling stock units for maintenance (configuration changes, software updates, etc.).

3. Authorisation (30%).
   For optimizing the authorisation proces, see Specification for Authorisation, Integration and Upgradeability of modular CCS-OB subsystem including train interface [Ref.32].

5.5.3 Evaluation of CCS On-board migration process

5.5.3.1 Introduction

The System Pillar managed by Europe's Rail has rightly included activities, initially in Specific Contract 2.3 by the MIG Domain and currently in Sprecific Contract 2.4 by the TrainCS and TrafficCS domains, to assess the economic viability of individual functionalities and the so-called migration steps.

These activities are critical, as they will provide recommendations to Europe's Rail, ERA, and the European Commission (DG MOVE) on the process and planning of bringing new functionalities into TSIs (or standards) through the legislative framework. This paragraph evaluates the foreseen on-board migration targets from a business perspective, examining the current challenges stakeholders face and recommending ways to improve and ease migration.

5.5.3.2 Identified problems

The foreseen migration steps are, like the foreseen steps of TSI revisions, based on changes every 3-4 years.

The Targets as defined by the core group mention following timeframe;

- Migration Target 1 = first set of solutions largely based on today's technology (specifications for some elements are already ready, completion of specifications for all elements of target estimated around 2027, products sequentially delivered but with the full set in the early 30s)
- Migration Target 2 = Enhanced digitalization introducing new technology (specifications progressively developed, completion estimated around 2030, and products delivered following that)
- Migration Target A = Automated European Railway

Migration Target 1 is clearly linked to the availability and adoption of mature (first edition) FRMCS specifications into the TSI. Migration Target 2 appears to align with the availability of new functionalities aimed at achieving SERA goals.

Historically, TSI CCS revisions have occurred roughly every 5 to 7 years . However, ERA now foresees a shorter cycle of 3–4 years, aligning with the Migration Target timeline. The TrainCS CCS evolution path follows a similar cadence, reinforcing this alignment since the Targets underpin architecture development.

Migration Targets will introduce new requirements being adopted into the TSI, which could lead to the need for (mandatory) upgrades following the same cadence of 3-4 years.

Many stakeholders, particularly Railway Undertakings, Vehicle Keepers, and Lessors, have expressed concerns about frequent TSI revisions, citing the rising costs and tight deadlines for mandatory fleet upgrades.

In this paragraph we make a distinction between "updates", which is the action of updating the software of an existing onboard equipment (typically a TSI related error correction), thus excluding any physical modification, and an “upgrade” of an existing onboard equipment (in general adding new features), which requires at least one physical modification and, possibly, one or more updates of existing equipment. If the onboard can be "update" or needs to be "upgraded" might differ between products from different suppliers.

Railways face unsustainable cost increases for upgrades, often without clear benefits.

According to a recent EC-commissioned study (INECO/EY study, see TEN-T NEWSLETTERS - Publication of the On-Board Cost Drivers Report), upgrade costs have significantly increased: “*Over recent years, the cost of retrofitting and upgrading ERTMS systems on board trains has about doubled. Between 2018 and 2022, the price of retrofitting a vehicle surged from €450 000 to €900 000, while the cost of an upgrade increased from €200 000 to €400 000.”* .

These costs are driven by engineering modifications, certification, ESC tests, and workshop downtimes. They stem from fragmented national systems, custom engineering requirements, lack of harmonised digital processes and long downtimes for testing and certification.

These high costs are often not supported by solid business cases that justify the investments. Or, in cases where the benefits are system-wide, public financial support is usually lacking or insufficient.

As mentioned above the timelines related to the Migration Targets and TSI Revision cycles seem generally to be aligned with the availability of new functionalities aimed at achieving SERA goals. However, they fail to consider the economic realities and business models of the involved stakeholders.

Such a (potential) short-cycle upgrade model is not economically viable. It may erode trust in rail as a sustainable market, not only among rail operators but across the entire industry ecosystem.

The transition regime aims to give flexibility, but without a very careful, harmonized and future-proof implementation, risks of fragmentation, bad investment and safety issues could seriously hurt Europe's railway goals.

The transition regime as defined in chapter 7 of the TSI (CCS) has been setup to;

- Prevent frequent mandatory upgrades for existing vehicles without added value.
- Provide legal certainty and predictability for investment decisions.
- Allow for gradual implementation of new functionalities.
- Clearly define deadlines and transitional measures depending on the stage of the vehicle’s life cycle.

The transition regime makes clear distinction between **several phases of a vehicle’s life** or development on bases of which TSI requirements apply differently at the time of TSI adoption;

1. Concept / Design Phase; Vehicle or subsystem is not yet contracted or under construction. TSI requirements fully apply. These vehicles must be equipped according to the latest TSI version, including new functionalities, baselines, or system versions.
2. Under Construction / Pre-authorisation; Contracted but not yet authorised for placing on the market. A transitional clause may apply if the design was based on a previous TSI version. ERA or NSA may allow it to proceed with the originally applied version (e.g. Baseline 3), if justified.

