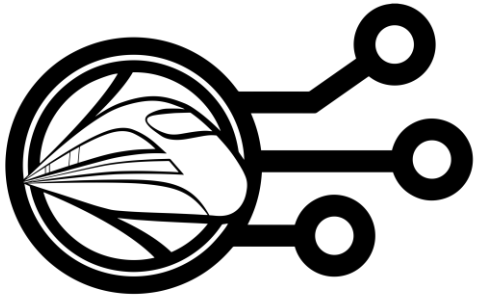


OCORA

Open **C**CS **O**n-Board **R**eference **A**rchitecture

A Collaboration of 5 European Railway Undertakings

Technical Slide Deck

OCORA-BWS02-030 / v3.00 / 08.12.2022

Presentation Overview

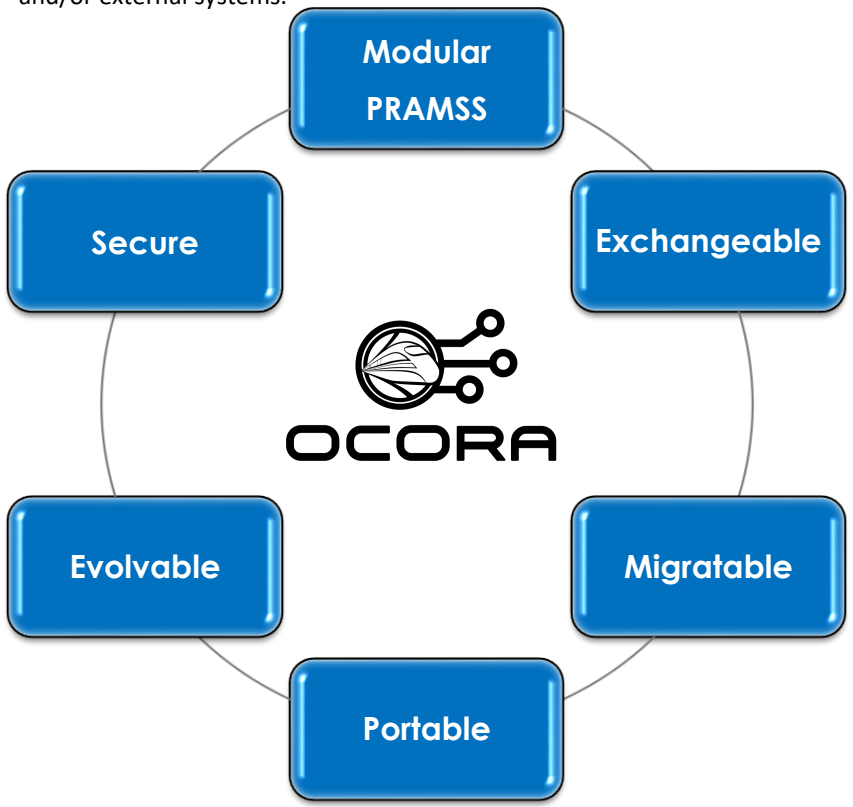
- **OCORA Design Objectives**
- **OCORA Roadmap**
- **OCORA Scope**
- **CCS On-Board – Logical Architecture**
- **CCS On-Board – Physical Architecture**
  - Building Blocks
  - Hardware Block Diagrams
  - Train Integration Scenarios
  - Network Topology Scenarios
- **Safe Computing Platform (SCP)**
- **Configuration Management Concept**
- **Functional Vehicle Adapter (FVA)**
- **Modular Safety**
- **Methodology & Tooling**
- **Operational Concept**
- **OCORA Release R2 Style Graphics**

OCORA Design Objectives

OCORA-BWS02-030 / v3.00 / 08.12.2022

OCORA Design Objectives

A reasonable number of Building Blocks are defined for CCS On-Board. Each Building Blocks has standardised functionality, standardised PRAMSS requirements (including Tolerable Functional Failure Rate [TFFR], Safety Integrity Level [SIL] and Safety Related Application Conditions [SRAC]), standardised interfaces (on all OSI Layers) towards other building blocks and/or external systems.



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 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 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.

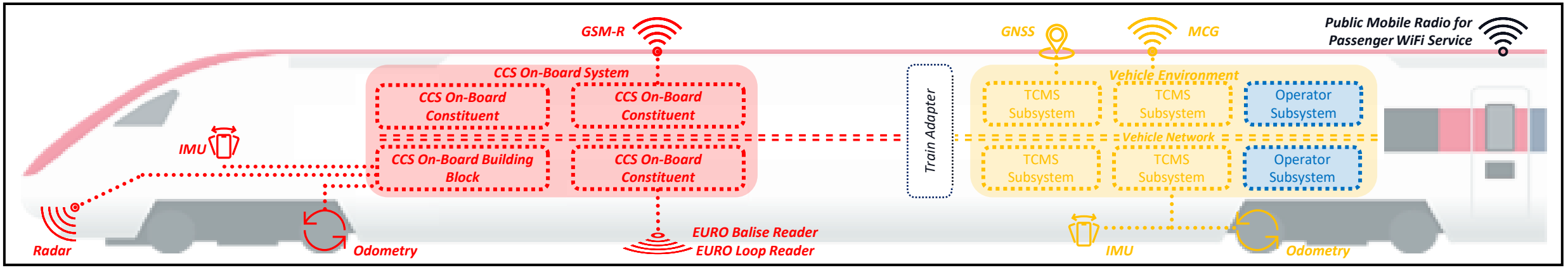
Ability to introduce changes to any CCS On-Board Building Block. In the context of OCORA migrateability is the ability to introduce changes (bug-fixes, improvements, new functionality) to one or multiple OCORA defined building blocks, without affecting other building blocks or the overall CCS on-board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

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).

OCORA Roadmap

OCORA-BWS02-030 / v3.00 / 08.12.2022

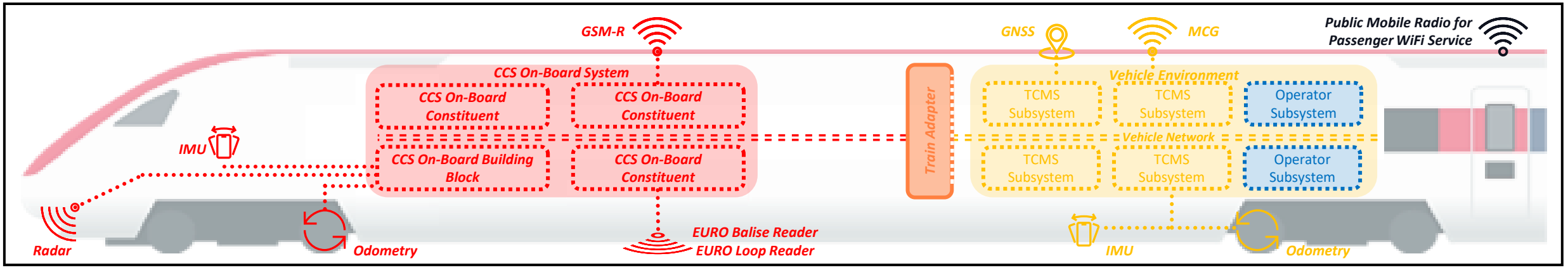
Technical Roadmap – Current Situation



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.

Technical Roadmap Step 1 – Short-Term



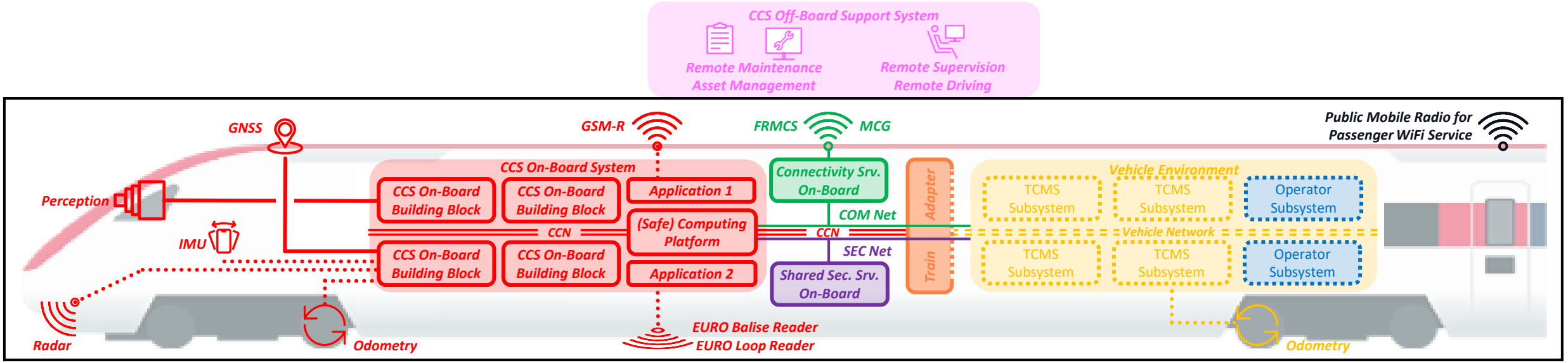
Step 1: Short-Term (TSI-2022/23)

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

Step 1 is enabling exchangeability, is 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.

