ERA ERTMS conference

Operational harmonization workshop

Why is it so complex to deploy ERTMS?

How can I deal with so many specifications?

Why change anything?

We want to know your opinion

Index

- System Pillar objectives
- OH current activities and SP complementarity
- From OH to target system requirements

SP objectives

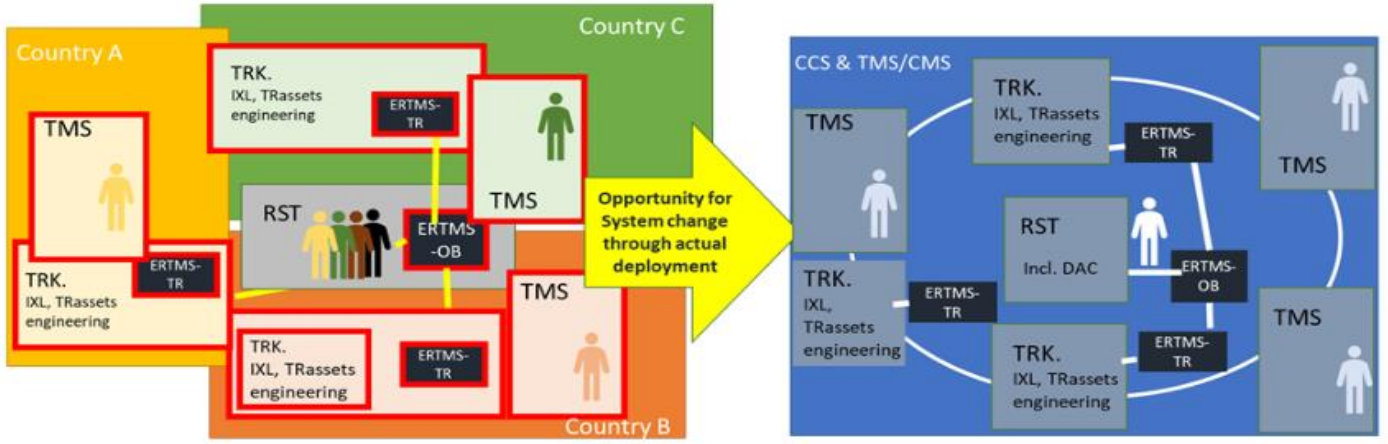
System Pillar

- The System Pillar is the “generic system integrator” for the Europe’s Rail Joint Undertaking (EU-Rail), and the architect of the future EU’s railway system.
- Whilst most individual railway systems have views of the future railway architecture, there is no common EU railway system view that is used today. **The problem with this is that innovations and changes to the system are very difficult and costly to achieve**.
- System Pillar is the opportunity for the sector to converge on the evolution of the railway system – operational concept and system architecture.

System Pillar
4 Years Program

~ 400 *experts from Sector*

Cost: 50 *m EU funded*



Goals

Rail as integral part of mobility services and intermodal transport

Cost efficiency: integration, maintenance and evolution

Increase Performance and interoperability.

Strengthen the market with large scale, **Support** European rail industry **Competitiveness.**

System Pillar CCS view Logical Architecture & Organization

Operation Harmonization

Transversal systems

- Provide engineering and topology data
- Provide asset condition and intervention management
- CCS configuration management
- Identity and access management for systems and persons
- Integrated user interface

Integrated user interface is an objective, but the architectural approach is an open point

Traffic Management (TM)

PE-APS (IXL – RBC)

Traffic control and supervision (Traffic CS)

ETCS OB

OC-WSO

Train control and supervision (Train CS)

Field force applications, control and supervision (Field Force ACS)

Trackside assets control and supervision (SA CS)

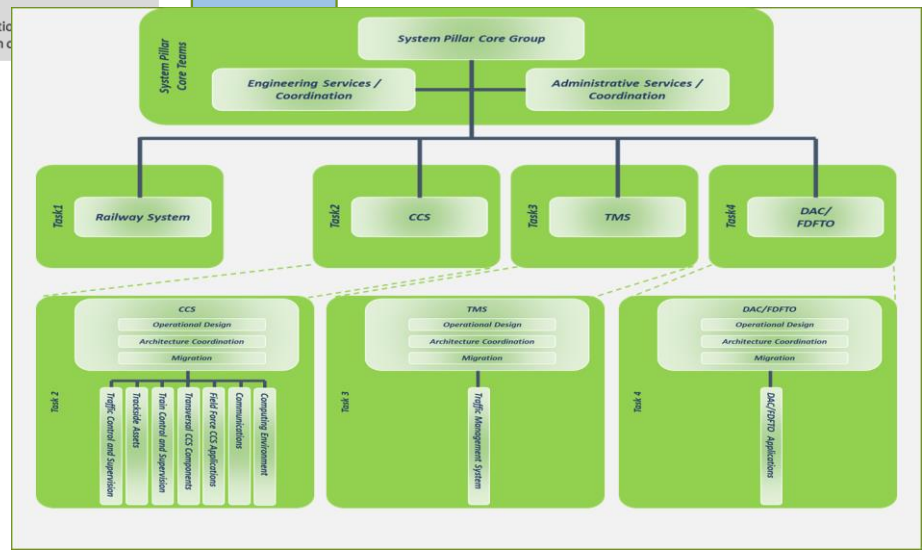
Communication Stack

Runtime environment (some standard APIs)

Scope and depth of specificatio computing environment is an o

DAC

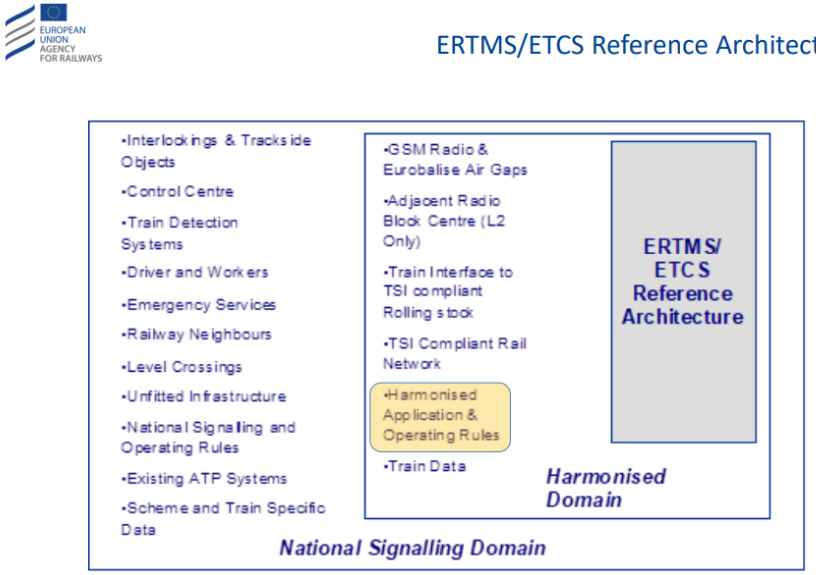
SP Organization (Domains)

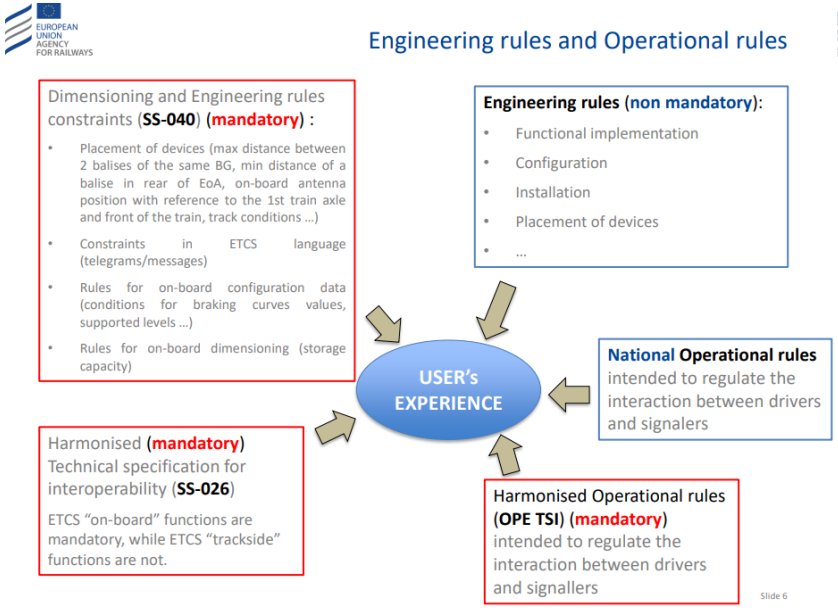


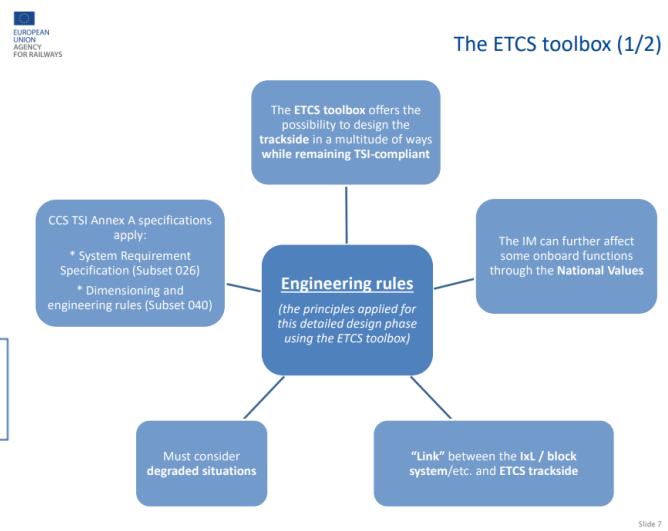
OH current activities and SP complementarity