3. Authorised / In Operation; Already operating or authorised. Not required to be upgraded unless: There's a major modification (as defined in other EU legislation), the upgrade is safety-critical, it's explicitly mandated by Chapter 7 with a deadline.
4. Re-authorisation / Renewal; When a vehicle undergoes significant modification (e.g., upgrade, refurbishment). A case-by-case assessment is made to determine if re-authorisation is needed. TSI compliance might then be required for only the modified part.

Transition regime and implementation risks:

These goals and distinction in different phases of a vehicle's life do help and support to allow flexibility for railways to implement. However without a very careful, harmonized and future-proof implementation, risks of fragmentation, bad investment and safety issues could seriously hurt Europe's railway sector.

1. Interoperability Fragmentation Risk;
   If different infrastructure managers or operators apply different interpretations of "partial fulfilment" or transitional provisions, networks could become inconsistently equipped. Example: A train prepared for ETCS Level 2 with hybrid Train Detection and Fixed Virtual Block, or ETCS Level 2 with moving block on one corridor might not be compatible with systems elsewhere, forcing costly retrofits or creating "islands" of interoperability. Result: Loss of the EU goal of seamless cross-border operation.
2. Investment and Obsolescence Risk;
   During transition, there's a real danger of investing in systems (like an early ERTMS system version or cybersecurity solution) that soon become non-compliant or require expensive upgrades. Especially relevant for projects making heavy investments now without fully matching the future mandatory standards (e.g., ATO-ready ETCS). Result: Wasted capital, stranded assets, financial instability.
3. Safety and Reliability Risk;
   If systems are deployed partially or unevenly, there's a higher chance of technical interfaces failing, increased operational complexity for drivers, dispatchers, and maintainers. Mixed traffic (e.g., ETCS-only vs ETCS + national systems vs ETCS Level 2 with Hybrid Train Detection and Fixed Virtual Block) adds new operational risks. Result: Possible safety incidents or service disruptions if not properly managed during the transition phase.

Example related to the migration from GSM-R to FRMCS:

Risk	**Impact on GSM-R to FRMCS migration**
1. Interoperability Fragmentation	If different countries/IMs (Infrastructure Managers) move to FRMCS at different speeds or use different early FRMCS profiles*, trains might need dual onboard equipment for years (GSM-R + FRMCS). This can delay true cross-border interoperability and create operational bottlenecks at borders.
2. Investment and Obsolescence	Operators might invest now in GSM-R renewal projects (because GSM-R is still mandatory) only to rip them out in 5–7 years when FRMCS becomes compulsory. Early partial FRMCS deployments might also lock in semi-final solutions that don't fit the final harmonized FRMCS spec.
3. Safety and Reliability	Running hybrid operations (GSM-R + FRMCS) could create handover problems: a train might lose communication during transition areas, especially if the early FRMCS network coverage isn't dense enough. This increases the risk of radio communication failures, affecting movement authority transmission under ETCS.

*) "Different early FRMCS profiles" meaning partial, non-unified implementations of FRMCS before the final standard is fully in place, leading to potential fragmentation risks in European rail operations.

Concrete examples of possible differences in early FRMCS profiles:

Example	**Early Profile Variation**
Country A	Starts with FRMCS over LTE, voice and minimal train control data, limited handover.
Country B	Waits for full 5G FRMCS capability, including Mission Critical Video for cab signalling and diagnostics.
Country C	Runs FRMCS with old GSM-R frequencies initially, before getting the dedicated FRMCS bands.

A train operating internationally might have to handle multiple FRMCS profiles depending on the country it's crossing into. If the on-board equipment can't handle all variants, it would either need expensive multi-profile capability, or be blocked from cross-border service until full harmonization.

See our recommendations on the migration from GSM-R to FRMCS in chapter SPT2TRAIN-8358 - FRMCS Migration

5.5.3.3 Recommendations;

We would like to make following recommendation;

<u>**Make a clear split in target setting based on the phases of a vehicle's life**</u>

For New vehicles current 3-4 year TSI revision cycles can be sustained.
For New vehicles the situation is totally different as compared to Existing fleets. 3-4 year TSI revision cycles with new updates of functionality seem to fit well for railways as:

- <u>Latest features can be included</u>; which keeps railways aligned with market and innovation, avoids technological lock-in;
- <u>It improves foreseen ROI</u>; Vehicles would stay compliant and interoperable longer, extending their operational life (if still economically attractive / feasible). Lifecycle costs can be reduced through fewer mid-life retrofits, fewer national-specific upgrades and easier authorisation in multiple countries.
- <u>It ensures faster response to regulatory gaps or safety issues</u>; Unintended regulatory gaps or safety risks can be fixed earlier, before they propagate widely across the network.

Adopt a minimum 10-Year upgrade cycle for Existing vehicles.
While innovation adoption may be swift for New vehicles, existing vehicles (meaning vehicles that are authorised / in operation and/or vehicles that are renewed) should follow a much more stable and predictable upgrade cycle—no shorter than 10 years after being authorized and put into operation (see paragraph on transition regime SPT2TRAIN-8348 - Identified problems) —to ensure economic sustainability and operational continuity.

Such longer cycle avoids the situation of overlapping migration paths, as it can be assumed that a timeframe of 10 years is sufficient for executing such upgrades. Error corrections that would otherwise cause safety related issues need to be exempted from this rule, as safety at all times needs to be ensured.

