

# OCORA

Open CCS On-Board Reference Architecture  
A Collaboration of 5 European Railway Undertakings



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## Technical Slide Deck

- Design Objectives / Technical Roadmap & Vision
- OCORA Scope
- CCS On-Board Logical Architecture
- CCS On-Board Physical Architecture
- Building Blocks
- Train Integration Scenarios
- Network Topology Scenarios
- Computing Platform
- Functional Vehicle Adapter (FVA)
- Modular Safety
- Methodology & Tooling
- Operational Concept



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# Design Objectives Technical Roadmap & Vision

OCORA-BWS02-030 / v2.21 / 14.07.2022

# OCORA Design Objectives



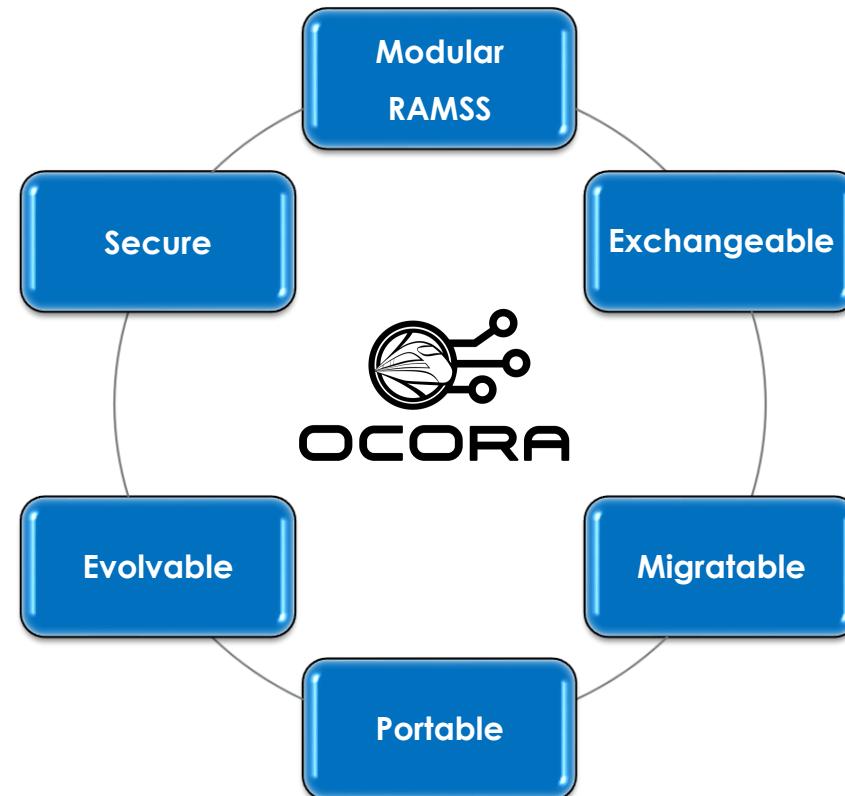
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**Ability to protect the CCS On-Board from attacks.** In context of OCORA security means the protection of (especially safety related communication and data used in) CCS on-board systems against threats (in particular cyber-attacks and hacks). To achieve this, all main security functionality like identify, protect, detect, respond and recover are considered.

**Ability to easily adapt the CCS On-Board to new technologies and to easily add new Building Blocks.** In the context of OCORA evolvability means the ability to easily adopt to new technologies or to extend the functionality of an on-board CCS system without the involvement of the original supplier.

**A reasonable number of Building Blocks are defined for CCS On-Board.** Each Building Blocks has standardised functionality, standardised interfaces, standardised performance (RAM), standardised safety (including Tolerable Functional Failure Rate [TFFR], Safety Integrity Level [SIL] and Safety Related Application Conditions [SRAC]), and standardised security.

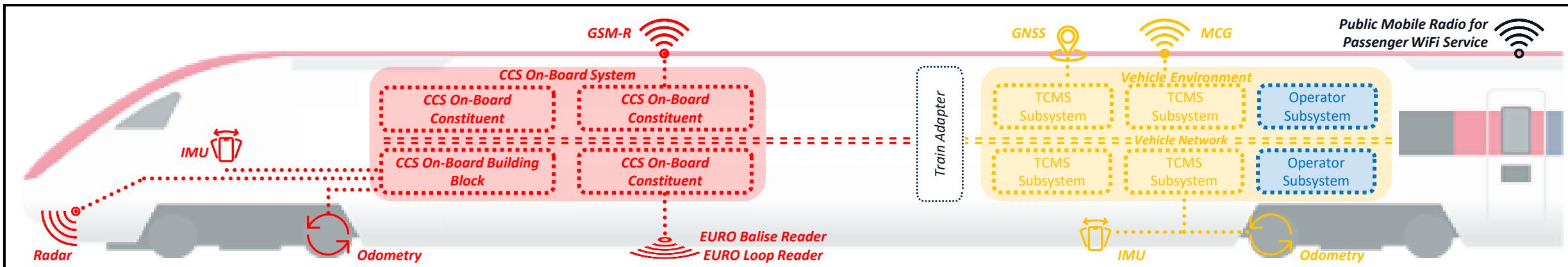


**Ability to port CCS On-Board Software Building Blocks (software applications) from one computing platform to another.** In the context of OCORA portability is achieved when a functional application, based on the generalized abstraction, runs un-changed on different (computing) platform implementations. For this, the functional application shall only use external functions through a defined application programming interface (API).

**Ability to replace CCS On-Board Building Block.** In the context of OCORA exchangeability means the ability to replace one or multiple OCORA defined building blocks with (a) respective building block(s) of (an)other supplier(s), without affecting other building blocks of the train or the overall CCS on-board system.

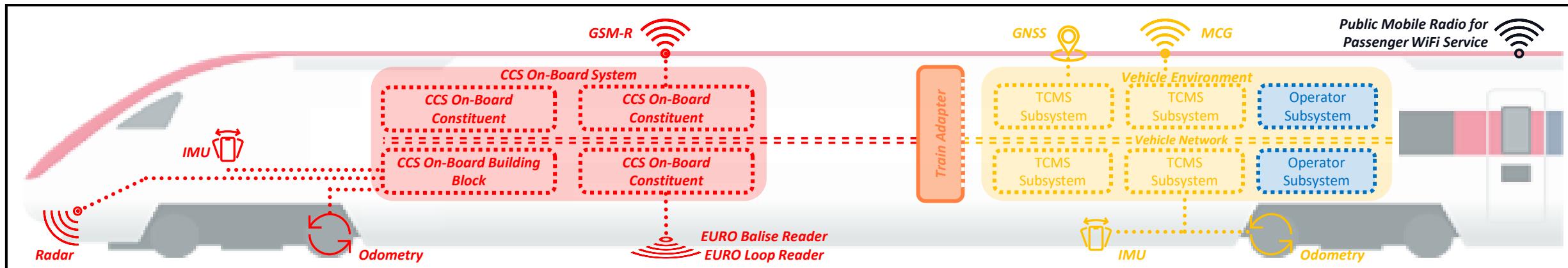
**Ability to introduce changes to any CCS On-Board Building Block.** In the context of OCORA migrateability is the ability to introduce changes to one or multiple OCORA defined building blocks, without affecting other building blocks or the overall CCS on-board system.

# Technical Roadmap – Current Situation



## Step 0: Current Situation

Today, the proprietary CCS On-Board System is fully integrated in the proprietary Vehicle Environment, driving costs, risks, and complicating the life-cycle and obsolescence management for the railway undertakings. This current situation hinders the railways to take advantage of innovations in a timely and cost-effective manner.

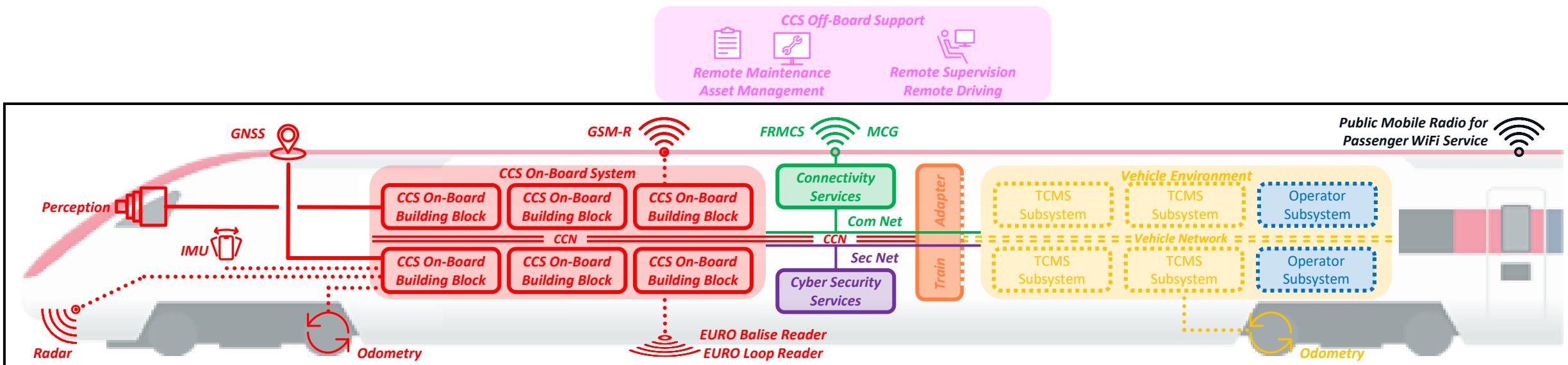


## Step 1: Short-Term (TSI-2022)

The interface between the proprietary CCS On-Board System and the Vehicle Environment is unambiguously standardised.

**Step 1** is enabling exchangeability, supporting migrateability and portability of the CCS On-Board System without affecting the Vehicle Environment.

**Step 1** is simplifying life-cycle and obsolescence management for the CCS On-Board System.



## Step 2: Mid-Term (TSI-2025)

The CCS On-Board System consists of a well balanced number of CCS On-Board Building Blocks. Each Building Blocks has standardised functionality, standardised performance (RAM), standardised safety (including Tolerable Functional Failure Rate [TFFR], Safety Integrity Level [SIL] and Safety Related Application Conditions [SRAC]), standardised security, and standardised interfaces towards other building blocks and/or external systems, allowing to mix-and-match Building Blocks from different suppliers.

The CCS On-Board Building Blocks communicate with each other, with the Vehicle Subsystems and any Off-Board System via the standardized CCS Communication Network (CCN) and the Connectivity Services, using FRMCS or the MCG. Cyber Security Services provide Identity and Access Management (IAM), security patch updates, synchronized time services, and other means to allow secure operations.

**Step 2** is enabling exchangeability, is supporting migrateability and portability of the individual CCS On-Board Building Blocks without affecting other CCS On-Board Building Blocks, the Vehicle Environment, and any Off-Board Systems. This step is simplifying life-cycle management and is the basis for the railways to consider adding new functionality such as:

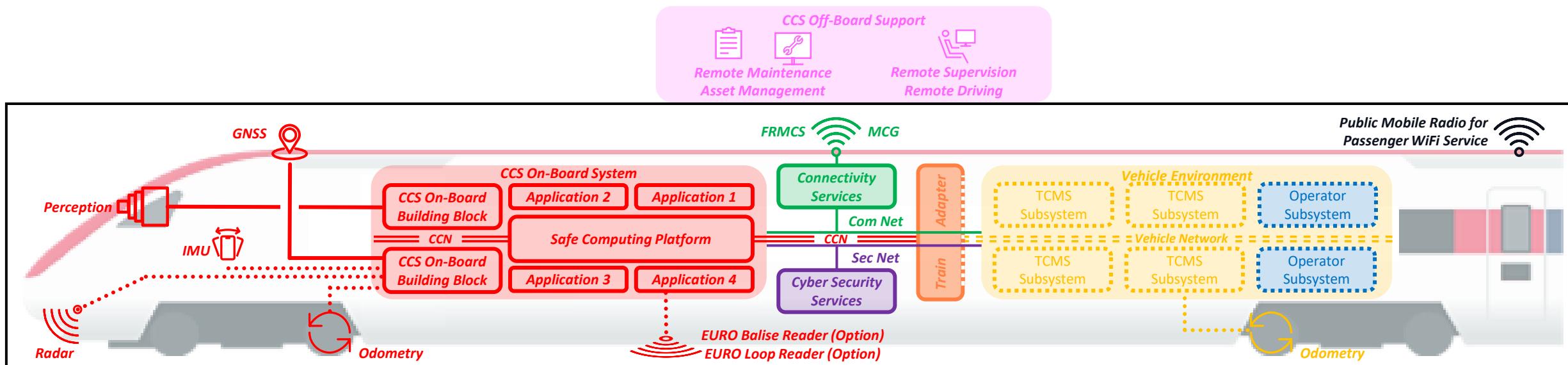
- Remote Maintenance
- Asset Management
- Absolut continues safe localisation (GNSS)
- Safe Train Integrity determination
- Safe Train Length determination
- ETCS L3
- ATO GoA 1-4
- Remote Supervision
- Remote Driving

**Step 2** is enabling the sharing of the following peripheral devices between CCS On-Board and the Vehicle Environment:

- Mobile Communication Gateway (MCG)
- GNSS antenna and receiver
- Inertial Measurement Unit (IMU)



# Technical Roadmap Step 3 – Long-Term



## Step 3: Long-Term (TSI-2028)

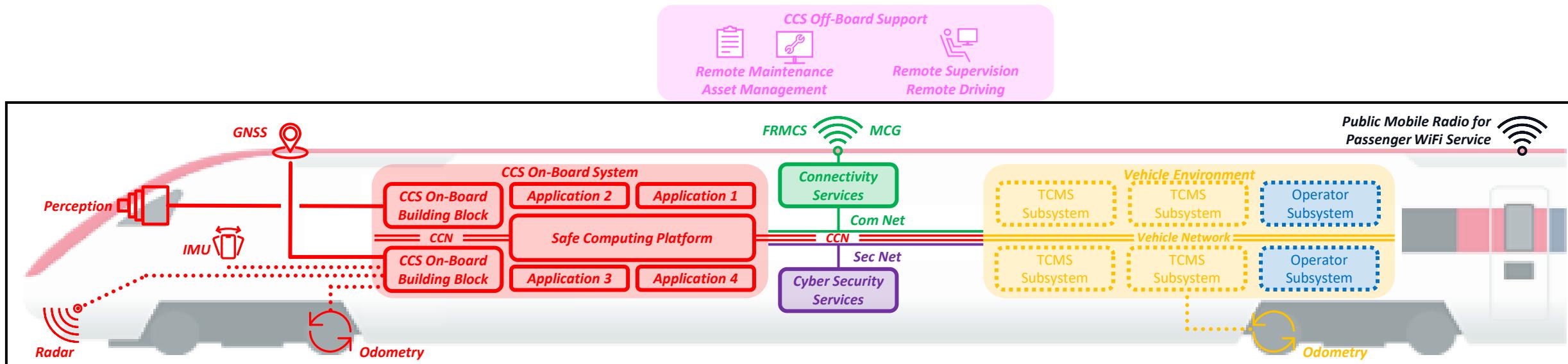
The CCS On-Board System includes a safe computing platform, hosting CCS Building Blocks as applications that communicate with each other, with the Vehicle Subsystems and any Off-Board System via a standardized API, the standardized CCS Communication Network (CCN) and the Connectivity Services, using FRMCS or Public Mobile Radio.

Due to the increased performance of the CCS On-Board localisation, EURO Balise and EURO Loop readers may not be needed anymore for trains running on certain tracks.

**Step 3** is simplifying the portability of the business logic.

**Step 3** is simplifying the development and deployment of new functionalities by separating the business logic from the hardware. In addition, the Safe Computing Platform is reducing the number of CCS computing units (CCUs) needed, increasing availability and reducing maintenance efforts.

# Technical Roadmap Step 4 – Vision



## Step 4: Vision (> TSI 2028)

The standardised CCS On-Board Communication Network (CCN) is fully integrated with the Vehicle Network, allowing to interface from any CCS On-Board Application directly with any Vehicle Subsystems and vice-versa. The need for a Train Adapter vanishes and certain Applications from the Vehicle Environment may be hosted on the CCS On-Board Safe Computing Platform.

Due to the increased performance of the CCS On-Board localisation through better sensor fusion algorithms, the use of GNSS localisation, digital map data, and augmentation data, the EURO Balise and EURO Loop readers are not needed anymore.

**Step 4:** integrating the CCS On-Board domain with the Vehicle Environment allows to reuse peripherals and applications throughout the whole train, reducing the level of hardware systems and applications needed on a train. This again will increase availability and will reduce maintenance

**Step 4:** eliminating the EURO Balise and EURO Loop readers further reduces the maintenance efforts and enables the infrastructure managers to implement changes more quickly.