Technical Roadmap Step 2 – Mid-Term



Step 2: Mid-Term (e.g. TSI-2025/26)

The CCS On-Board System consists of a reasonable number of CCS On-Board Building Blocks. Each Building Blocks has standardised functionality, standardised PRAMSS requirements (including Tolerable Functional Failure Rate [TFFR], Safety Integrity Level [SIL] and Safety Related Application Conditions [SRAC]), standardised interfaces (on all OSI Layers) towards other building blocks and/or external systems. 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). **First applications (e.g. MDCM, ATO GoA 1-2) are running on a (safe) computing platform.**

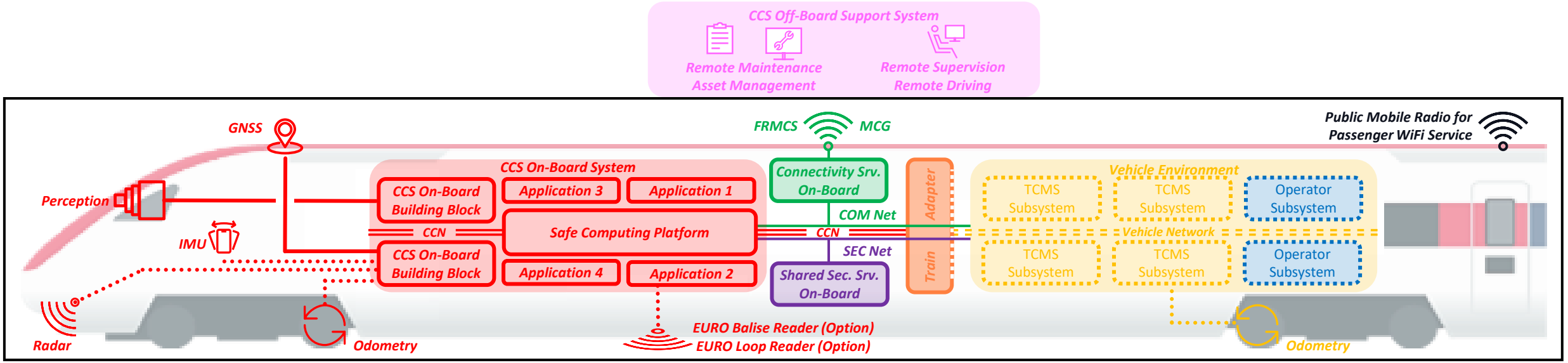
Step 2 is enabling exchangeability, is supporting migrateability and portability of the individual CCS On-Board Building Blocks without affecting other CCS On-Board Building Blocks, the Vehicle Environment, and any Off-Board Systems. This step is simplifying life-cycle management and is the basis for 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-2028/29)

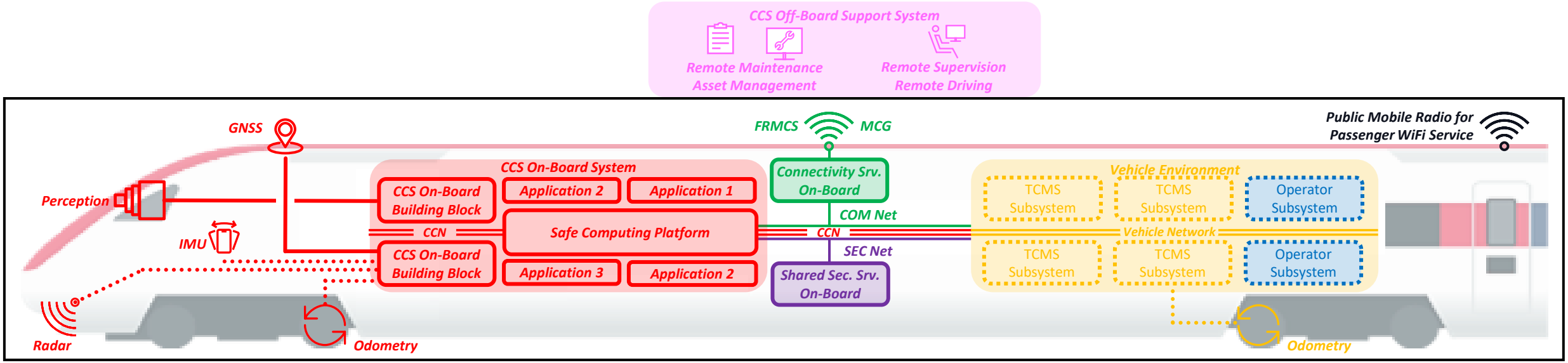
The CCS On-Board System includes a safe computing platform, hosting CCS Building Blocks as applications (SW Building Blocks). They are deployed on an instance of the Generic Safe Computing Platform (SCP) and communicate with each other through the standardised Platform Independent Application Programming Interface (PI-API). Communication with computing platform external building blocks and systems is realised by the Computing Platform (integrating with the CCN).

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 2028/29)

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

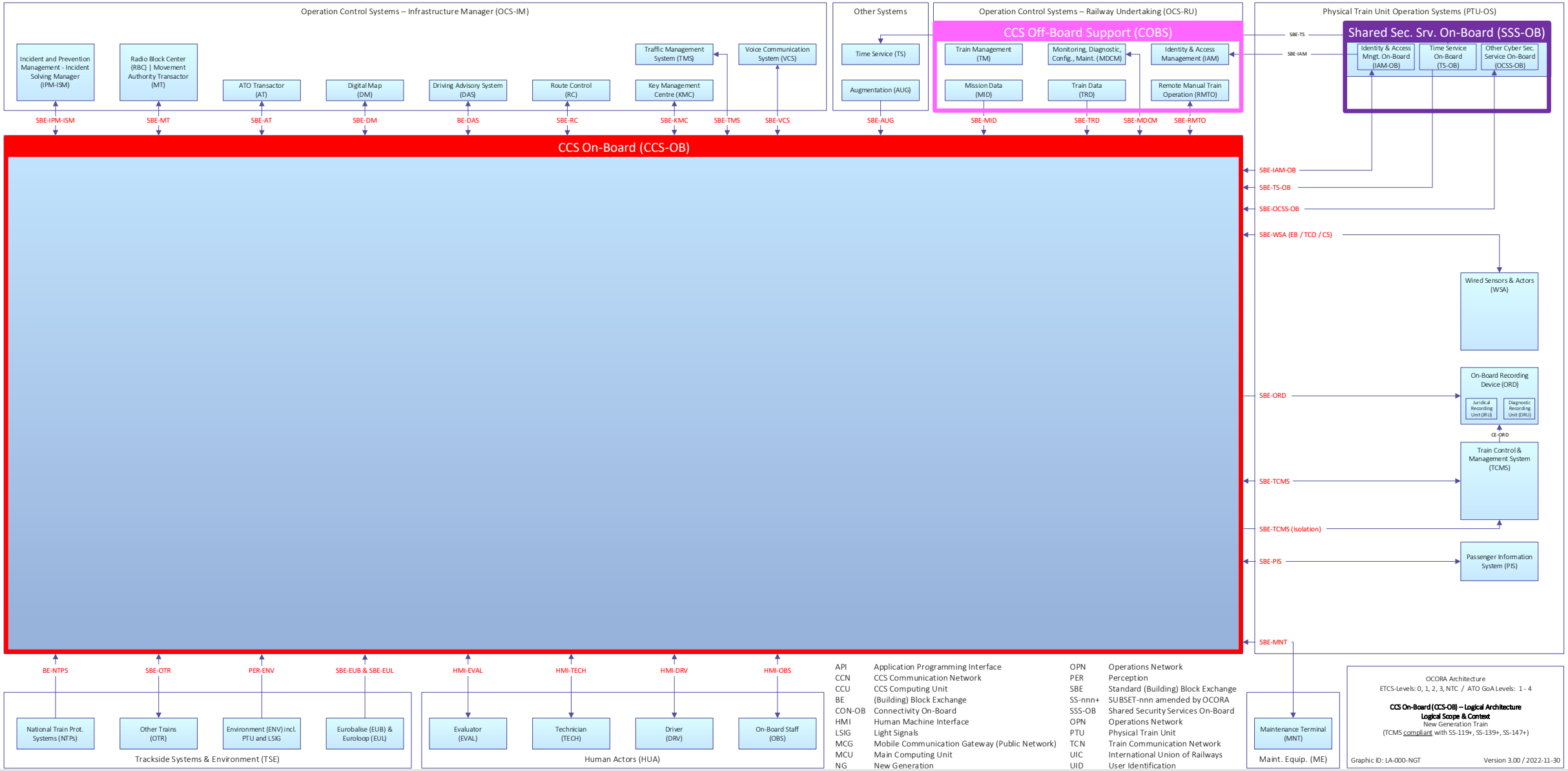
Step 4: eliminating the EURO Balise and EURO Loop readers further reduces the maintenance efforts and enables the infrastructure managers to implement changes more quickly.