The 10-year timeframe could in time be reduced if;

- The costs for updates and upgrades are significantly reduced
- Clear benefits for all stakeholders involved are identified, or benefits are foreseen on system-wide scale and public financial support has been arranged.
- Backward compatibility is ensured
- Sufficient time for migrating has been arranged.

We should strive to exclude vehicles older than 15 years from mandatory upgrades.

Excluding these vehicles will foster better planning, reduce unnecessary retrofits, and increase the overall efficiency of the European railway system.

If upgrade is requested specifically for a (clearly defined) area-of-use, supported by a vehicle-specific business case ensuring reasonable return on investment or (public) financial support for the investments requested, then upgrade of such vehicles could be considered.

Another reason for mandatory upgrade– which relates to all vehicles no matter in what phase of its life cycle – would be to correct safety related issues, as safety should always be a precondition.

We should strive to make upgradeability less complex and time consuming and more cost effective.

As stated in the recent EC-commissioned study (INECO/EY study, see TEN-T NEWSLETTERS - Publication of the On-Board Cost Drivers Report); *To address the issue of limited upgradeability, it is essential to determine the optimal level of granularity for both hardware (HW) platforms and software (SW) components. Developing a more modular software architecture would streamline upgrades by reducing the scope of software that needs updating, although it may increase integration complexity. Additionally, defining which functions of the CCS on-board systems can be managed through data or parameterisation would facilitate easier implementation of changes. Identifying elements that hinder obtaining a generic certificate for products, enabling modular integration at the subsystem level rather than project-specific integration, is crucial. Despite provisions in the current CCS TSI to avoid impacting certification or authorisation procedures for SW updates due to error corrections, this hasn't been effectively implemented in projects. It is necessary to explore reasons for this discrepancy across various retrofit projects.*

The means to achieve a lean SW update of digital systems installed in the rolling stock need to be defined. The identification of which changes can be done without HW updates will be beneficial. Allocating public money to the development of standardised interfaces on new and existing vehicles to secure future upgrades with more competition between ETCS providers should therefore be considered as a priority for the sector.

Backwards compatibility should be a prerequisite for any new specification or requirement.
Ensuring backwards compatibility is strategically and economically essential, especially during long technology transitions (e.g. migration from GSM-R to FRMCS or ERTMS from Baseline 2 to 3 or 4). Sector stakeholders and EC and ERA should strongly support this as prerequisite for any new specification or requirement.

Backwards compatibility supports:

- Operational continuity; it allows onboard systems to operate across both old and new infrastructure, avoiding service disruptions.
- Future-proof investments; Backwards compatibility reduces the risk that onboard systems become obsolete or non-authorisable before the end of their life. It also supports gradual fleet upgrades, rather than needing a mass retrofit.
- Cross-Border and International Interoperability; Without backwards compatibility, trains need multiple onboard systems or be restricted to limited corridors, reducing commercial flexibility.
- Smoother authorisation and migration; by simplifying authorisation, reduce reliance on national rules and minimise partial fulfilment complexity.

The necessity to ensure compatibility with existing subsystems has also been adressed in the EU Directive 2016/797 on the interoperability of the rail system within the European Union (clause (17)); "*In the development of new TSIs, the aim should always be to ensure compatibility with the existing subsystems. This will help to promote the competitiveness of rail transport and prevent unnecessary additional costs through the requirement of upgrading or renewal of existing subsystems to ensure backward compatibility*..."

Ensure coordinated and realistic timeframes for fleet migration.

Coordination:

There is currently no clear coordination of deployment of railway technological innovations in the EU beside soft obligations or recommendations through TSIs, TEN-T Guidelines and the ERTMS Coordinator.

Currently it seems that Infrastructure Managers (IM's) have completely independent and individual strategies to rollout features, where railway undertakings (RU's) are obliged to follow these continuously changing strategies. IM's and RU's need to coordinate their rollout strategies with a long-term view and this needs to be done also across borders between countries.

In addition the impact on operating rules should not be neglected, as thes independent and individual strategies might make the scheduling of correctly trained drivers even more challenging than the scheduling of correctly equiped vehicles.

Related to coordination of deployment railways can learn from the airline industry (see About us | SESAR DM, which specifically is related to aviation air traffic management). Although there are similarities with the ERJU High Level Deployment Group, there also seem to be essential differences;

- In the Air Traffic Management (ATM) sector a Deployment Manager function is defined, the so called SDM(SESAR (Single European Sky ATM Research project) Deployment Manager) is responsible for the coordination of the implementation of the most essential operational improvements through the concept of Common Projects.
- A Common Project is based on mature solutions to be deployed in a synchronized and timely manner across Europe, translated into an European Law. Such Common Project binds the Member States of the European Union and their operational stakeholders.
- The SDM synchronises and coordinates implementation against the Deployment Programme which is a project view of the Common Projects organising their implementation into optimum sequences of activities by all the stakeholders required to implement.

A more centralized coordination on migration has several benefits amongst which:

- It reduces costs via economies of scale; central planning allows for joint procurement, standardized specifications, testing and certification.