Background

- Already in the last ERTMS Conference 2022, the need for the sector to work on a more uniform ERTMS deployment was identified by ERA
- Harmonised trackside engineering was recognised to have a strong effect on operational interoperability





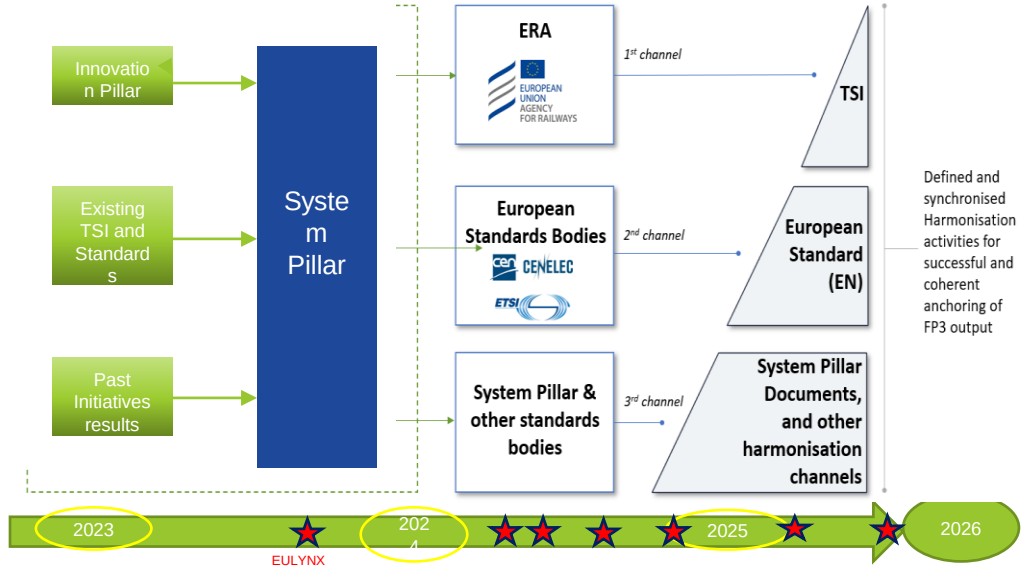


System Pillar operational activities

- The work in the System Pillar focuses on a particular subset of implementation – Level 2 ETCS without lineside signalling , and specific harmonised technical approaches and the associated operational processes, harmonized architecture, and linked engineering rules.
- In this way harmonised operational processes – for this particular subset of implementation - can be derived beyond the current scope of the OPE TSI.
- ETCS toolbox can be used in numerous ways, all leading to TSI-compliant implementations. However attractive to designers, this freedom can lead to a large disparity among implementations, each offering substantially different “user experience” to the driver
- for ETCS Level 2 , there is a certain degree of freedom e.g. when to use which mode, how the sequences of message exchanges happen, where to place balises with what content, or what the sequences of human and system actions are in different situations. This freedom leads to different processes for actors and to different product implementations (for example in interlockings and RBC) on the trackside

System Pillar complementarity

- The focus of the System Pillar work on a harmonised target system - radio-based ERTMS implementation without lineside signalling – potentially allows for a number of complementary changes compared to the current TSI OPE that contribute to a further step towards further harmonisation of operational processes and operational rules = in the case of implementation of the target system.



- In addition to the currently harmonised system, this **uniformity** will reduce freedom of implementation flexibility but also bring several positive side-effects, for example in standardising hardware and software modules, reducing cost, freeing capacity for faster development and implementation, accelerating deployment and streamlining certification and authorisation

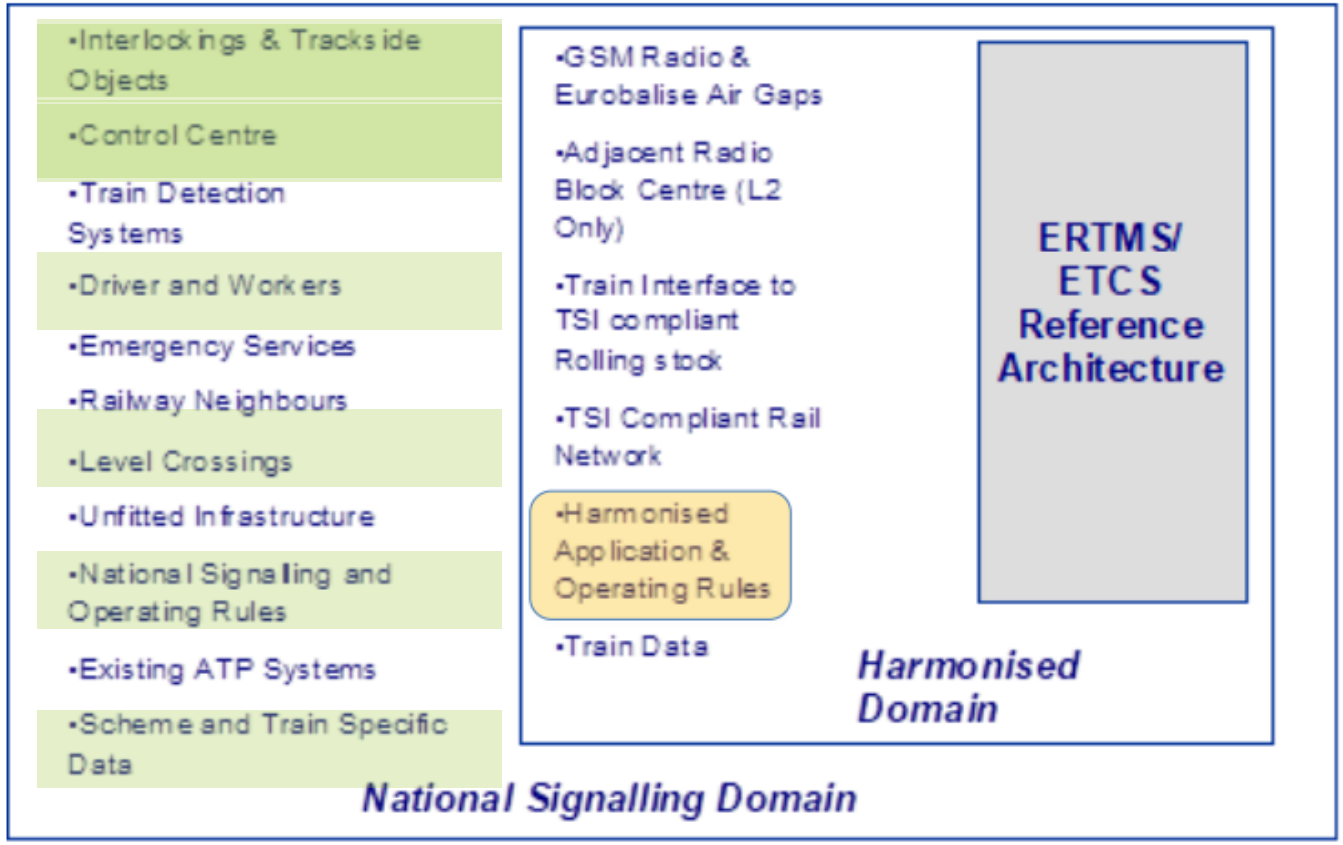
System Pillar complementarity

- Scope of actors
  - Consideration of all actors (especially signaller) included in the analysis beyond a driver focus
- Scope of rules
  - Harmonised rulebook through reducing the variability of trackside implementation, i.e. by discipline and uniform in the implementation of the functions and engineering
  - Deeper consideration of processes
  - Consideration of harmonised degraded modes taking opportunity of new only ETCS lines including steps of harmonized and uniform system requirements for other underlying systems
  - Configuration dependency of harmonised operational processes
- Presentation and structuring of the Operational rules
  - A scenario-based (situation specific time-ordered process sequences of state-dependent actor actions and interactions with systems) as well as functionality-based description, with the advantage of a description from the perspective of the user that this text can be copied in its entirety in a rulebook subset for the RU.

ERTMS/ETCS Reference Architecture

Harmonized Target System

In green those additional aspects SP considers relevant for harmonisation



Engineering rules and Operational rules

Dimensioning and Engineering rules constraints (**SS-040**) (**mandatory**) :

- Placement of devices (max distance between 2 balises of the same BG, min distance of a balise in rear of EoA, on-board antenna position with reference to the 1st train axle and front of the train, track conditions …)
- Constraints in ETCS language (telegrams/messages)
- Rules for on-board configuration data (conditions for braking curves values, supported levels …)
- Rules for on-board dimensioning (storage capacity)

Engineering rules (**non mandatory**):

- Functional implementation
- Configuration
- Installation
- Placement of devices
- …

National Operational rules intended to regulate the interaction between drivers and signalers

USER's EXPERIENCE

Harmonised (**mandatory**) Technical specification for interoperability (**SS-026**)

ETCS "on-board" functions are mandatory, while ETCS "trackside" functions are not.