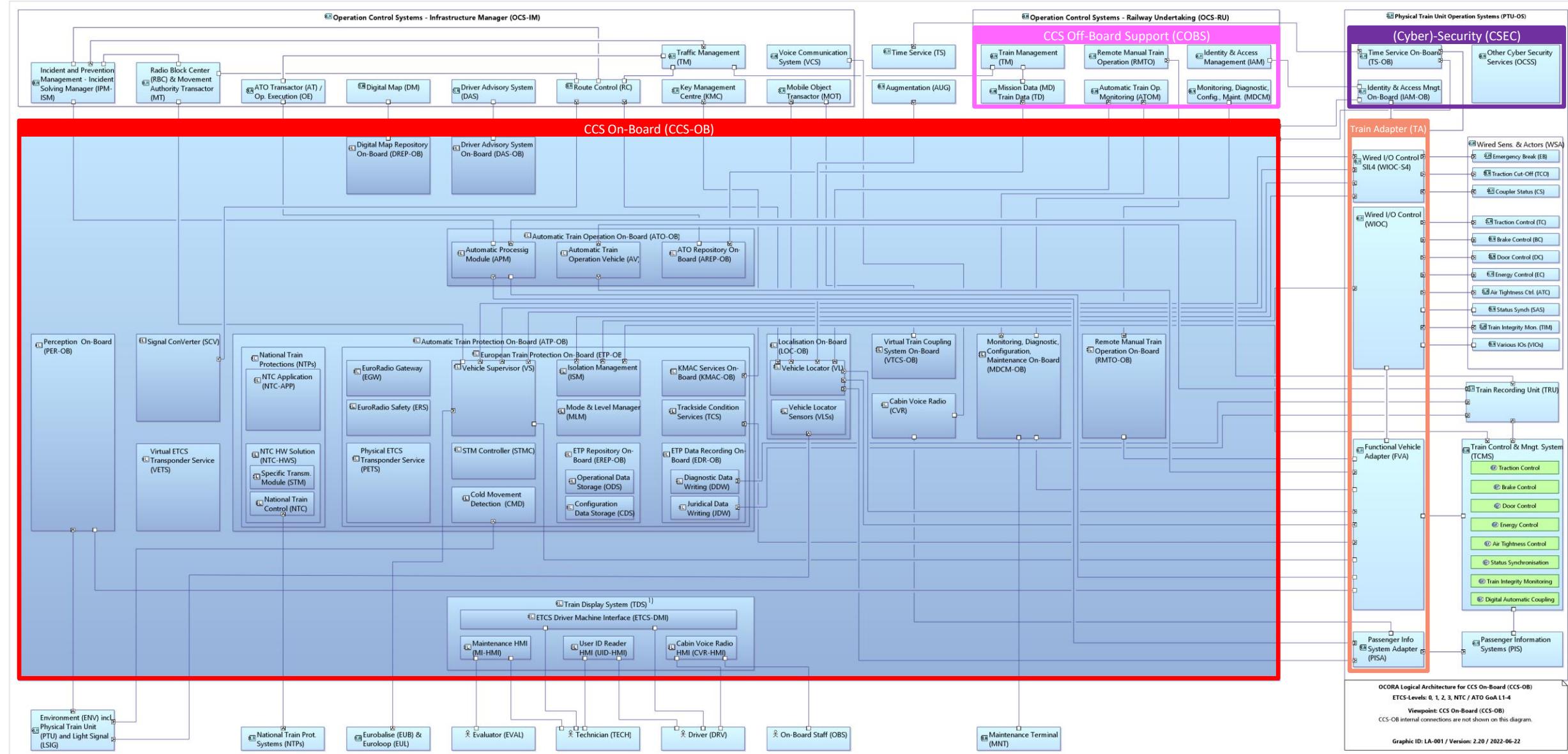
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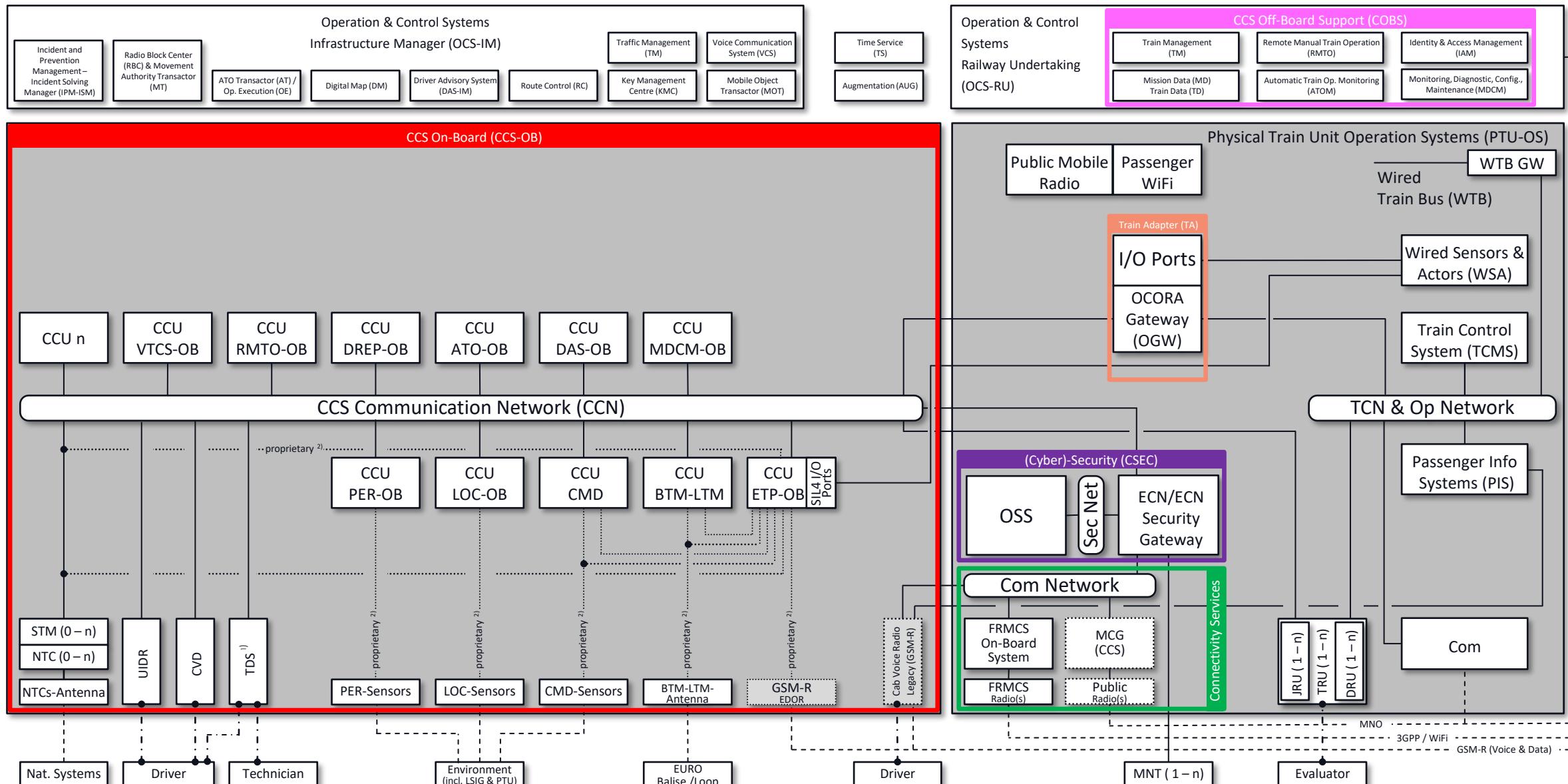
# OCORA Scope

OCORA-BWS02-030 / v2.21 / 14.07.2022

# OCORA Scope – Logical Architecture



# OCORA Scope – Physical Architecture (Legacy Train)

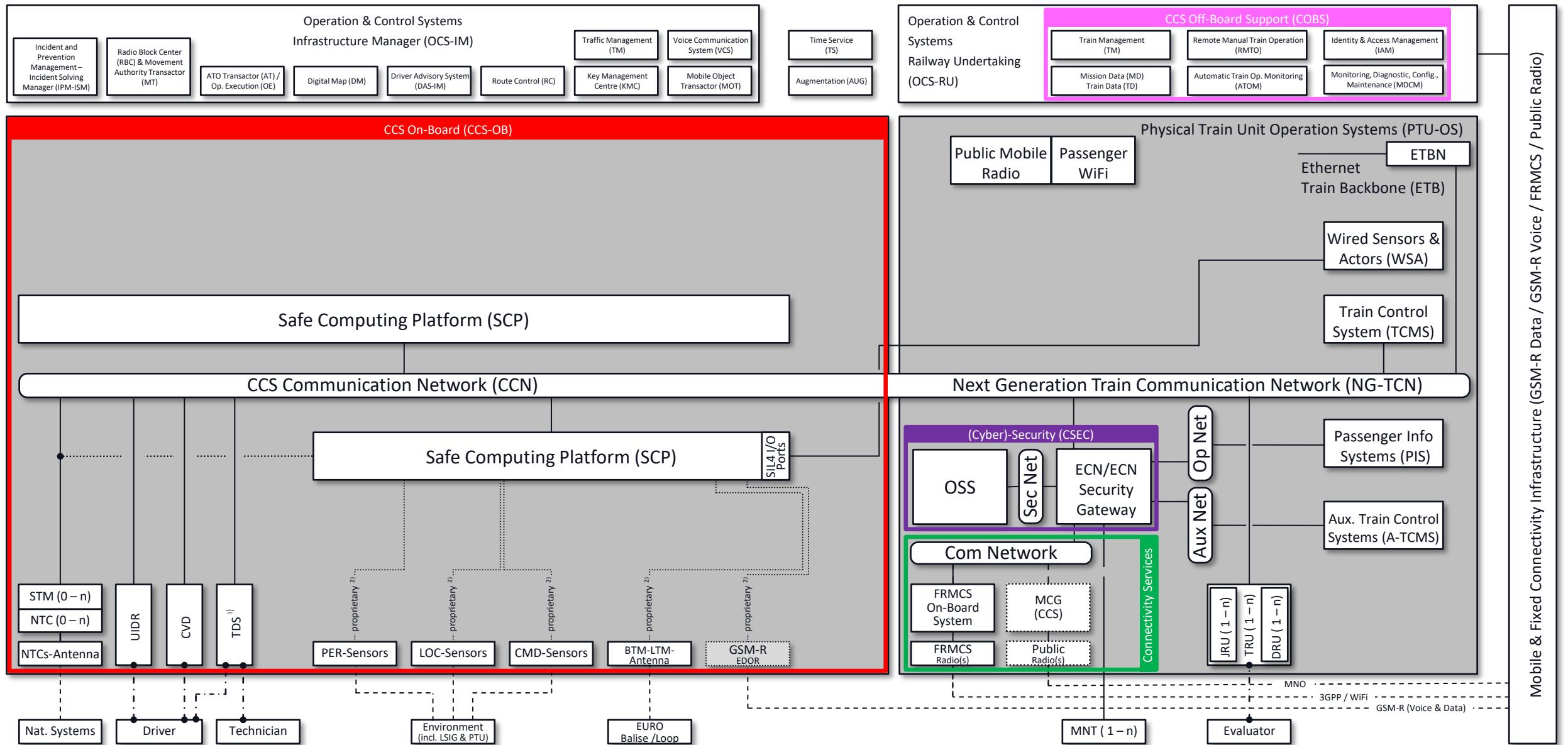


Remark: solid lines indicate wired connections, dashed lines "over the air" communication, dotted lines represent proprietary connections, and dashed-dotted lines represent user interactions.

1) May be moved into the PTU-OS / LOC&PAS domain.

2) Lower ISO layers are standardized to ease the introduction of the safe computing platform. Alternatively, the interface with the backbone of the safe computing platform needs to be standardized.

# OCORA Scope – Physical Architecture (New Generation Trains)



Remark: solid lines indicate wired connections, dashed lines "over the air" communication, dotted lines represent proprietary connections, and dashed-dotted lines represent user interactions.

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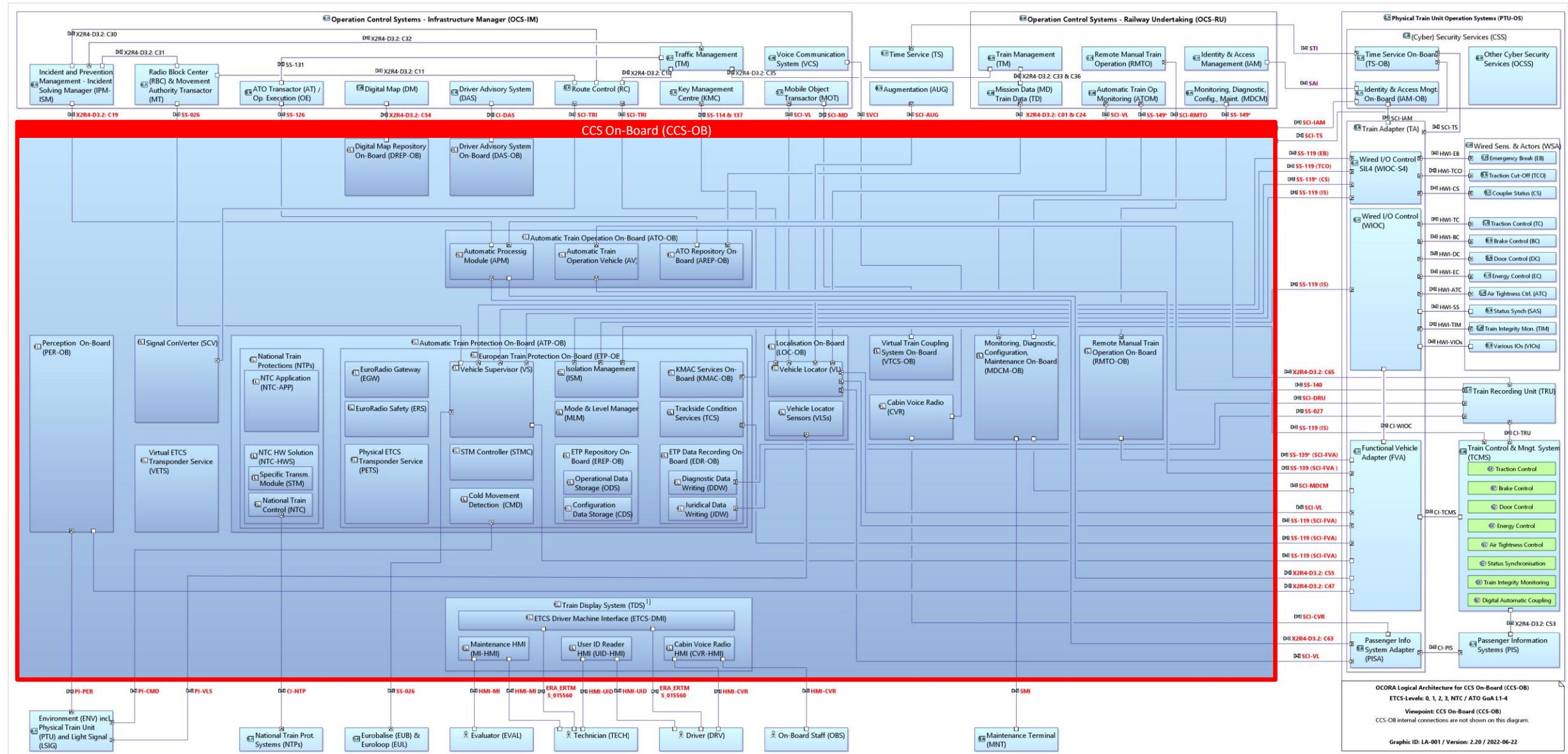


# CCS On-Board (CCS-OB)

## Logical Architecture

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Logical Architecture CCS-OB Actors, External Interfaces, Functional Components



1) May be moved into the PTU-OS / LOC&PAS domain.

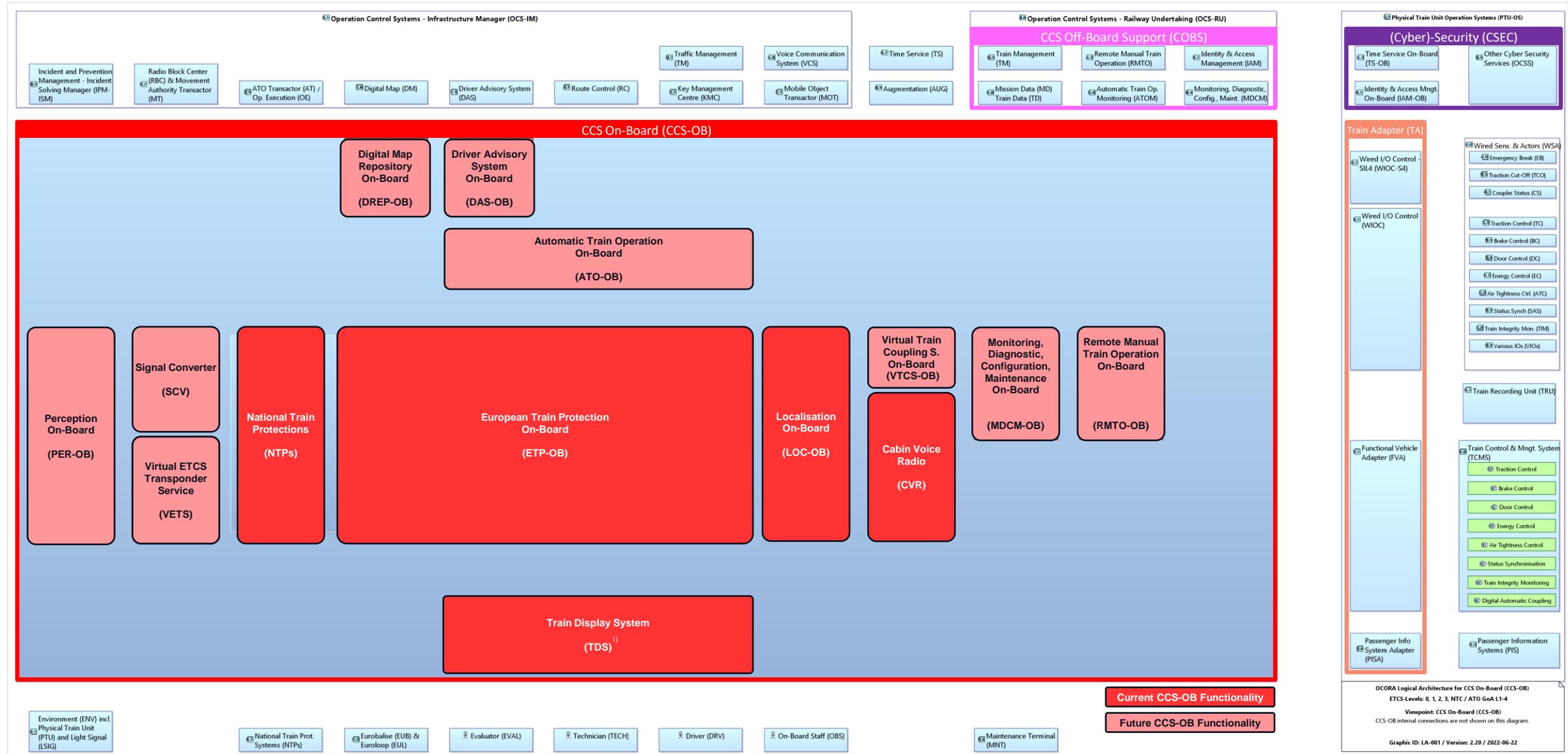
1) May be moved into the PTU-OS / LOC&PAS domain.

SS-ppn      Respective subset contains information for the interface

**SS-nnn\*** Respective subset does not address the interface but should contain the information in the future



# Logical Architecture CCS-OB Functional Clustering for Building Block Assignment



Environment (ENV) incl.  
Physical Train Unit  
(PTU) and Light Signal  
(LSIG)

National Train Prot.  
Systems (NTPs)

Eurobalise (EUB) &  
Euroloop (EUL)

Evaluator (EVAL)

Technician (TECH)

Driver (DRV)

On-Board Staff (OBS)

Maintenance Terminal  
(MNT)



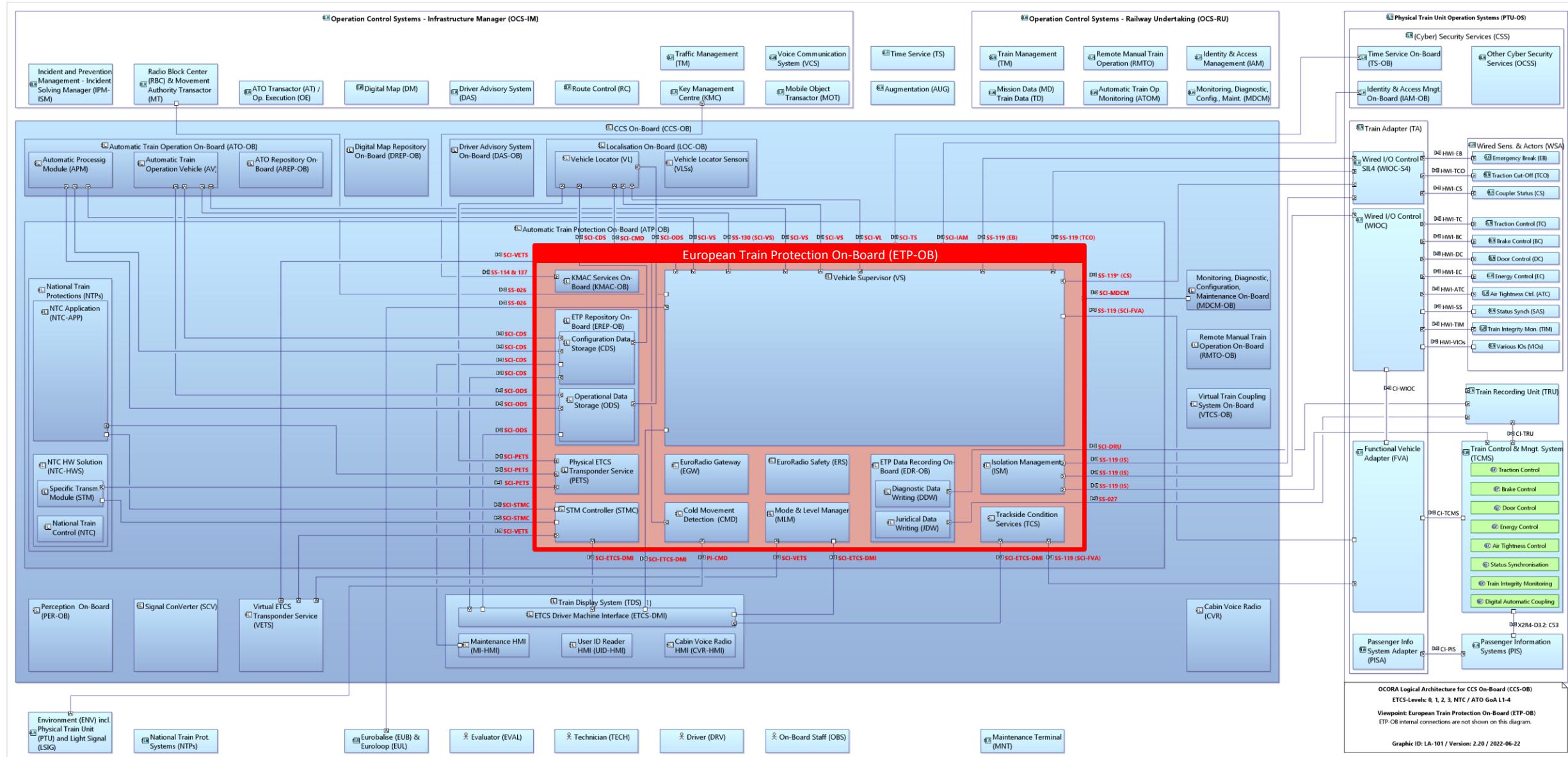
1) May be moved into the PTU-OS / LOC&PAS domain.