- <u>Creates predictability for stakeholders;</u> all sector stakeholders benefit from synchronized timelines, that reduces the risk and allows better planning for manufacturing capacity, workforce training, investment cycles.
- <u>Accelerates innovation adoption;</u> it can overcome inertia caused by national hesitation or fragmented decision-making. It creates a shared sense of urgency, encouraging early movers and aligning stakeholders.
- <u>Strengthens railway competitiveness</u>; by making rail more efficient and reliable.

Realistic timeframes for migration:

When deciding on deadlines for having new functionality mandatory, realistic timeframes for industry and railways should be set, that ensure feasible migration paths for migration of fleets.

As we are experiencing with e.g. FRMCS, an innovation / new feature can take several years before becoming mature and being ready to be adopted in a TSI and/or standard. Although industry is or might be involved in the early stages of the development, finalization of these developments need to be based on mature and approved requirement specifications, so final stages of development, testing, certification up to delivery of a (generic) product ready to be placed on the market, will subsequently follow after TSI adaptation.

Vehicle owners will also need to go through different process steps. Aware of ongoing developments, they can meanwhile (so before TSI adoption) set out a high level migration strategy, analyse the foreseen impact on their fleet (time needed in the workshop / withdrawal from operation, do first cost calculation, risk assessment, setup a procurement strategy) up to initiating a tender. They however are in need of the final requirements to finalize these preparations and send out a Request for Proposal. Next steps for vehicle owners / keepers consist generally of; execution of the tender(s) up to closing contract, engineering for integration of the product in the specific vehicle type, develop / produce First in Class, execute conformity assessment, executing tests, authorisation of First in Class further technical and operational integration testing, start series upgrade.

Lead times for such steps depend on many different factors, amongst which; technical complexity of the product including its (inter-) dependency of other subsystems, availability of industry knowledge / capacity, complexity of the specific vehicle, availability of workshop capacity, complexity of technical integration, scope of verification and validation testing, leadtimes for authorisation.

In the case of the ERTMS Retrofit Marseille-Ventimiglia project, one speaks for the type authorisation of a period of about 12 months for the conformity assessment and 36 months for the strict authorisation workload which includes ETCS System Compatibility tests. Based on the assumption that a train type consists of 20 vehicles and taking into account that not all works can be done in parallel due to limited space in workshops, it can be concluded without any overestimation that an upgrading cycle should not be less than 10 years.

A cycle of 10 years would bring the necessary stability. The period between incompatible baselines should thus be 10 years plus the time to market of corresponding products. The period between TSI versions can be shorter if chapter 7 makes a clear distinction between deadlines applicable to New vehicles and existing vehicles, but the same type/vehicle should not be subject to two successive mandatory upgrade in less than 10 year.

<u>**Focus not only on long-term, but also on short-term solutions that can reduce costs of (mandatory) upgrades.**</u>

This is essential to ensure affordable, feasible and sustainable migration, especially for sector stakeholders like operators, facing immediate budget pressures. Many rail operators and infrastructure managers have limited annual CAPEX or OPEX budgets.

If only long-term strategies are considered, urgent compliance needs may be delayed or unaffordable, leading to fines or penalties for non-compliance, denied authorisations and/or operational disruptions.

Short-term wins build momentum and confidence. Demonstrating early success helps to convince decision-makers, justify future investments and build technical capacity. If only long-term solutions are planned, the industry may be left with unmanaged risks, stranded assets, or outdated systems before the full plan is realized. Smart short-term actions — if aligned with future goals — make the migration more practical, less risky, and more affordable.

For example; The INECO/EY report as mentioned previously states that a significant part of the costs for upgrades stem from costs related to authorisation, certification and testing. From this report following measures can be derived that if adopted promptly, can yield significant short-term cost savings and improve the predictability and speed of certification/authorisation — especially for retrofits and upgrades under tight project timelines;

Measure	**Purpose**	**Benefit**
Reduce ESC/RSC testing	Cut redundant test effort	Lower test costs
Generic authorisation templates	Broaden reuse of approvals	Fewer prototypes needed
Improve ERATV	Easier access to type history	Faster documentation & checks
Share authorisation experience	Avoid repeating mistakes	Smoother approvals
Translate and structure vehicle data	Support integration	Minimise re-engineering
Create national rule repositories	Clarity and transparency	Lower administrative burden

5.5.3.4 Conclusion

Short-term and long-term solutions must be pursued in parallel. A stable 10-year cycle for existing fleets, strict backward compatibility, and a centralised deployment model will support sustainable rail transformation. Addressing immediate cost pressures through early coordination, process simplification, and smarter authorisation can accelerate progress and reduce the financial burden on the sector.