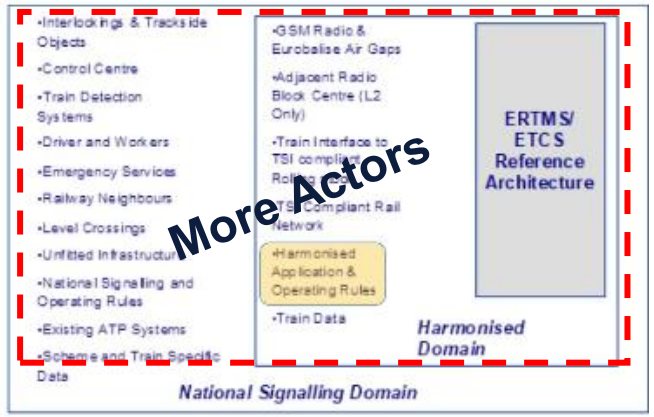
Harmonised Operational rules (**OPE TSI**) (**mandatory**) intended to regulate the interaction between drivers and signallers

Slide 6

To

Harmonized Target System

OPE TSI



New Engineering rules:

- implementation of rules for system functions, which assure the same system behaviour from operational perspective (including safety logic rules and situation specific message protocol sequences) **Harmonized Processes using Harmonized Functions**
- Rules for positioning and configuring trackside CCS assets for ETCS Level 2 for example balises and boards.

Leading to

Limited diversity of User Experience

Harmonized European Rule books

Products Standardization

Future TSI OPE considerations

Current TSI : App A

Functional based description of the use of the system that fits in all the variants of ETCS.

(B2, B3, B4, L1, L2, with signals/without signals, with packet88/ without packet88, with baliselist /whitout baliselist etc.)

List of functions from the perspective of the driver

“Add on”: App B, C , D if also applicable on a certain implementation

Future TSI : App A + App A2 ?

Scenario based description of the use of the ERJU Target System. Including possible “Add on” from App B, C, D

List of scenarios including perspective of all relevant actors in the scenario

Easy way to derive content for harmonized rulebooks.. Or should the rulebook also be part of the TSI OPE ?

Future TSI OPE considerations

Current TSI : App A

6.44. .**Managing a level crossing not protected**

The train is approaching a level crossing which is not protected.
Levels 1, 2

6.44.1.
If in FS, OS or LS
When the following symbol is displayed:
the driver shall apply rule 7 of Appendix B2.

6.44.2.
If in SR
When the following text message is displayed:
“Level crossing not protected”,
the driver shall apply rule 7 of Appendix B2

Future TSI : App A + App A2 ?

SP OD 315 **Managing a level crossing not protected (driver)**

When approaching a defective level crossing the following symbol on the DMI is shown.

A braking curve is offered to an EOA that is in approach of the level crossing.

If the train is close enough to the level crossing, the MA will be extended by a maximum speed of 30 km/h.

When approaching the level crossing, the driver sounds the horn and stops in front of the level crossing if safety so requires.

If the level crossing is obstructed, the driver shall call the signaller

As soon as the front end of the train has passed the level crossing, the LX symbol disappears of the DMI and the MA shows a higher speed again.

Future TSI OPE considerations

Current TSI : App A

6.44. .**Managing a level crossing not protected**

The train is approaching a level crossing which is not protected.
Levels 1, 2

6.44.1.
If in FS, OS or LS
When the following symbol is displayed:
the driver shall apply rule 7 of Appendix B2.

6.44.2.
If in SR
When the following text message is displayed:
“Level crossing not protected”,
the driver shall apply rule 7 of Appendix B2

Future TSI : App A + App A2 ?

SP OD 315 **Managing a level crossing not protected (signaller)**

A route is set to a part of the line in which there is a defective level crossing. The system will automatically detect this defect and give the trains on that line an adjusted MA with an instruction on how to act at the level crossing. The driver follows up on this MA.

If it is not possible to give an MA, the train will be able to continue in SR.
In this case, the signaler must contact the driver and provide him with a European Instruction #8

From OH to target system requirements

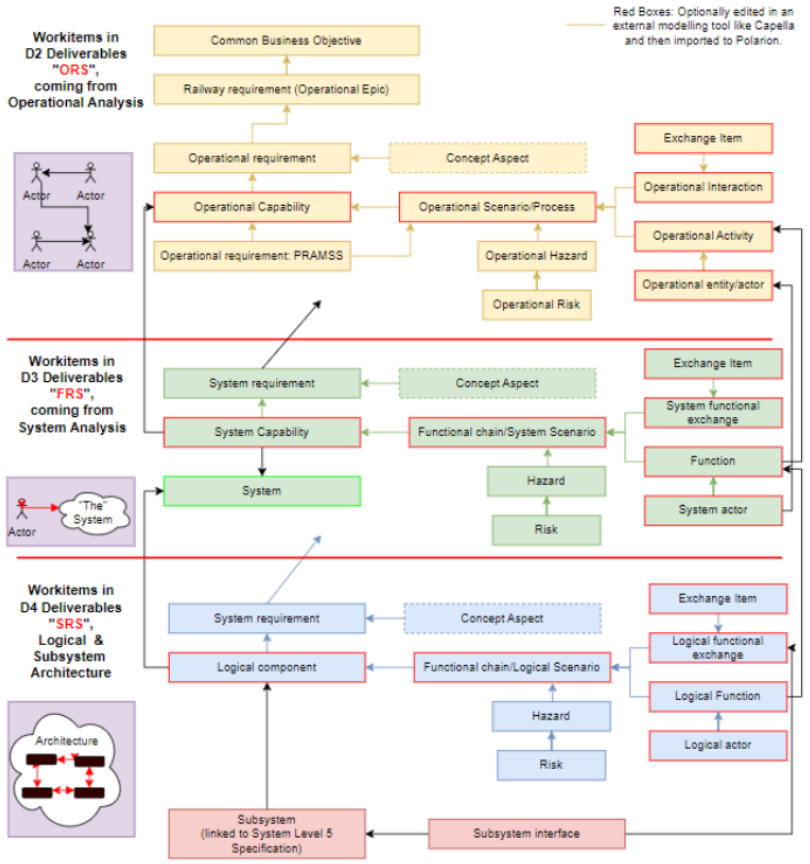
Operational domain

1. Scope of Work and Methodology
2. List of OD Operational Capabilities
3. Concept Template
4. Example 315: Passing non protected LX
5. Next Steps

1. Scope of Work and Methodology (2)

OD Scope of Work: ERTMS/ETCS operational harmonization

SEMP methodology



ARCADIA OA methodology

- analyzing stakeholder requirements
- analyzing national variants
- deriving operational needs
- defining harmonized processes

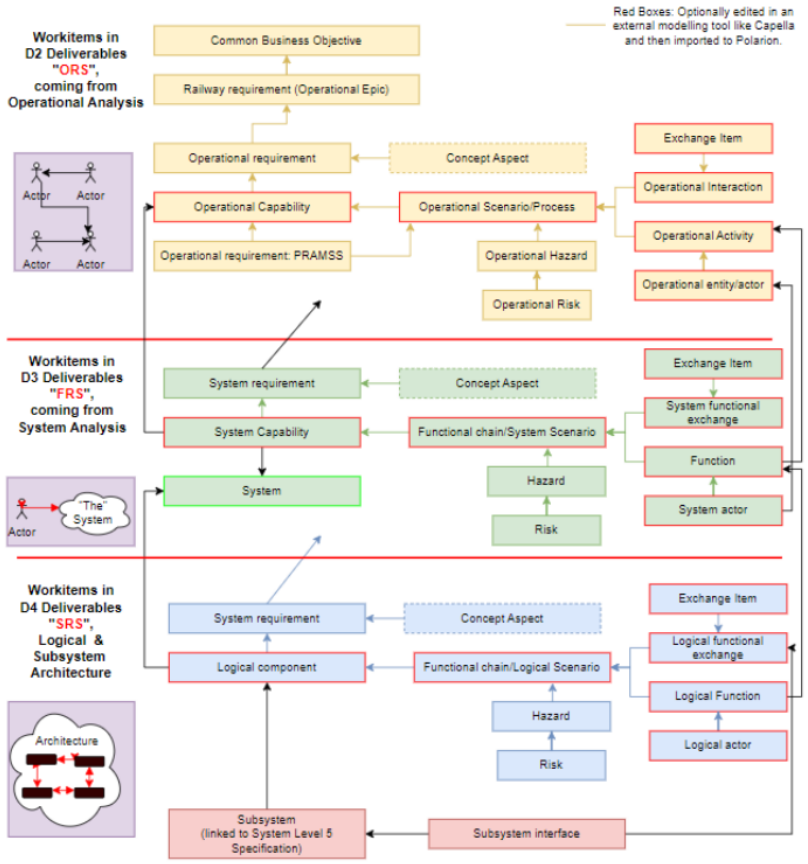
Major advantage of this method

- Layering: OD focuses on operational needs
- Other domains: Technological decisions, migration