OCORA Scope

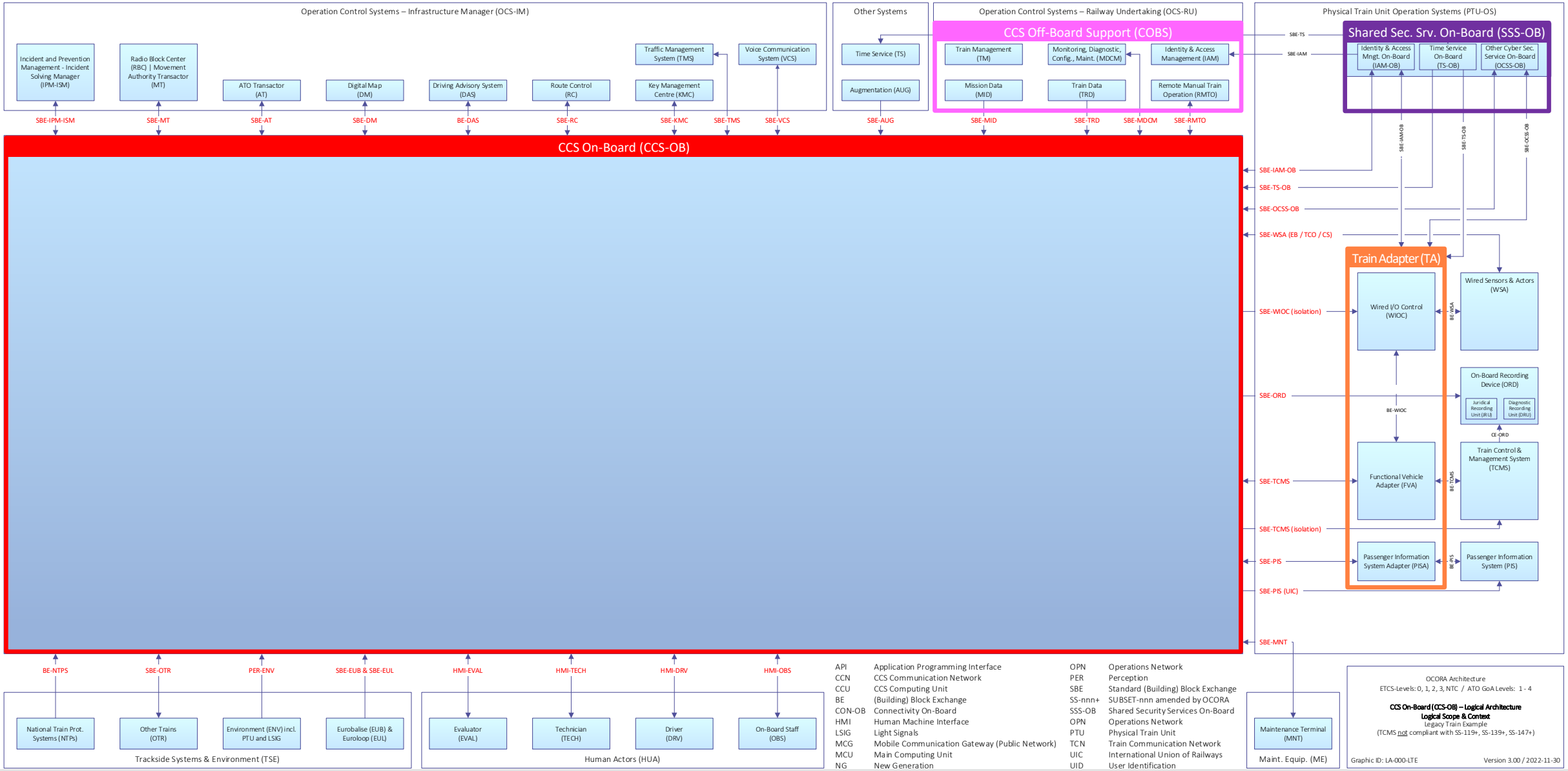
Logical & Physical Architecture

OCORA-BWS02-030 / v3.00 / 08.12.2022

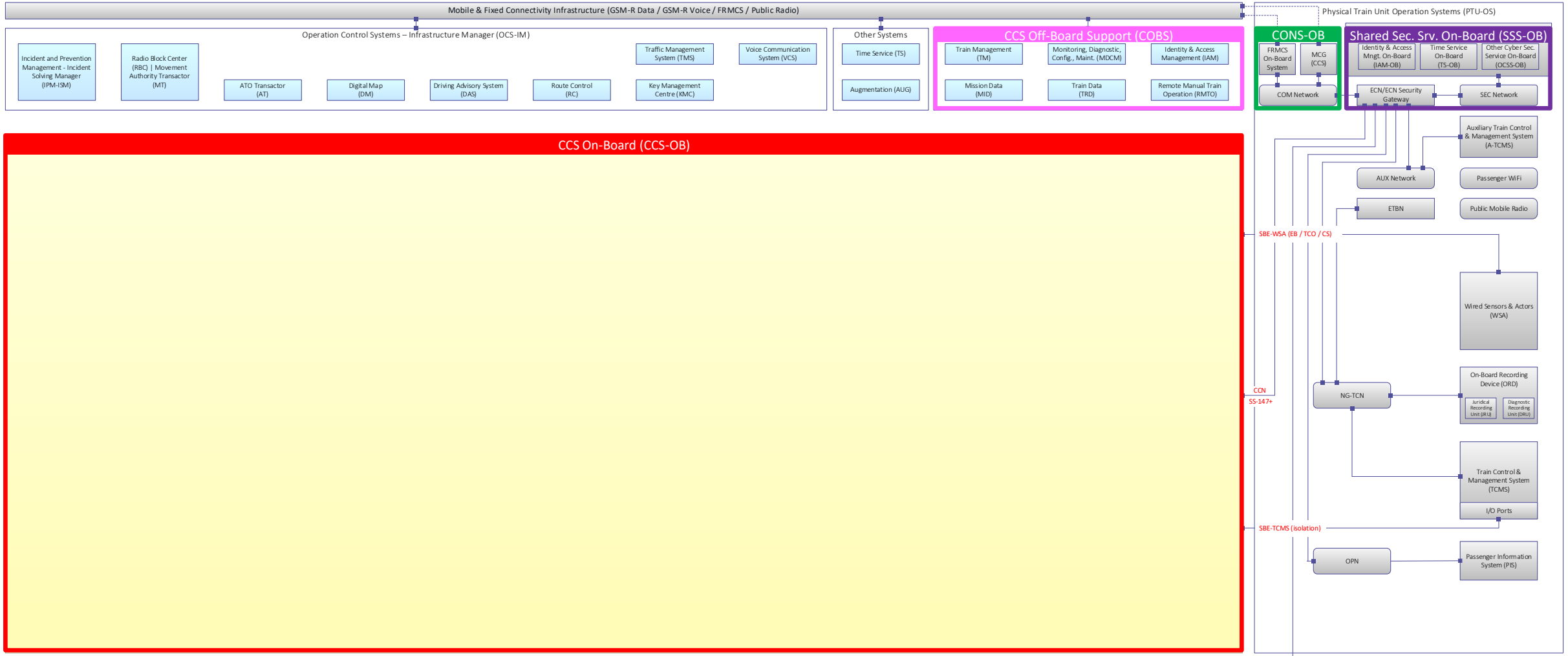
Logical Architecture – Scope & Context (New Generation Train)



Logical Architecture – Scope & Context (Legacy Train Example)



Physical Architecture – Scope & Context (New Generation Train)



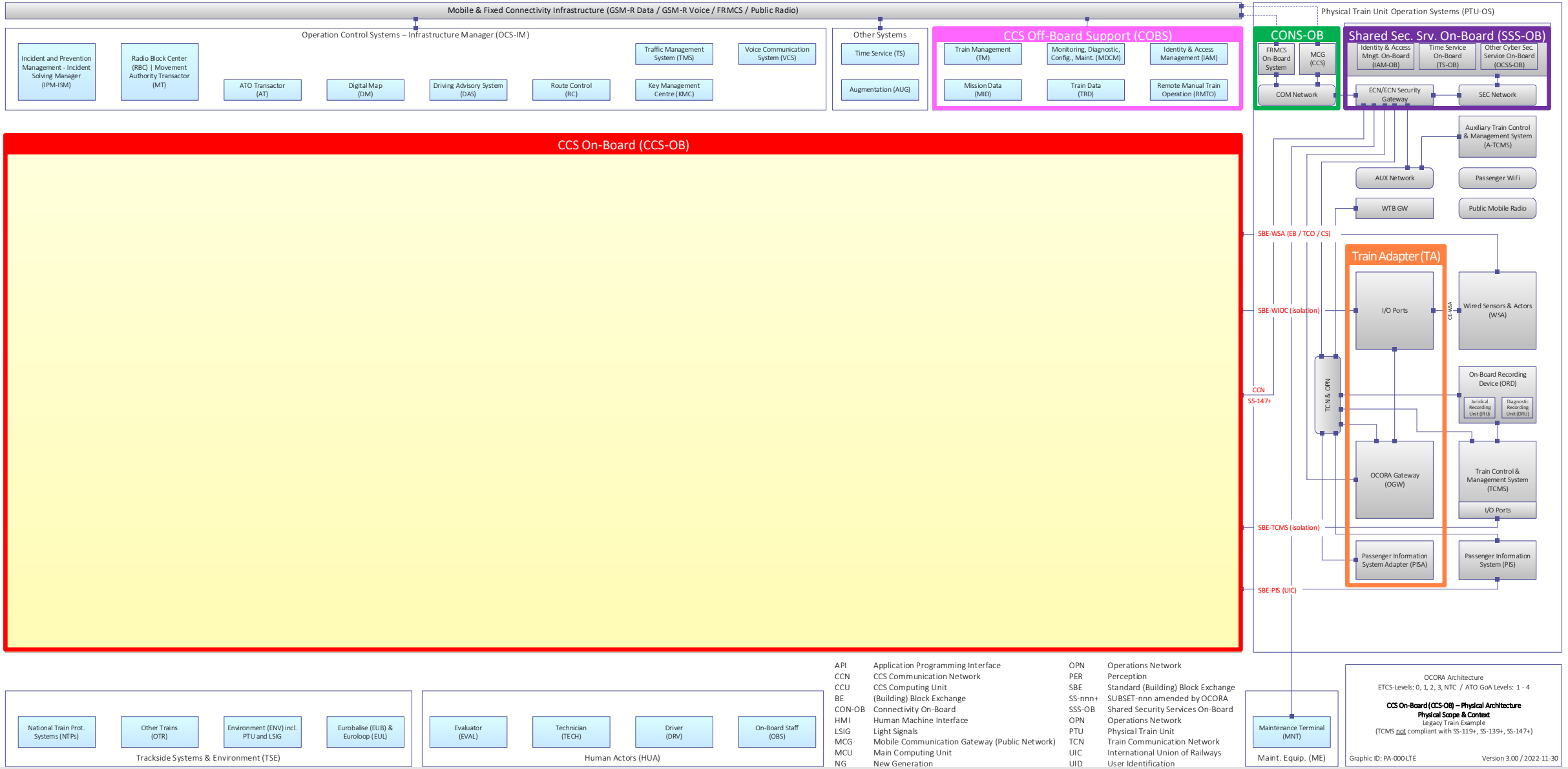
API	Application Programming Interface	OPN	Operations Network
CCN	CCS Communication Network	PER	Perception
CCU	CCS Computing Unit	SBE	Standard (Building) Block Exchange
BE	(Building) Block Exchange	SS-nnn+	SUBSET-nnn amended by OCORA
CON-OB	Connectivity On-Board	SSS-OB	Shared Security Services On-Board
HMI	Human Machine Interface	OPN	Operations Network
LSIG	Light Signals	PTU	Physical Train Unit
MCG	Mobile Communication Gateway (Public Network)	TCN	Train Communication Network
MCU	Main Computing Unit	UIC	International Union of Railways
NG	New Generation	UID	User Identification

OCORA Architecture
ETCS-Levels: 0, 1, 2, 3, NTC / ATO GoA Levels: 1 - 4

CCS On-Board (CCS-OB) – Physical Architecture
Physical Scope & Context
New Generation Train
(TCMS compliant with SS-119+, SS-139+, SS-147+)

Graphic ID: PA-000-NGT Version 3.00 / 2022-11-30

Physical Architecture – Scope & Context (Legacy Train Example)