5.6 CCS-OB Final Architecture

The CCS-OB Single European Railway Architecture, after the phase-out of GSM-R:

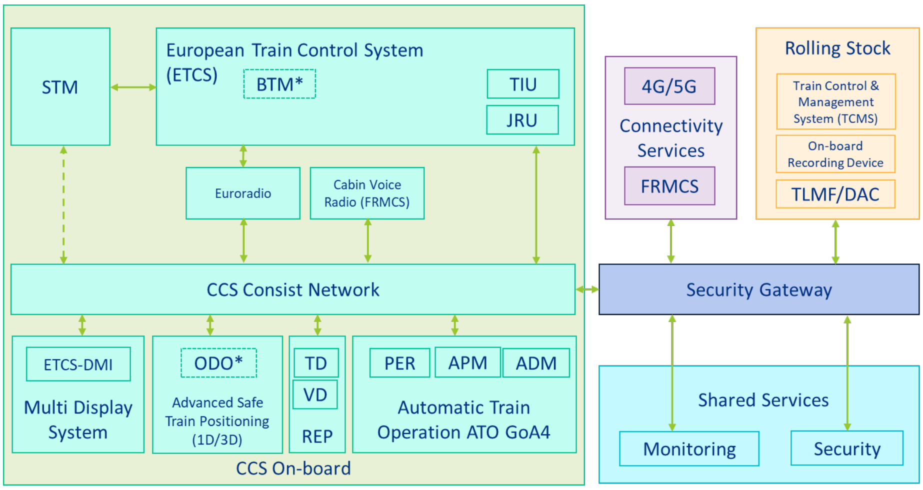


Figure 41 Simplified Final SERA Architecture view, after phase-out of GSM-R

Note on the figure:

- Euroradio can be split from ETCS-OB after the phase out of GSM-R. Rationale is that it is separate functionality with a lower SIL-level (SIL-0) than the other ETCS-OB-functionalities.

5.7 Conclusions and recommendations

This paragraph consists of three steps:

1. Migration priorities from a business benefit perspective.
2. Migration recommendations per target, following the migration priorities
3. Key recommendations for programming

5.7.1 Migration Priorities

Given the facts that costs for upgrades and retrofits are increasing and budgets are decreasing, recommendations for the migration to the Command Control & Signalling (CCS) final architecture are formulated.
These recommendations are based on the following priorities:
1) Limit the number of upgrades, especially for the existing fleet.
2) Focus the upgrades primarily on:

1. Business continuity:
    a. FRMCS, and
    b. Cybersecurity.
2. Achieving main benefits for the users:
    a. ERTMS/ETCS Level 2 with hybrid train detection and fixed virtual blocks -> more trains on the same infrastructure and less trackside assets,
    b. Remote Driving (independent from ERTMS/ATO) -> Higher productivity (in shunting areas, mostly not equipped with ERTMS/ETCS Trackside), and
    c. ERTMS/ATO up to GoA4 -> more trains on the same infrastructure and higher productivity.

5.7.2 Migration recommendations per target

Based on the evaluation of the three targets, the migration recommendations per target are the following:

Target 1: to only include the following features:

- Final FRMCS TSI related functionality
- CCS consist network (namely SS-147)
- Cyber security On Board as to ensure compliance to the Cyber Resilience Act
- Train Integrity Management: to enable ETCS Level 2 with hybrid train detection and fixed virtual blocks -> more trains on the same infrastructure and less trackside assets
- Train interface enhancements
- Basic ASTP

Target 2:

- Remote Driving (independent from ERTMS/ATO)
- Full ASTP
- Multi-Display System
- Shared safe and secure computing environment
- Diagnostics

Target A:

- ERTMS/ATO up to GoA4
- Any feature not yet specified in target 1 or 2.

5.7.3 Key recommendations for programming

The migration from GSM-R to FRMCS is critical for ensuring business continuity and introduces the opportunity to introduce digitalization and facilitate the future evolution of CCS on board. However, delays in FRMCS specification development, lack of coordination, high upgrade costs, and compatibility issues with existing ETCS fleets pose major risks. Without decisive action, these factors could lead to fragmented implementations, financial inefficiencies, and hindered interoperability.

While the roadmap is technically sound, **economic viability—particularly for existing fleets—is under pressure** due to frequent upgrades and lack of backward compatibility.

1. **Accelerate delivery and adoption of mature FRMCS specifications** (especially V3) into the TSI, ensuring system stability and readiness.
2. **Establish strong EU-level coordination and governance for FRMCS deployment** (e.g. similar to the aviation sector's deployment manager model).
3. **Make a clear split in target setting based on the phases of a vehicle's life:** Adopt a minimum 10-year upgrade cycle for existing vehicles and exempt those older than 15 years from mandatory upgrades unless safety-critical or supported by a sound business case. For New vehicles current 3-4 year TSI revision cycles can be sustained.
4. **We should strive to make upgradeability less complex and time consuming and more cost effective.** Limited upgradeability can be improved by determining the optimal level of granularity for both hw and sw components, developing a more modular software architecture, defining which functions of the CCS on-board systems can be managed through data or parameterisation, identifying elements that hinder obtaining a generic certificate for products and by avoiding impact on certification or authorisation procedures for SW updates due to error corrections.
5. **Backwards compatibility should be a prerequisite for any new specification or requirement,** as to avoid stranded assets and promote interoperability.

6. **Ensure coordinated and realistic timeframes for fleet migration.**
7. **Focus not only on long-term, but also on short-term solutions that can reduce costs of (mandatory) upgrades.**(e.g., streamlined certification, shared authorisation templates, harmonized tender requirements) to ease upgrade burdens and maintain sector viability.