1. Scope of Work and Methodology (1)

OD Scope of Work: ERTMS/ETCS operational harmonization

SEMP methodology

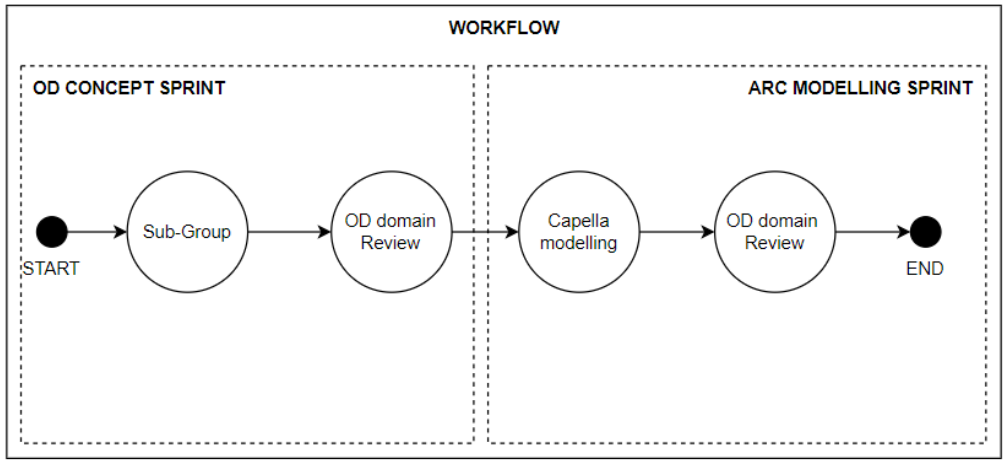


Operational Analysis — OD domain

System Analysis — ARC domain

Logical Analysis — ARC domain

Three sub-groups for concept specification



2. List of Operational Capabilities

N. 32 Operational Capabilities

- N. 12 Regular
- N. 3 Transitions
- N. 14 Degraded
- N. 3 Maintenance

SPT2OD-1942	101-Preparation to train departure and starting a journey
SPT2OD-1943	102-Operate the train from A to B (force movement permission)
SPT2OD-1944	103-Train arrival (ending journey)
SPT2OD-1945	104- Splitting a train
SPT2OD-1946	105- Joining trains
SPT2OD-1947	106-Change of train orientation
SPT2OD-1948	107- Approaching stop location
SPT2OD-1949	108-Revoke Movement permission
SPT2OD-1950	109- Pass a level crossing
SPT2OD-1951	150- Shunting inside controlled areas
SPT2OD-1953	152-Entering into a non controlled area (Shunting yard)
SPT2OD-1954	153-Exiting from a non controlled area (Shunting yard)
SPT2OD-1956	21-Entry Transition from non CCS area
SPT2OD-1957	22-Exit Transition to CCS area
SPT2OD-1958	23-HO Handover between ETCS systems

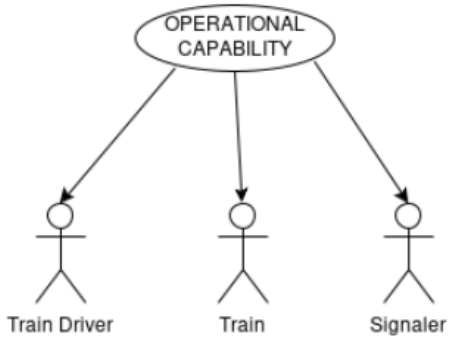
SPT2OD-1961	302-Moving under driver responsibility
SPT2OD-1962	305-Reversing
SPT2OD-1963	306- Continue After Trip/ Post Trip
SPT2OD-1964	307-Handling of Emergency situations
SPT2OD-1965	308- Train assistance
SPT2OD-1966	309-Handling of a train after loss of communica
SPT2OD-1967	310-Proceed after TIMS failure
SPT2OD-1968	311-Runaway Vehicle
SPT2OD-1969	312-OS Sweeping a track section
SPT2OD-1970	314-Pass a technically non-supervised point
SPT2OD-1971	315-LX Pass a defective level crossing
SPT2OD-1972	316-INIT Trackside initialisation
SPT2OD-5637	317 - Obstacle detection
SPT2OD-1974	401-Working area excluding normal train operat
SPT2OD-1975	402-Working area allowing normal train operati
SPT2OD-1976	403-UR Manage usage restrictions

List of Actors: https://polarion.rail-research.europa.eu/polarion/redirect/project/SPT2OperationDesign/workitem?id=SPT2OD-1568
List of Operational Capabilities: https://polarion.rail-research.europa.eu/polarion/redirect/project/SPT2OperationDesign/workitem?id=SPT2OD-1937

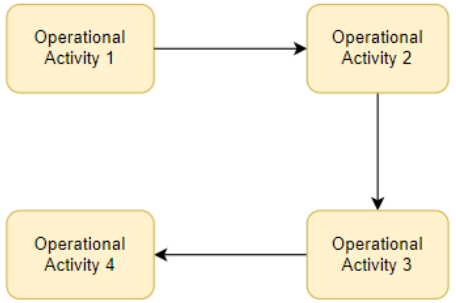
3. Concept Template

1. Sources
2. Abstract
3. Target and Ambitions
4. Actors
5. Identification of national variants
6. Hazard Analysis
7. Analysis of national variants
8. Harmonized proposal
9. Harmonization conflicts
10. Annex: Remarks and recommendations

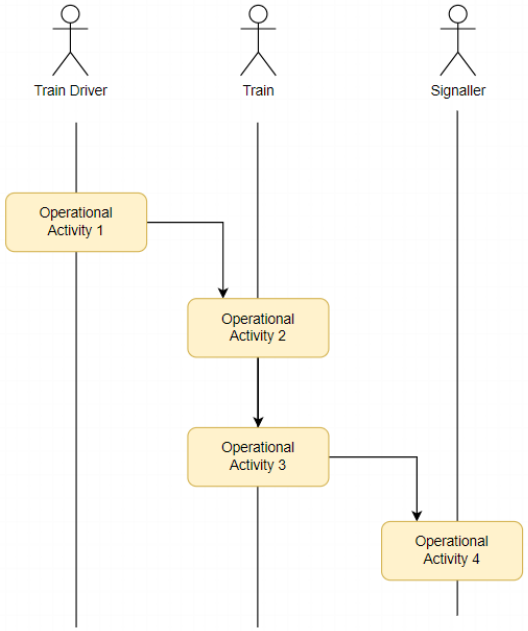
ARCADIA diagrams to complement textual description



Operational Capability diagram



Operational Activity diagram



Scenario diagram

https://polarion.rail-research.europa.eu/polarion/redirect/project/SPT2OperationDesign/workitem?id=SPT2OD-860

4. Example 315 - Passing non protected Level Crossing (1)

Target and ambition
Increasing automation of protection measures
Minimize delay to pass non protected LX
Abolish need for written instructions

National Variants
On-Sight (e.g. max speed 5 Km/h)
Staff Responsible/Shunting (e.g. max speed 10 Km/h)
Packet 88, LX icon & Full Supervision (e.g. max speed 30 Km/h)
European Instruction 8
…

Common operational need
Hazard prevention: Raise the attention of the driver

Harmonized Proposal
Full Supervision with Temporary EoA
Blinking yellow icon shown to the train driver
Acknowledgment before passing the LX
Parameters: Speed and compulsory stop

ARCADIA OA methodology
- analyzing stakeholder requirements
- analyzing national variants
- deriving operational needs
- defining harmonized processes

https://polarion.rail-research.europa.eu/polarion/redirect/project/SPT2OperationDesign/workitem?id=SPT2OD-1267

4. Example 315 - Passing non protected Level Crossing (3)

Excerpt from TSI OPE Appendix A, B, D

6.44 MANAGING A LEVEL CROSSING NOT PROTECTED

The train is approaching a level crossing which is not protected.

Levels 1, 2, 3

6.44.1 If in FS, OS or LS

When the following symbol is displayed:

the driver shall apply Rule 7 of Appendix B.

6.44.2 If in SR

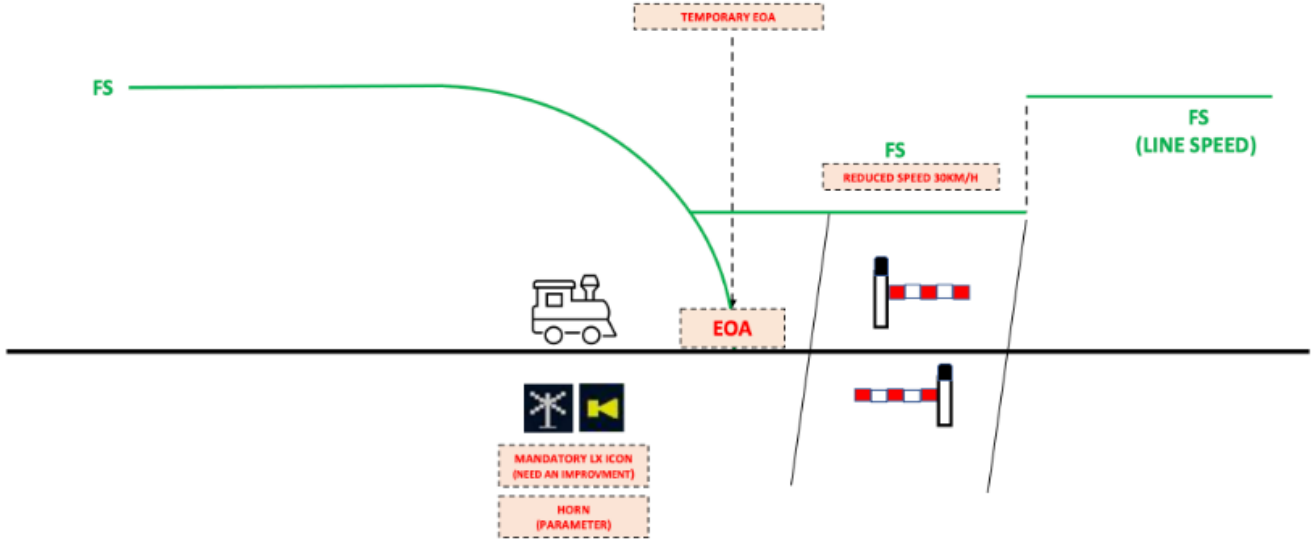
When the following text message is displayed:

"Level crossing not protected",

the driver shall apply Rule 7 of Appendix B.