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MCU	Main Computing Unit
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OPN	Operations Network
PER	Perception
SBE	Standard (Building) Block Exchange
SS-nnn+	SUBSET-nnn amended by OCORA
SSS-OB	Shared Security Services On-Board
OPN	Operations Network
PTU	Physical Train Unit
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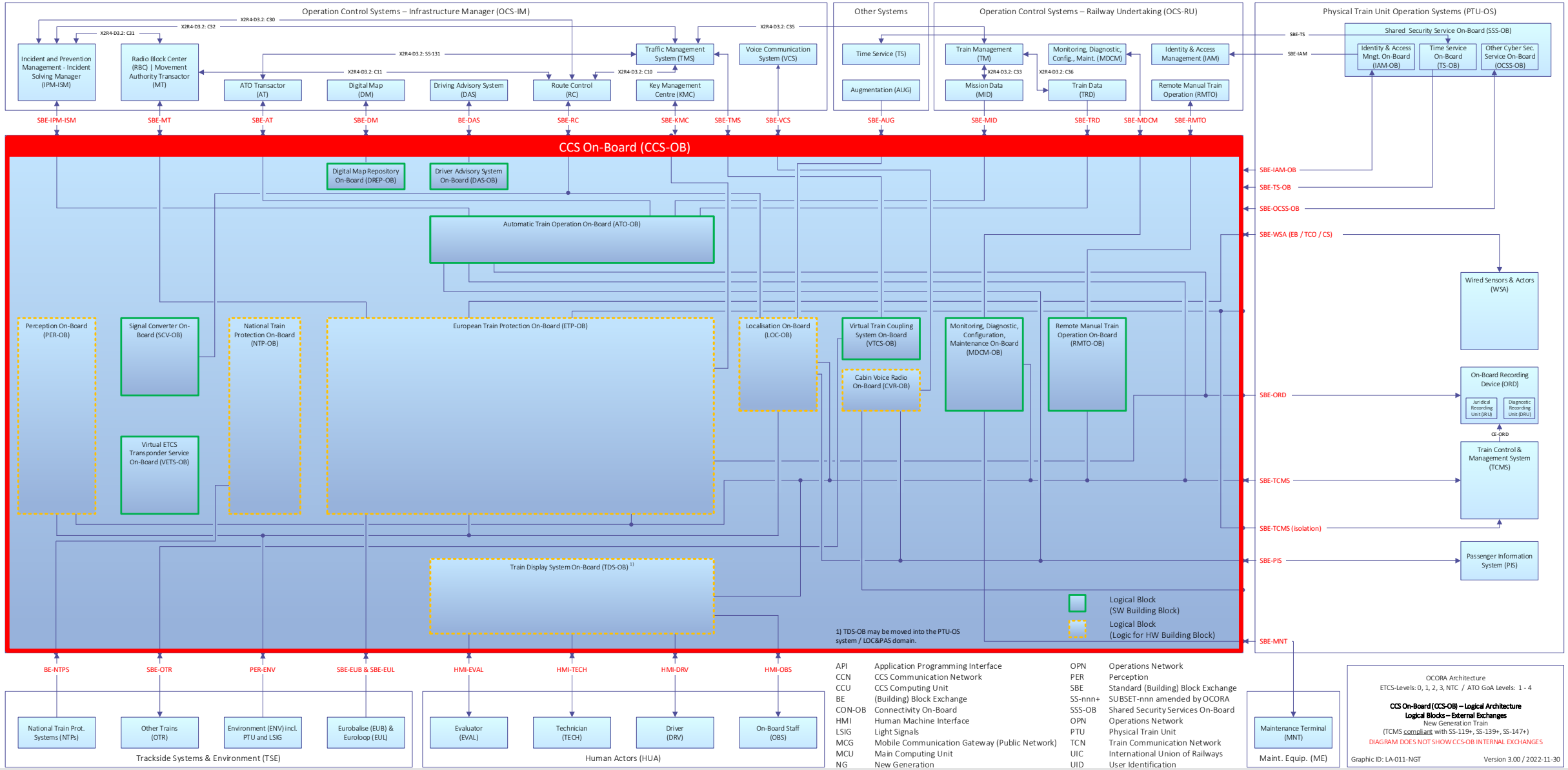
CCS On-Board (CCS-OB)

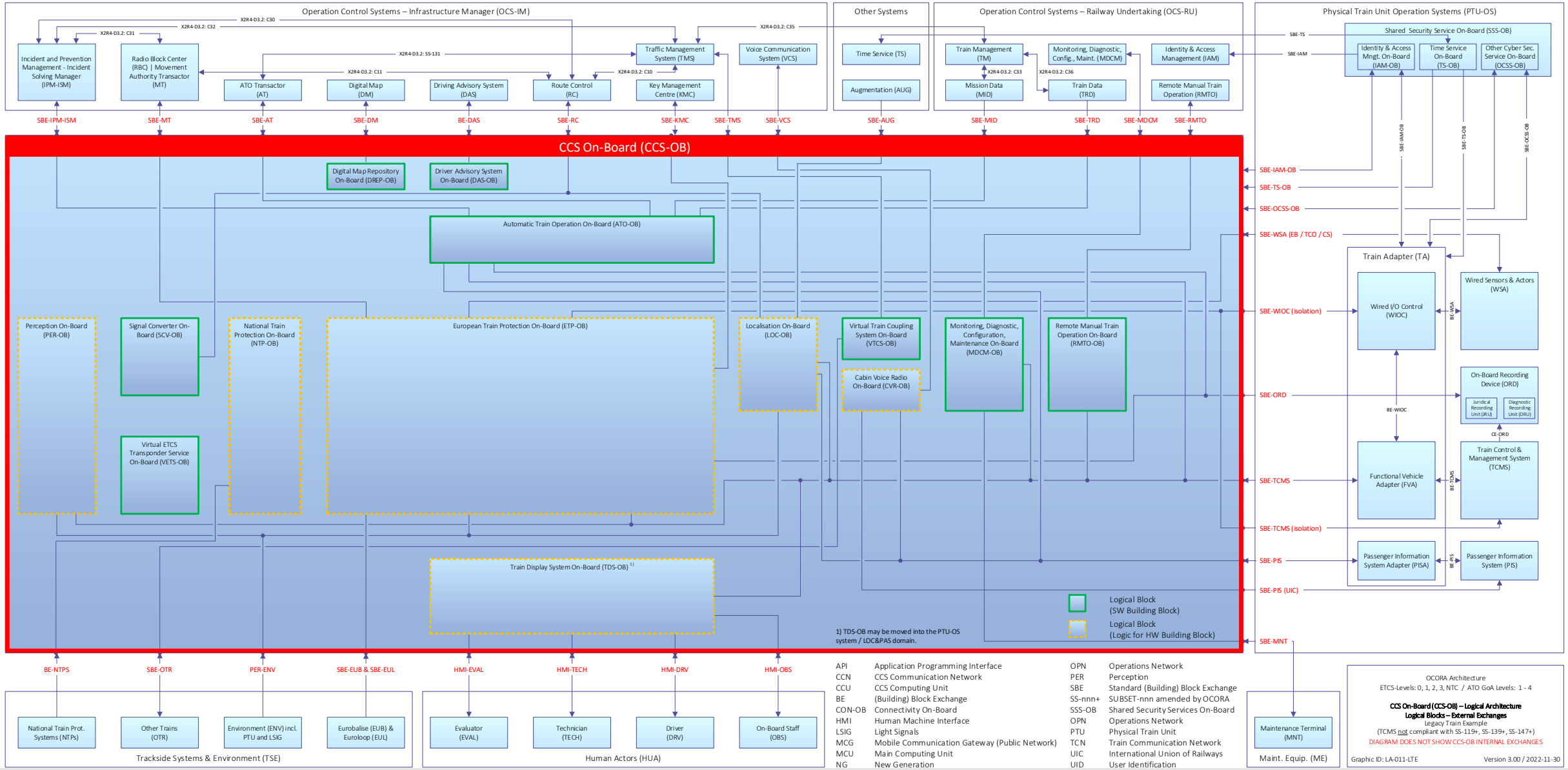
Logical Architecture

OCORA-BWS02-030 / v3.00 / 08.12.2022

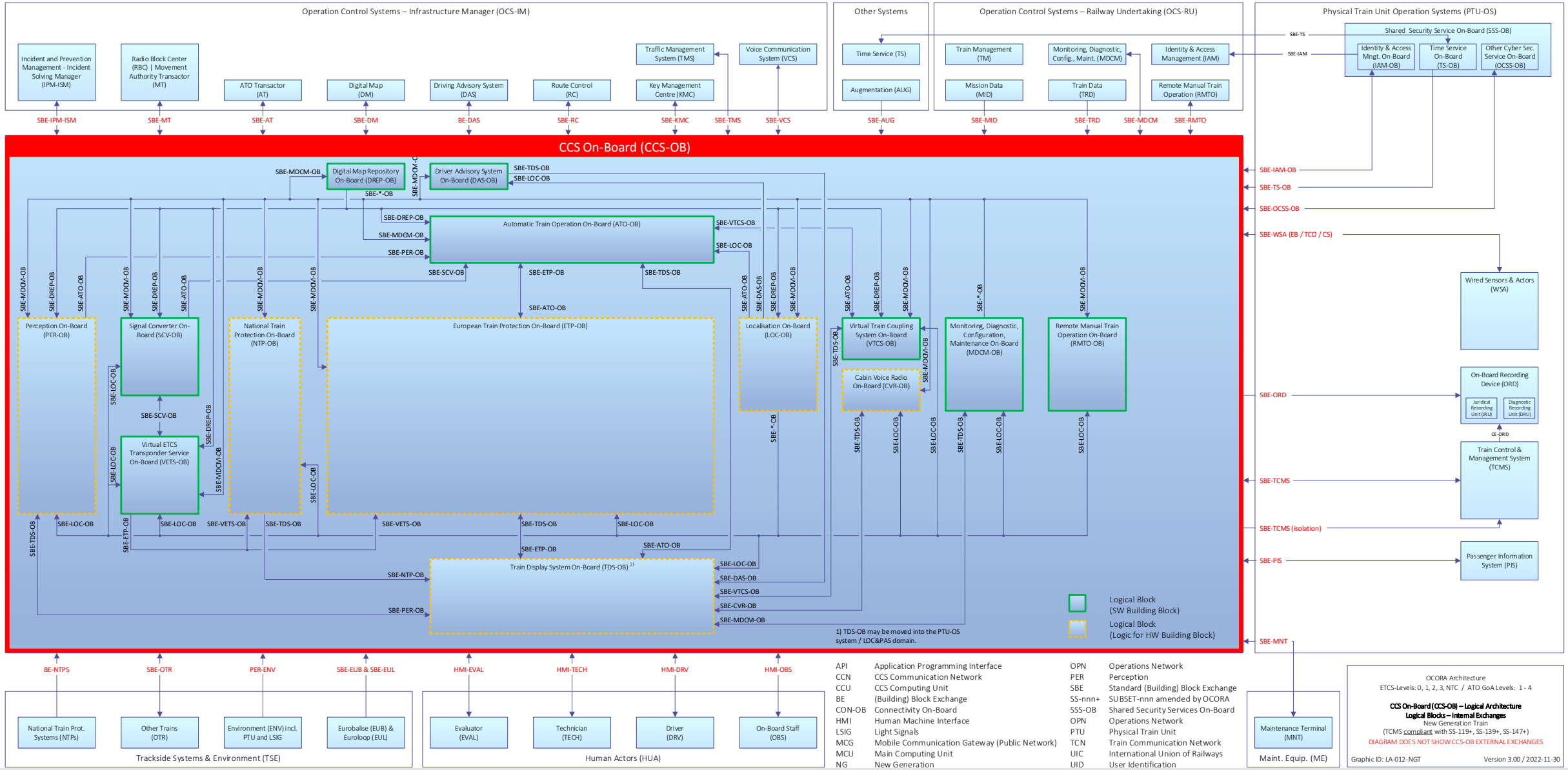
Logical Blocks – External Exchanges (New Generation Train)