6 Appendix

6.1 Appendix 1: Migration scenarios for Target 1 and current Train CS studies

This paragraph is elaborating on the possible migration scenarios for the functionalities in scope for Target 1 and current Train CS studies. These migration scenarios have been produced during workshops and are still containing open questions and topics to be further elaborated in next phases.

6.1.1.1 FRMCS Migration

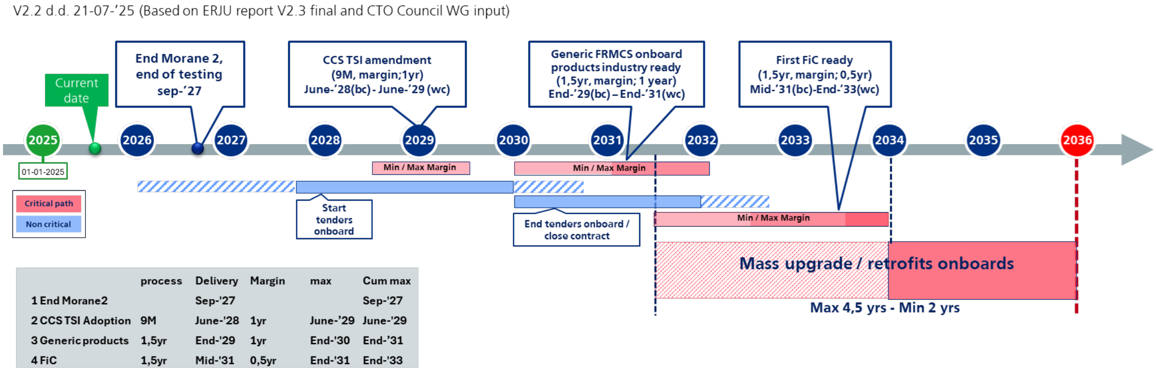
Within SC2.3 the Migration domain already elaborated on FRMCS migration, see Link to MIG / FRMCS. The information in this paragraph is an update / extension of the information already provided.

Problem definition / Timeline

The timeline on FRMCS migration for vehicle owners (and infrastructure managers) is more and more squeezed by;

- **The shifting date of adoption of FRMCS specifications in the TSI**. As stated in the draft EU-Rail Report V2 from March '25 (Ref. 34, link; Draft FRMCS Report V2); '*Based on the current assessment, if the current approach remains unchanged, the new TSI is expected significantly later than originally planned and overall with a reduced scope focussed on GSM-R replacement, with additional functionalities to be introduced in later versions. There remain significant risks in the overall delivery of the specifications*.'. In the recent update in May of the report, the foreseen planning for CCS TSI amendment adoption of the FRMCS specifications is foreseen best case June 2028, worst case June 2029.
- **It is generally assumed that GSM-R will become obsolete from the end of 2035 onwards. When this will actually come into effects depends on bilateral agreements between (national) infrastructure managers and their telecommunication providers.** Generally it is foreseen that GSM-R will become obsolete after 2035 (as this has been stated numerous times on the UIC FRMCS world conference (d.d. june-'23)). Formally a support statement from UNITEL (2021) states that its Railway Operation Communication Industry Group (ROC IG) is "committed to provide support for GSM-R at least until 2030 on a general basis" (see https://www.unife.org/wp-content/uploads/2021/07/UNITEL-Committee_GSM-R-Long-term-Support-Statement_v28072021Final.pdf). The actual date when (which) GSM-R (service) will become obsolete is depending on bilateral arrangements between individual Infra Managers and GSM-R Telecommunication providers.

Based on current (19-05-'25) information on foreseen planning and indicated margins we can derive following window, of between 2-4,5 years, for migrating the EU fleet from GSM-R to FRMCS.



	process	Delivery	Margin	max	Cum max
1 End Morane2		Sep-'27			Sep-'27
2 CCS TSI Adoption	9M	June-'28	1yr	June-'29	June-'29
3 Generic products	1,5yr	End-'29	1yr	End-'30	End-'31
4 FiC	1,5yr	Mid-'31	0,5yr	End-'31	End-'33

Figure 42 FRMCS Planning

Problem definition / Scope of the EU fleet to be migrated

The feasibility of this "challenging" timeframe for migration towards FRMCS becomes even more clear when looking at the volume of the fleet that will most likely migrate to FRMCS.

The size of the EU fleet is estimated at around 41.000 vehicles of which between 28.000-35.000 are expected to be (are or will be in coming years) equipped with ETCS, and 14.000-7.000 will not (see https://www.era.europa.eu/system/files/2022-12/1_-ertms_deployment._where_do_we_stand_now._where_are_we_going_-_matthias_ruete.pdf). Possibly a part of these 14.000-7.000 will migrate to FRMCS for replacing GSM-R voice communication only, we could not derive any further quantification on this.

Problem definition / Scope of the FRMCS specifications

Compared to the expectations on scope and timing set out in the 2023 System Pillar report there are significant delays in the specification delivery by the UIC FRMCS programme. A completed V2 specification is currently estimated by February 2026, compared to the original estimation of June 2024. In order to reduce the delays, a scope reduction, focussed on GSM-R replacement is foreseen. The delayed V2 specifications will have an impact on testing and validation, then on V3 completion and finally on deployment considerations.