1)  
SS-nnn May be moved into the PTU-OS / LOC&PAS domain.

Respective subset contains information for the interface

SS-nnn\* Respective subset does not address the interface but should contain the information in the future.

Logical Architecture ETP-OB Actors, External Interfaces, Components



1) May be moved into the PTU-OS / LOC&PAS domain.

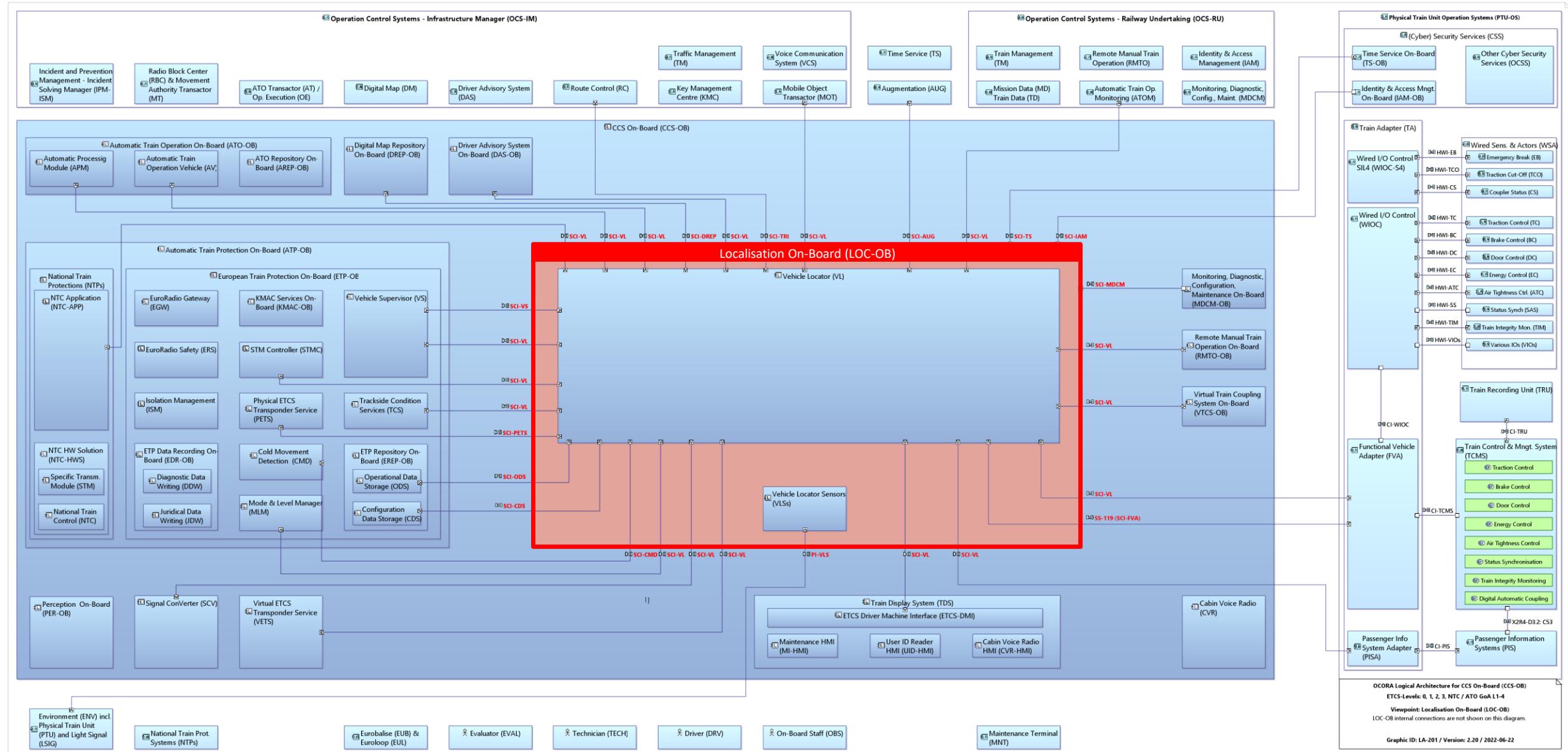
1) May be moved into the PTU-OS / LOC&PAS domain.

SS-nnn Respective subset contains information for the interface

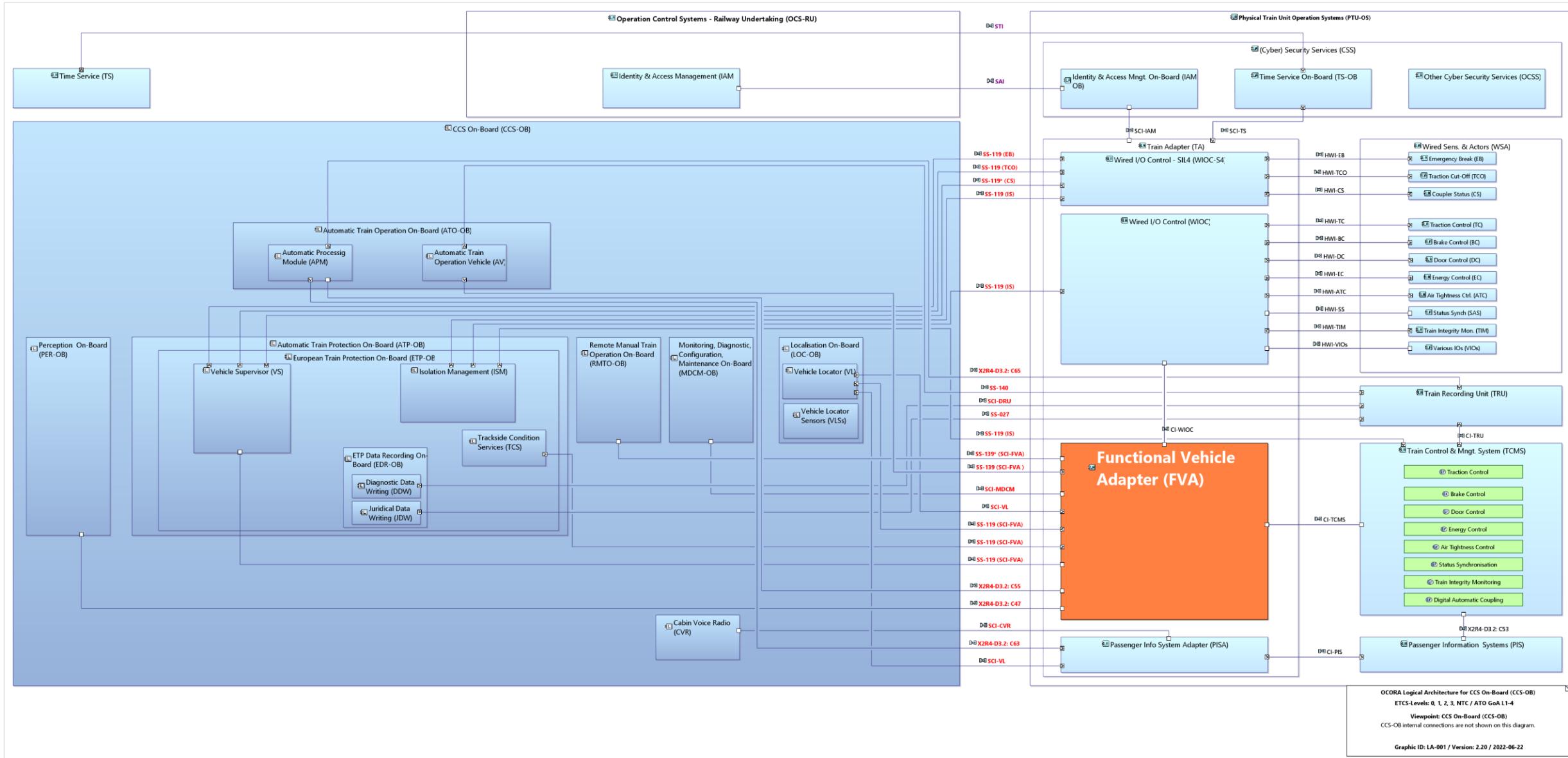
**SS-nnn\*** Respective subset does not address the interface but should contain the information in the future.



# Logical Architecture LOC-OB Actors, External Interfaces, Components



# Logical Architecture FVA Actors and External Interfaces





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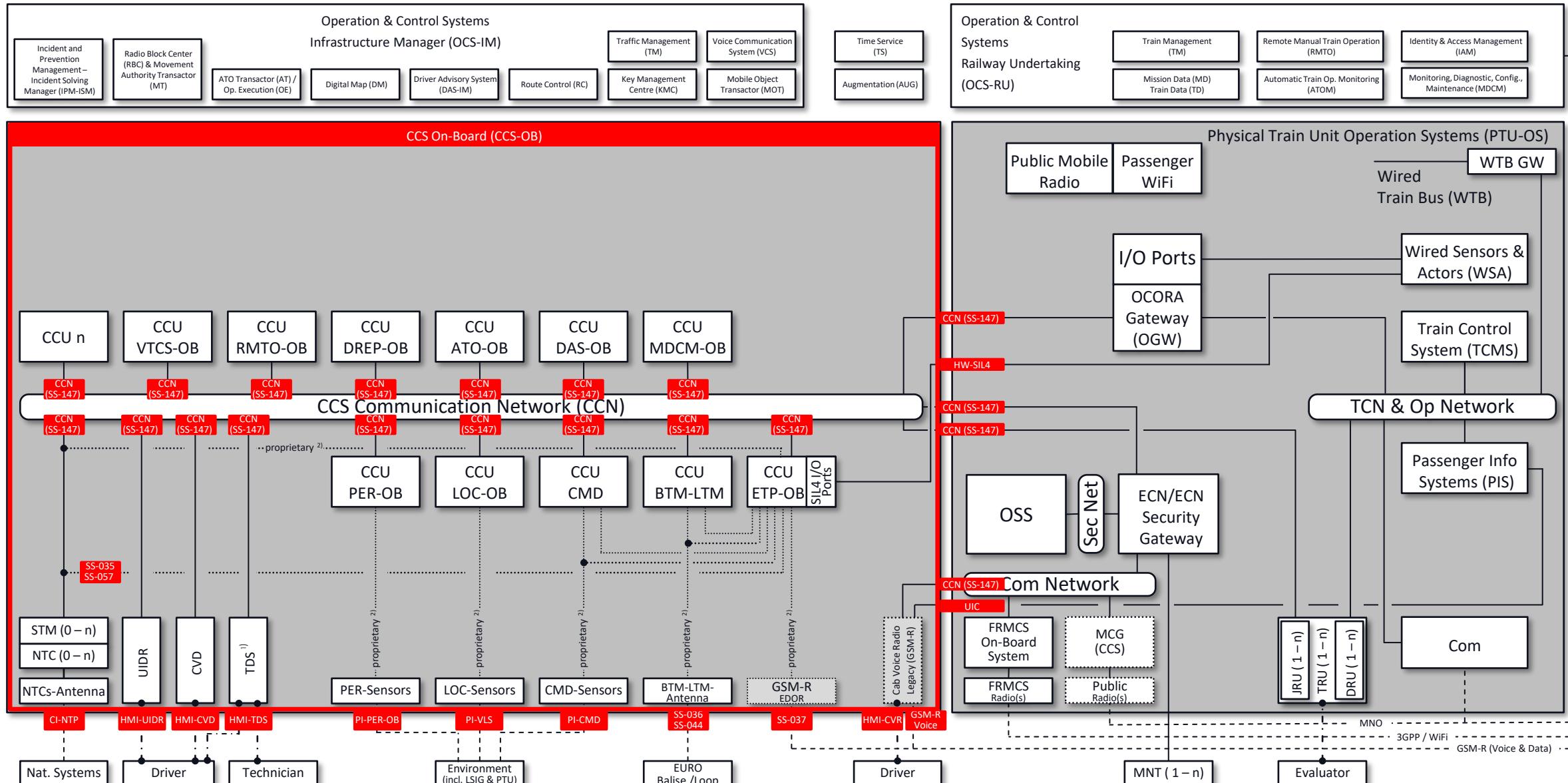
# CCS On-Board (CCS-OB)

## Physical Architecture

OCORA-BWS02-030 / v2.21 / 14.07.2022

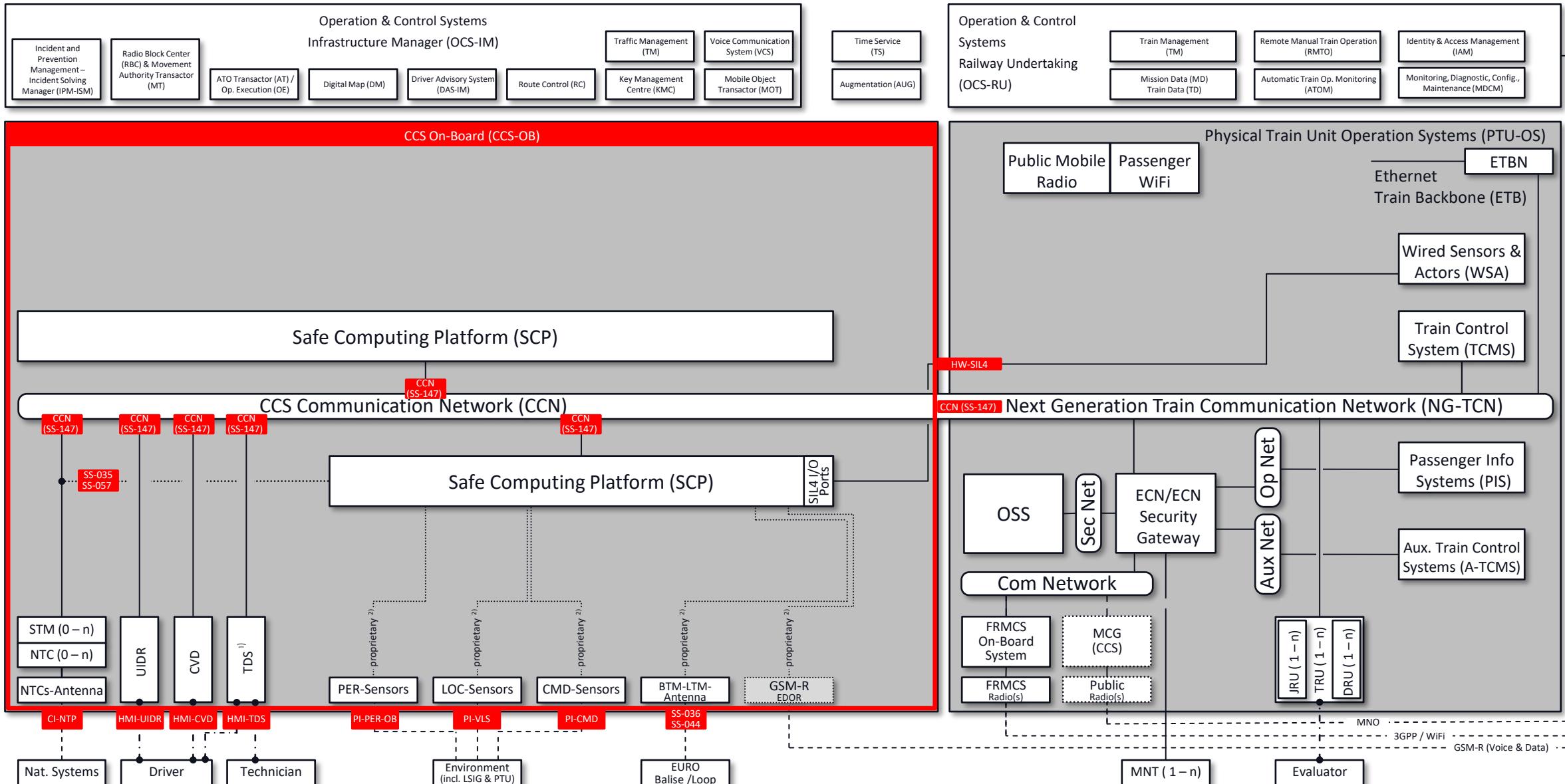
# Physical Architecture CCS-OB – Legacy Train

Actors, Interfaces, Hardware Components



# Physical Architecture CCS-OB – NG Train

Actors, Interfaces, Hardware Components



1) May be moved into the PTU-OS / LOC&PAS domain.

2) Lower ISO layers are standardized to ease the introduction of the safe computing platform. Alternatively, the interface with the backbone of the safe computing platform needs to be standardized.



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# Building Blocks

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A building block is a sourceable unit of the CCS on-board system (hardware and/or software), having standardised functionality, standardised performance (RAM), standardised safety (including Tolerable Functional Failure Rate [TFFR], Safety Integrity Level [SIL] and Safety Related Application Conditions [SRAC]), standardised security and standardised interfaces towards other building blocks and/or external systems.

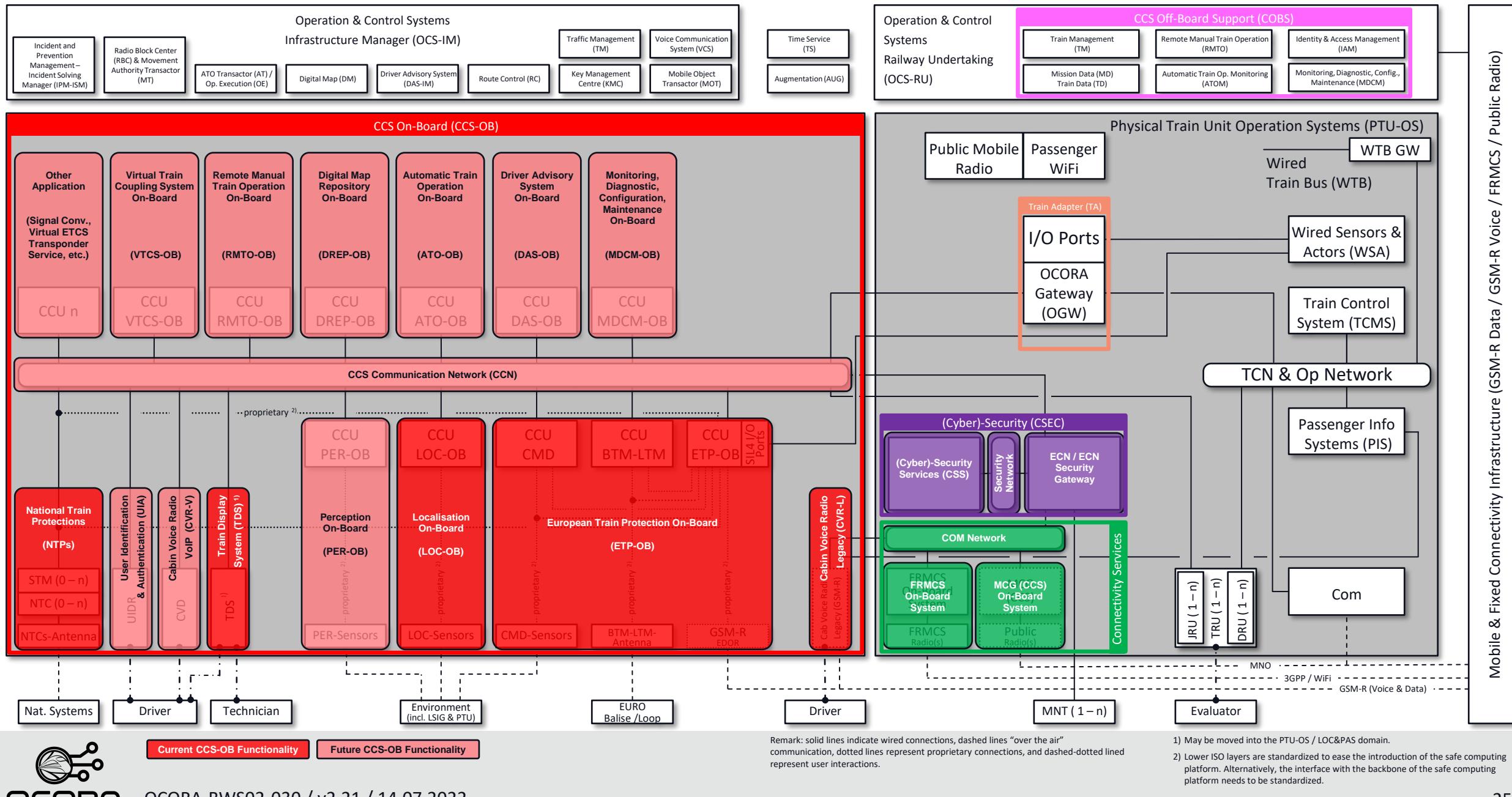
Combined HW/SW Building blocks exclusively communicating with each other through the CCS Communication Network (CCN) through standardise interfaces.