Harmonized uniform Proposal

Full Supervision with Temporary EoA
Blinking yellow icon shown to the train driver
Acknowledgment before passing the LX
Parameters: Speed and compulsory stop



https://polarion.rail-research.europa.eu/polarion/redirect/project/SPT2OperationDesign/workitem?id=SPT2OD-1267

5. Next Steps

- Consolidating ERTMS/ETCS operational capabilities
- Integrating operational capabilities for GoA 2
- Proposing desired rulebook structure and format

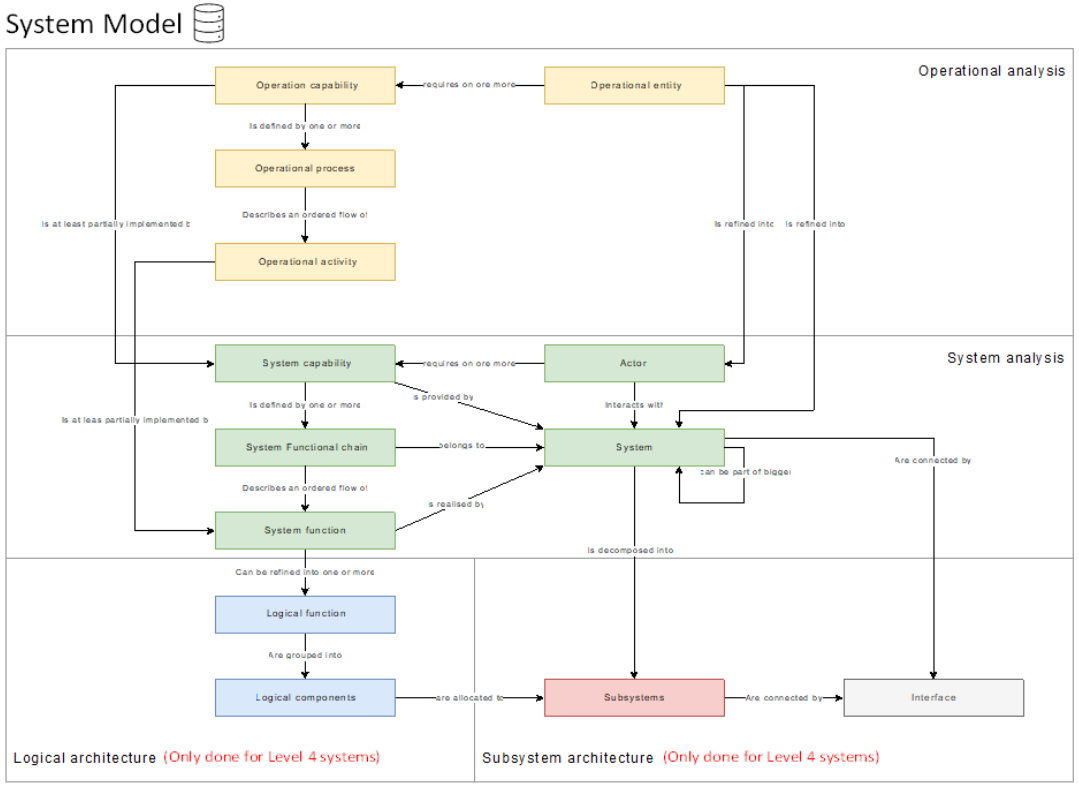
ARC domain


Operational domain
Architecture domain
Traffic control & supervision
Train control & supervision

ARC domain Key topics

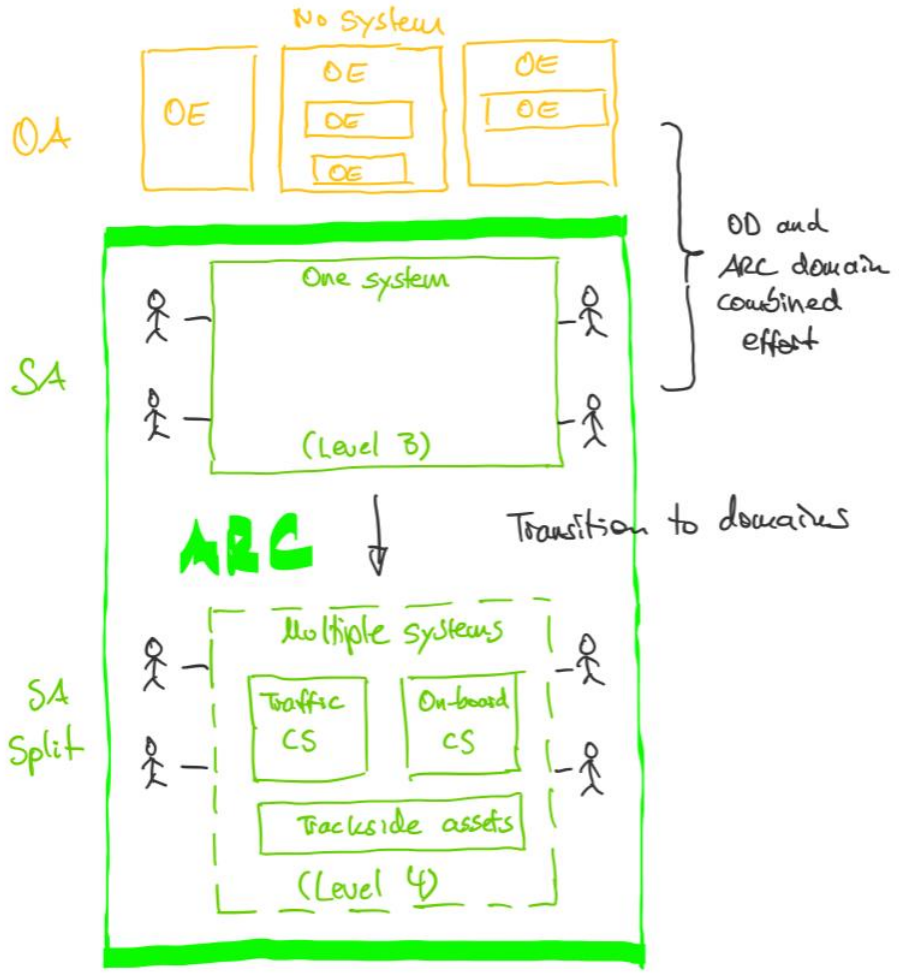
- Why is architecture important?
  - Common understanding through a clear and concise description on the system needs, behaviour and functionality.
- What do we do?
  - Analyze Operational Need and determine the system function and actor role responsibilities. Including the CCS system boundary and external actors.
  - Functional allocation between different systems based upon functional and non-functional requirements.
- What is it used for and by who?
  - Agree with Operational Design on how the technical system fulfils the harmonized operational processes.
  - Inform the system domains on their functional and interface requirements.
  - Provides the link from the business and operational targets to the detailed system specifications.

MBSE systems engineering



- In system pillar we will use a model-based systems engineering approach based on ARCADIA and Capella
- Processes and methods are defined in the SEMP. Modelling principles are defined in Annex B
- Documents in Polarion as output artefacts are generated from the model
- “Avoid writing, encourage modeling” - principle

ARC domain involvement

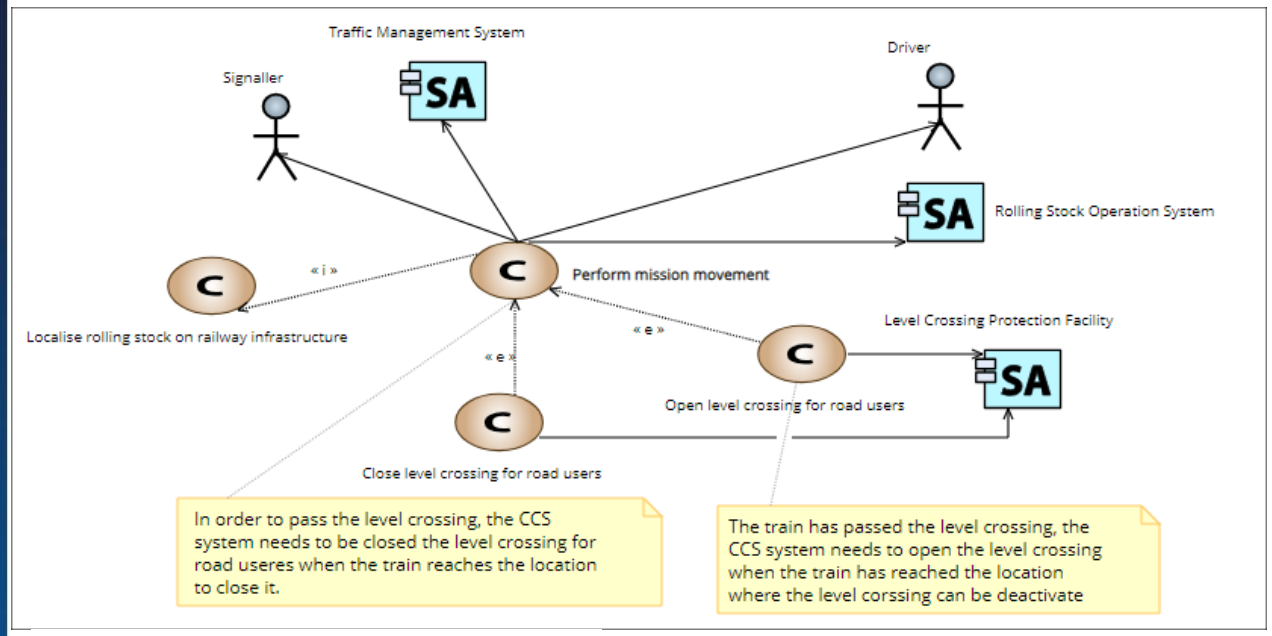


Core activities of the ARC domain will be

- Define the operational vision together with OD domain, as a typical operational process description is a mixture from OA and SA layer
- Define the black box level 3 system with concrete actors
- Split the level 3 system into multiple systems for the individual domain in level 4