The delay compared to the initial planning requires the sector to rethink the ambitions and the timing of the next steps in the development of the system. As a result of the ERA Technical Opinion and the sector’s call to accelerate the development of specifications, there has been a review of the overall scope for the FRMCS specifications V2 and V3, resulting in a revised and reduced scope proposed by the EECT.

The proposed scope has been reduced compared to the original ambition, with the V2 and V3 scope now more focussed on GSM-R replacement plus certain additional functionalities.

Problem definition / Costs for migration

As stipulated in 5.5.3 - Evaluation of CCS On-board migration process meanwhile the costs for ETCS upgrades are rising fast. As FRMCS is foreseen only to be compatible with ETCS onboard Baseline 4-SV3.0 and trackside Baseline 4-SV2.3, current and contracted ETCS equipped fleets will need to undergo an ETCS upgrade in order to operate with FRMCS under ERTMS.

Problem definition / lack of overarching coordination

No overarching responsibility has been assigned for the coordination of implementation and deployment of FRMCS in Europe, or for the coordination of prolonging GSM-R services up to 2040-2045. If the implementation of FRMCS is not well coordinated, the impact on railway undertakings, fleet owners , lessors and keepers might become a disaster. Hence the decision taken in June 2024 of EU-RAIL to set up a subgroup of the EU-Rail Deployment Group.

Problem definition / ETCS-FRMCS compatibility

FRMCS is foreseen only to be compatible with ETCS onboard Baseline 4-SV3.0. This means that existing and contracted fleets that will be equipped with a lower version will need to be upgraded, if these vehicles are foreseen to continue operation under ERTMS after GSM-R obsolesence. As operators are now experiencing, the upgrade of the ETCS Onboard unit is a timeconsuming and costly exercise.

ETCS Baseline 4-SV3.0 compared to existing Baseline 3 fleets not only contains FRMCS (2 enhancement CR's), it contains in total some 110 error corrections and 25 additional enhancements. These additional CR's impact the reusability of existing EVC's, as indicated by UNIFE (UNIFE answer to EC dd 28-02-2025); " *For Baseline Light; we estimated 60 % to 70 % of the EVC HW being capable to host a Baseline Light SW. With the higher complexity of BL4, SV2.1 plus FRMCS, this might reduce the reusability to 30 % to 50 %.*".

Railways have - via the CTO Council - in the past two years suggested solutions that could ease the migration towards FRMCS, focussing on preventing or reducing the impact on the ETCS onboard.

Many different solutions have been proposed, amongst which the "Baseline Light" concept, which was based on compatibility of FRMCS with ETCS Baseline 3, aimed at realising a minimum impact on the ETCS SIL-4 core part and no ETCS OBU hardware replacement. Disadvantages of the Baseline Light solution is that it does not include the Change Request (CR's, existing of error corrections and enhancements) that form the delta between Baseline 3-SV2.1 and Baseline 4 - SV3.0, amongst which (enhancement) CR's that include ATO and Supervised Maneouvre.

After a negative ERA opinion, mainly focussing on how to deal with error and enhancement CR's a "**Compromise solution**" was proposed by the CTO Council ensuring **FRMCS compatibility with ETCS Baseline 4-SV2.1**. This proposal would include (next to the full CR1359 and CR1360 (which entail the FRMCS functions) and CR1370 (relocation without linking)) the error corrections (total some 110 CR's), thus enable to avoid NTR's.

Advantages Compromise solution;

- Compared to Baseline Light it includes (next to the full CR1359 and CR1360 (which entail the FRMCS functions) and CR1370 (relocation without linking)) the error corrections, thus enable to avoid NTR's.
- Like Baseline Light there is no need for a change of the technical content of specifications, only the sequence of adding FRMCS functionality is changed, reflecting market demand
- Compared to Baseline 4-SV3.0 solution ETCS HW upgrade can be avoided in some fleets (note; FRMCS itself requires new communications HW irrespective of chosen solution for ETCS compatibility)
- Compared to Baseline 4-SV3.0 solution less functionality for FRMCS needs to be introduced, which reduces the complexity
- Compared to Baseline 4-SV3.0 solution a faster start of FRMCS vehicle migration should be possible as additonal functionality (delta CR's between B4-SV2.1 and B4- SV3.0) does not need to be developed into products.
- Compared to Baseline 4-SV3.0 solution no new NTRs are triggered by heterogeneous approach to error corrections

Disadvantages of the Compromise solution;

- Compared to Baseline Light it will most likely reduce the foreseen cost savings (product dependent) - based on first analyses with industry - although it is expected that extensive hardware upgrade can still be avoided (further analyses on cost-benefit is ongoing)
- Compared to Baseline Light solution it is clear that the SIL-4 core part of ETCS will be touched (which anyhow would be irrelevant if ERA does not distinguish between the SIL-4 Core of ETCS and the not directly safety relevant communication functions of ETCS Euroradio in terms of authorization requirements, as suggested by the CTO Council)
- Compared to the Baseline Light solution it can potentially have a more negative impact on FRMCS specification timeline up to TSI CCS amendment
- As is the case with Baseline Light it increases the complexity in handling ETCS system version management, simply by having more FRMCS compatible combinations

- Like Baseline Light, foreseen enhancements part of BL4-SV3.0 are not included, amongst which CR's that cover ATO and supervised maneouvre.