SW Building blocks, deployed on an instance of the generic Safe Computing Platform, shall communicate with each other through the standardised platform independent Application Programming Interface (API). Communication with computing platform external systems will be realised by the computing platform (integrating with the CCN).

Building blocks are modifiable / adaptable and therefore portable / replaceable, without impacting other building blocks.

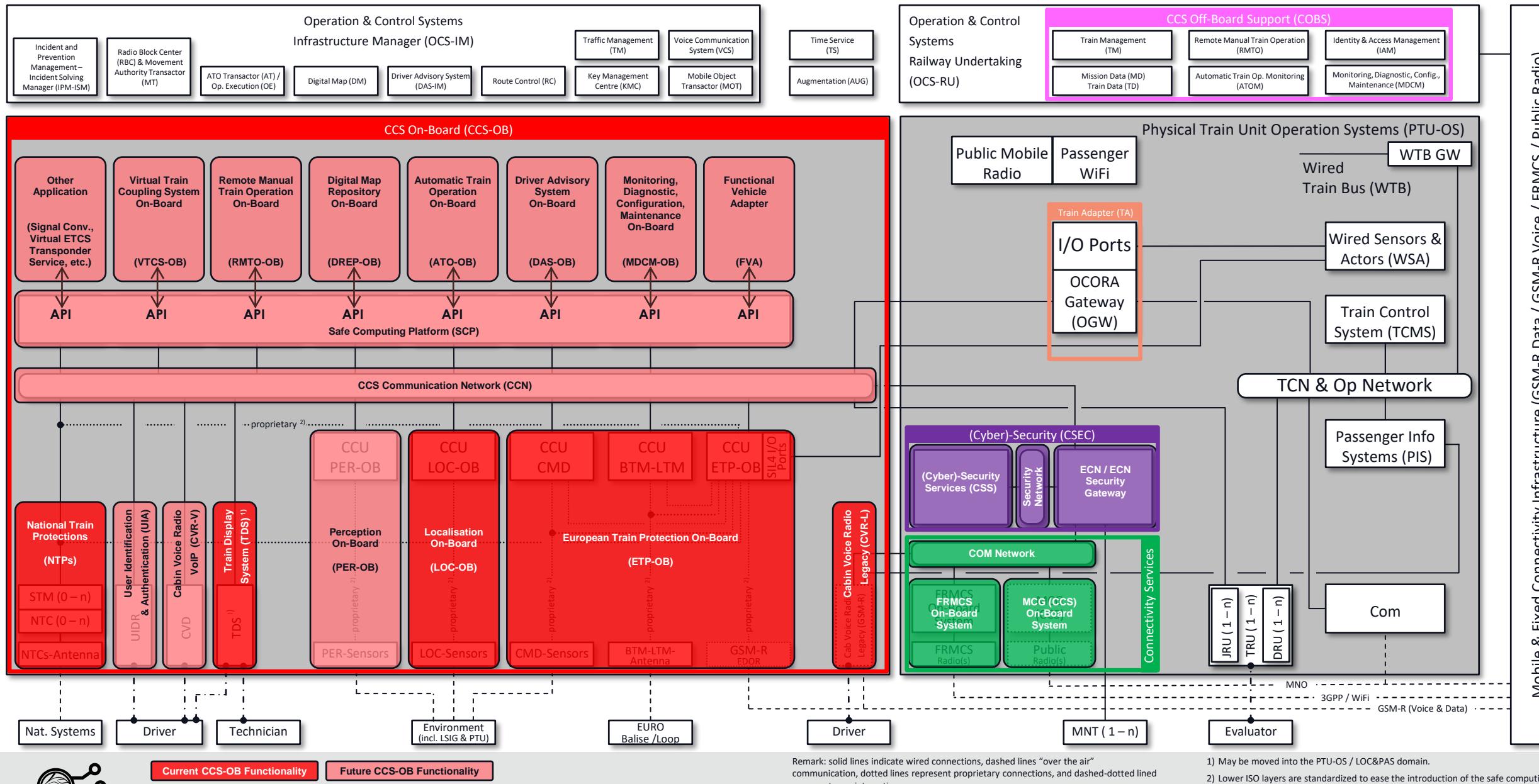
# Scenario 1

Building Blocks without Safe Computing Platform (dedicated hardware for each functional cluster)  
Legacy Train Example



## Scenario 2

## Building Blocks with Safe Computing Platform for some Applications Legacy Train Example



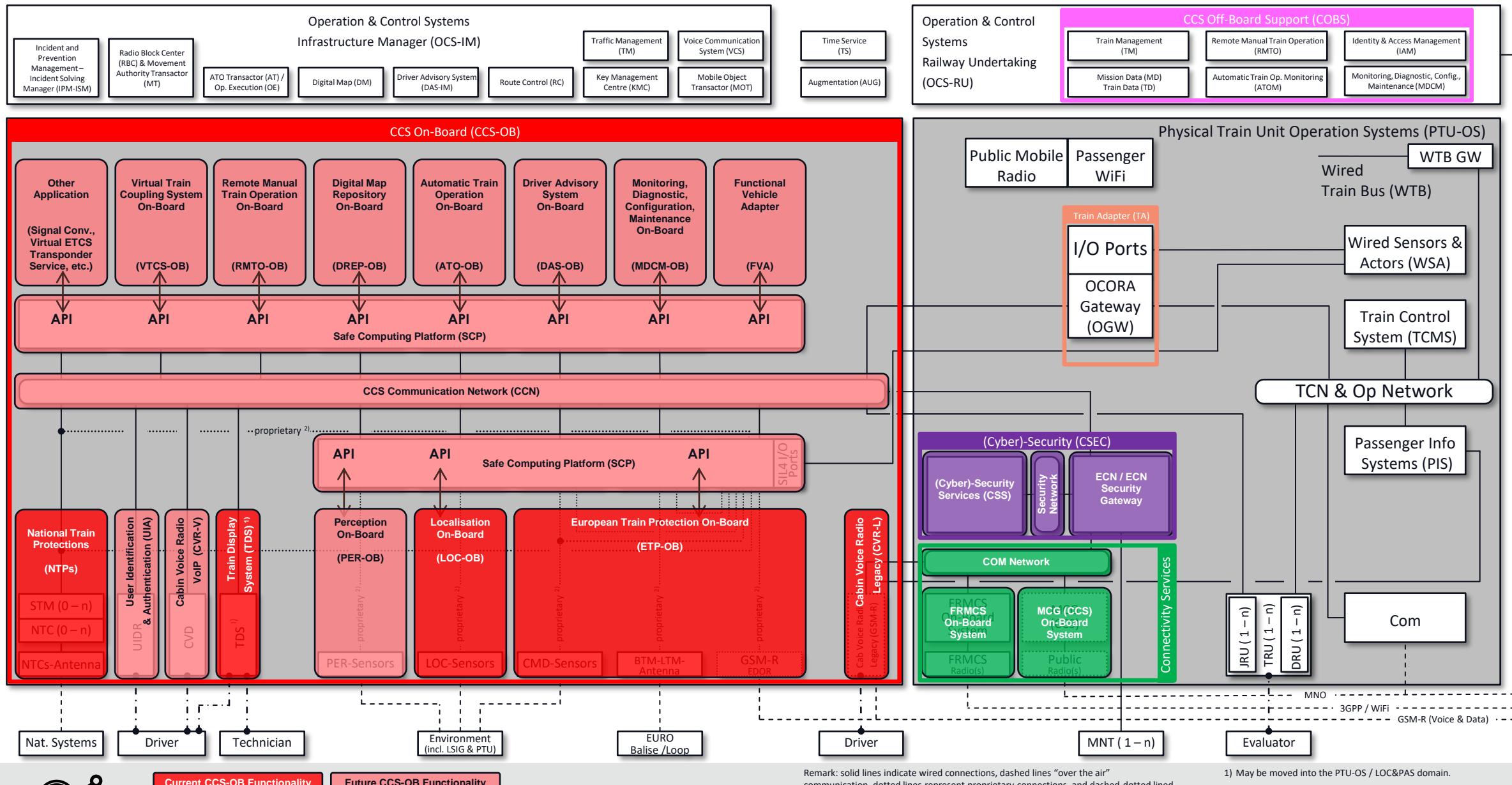
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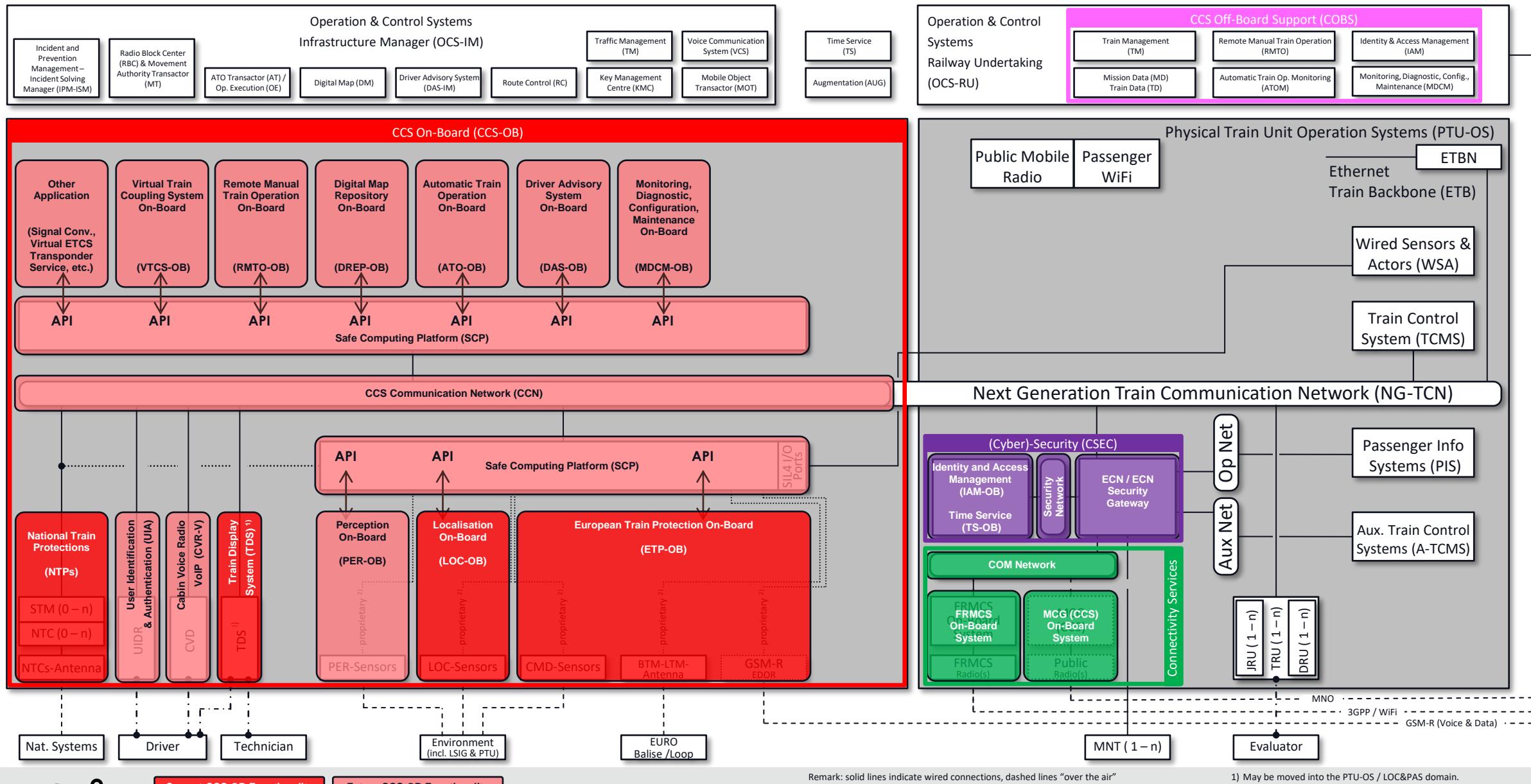
# Scenario 3

## Building Blocks with Safe Computing Platform for all Applications Legacy Train Example



# Scenario 4

## Building Blocks with Safe Computing Platform for all Applications New Generation Train Example



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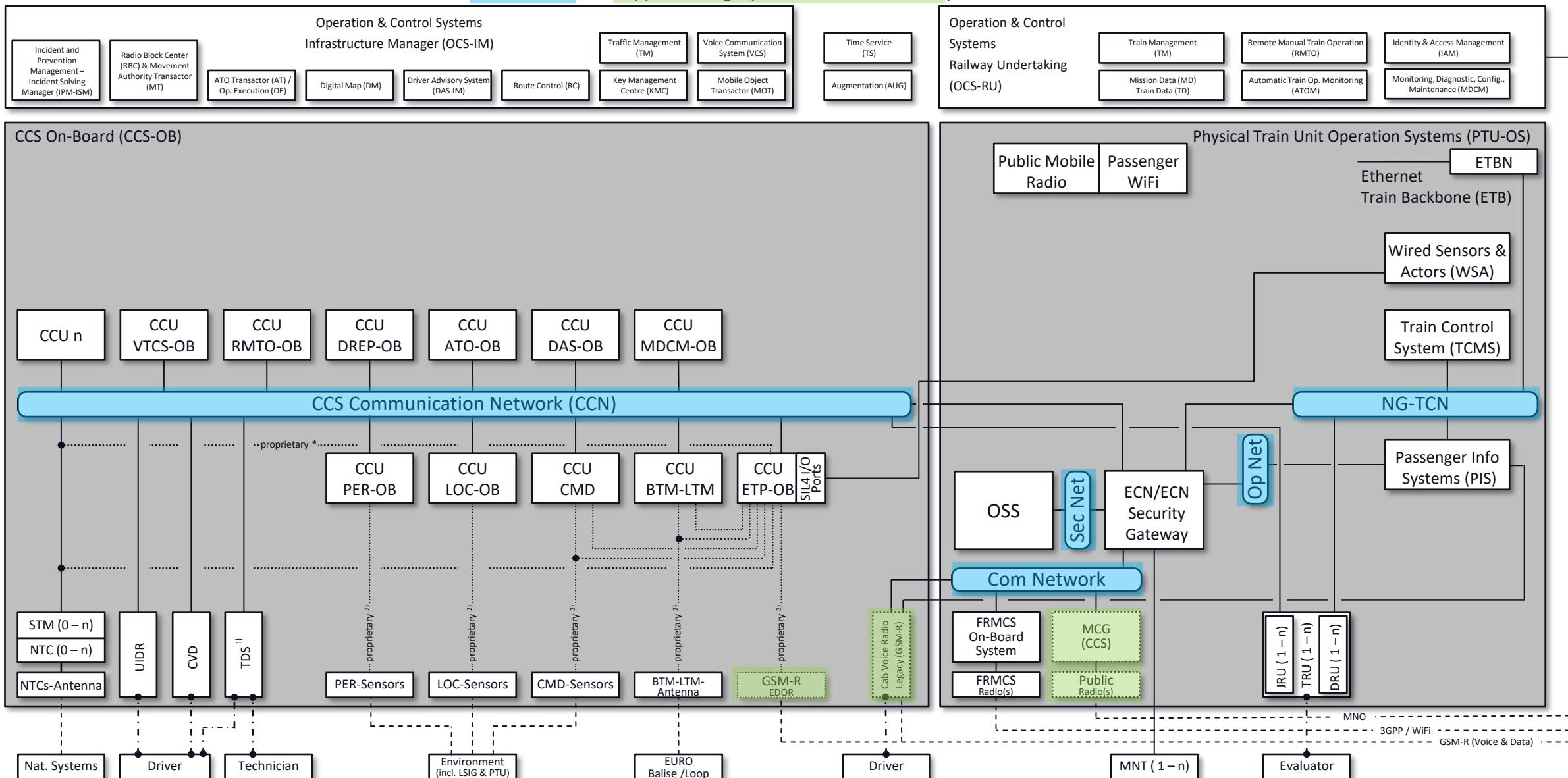


# Train Integration Scenarios

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## NG-TCN Train – Scenario A

(CCN as physically separated network from Sec Net, Op Net, NG TCN and Com Net with support for legacy trackside infrastructure)



Remark: solid lines indicate wired connections, dashed lines “over the air” communication, dotted lines represent proprietary connections, and dashed-dotted lines represent user interactions.

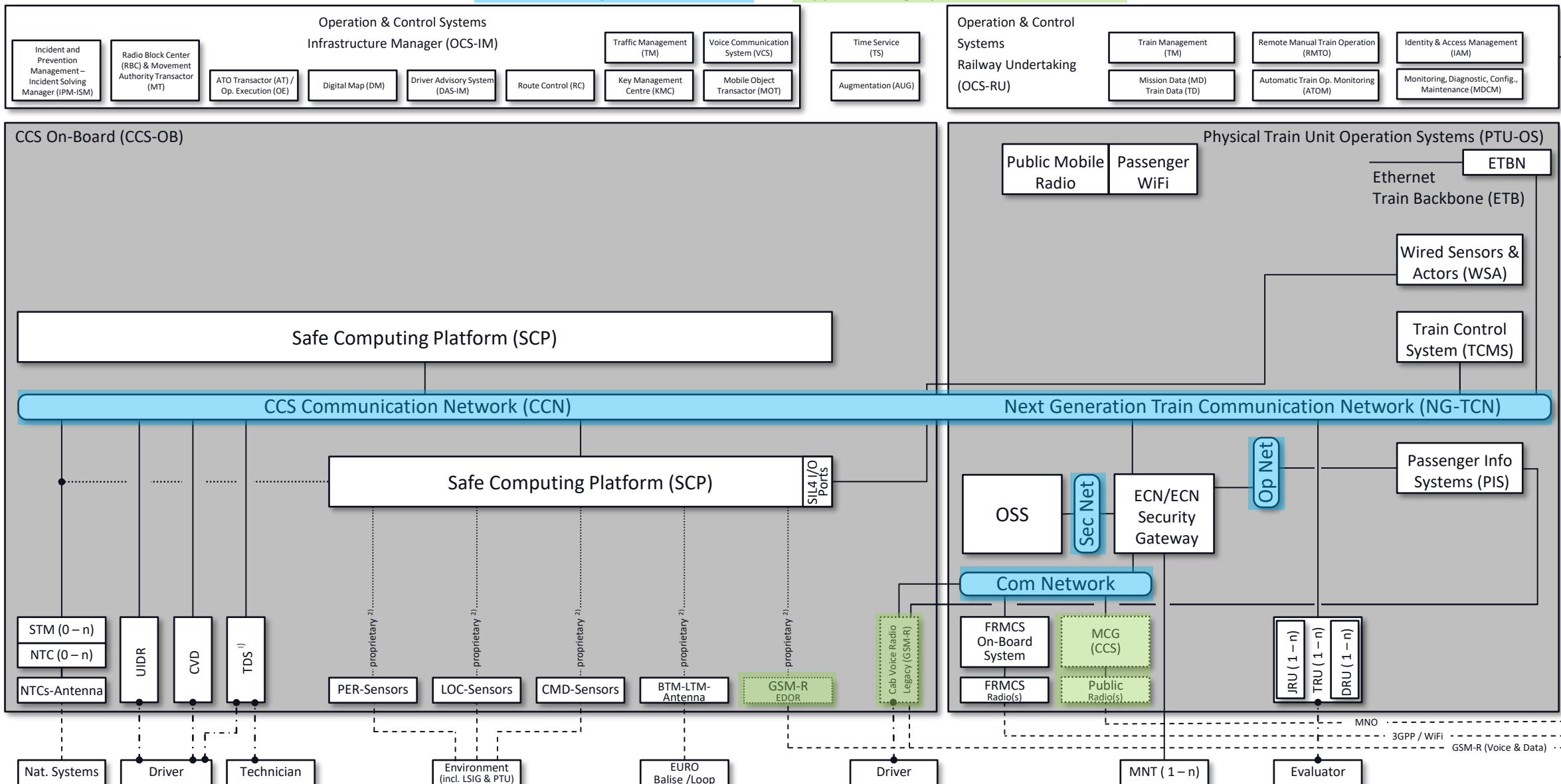
1) May be moved into the PTU-OS / LOC&PAS domain.

2) Lower ISO layers are standardized to ease the introduction of the safe computing platform. Alternatively, the interface with the backbone of the safe computing platform needs to be standardized.