Logical Blocks – External Exchanges (Legacy Train Example)



Logical Blocks – Internal Exchanges (New Generation Train)



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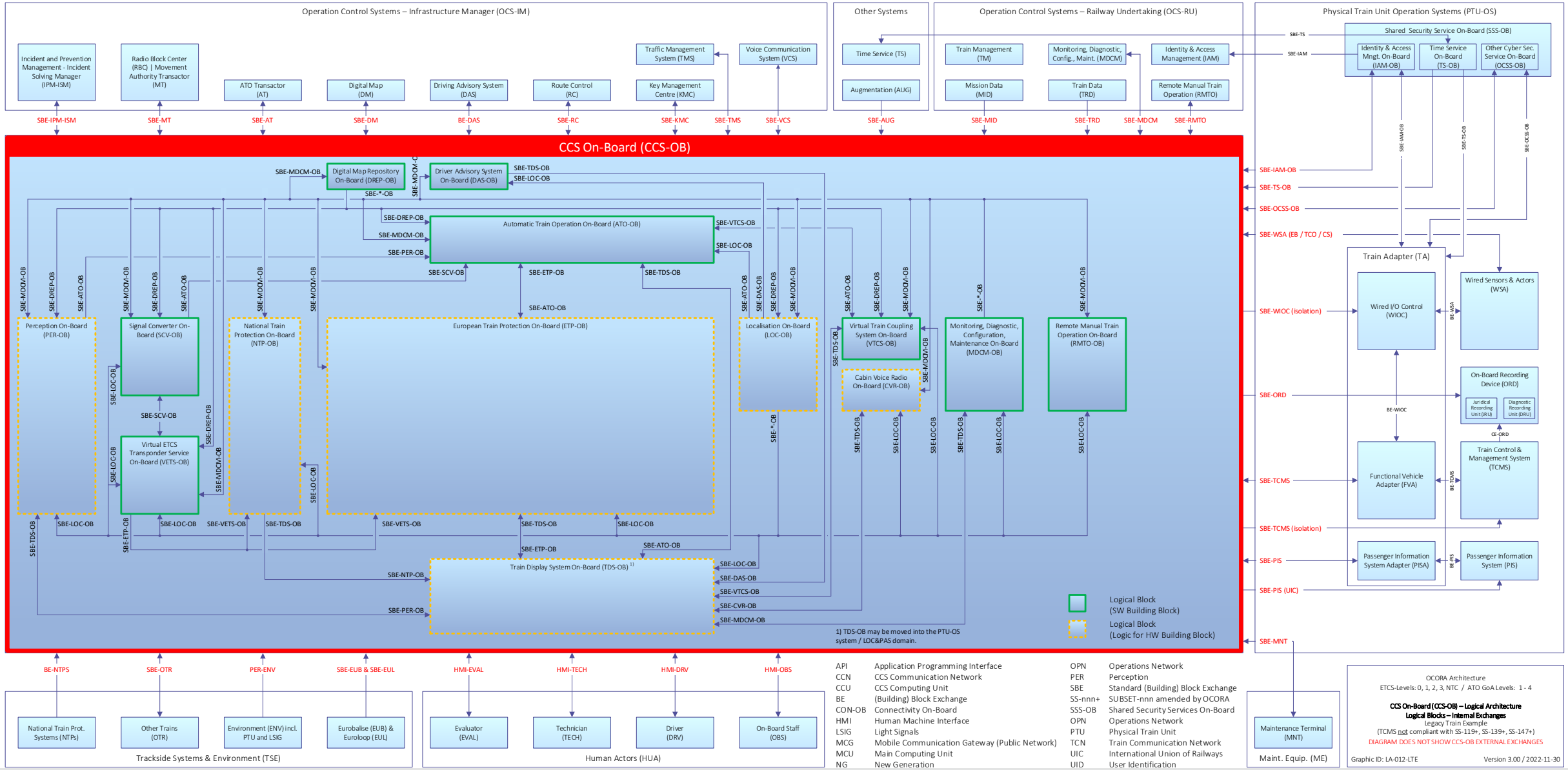
OCORA Architecture
ETCS-Levels: 0, 1, 2, 3, NTC / ATO GoA Levels: 1 - 4

CCS On-Board (CCS-OB) – Logical Architecture
Logical Blocks – Internal Exchanges
New Generation Train
(TCMS compliant with SS-119+, SS-139+, SS-147+)
DIAGRAM DOES NOT SHOW CCS-OB EXTERNAL EXCHANGES

Graphic ID: LA-012-NGT Version 3.00 / 2022-11-30

Logical Blocks – Internal Exchanges (Legacy Train Example)



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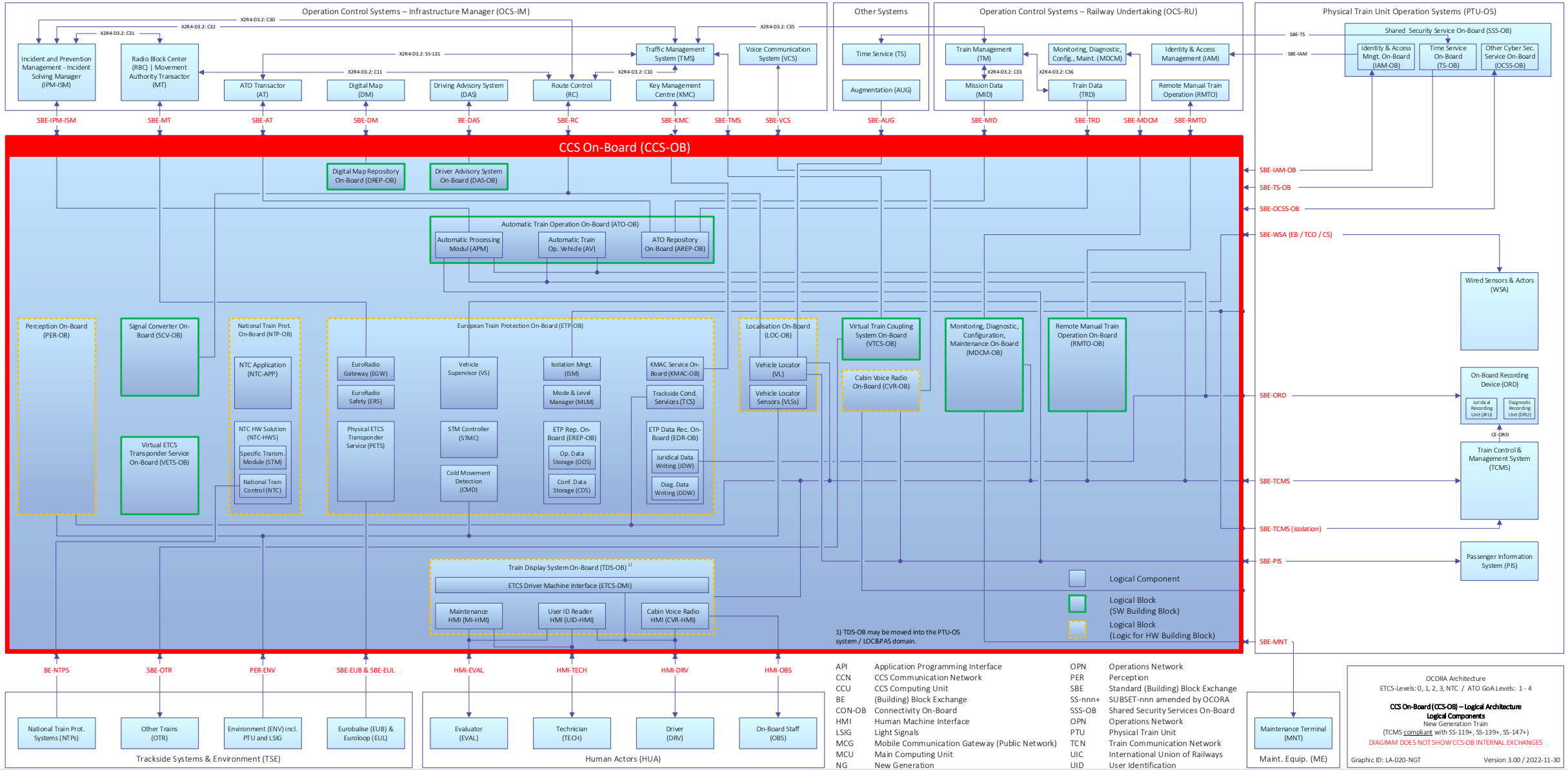
OCORA Architecture
ETCS-Levels: 0, 1, 2, 3, NTC / ATO GoA Levels: 1 - 4