How can operational harmonisation be represented in the CCS system definition

Definition of the system capabilities needed to pass level crossing and involved external actors



Definition of system functions involved into the system capabilities for the black box CCS system

<<e>> extend; <<i>> include; C Capability

Operational domain | Architecture domain | Traffic control & supervision | Train control & supervision

Example: Pass Level Crossing.

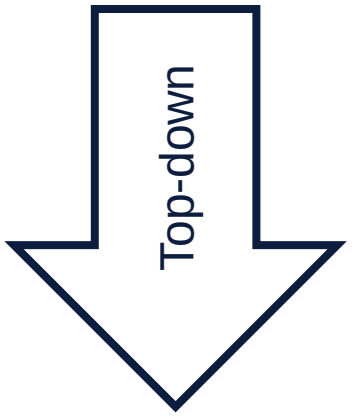
Show tracing from OD concept over CCS SysC to Traffic CS SysC + functions

Traffic Control and Supervision domain

Design approach for Traffic CS

Linking top-down and bottom-up work

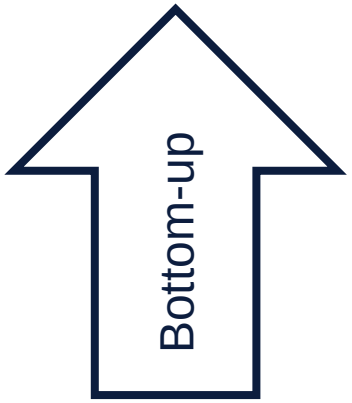
Operational domain → Architecture domain → **Traffic control & supervision** → Train control & supervision



Common Business Objectives

Operational Concept

Functional Architecture



Existing harmonised specifications (e.g. ETCS, EULYNX)

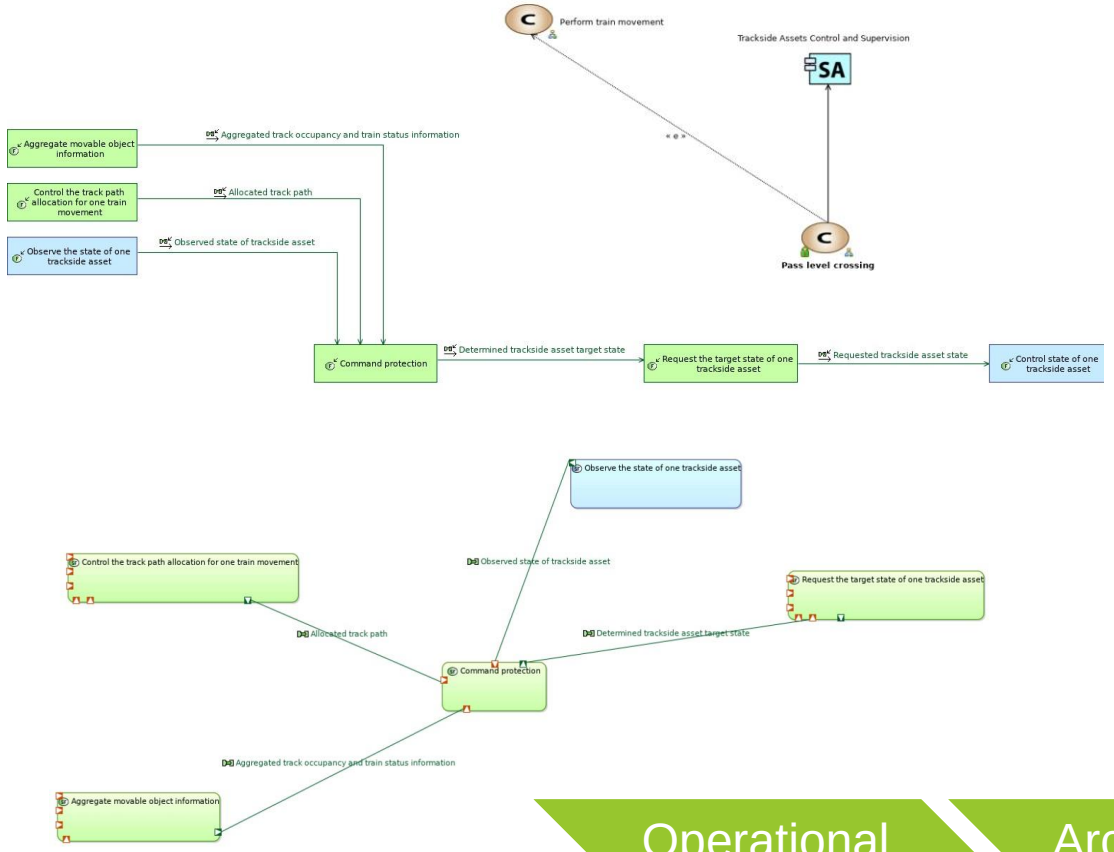
Without operational concept

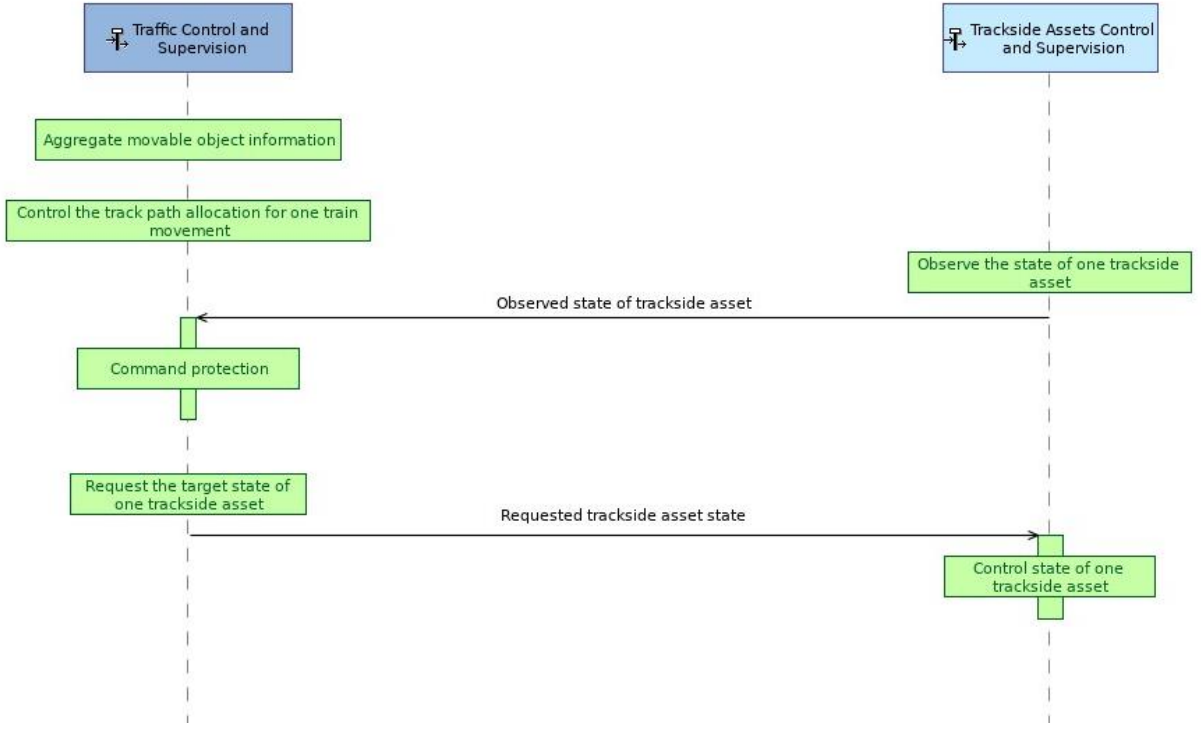
Concepts/drafts for technical specifications from RCA and Shift2Rail

Traffic CS Specification

- Linking from operational and functional requirements to technical requirements
- specification achieves consistency and traceability of requirements as well as re-use of existing work as much as possible

How can operational harmonisation simplify the technical specifications of Traffic CS