This proposal is currently (d.d. 04-06-2025) under consideration of the European Commission (EC). The EC has requested several sector stakeholders to deliver additional information in order to "continue the discussion", last input to be delivered on the 24th of June '25.

It is to be noted that not all railway stakeholders agree to having this Compromise solution. In particular AERRL, the association for European Rail Rolling stock Lessors, opposes. AERLL is requesting a solution based on compatibility with SRS 3.4.0 (Baseline 3-SV2.0).

Recommendations

We need to be aware that we are in a GSM-R obsolesence crisis. All Stakeholders (EC, ERA, RU, IM, UIC, Industry, etc.) have to do their best to reduce the timeline of specification development and adoption in the TSI, and make sure that everything is delivered on time in the right quality:

- **To avoid disruptions to rail services in Europe, the EC should coordinate the dialogue between industry suppliers and railways to explore possibilities to extend GSM-R services, assuring a viable and feasible migration for railways.**
- **We need to assure that FRMCS specification “V3” becomes available as fast as possible** in the next TSI CCS amendment. No further delays can be accepted due to the fundamental risks raising from the GSM-R obsolescence crisis. A lean process needs to be established by DG Move. The V3 specification needs to be largely tested before putting it into the TSI (no surprises for the deployment and maximum stability).
- **We need to have effective project management and governance in place**. The EC should have a more prominent role, being the entity that should steer/oversee the overall transition to FRMCS.
- **We need reasonable Functionalities**, which allow to reduce the V3 functionalities in order to stabilize the work plan and safeguard the vital TSI milestone: Priority #1 is to have a largely tested, demonstrated and approved FRMCS specification in the TSI being capable to fully replace GSM-R and support the technical migration and rollout (when both GSM-R and FRMCS are in parallel operation). Future Functionalities shall not further delay this procedure and/or put (parts of) the sector at high risk.
- **We need a reasonable FRMCS Migration planning**. A consolidated feasible European migration plans for Rolling Stock and Infrastructure needs to be developed. For this we need to understand the time needed for retrofitting and upgrading (including time needed for procurement and contracting etc…), we need to understand the limited resources available on the market, we need to understand the various different starting positions (regional, sectoral, IM vs RU etc), we need to understand the financial and business impact, in particular for RU in the competitive environment, we need to investigate and develop plans and ways to possibly further extend the operation of GSM-R.
- **We need to accelerate the rollout by ensuring ETCS onboard BL4 SV2.1 compatibility with FRMCS**. Railways are in need for such solution for their existing and contracted ETCS fleets as it reduces the complexity and costs for upgrade and products could become earlier available (compared to SV3.0 solution) as less functionality (ATO, Supervised Manouvres) needs to be developed.
- **The CCS Consist Network (subset-147) should be introduced together with FRMCS** as to ensure that mainly for New vehicles FRMCS can connect to the CCS Consist Network.

6.1.1.2 (Full) ASTP/EGNOS

Possible migration steps to reach the target architecture have been discussed during a migration exercise (Paris meeting, 20 february 2025):

Target 1
Assumption: The TSI 2029 will trigger a major ETCS-OB architecture change (evolution)

The pre-condition for future evolution would be the Full ASTP readiness (which means starting to adapt already existing CCS-OB sub-system)
The alignment between performance and availability target with the current odometry system is necessary.

Target 2
Open point related to the Target 2 : is there a new odometry error formula needed ?
Will the Full ASTP be a mandatory equipment on-board? Or will it be only mandatory if required by RINF (as done for ATO) ?
The Digital Register Infrastructure and the availability of the data for ASTP is necessary for the Full ASTP.
Probably that 3D unsafe position could be a given with Full ASTP. The 3D unsafe position could be used by other components of the on-board.
The Full ASTP will bring benefit for ATO GoA2, especially a better precision for stopping points.

Target A
The main novelty for the Target A will be the 3D safe position provided by Full ASTP.
Will the Full ASTP be mandatory for ATO GoA4?

The current (Full) ASTP architecture variants [Ref.17] also contain two migration variants (Basic ASTP variants 2 and 5) as intermediate steps to come to the target Full ASTP architecture variants 2 and 5.

6.1.1.3 Multi Display System

Open point: what will happen if not all applications are adapted to MDS ?

ent priorities: (integration in respect of importance of the systems)
The ERTMS/ETCS and ERTMS/ATO applications will come first for MDS.
The TCMS and rolling stock application will come later on. Involvement of vehicle manufacturer will be essential.
Cabin voice radio application will come after.

Assumption: hardware and architecture for MDS must be finalized.

First step:
Integrate as much applications as possible for the signaling functions, (integrate NTCs in the ETCS view)
Rational: (ETCS can include NTCs and ATO already).
Remaining applications use the old existing display systems.

Second step:
Integration of TCMS application on the MDS
Remaining applications use the old existing display systems.

Third step:
Integration of communication and remaining applications on the MDS
(but maybe FRMCS is much more difficult to integrate in parallel to GSM-R, important comment from the team after presentation to the group).