# NG-TCN Train – Scenario B

(CCN as logically separated network from NG TCN and physically separated from Sec Net, Op Net and Com Net with support for legacy trackside infrastructure)

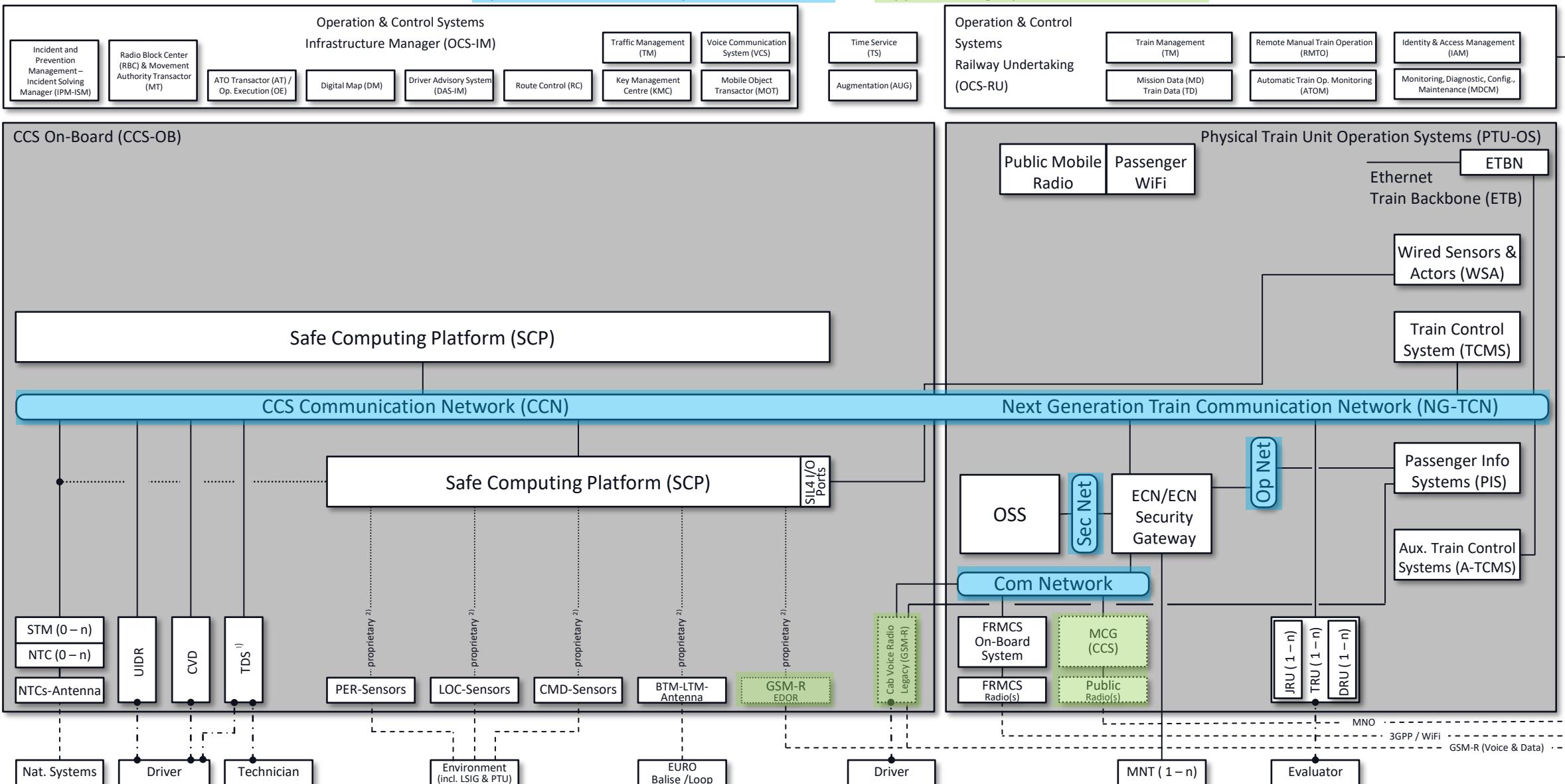


# NG-TCN Train – Scenario C

(Common CCN and TCMS network logically separated from A-TCMS and physically separated from Sec Net, Op Net and Com Net with support for legacy trackside infrastructure)



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Remark: solid lines indicate wired connections, dashed lines “over the air” communication, dotted lines represent proprietary connections, and dashed-dotted lines represent user interactions.

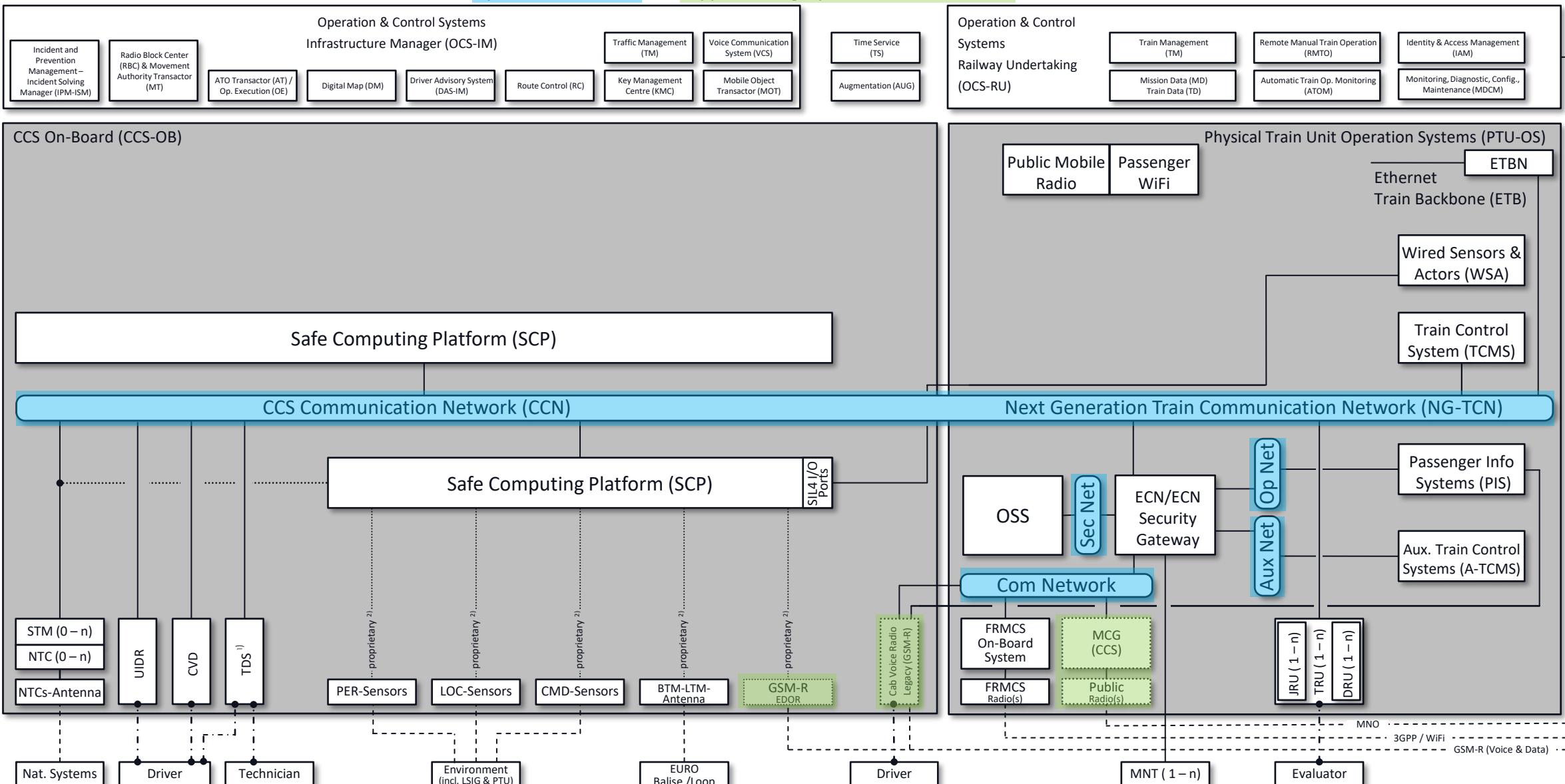
1) May be moved into the PTU-OS / LOC&PAS domain.

2) Lower ISO layers are standardized to ease the introduction of the safe computing platform. Alternatively, the interface with the backbone of the safe computing platform needs to be standardized.



# NG-TCN Train – Scenario D

(Common CCN and TCMS network physically separated from A-TCMS, Sec Net, Op Net and Com Net with support for legacy trackside infrastructure)

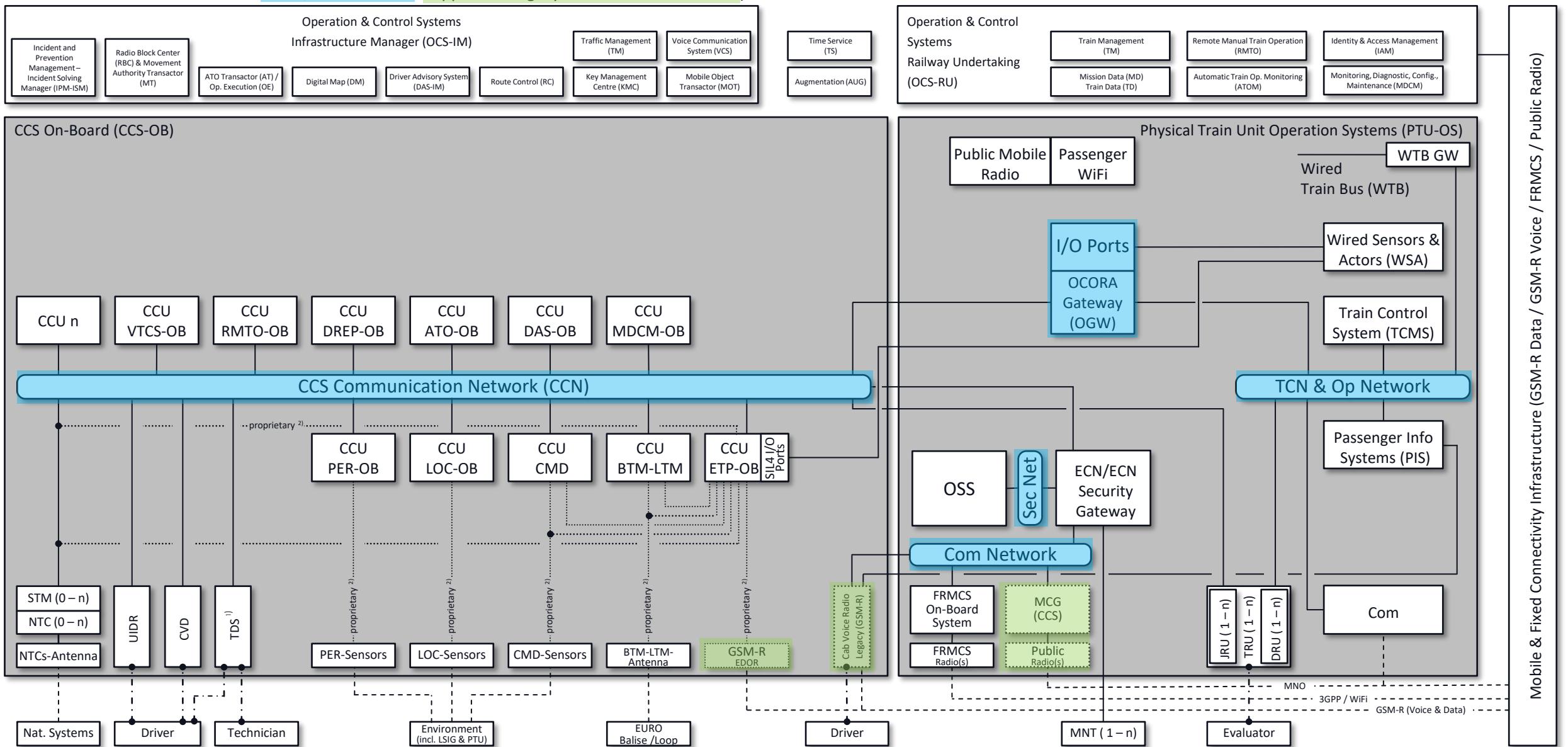


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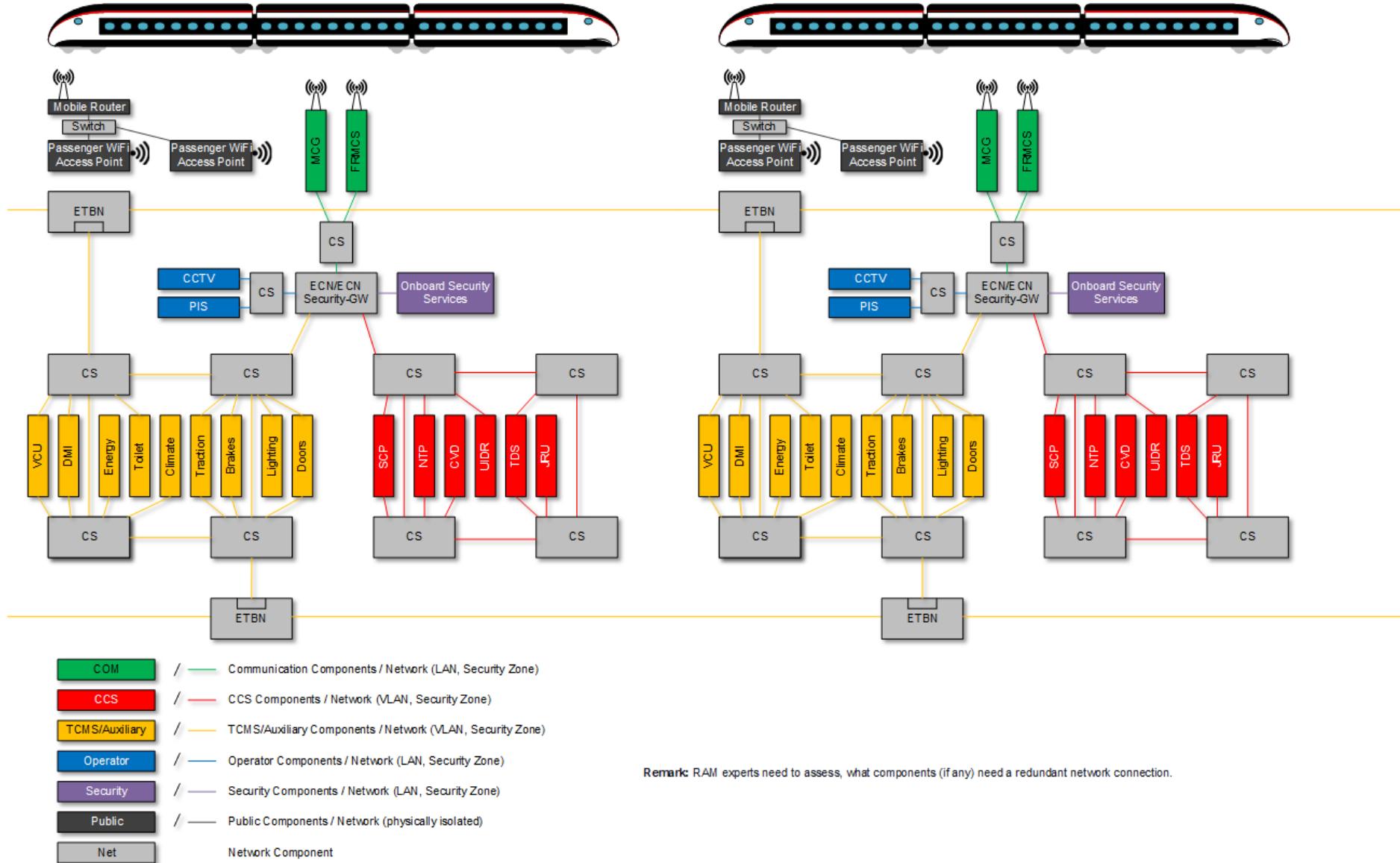