CCS On-Board (CCS-OB) – Logical Architecture
Logical Blocks – Internal Exchanges
Legacy Train Example
(TCMS not compliant with SS-119+, SS-139+, SS-147+)
DIAGRAM DOES NOT SHOW CCS-OB EXTERNAL EXCHANGES

Graphic ID: LA-012-LTE Version 3.00 / 2022-11-30

Logical Components (New Generation Train)



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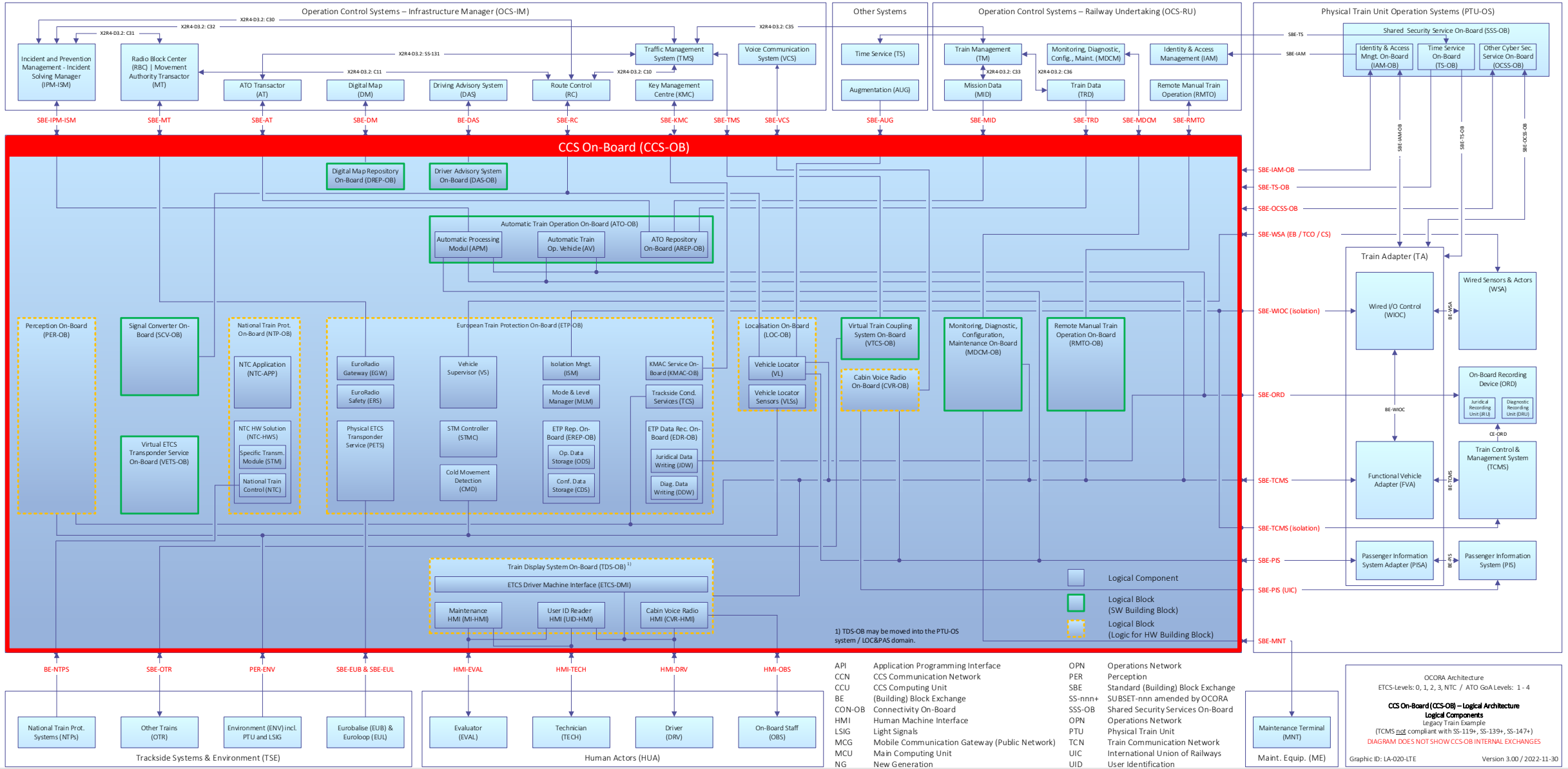
OCORA Architecture
ETCS-Levels: 0, 1, 2, 3, NTC / ATO GoA Levels: 1 - 4

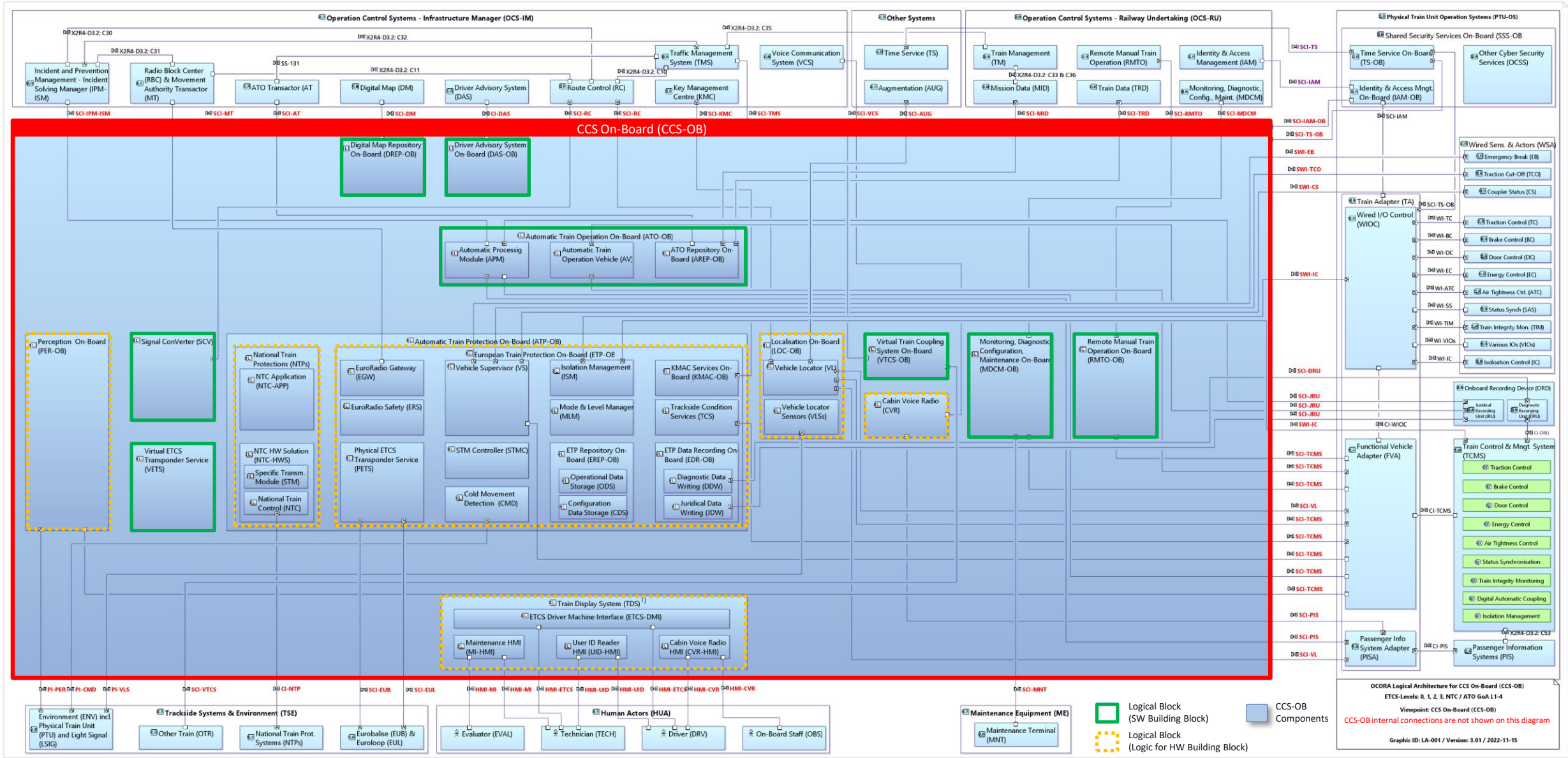
CCS On-Board (CCS-OB) – Logical Architecture
Logical Components
New Generation Train
(TCMS compliant with SS-119+, SS-139+, SS-147+)
DIAGRAM DOES NOT SHOW CCS-OB INTERNAL EXCHANGES

Graphic ID: LA-020-NGT Version 3.00 / 2022-11-30

Logical Components (Legacy Train Example)