Operational domain → Architecture domain → **Traffic control & supervision** → Train control & supervision

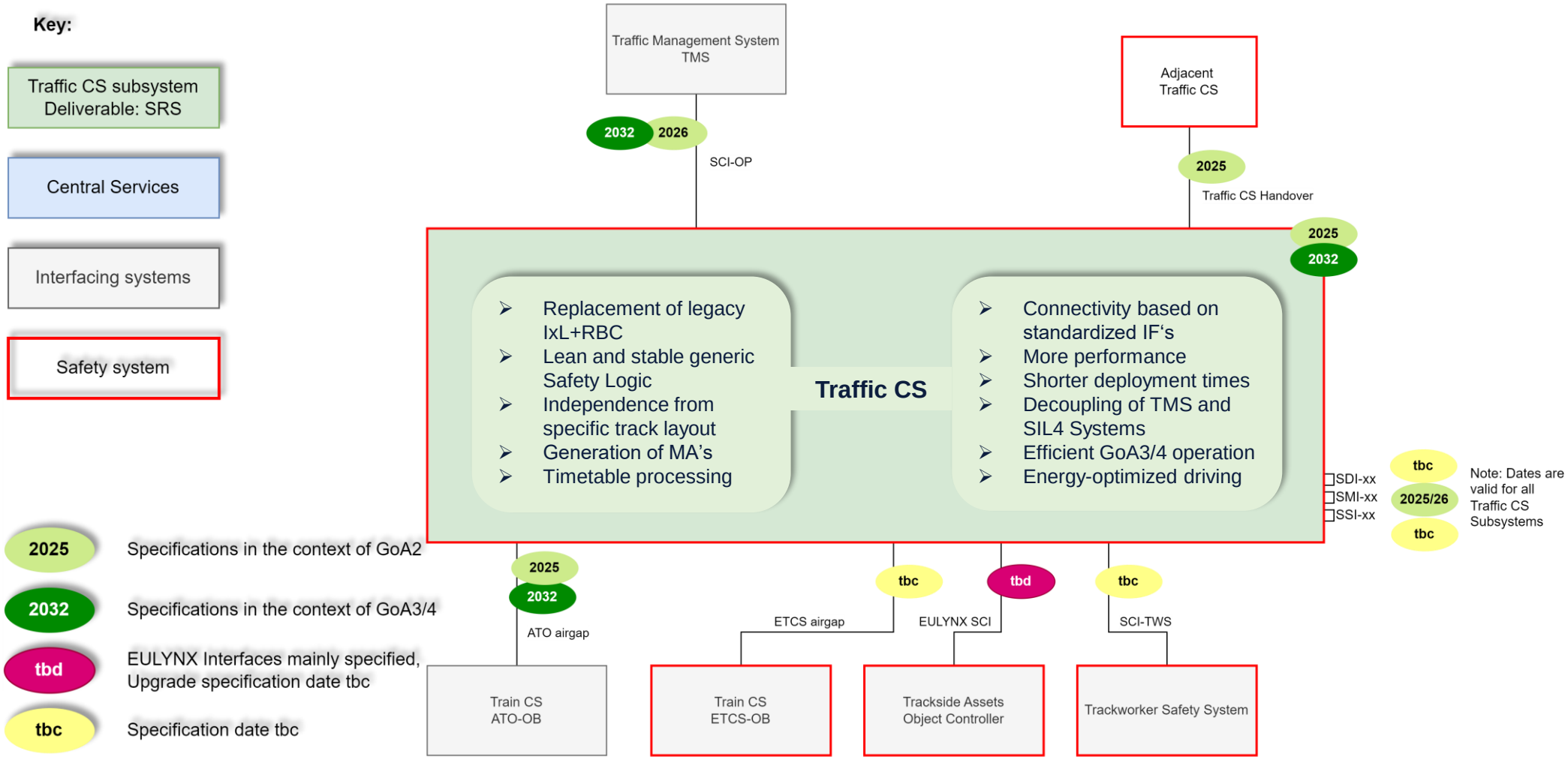
Example: Pass Level Crossing.

Show tracing from OD concept over L3 SysC to Traffic CS SysC + functions

Traffic CS

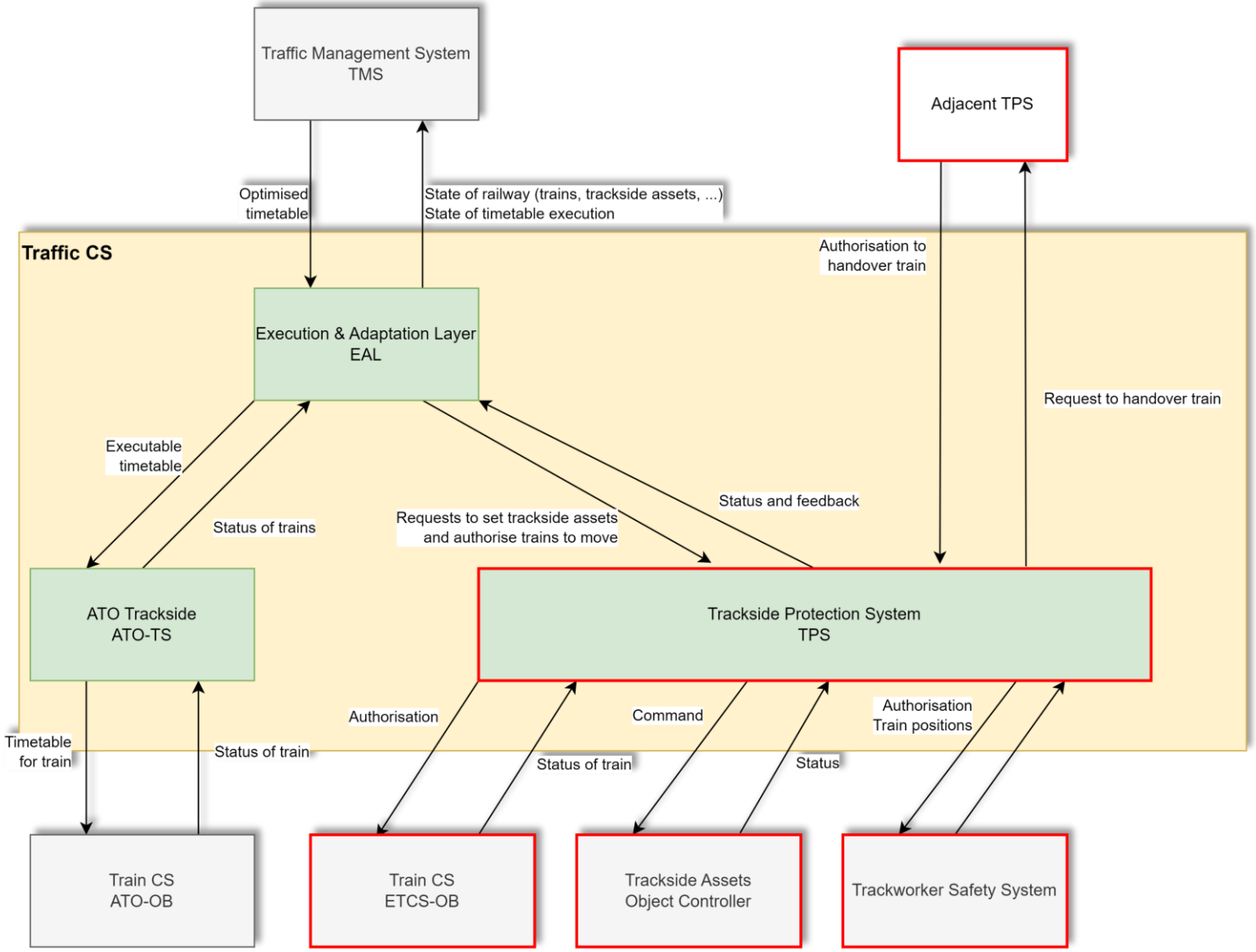
Implementation of Harm. Operat. Concept and Roadmap (see STIP)

Ramp-Up	SC2.1	SC2.3	Spec Subsystems + IF's / GoA2	Update Subsystems + IF's / GoA3/4	SERA
2022	2023	2024	2025 - 2026	2027 - 2032	



Traffic CS subsystems and data flow

Current draft from system concept



Key:

- Traffic CS subsystem
  Deliverable: SRS
- Central Services
- Interfacing systems
- Safety system