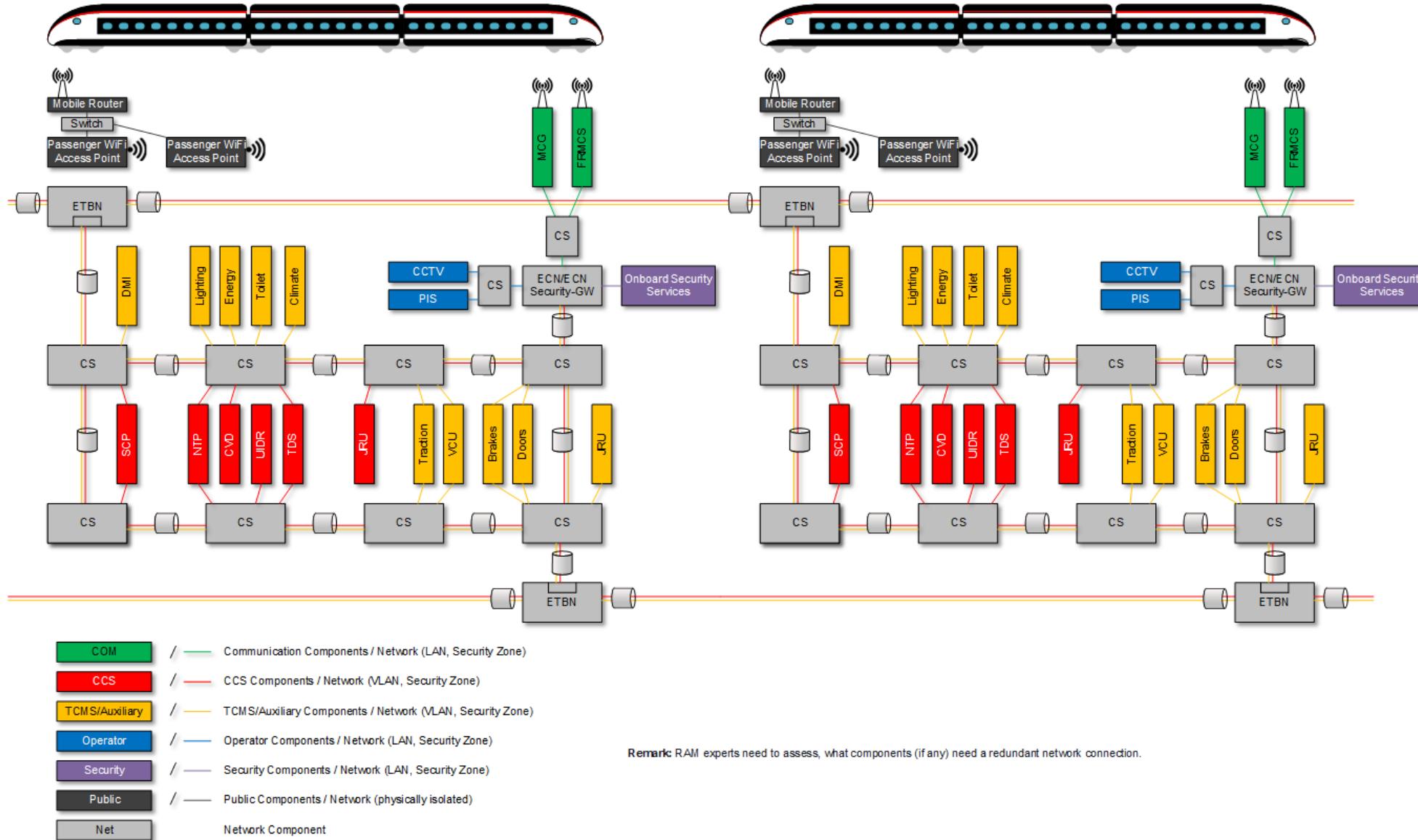
# Network Topology Scenarios

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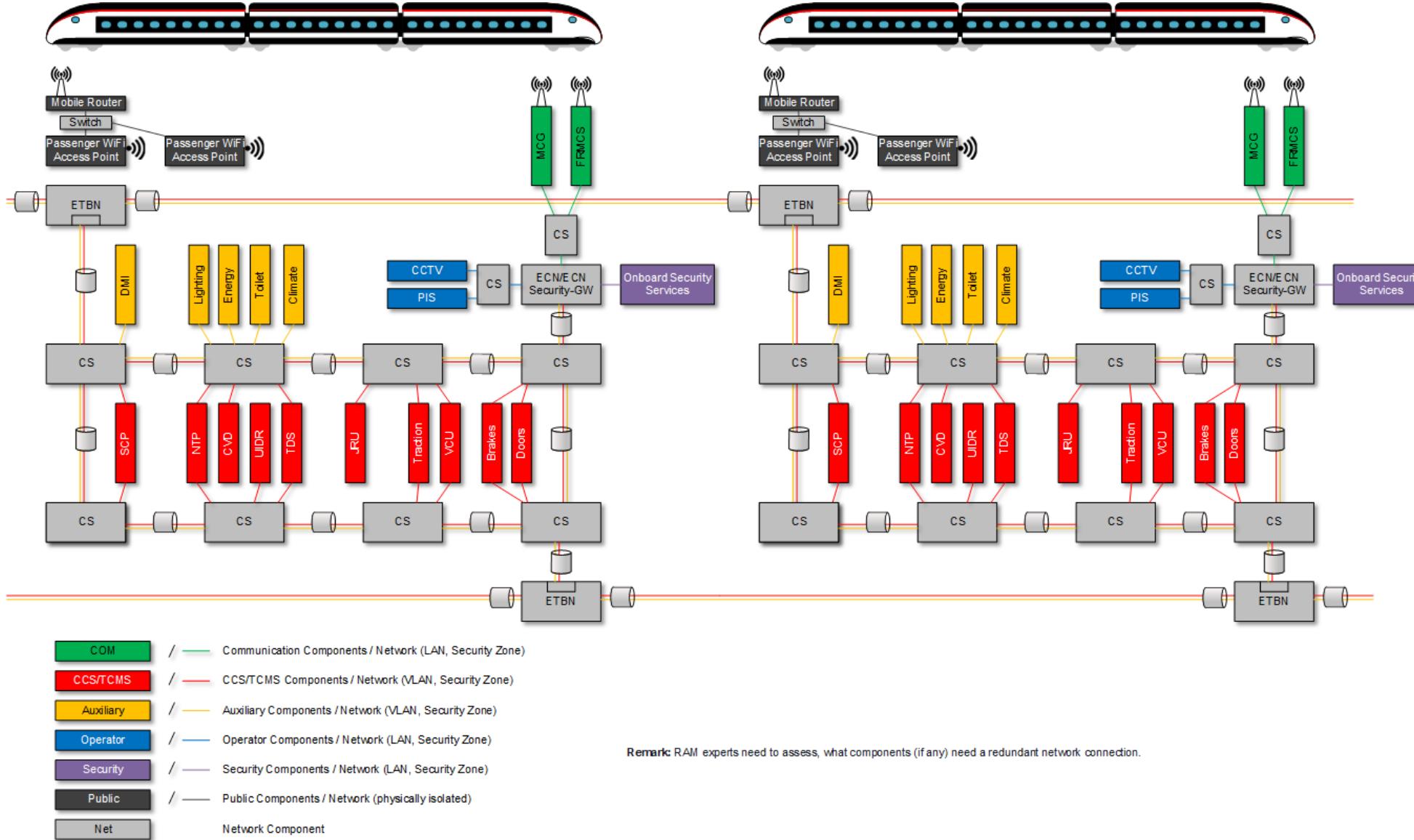
# Scenario A: CCN as physically separated network



# Scenario B: CCN as logically separated network



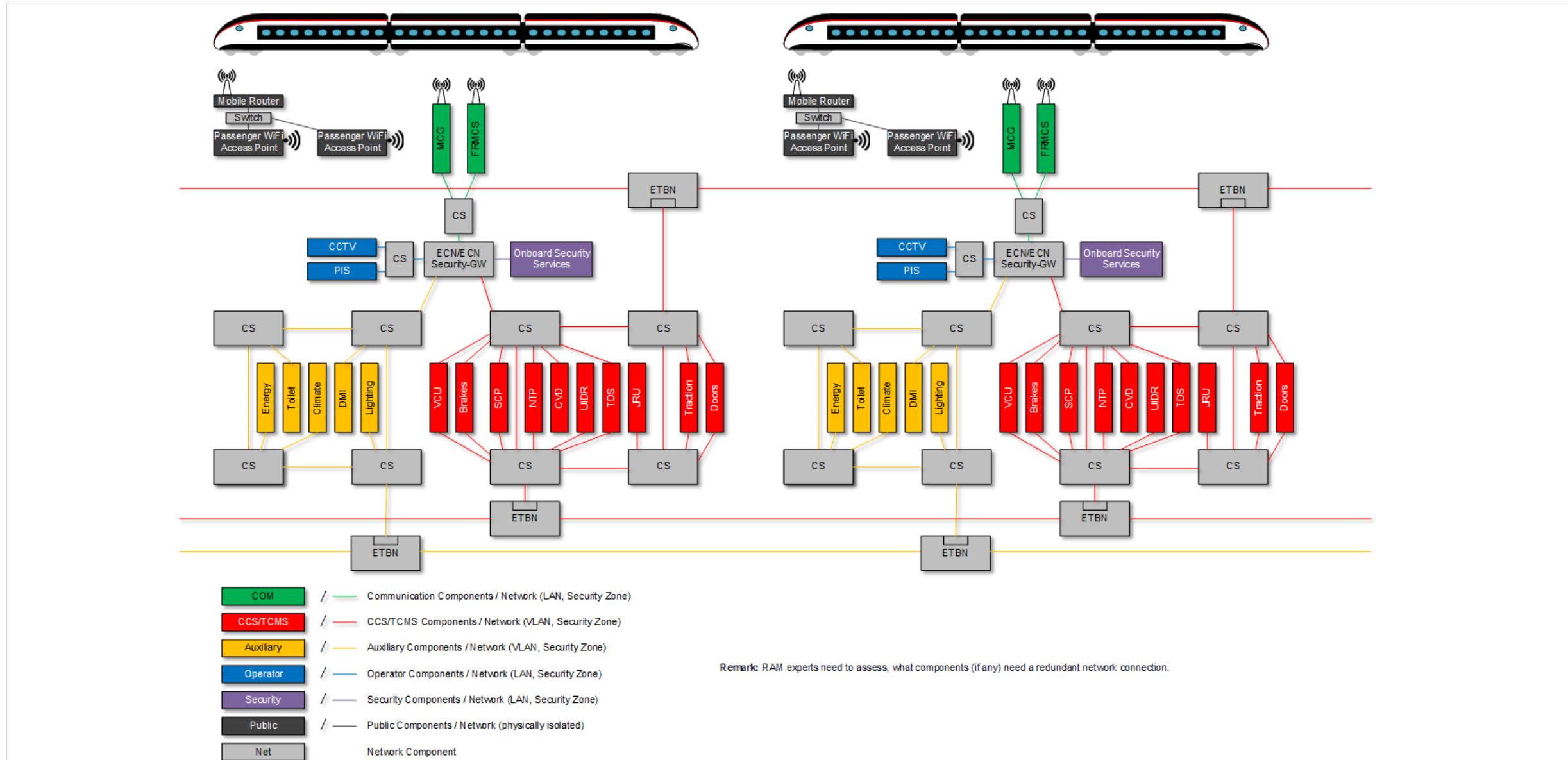
# Scenario C: Common critical control network logically separated



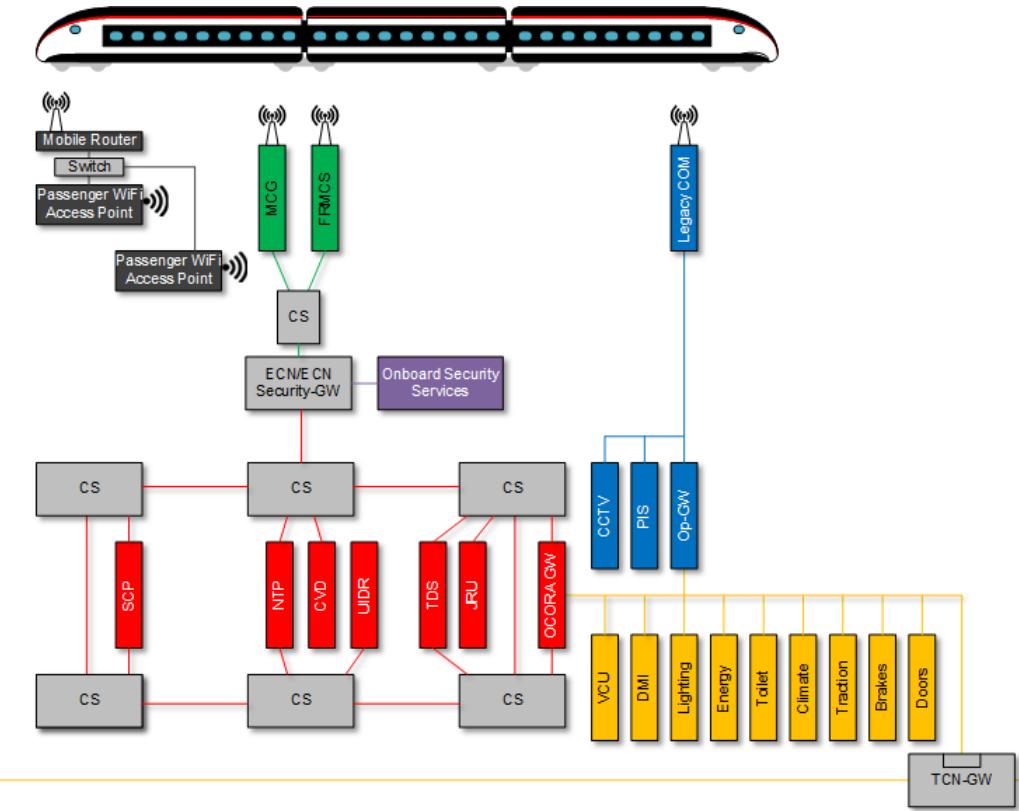
# Scenario D: Common critical control network physically separated



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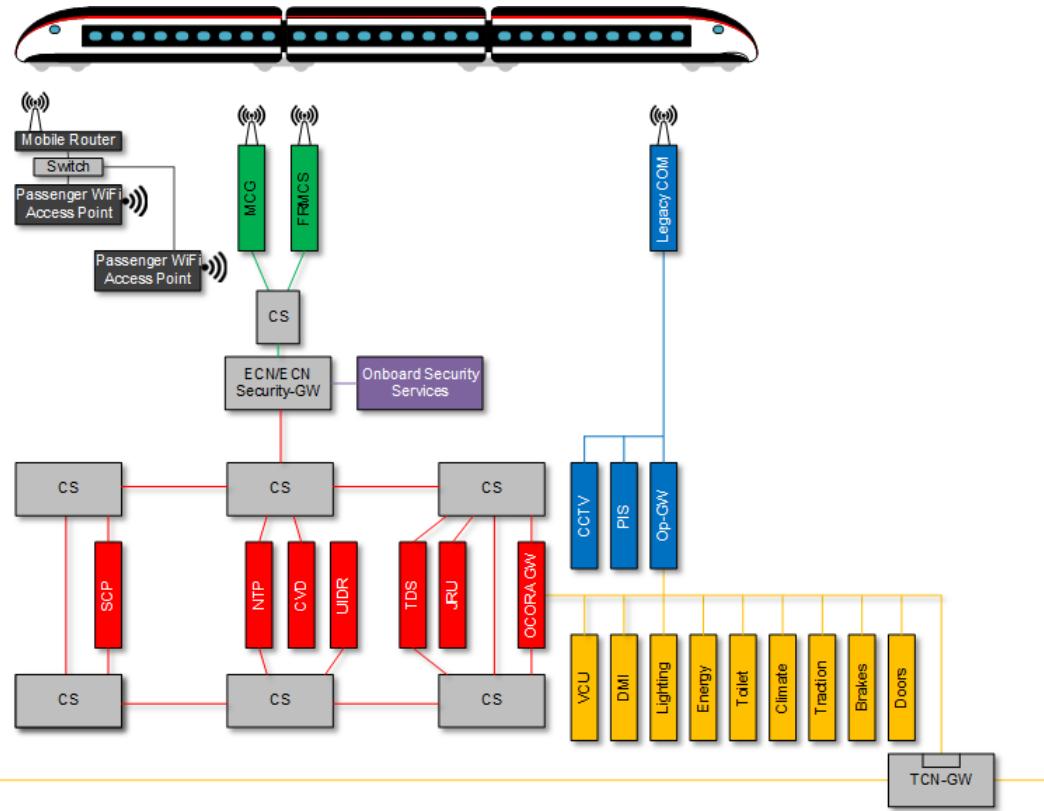
# Legacy Train – Integration with OCORA-GW



	/	Communication Components / Network (LAN, Security Zone)
	/	CCS Components / Network (VLAN, Security Zone)
	/	TCMS/Auxiliary Components / Network (VLAN, Security Zone)
	/	Operator Components / Network (LAN, Security Zone)
	/	Security Components / Network (LAN, Security Zone)
	/	Public Components / Network (physically isolated)
		Network Component

**Remark:** The network architecture of retrofit vehicles is only an example. Legacy architectures are always vehicle dependent and therefore the CCS integration is project specific.

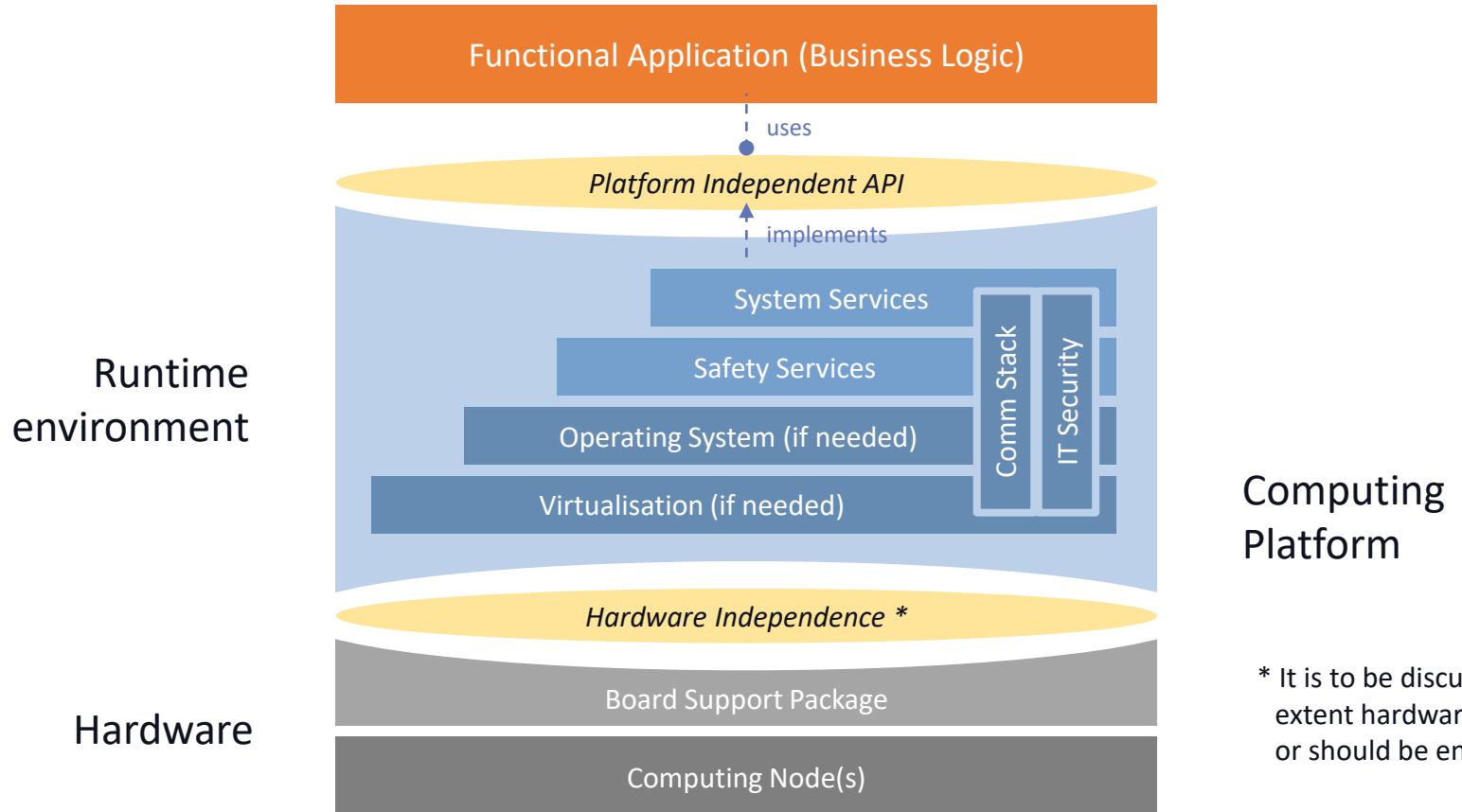
**Remark:** RAM experts need to assess, what components (if any) need a redundant network connection.



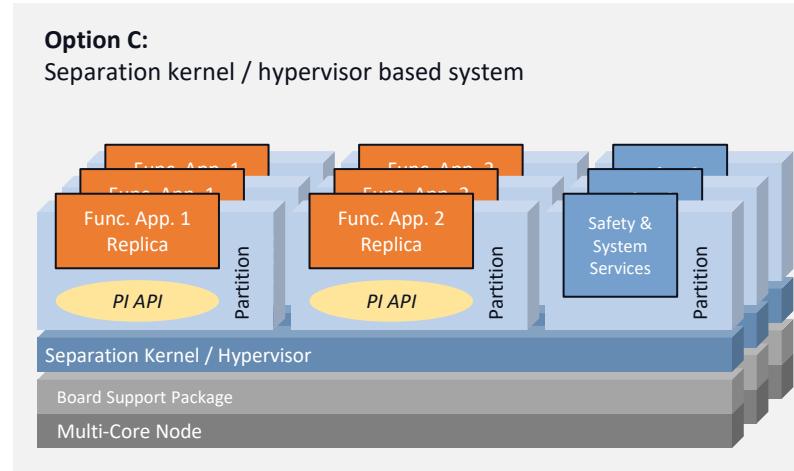
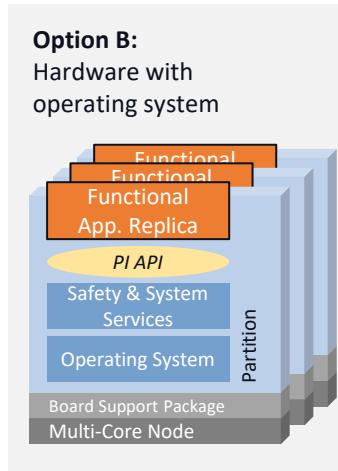
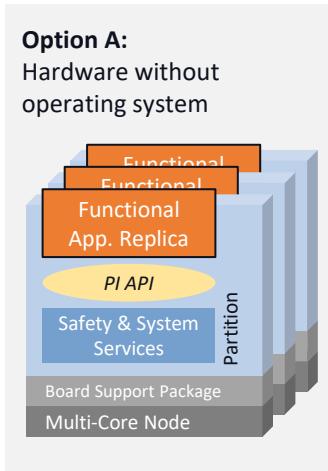


# Computing Platform

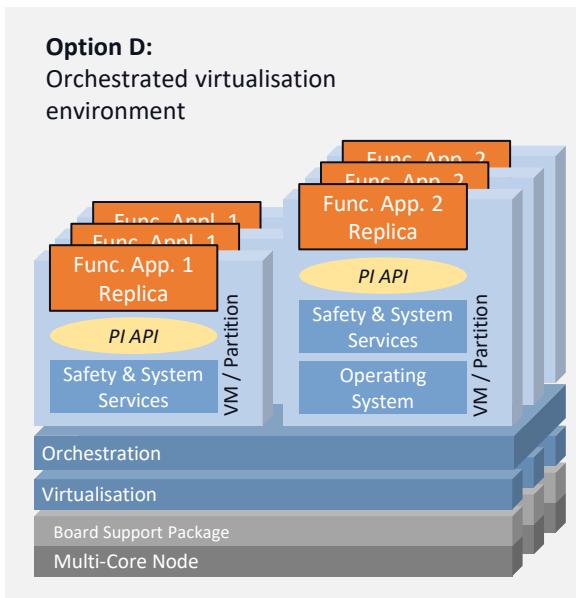
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# Computing Platform – Deployment Options