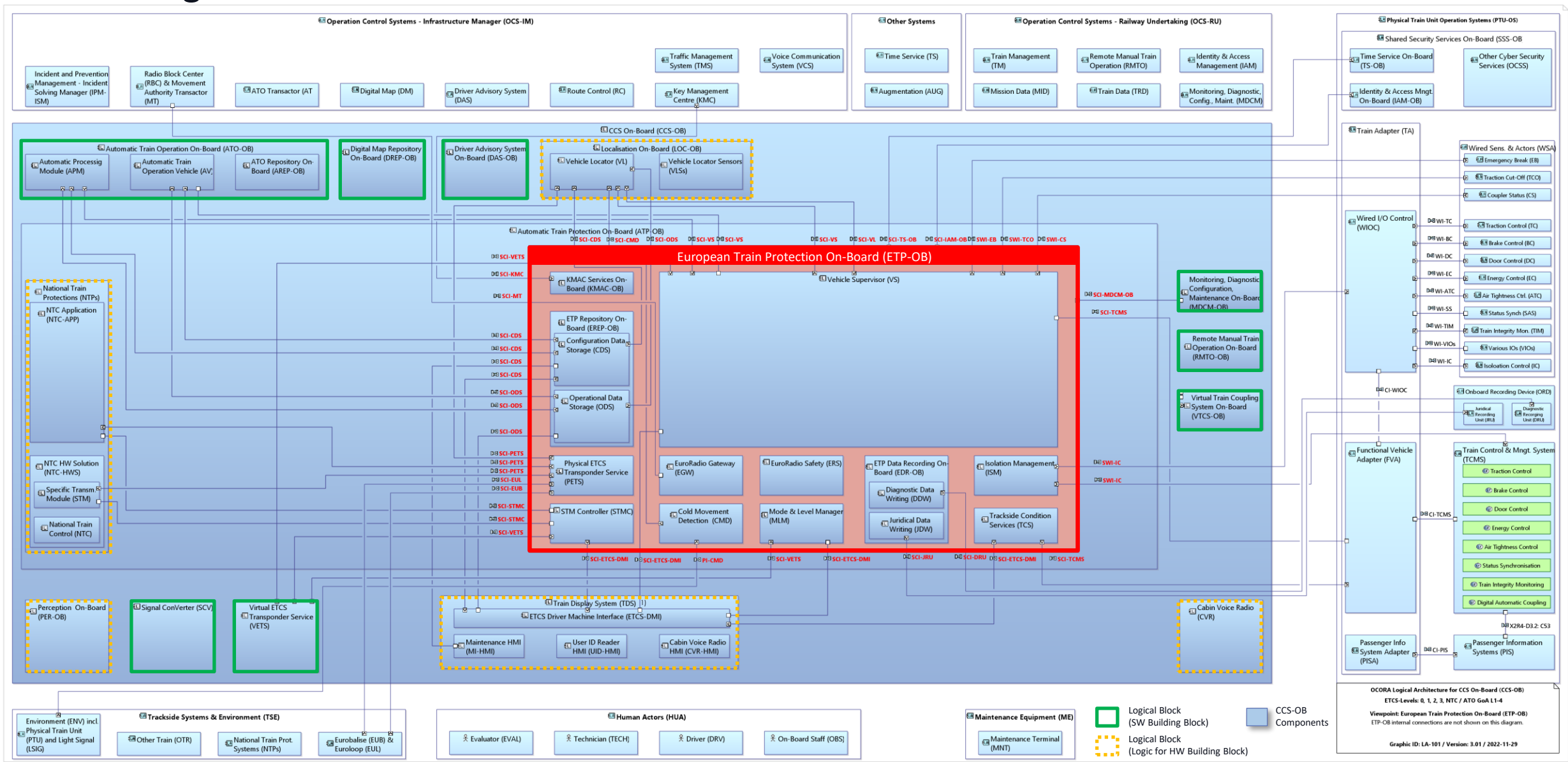


External Logical Interfaces (Legacy Train Example)



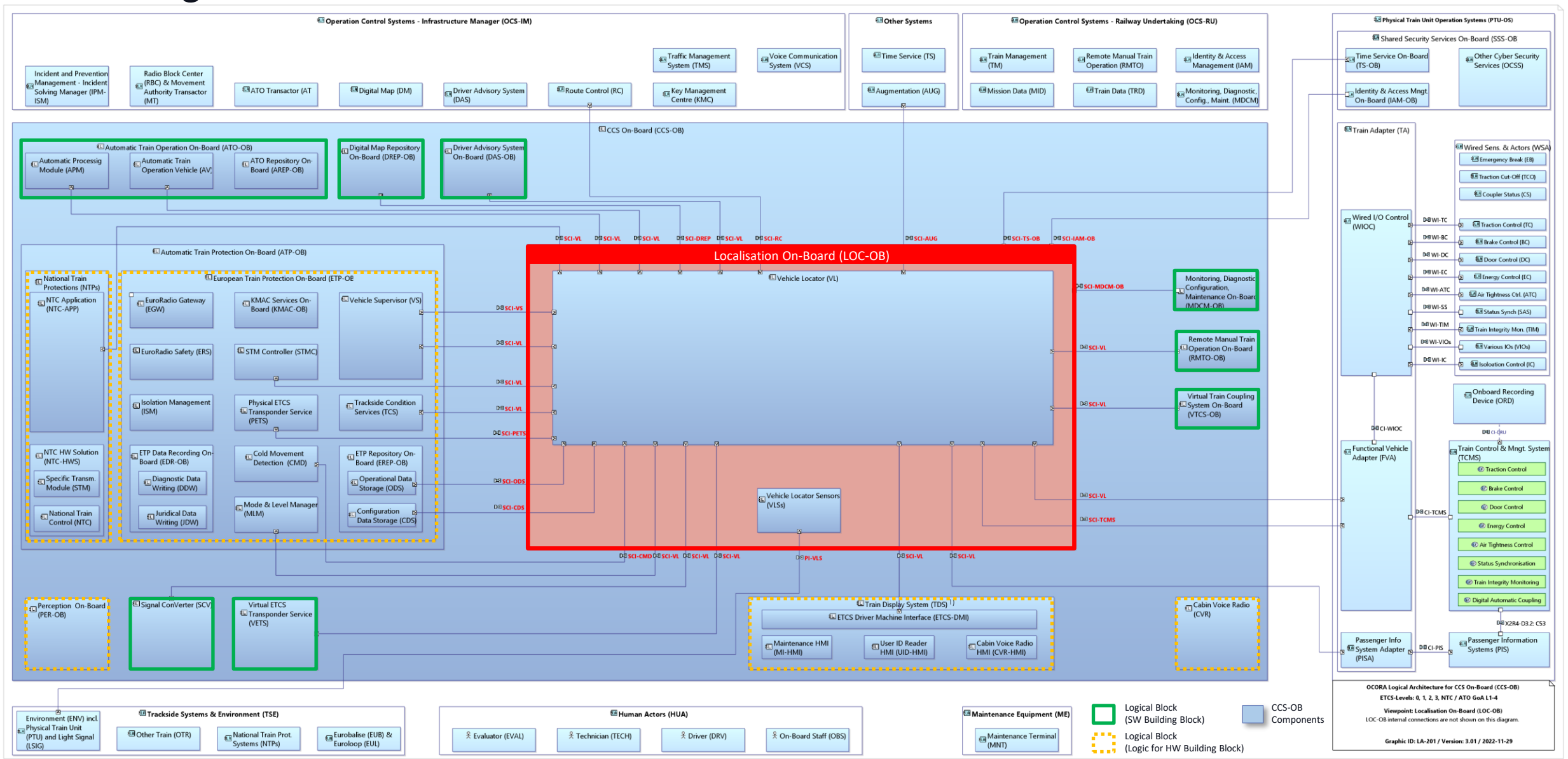
1) TDS-OB may be moved into the PTU-OS / LOC&PAS domain.

External Logical Interfaces – ETP-OB (Legacy Train Example)



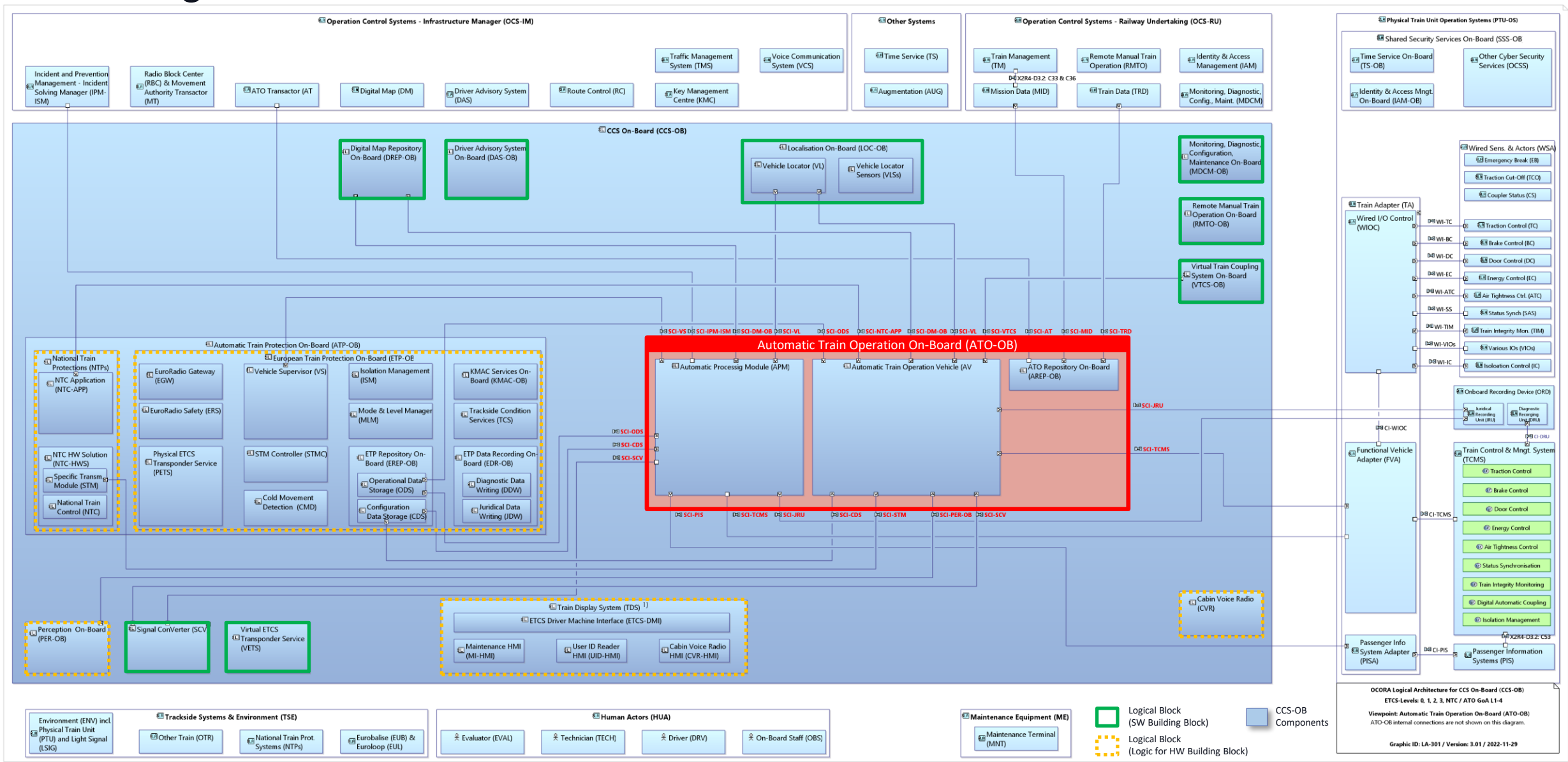
1) TDS-OB may be moved into the PTU-OS / LOC&PAS domain.