Train Control and Supervision domain

Train CS way of working

ARC Domain

TOP-DOWN

Reuse of existing material

OCORA

Shift2Rail Projects

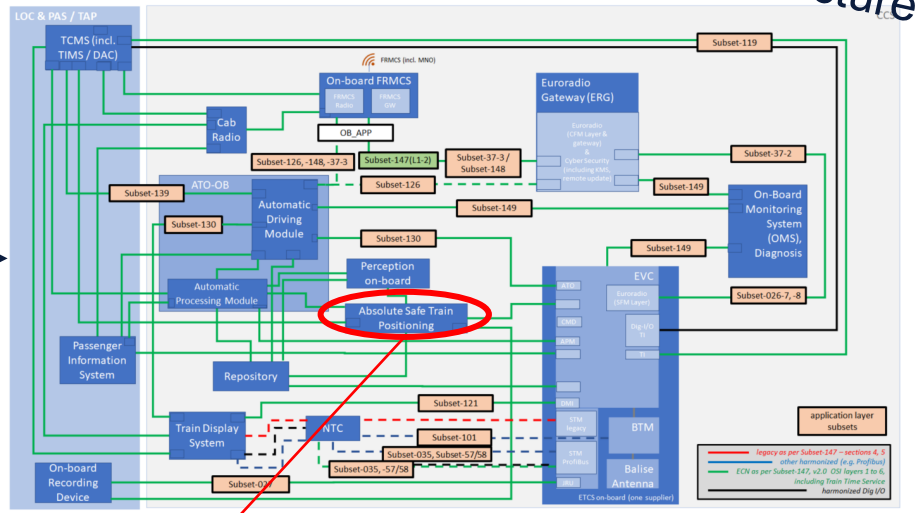
SUBSET-150

Train CS

Study of Flagship Project outputs

FP2R2DATO

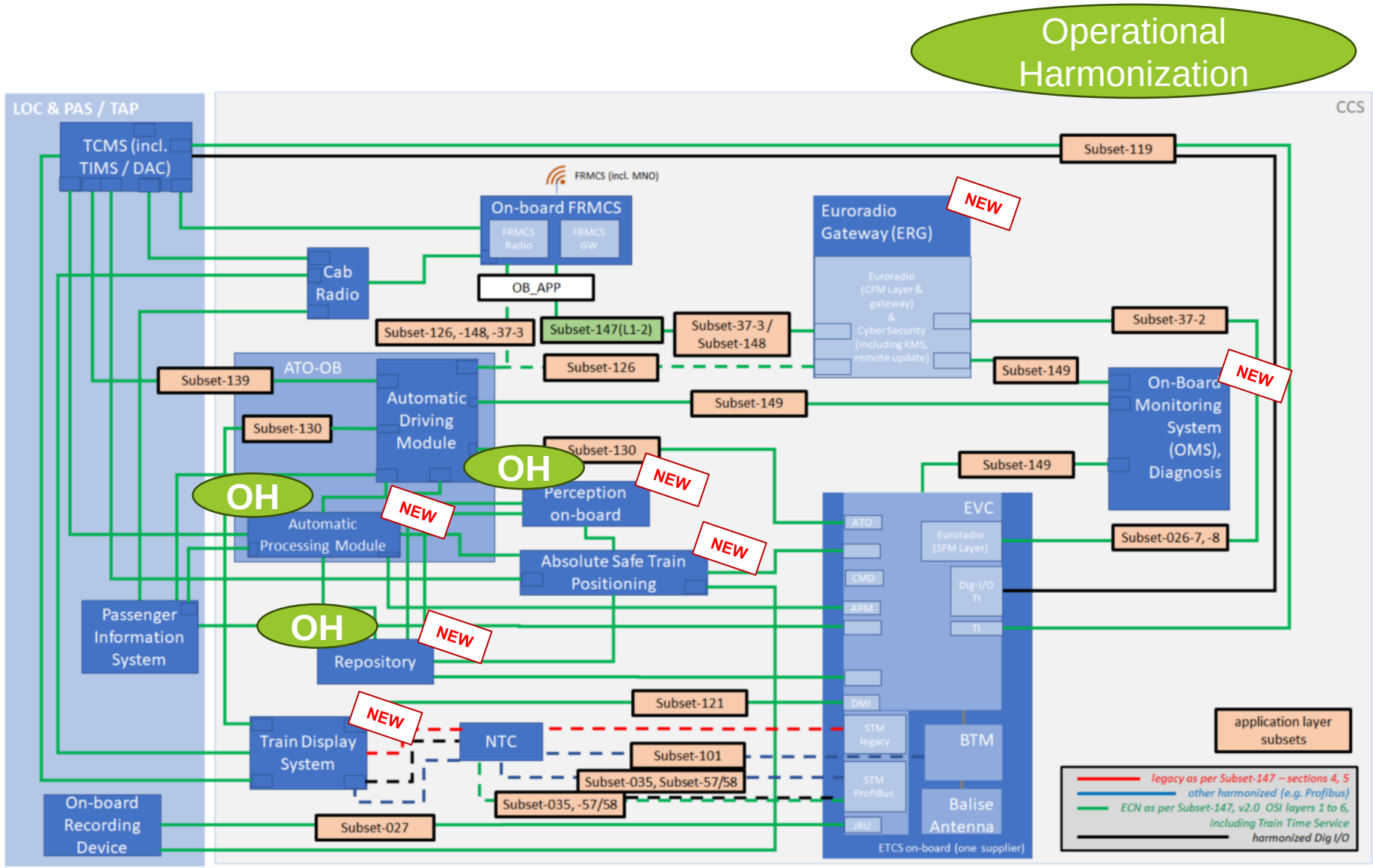
Preliminary CCS-OB Architecture



Sub-system study

Example on ASTP

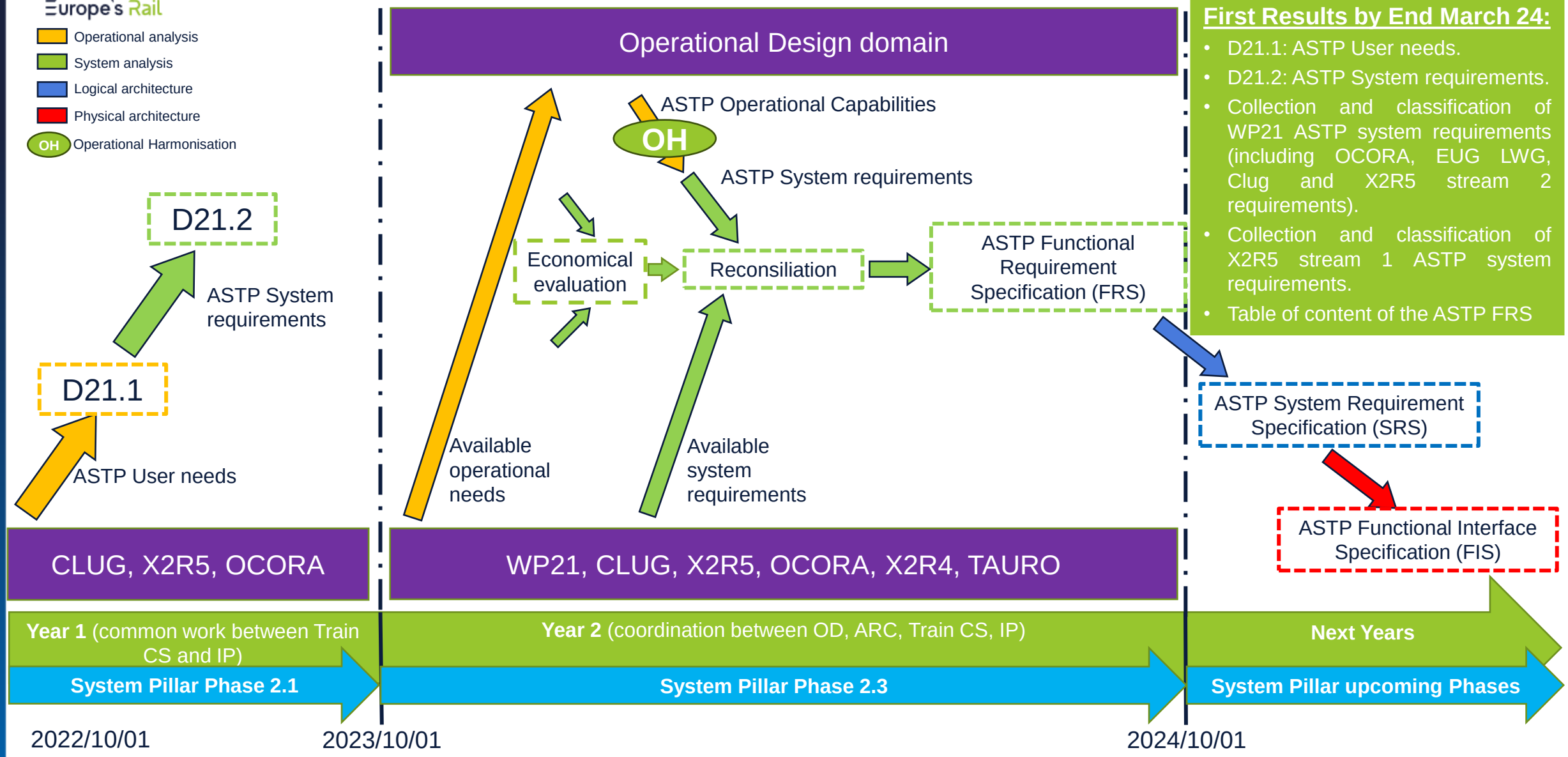
Preliminary CCS On-board architecture | Current understanding in the team



Next-steps :

- ✓ Refinement of the architecture with logical and physical perspective
- ✓ Consolidation of the functions allocated to components, based on existing material
- ✓ Continuous adjustments with the Top-Down (OH and ARC system analysis)

Specific ASTP (Advanced Safe Train Positioning)



First Results by End March 24:

- D21.1: ASTP User needs.
- D21.2: ASTP System requirements.
- Collection and classification of WP21 ASTP system requirements (including OCORA, EUG LWG, Clug and X2R5 stream 2 requirements).
- Collection and classification of X2R5 stream 1 ASTP system requirements.
- Table of content of the ASTP FRS

Now we want to hear from you