Likely options for **onboard** deployments



Likely option for **trackside** deployments

Platform options where applications are programmed against PI API  
*Approaches depicted in the diagram are non-exhaustive. The industry may propose different state-of-the-art solutions.*

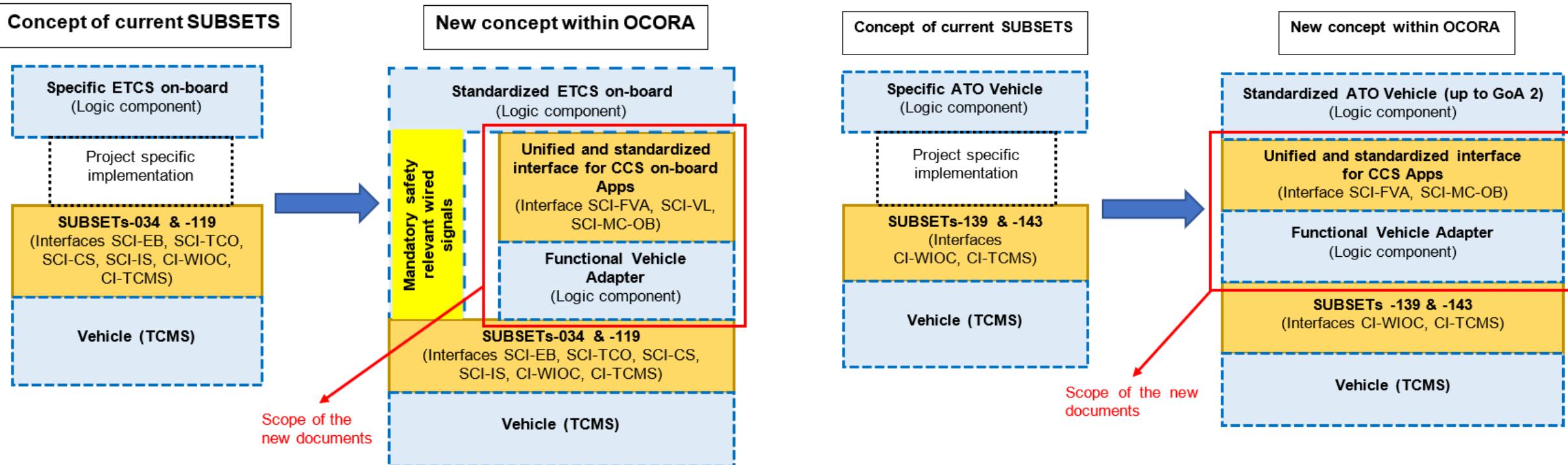


# Functional Vehicle Adapter (FVA)

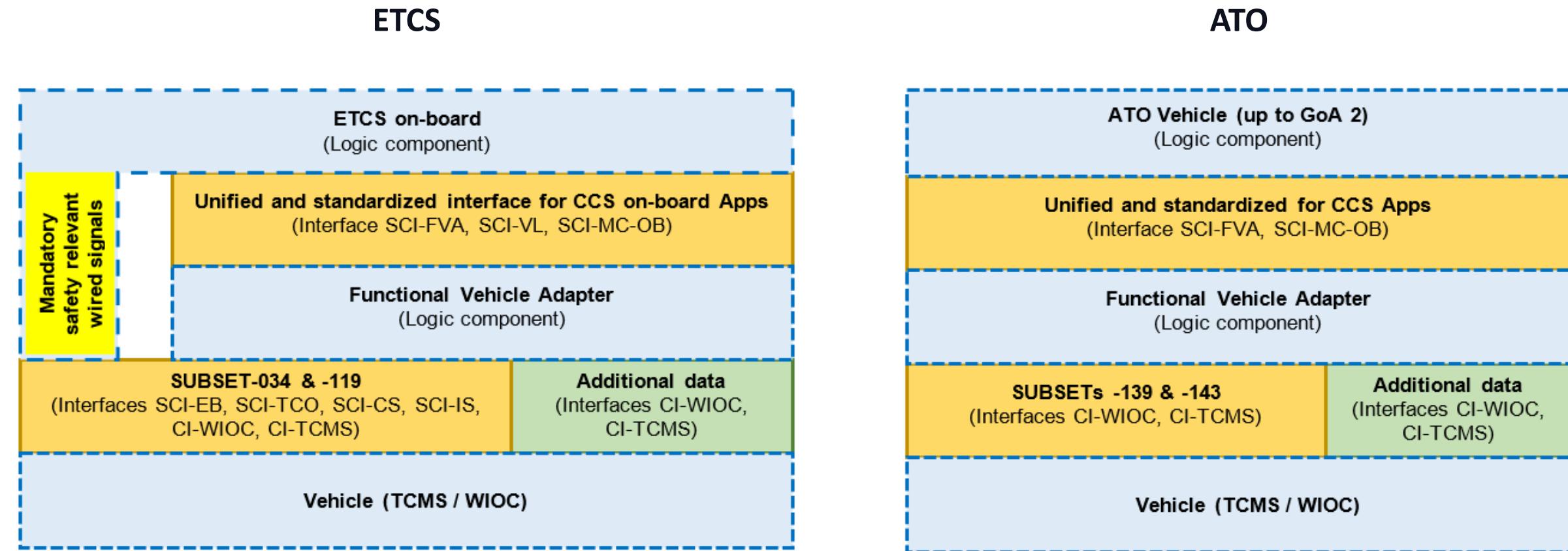
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## ETCS

## ATO



Details in Document: OCORA-TWS04-010 – Functional Vehicle Adapter - Introduction



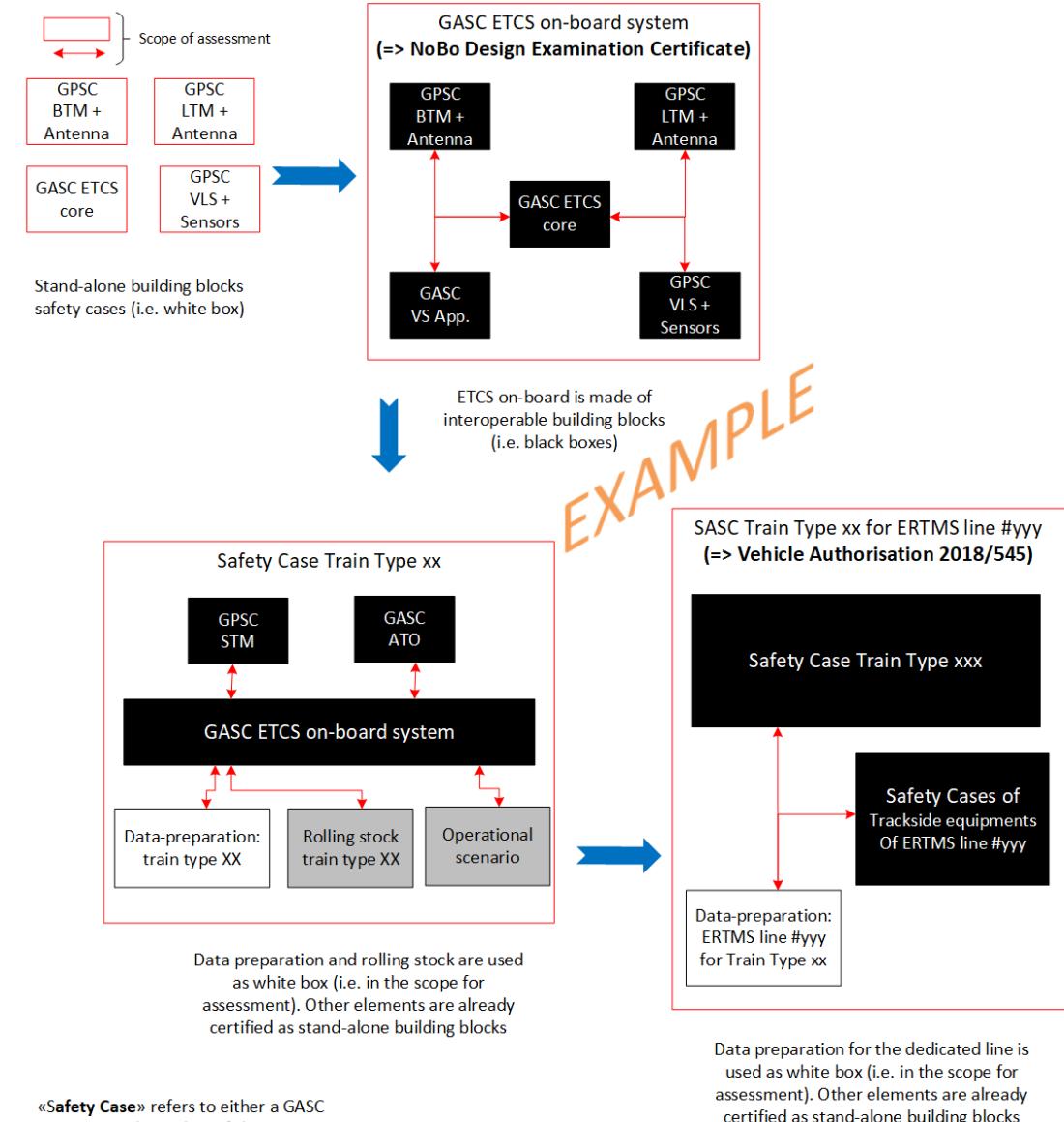
Details in Documents: OCORA-TWS04-013 – Design Guideline

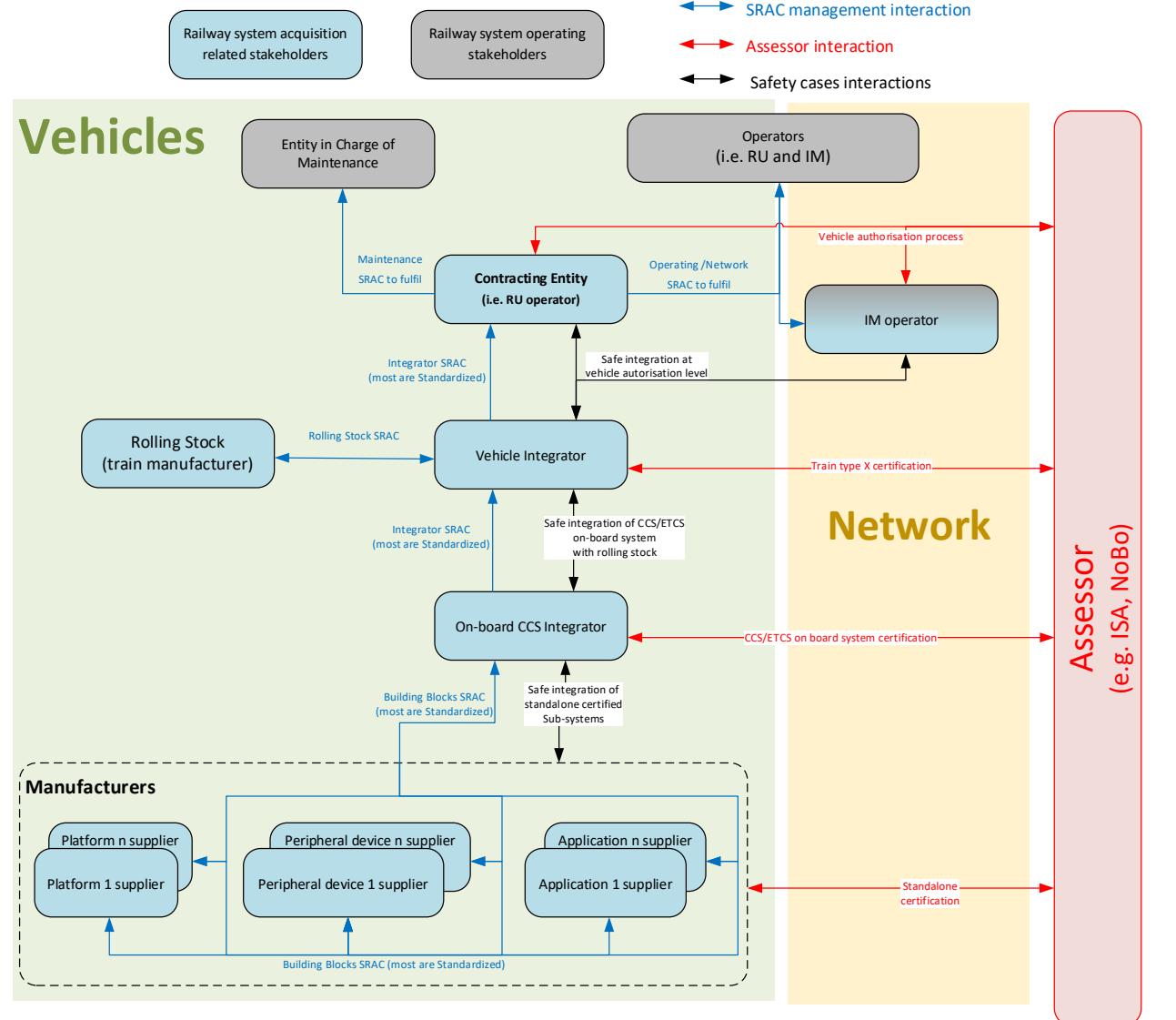


# Modular Safety

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- Modular Safety defines the hierarchy between safety cases from building blocks to specific application(s).
- One of the main goal is to **reduce the certification efforts** (initial- and re-certification) at all levels without degrading the safety level of the analyses.
- Modular Safety shall also defines the safety elements to allow the homologation of stand-alone building blocks:
  - Hazardous events based on TSI CCS SUBSET-088
  - TFFR (Tolerable Functional Failure Rate) based on TSI CCS SUBSET-088
  - Safety requirements based on OCORA Delta release
  - Harmonised and generic set of SRAC





The integrator of the CCS/ETCS on-board system shall **coordinate the activities** of the different suppliers to **integrate** their sub-systems and ensure that finally, ISA and NoBo certificates of the CCS/ETCS on-board system will be delivered by the assessor

→ Contracting entities (Operators)

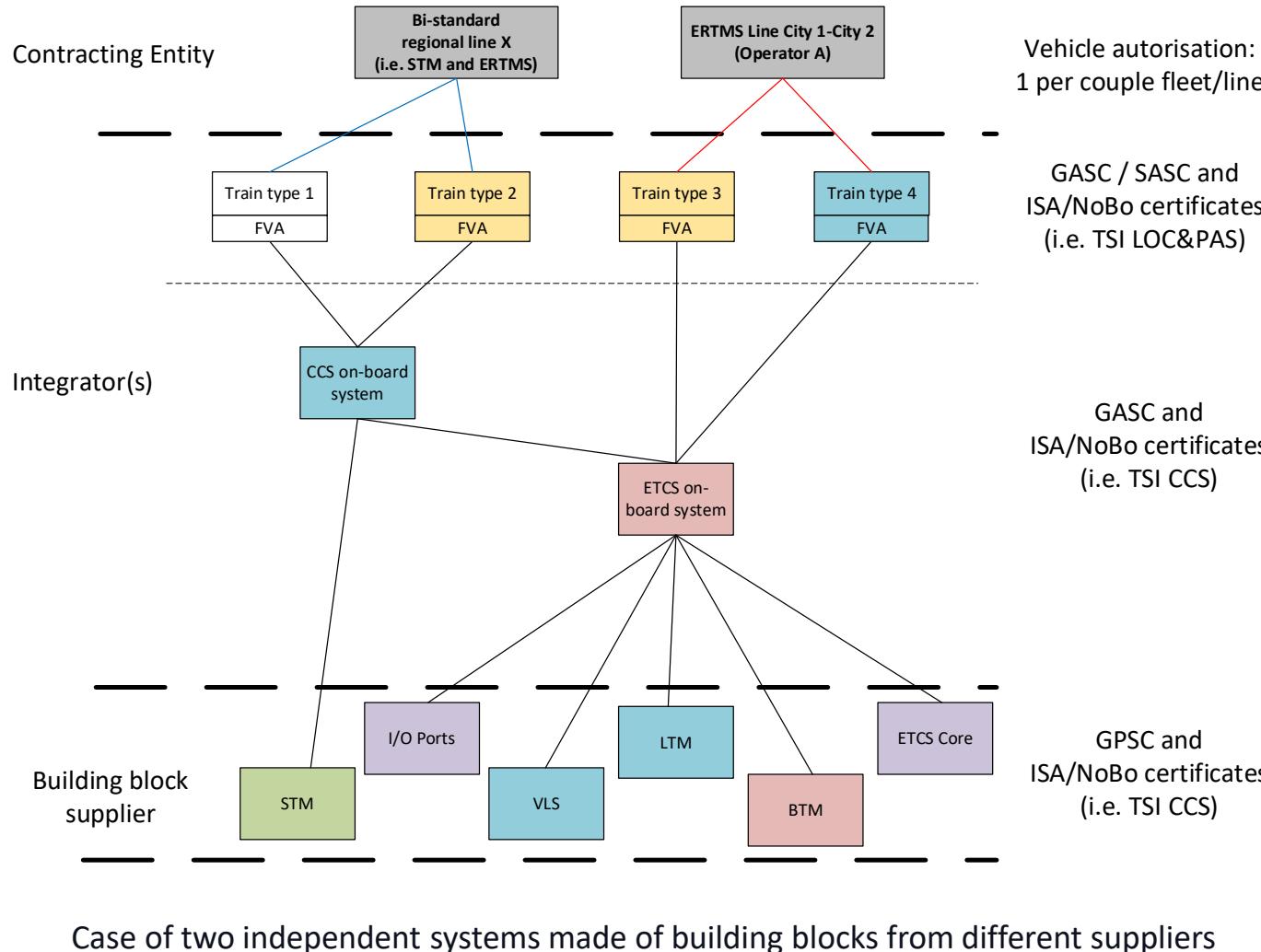
→ Integrator(s)

→ Manufacturers (Building Blocks, Application...)

→ Other (ISA/ NoBo, DeBo.)

## Key roles

Each color represents a different supplier

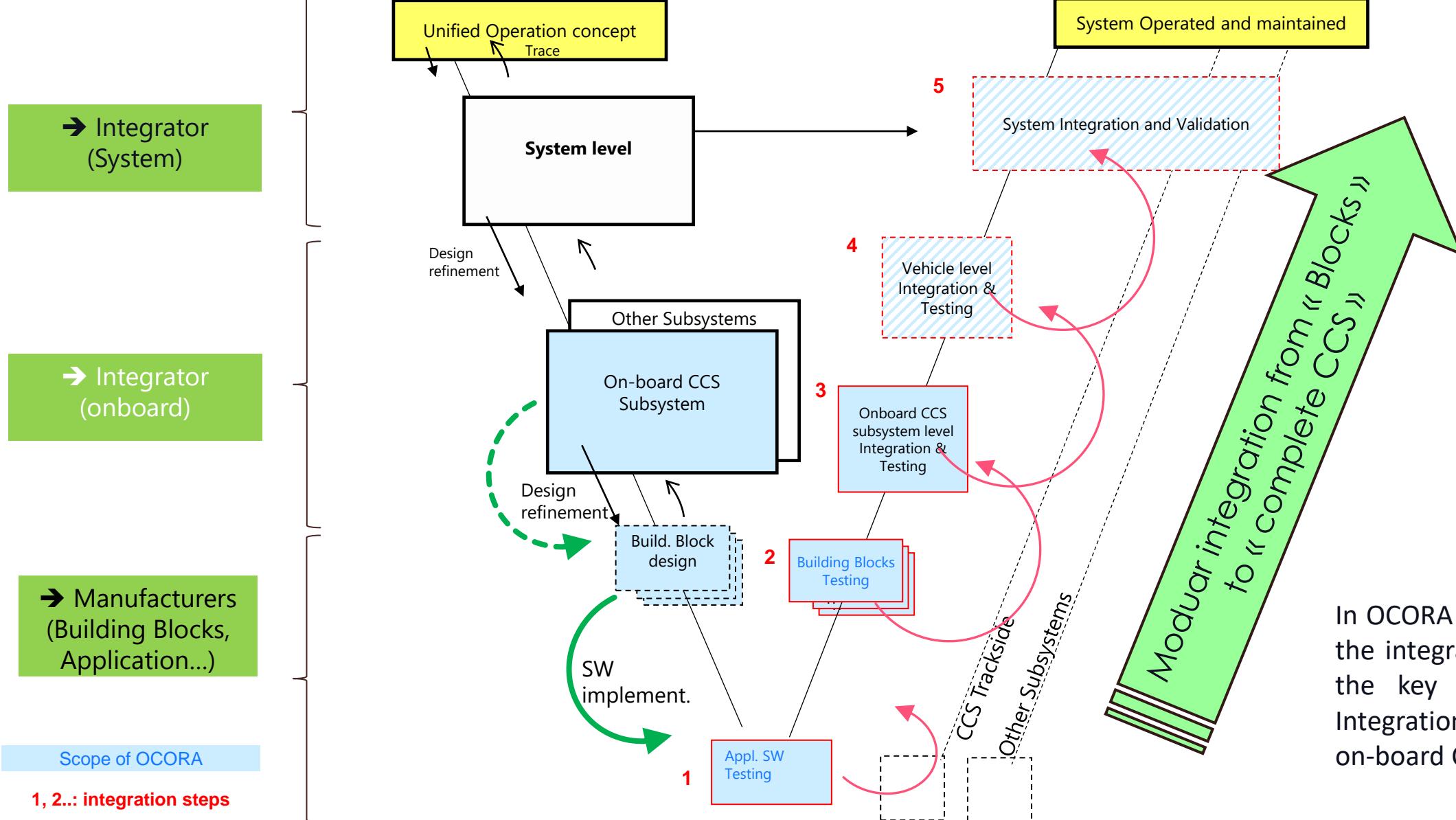


- **Each building block** is delivered to the ETCS on-board integrator with its **own ISA/NoBo certificates**
- ETCS on-board integrator realise their "**safe integration**" as defined in era\_1209-063 Clarification Note On Safe Integration (I.e. black boxes)
- Based on ETCS on-board ISA/NoBo certificates, CCS on-board integrator realise the **safe integration of the STM** (I.e. black boxes)
- CCS and ETCS on-board systems are used by the vehicle integrator to get the train type ISA/NoBo certificates (I.e. **integration is eased thanks to the FVA**)
- The contracting entity can apply for the different vehicle authorisations required
- A generic and systematic approach defined by OCORA, based on CSM-RA will then help any above stakeholder to handle easier (I.e. less delay and costs than today) the evolutions at any level

# OCORA – Modularity & Integration Tasks



SBB CFF FFS



In OCORA compliant projects, the integrator is identified as the key player for Safety, Integration and Testing of the on-board CCS system.



OCORA

OCORA-BWS02-030 / v2.21 / 14.07.2022

## Modular CCS Stakeholders

→ Contracting entities (RU  
§IM)

→ Integrator(s)

→ Manufacturers (Building  
Blocks, Application...)

→ Other (ISA/ NoBo, DeBo..)

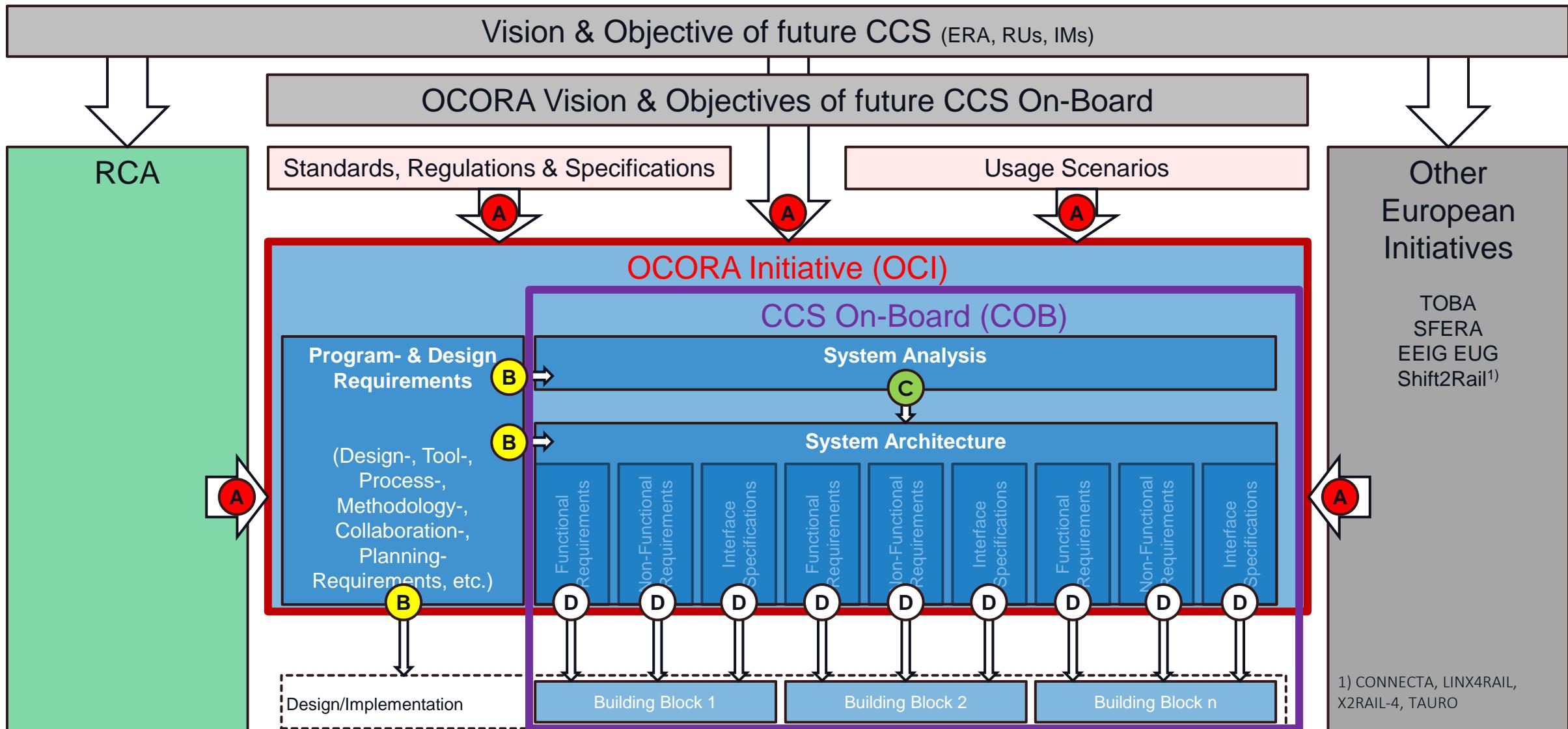
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# Methodology & Tooling

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## Structuring the Requirements



# OCORA Requirements Engineering

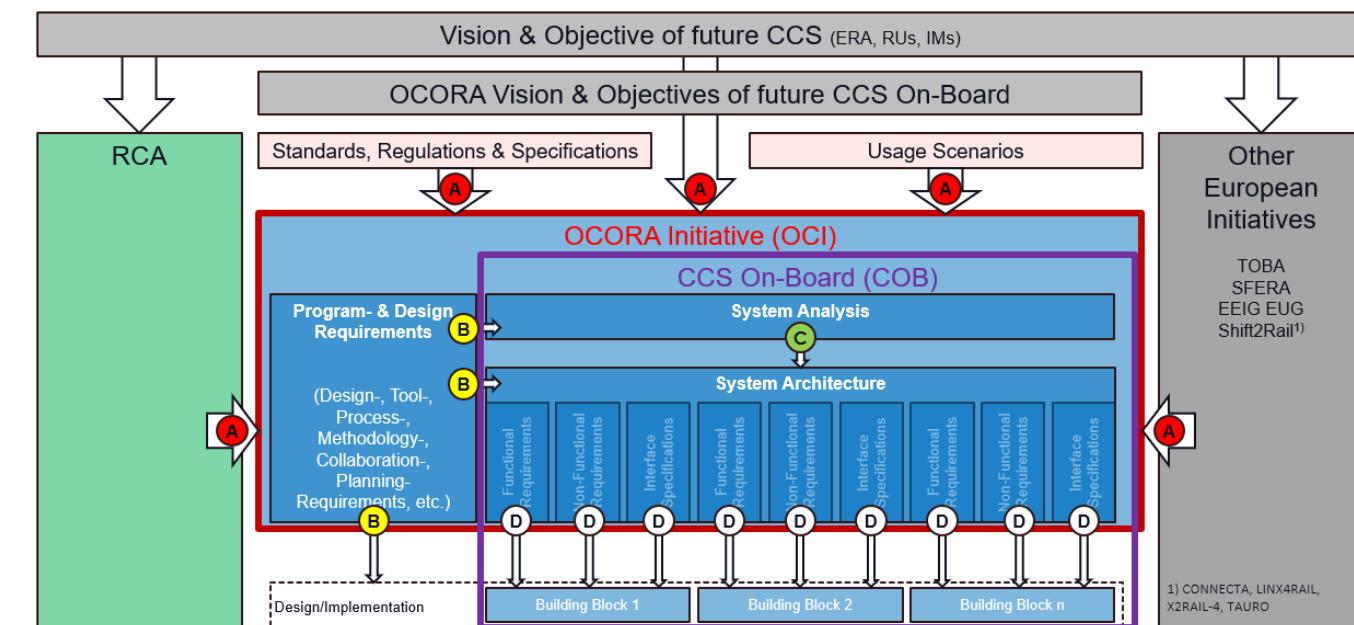
## Requirement Definitions

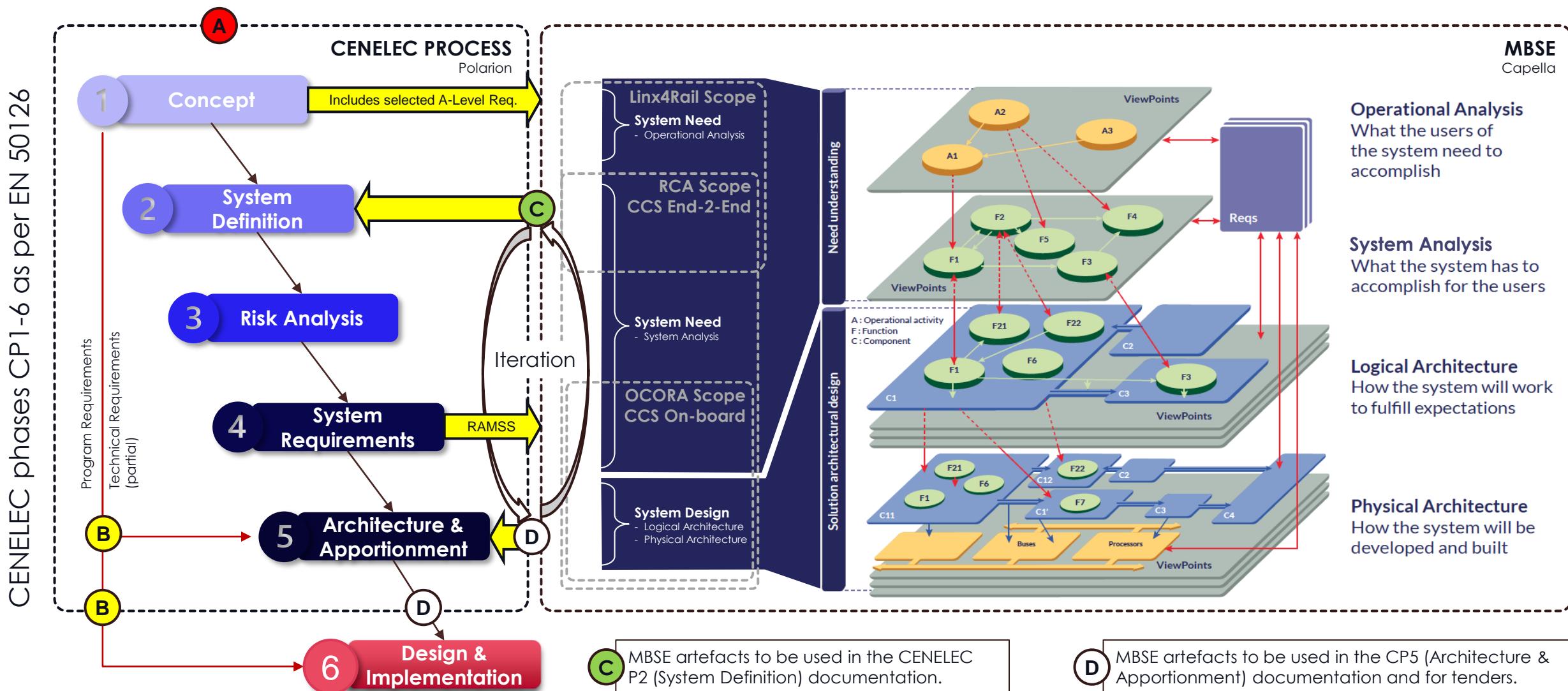
**A Stakeholder Requirements:** OCORA has to manage many different requirements, coming from many different stakeholders.

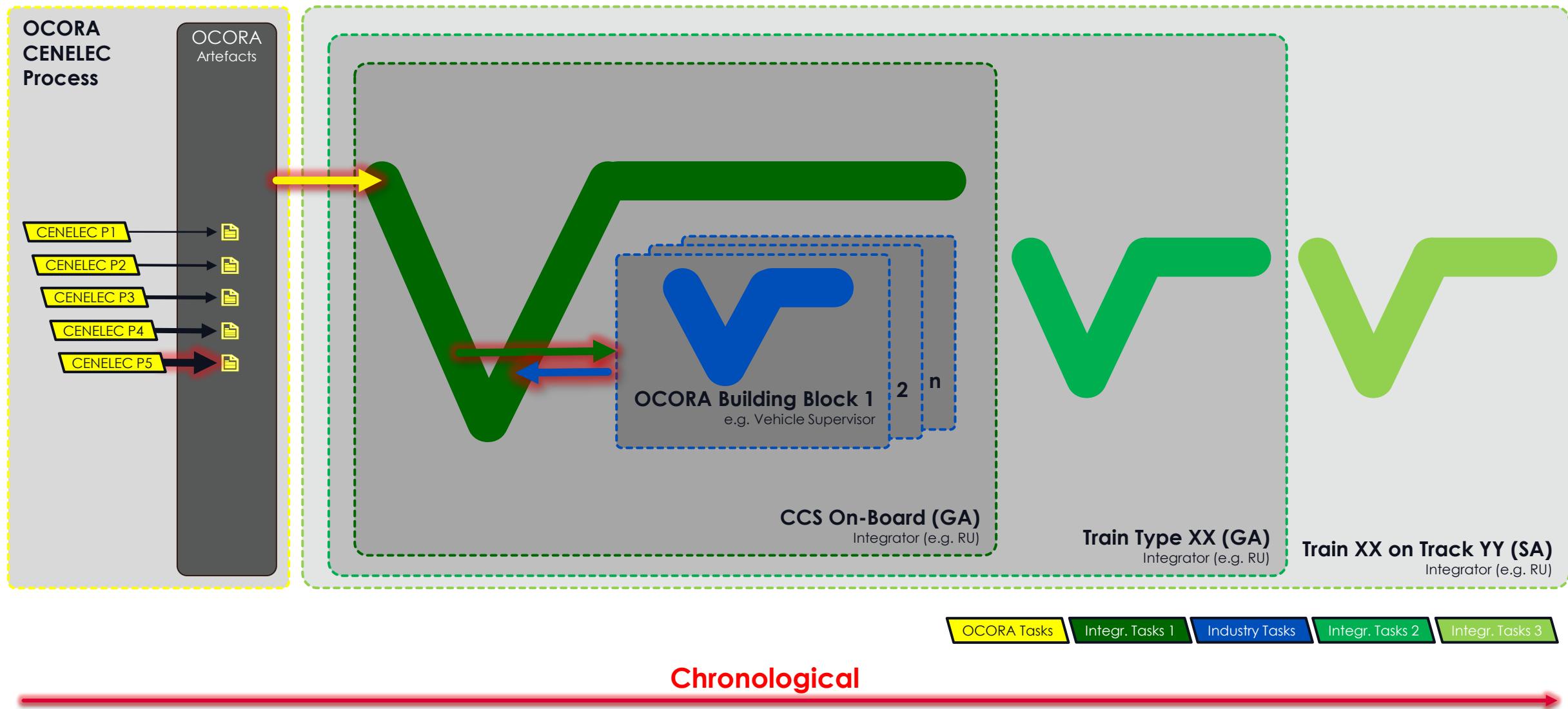
**B Program- & Design Requirements:** The OCORA program defines tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.

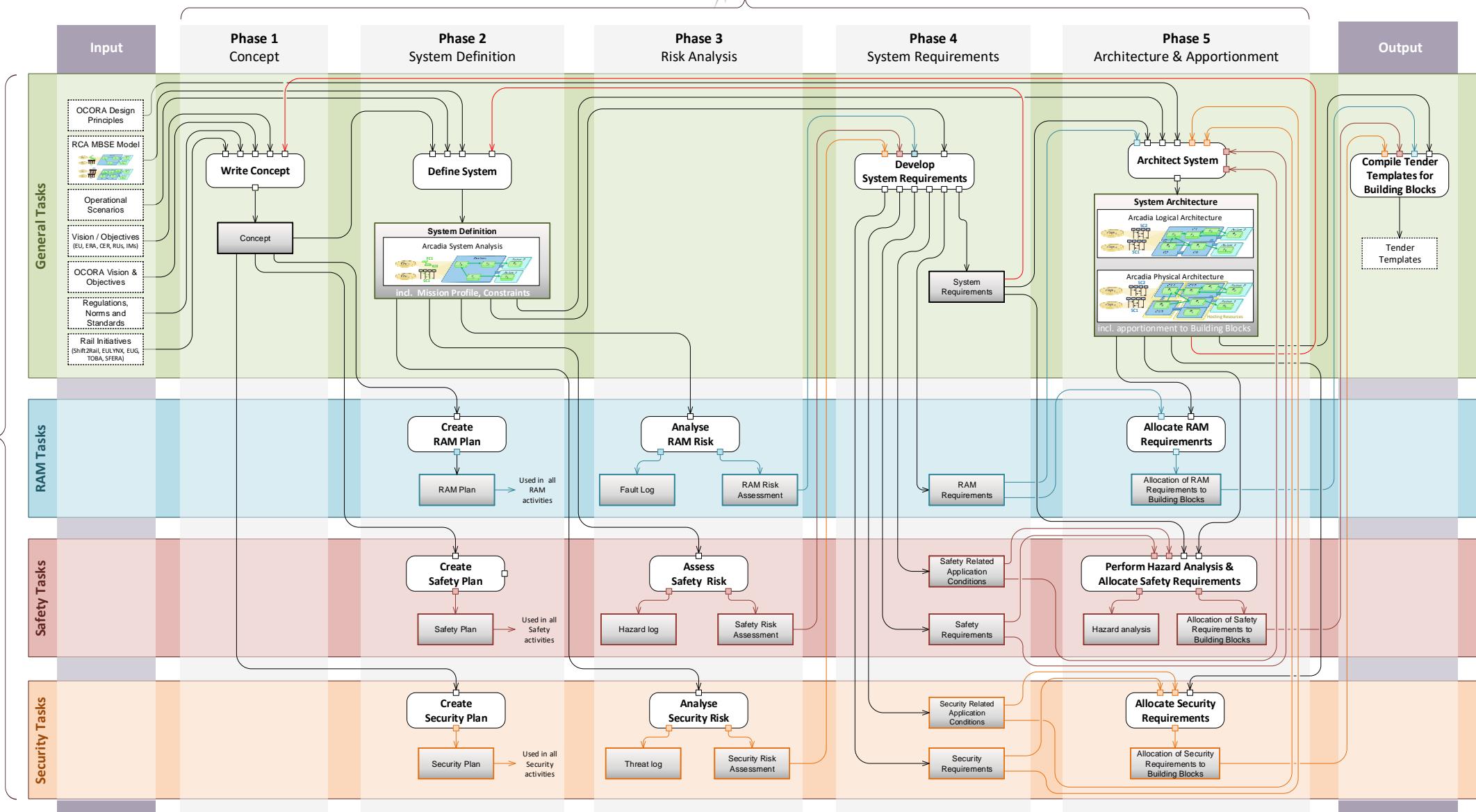
**C System Requirements:** Requirements in regards to the OCORA system are developed in the MBSE System Analysis (RCA & OCORA), taking into account the A- and B-Level Requirements.

**D Building Block Requirements:** Requirements in regards to the OCORA building blocks are developed in the MBSE System Architecture (logical / physical), taking into account the MBSE System Analysis. The resulting documentation form the OCORA tender templates, together with the applicable program requirements.











# Operational Concept

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# Operational Concept Overview

## Live Cycle of Passenger, Freight, and Construction Trains



+/- 40 years overall life-time