External Logical Interfaces – LOC-OB (Legacy Train Example)



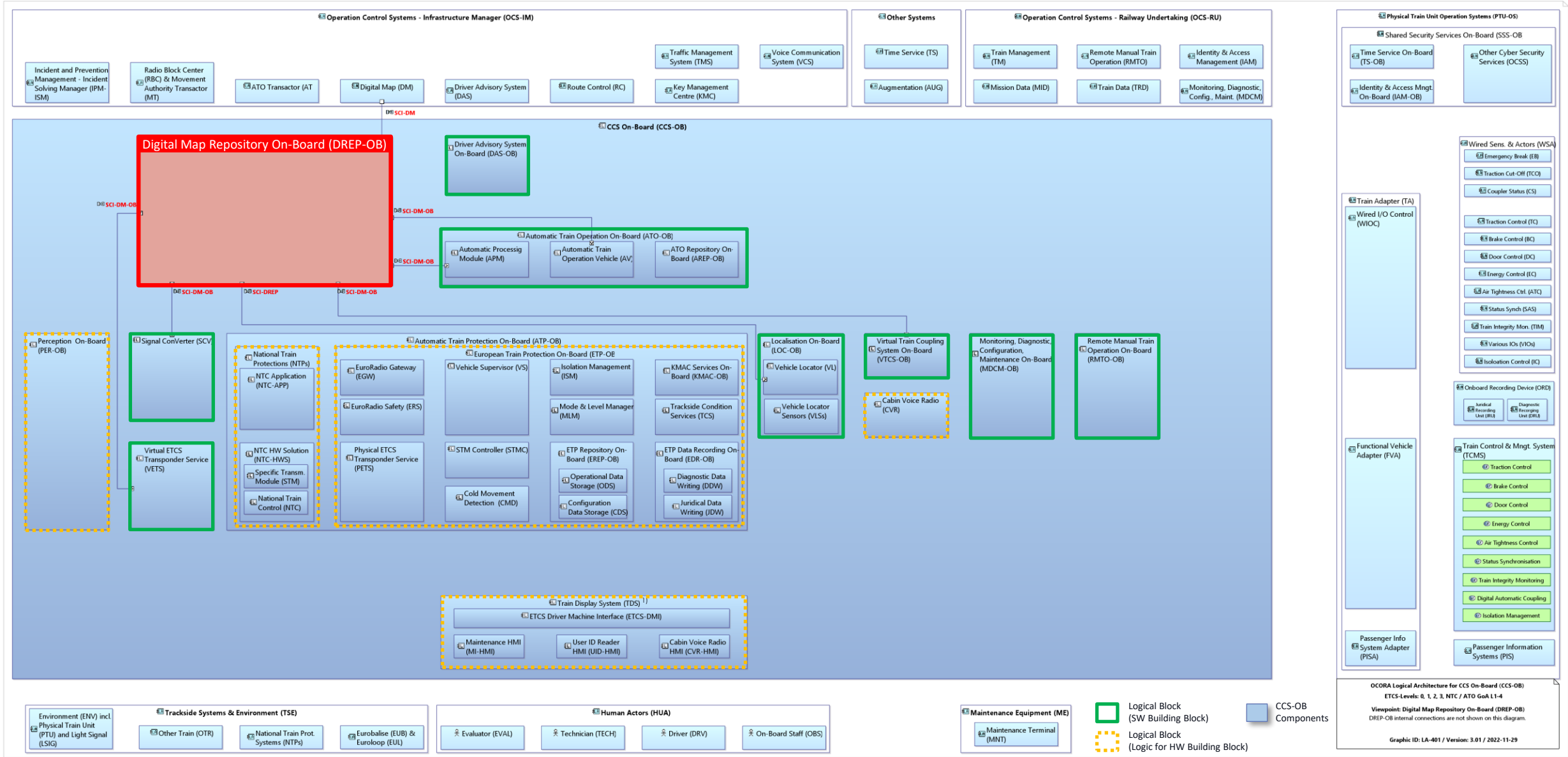
1) TDS-OB may be moved into the PTU-OS / LOC&PAS domain.

External Logical Interfaces – ATO-OB (Legacy Train Example)



1) TDS-OB may be moved into the PTU-OS / LOC&PAS domain.

External Logical Interfaces – DREP-OB (Legacy Train Example)



1) TDS-OB may be moved into the PTU-OS / LOC&PAS domain.

CCS On-Board (CCS-OB)

Physical Architecture – Building Blocks

OCORA-BWS02-030 / v3.00 / 08.12.2022

Building Blocks

Definition

- A **Building Block** is a sourceable unit of the CCS on-board system (hardware and/or software), having standardised functionality, standardised PRAMSS requirements (including Tolerable Functional Failure Rate [TFFR], Safety Integrity Level [SIL] and Safety Related Application Conditions [SRAC]), standardised interfaces (on all OSI Layers) towards other building blocks and/or external systems.

  Building Blocks are separately sourceable from different suppliers and capable of being integrated by a third party.

  There are 2 types of building blocks: a) Hardware Building Blocks and b) Software Building Blocks.

- **Hardware Building Blocks** consist of hardware and typically software that provide the building block's functionality. They exclusively communicate with each other and with external systems through the CCS Communication Network (CCN) using standardised interfaces.

- **Software Building Bocks** consist of software that provide the building block's functionality. They are deployed on an instance of the Generic Safe Computing Platform (SCP) and shall communicate with each other through the standardised Platform Independent Application Programming Interface (PI-API). Communication with computing platform external building blocks and systems is realised by the Computing Platform (integrating with the CCN).

  Software Building Blocks are portable i.e., they may be deployed on different Computing Platform implementations.

Building Blocks

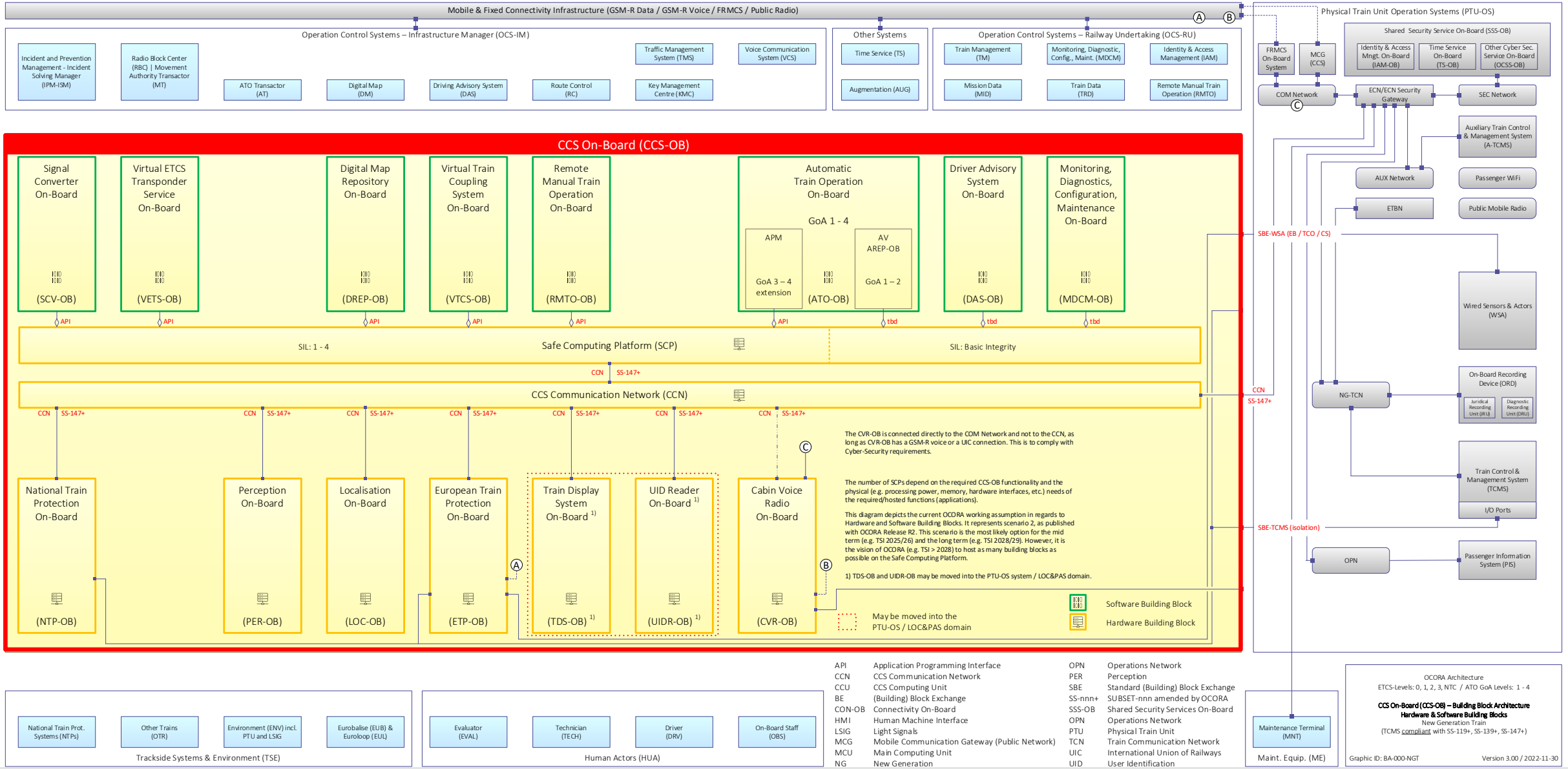
Support of OCORA design objectives and OCORA vision

Building Blocks support the following OCORA design objectives:

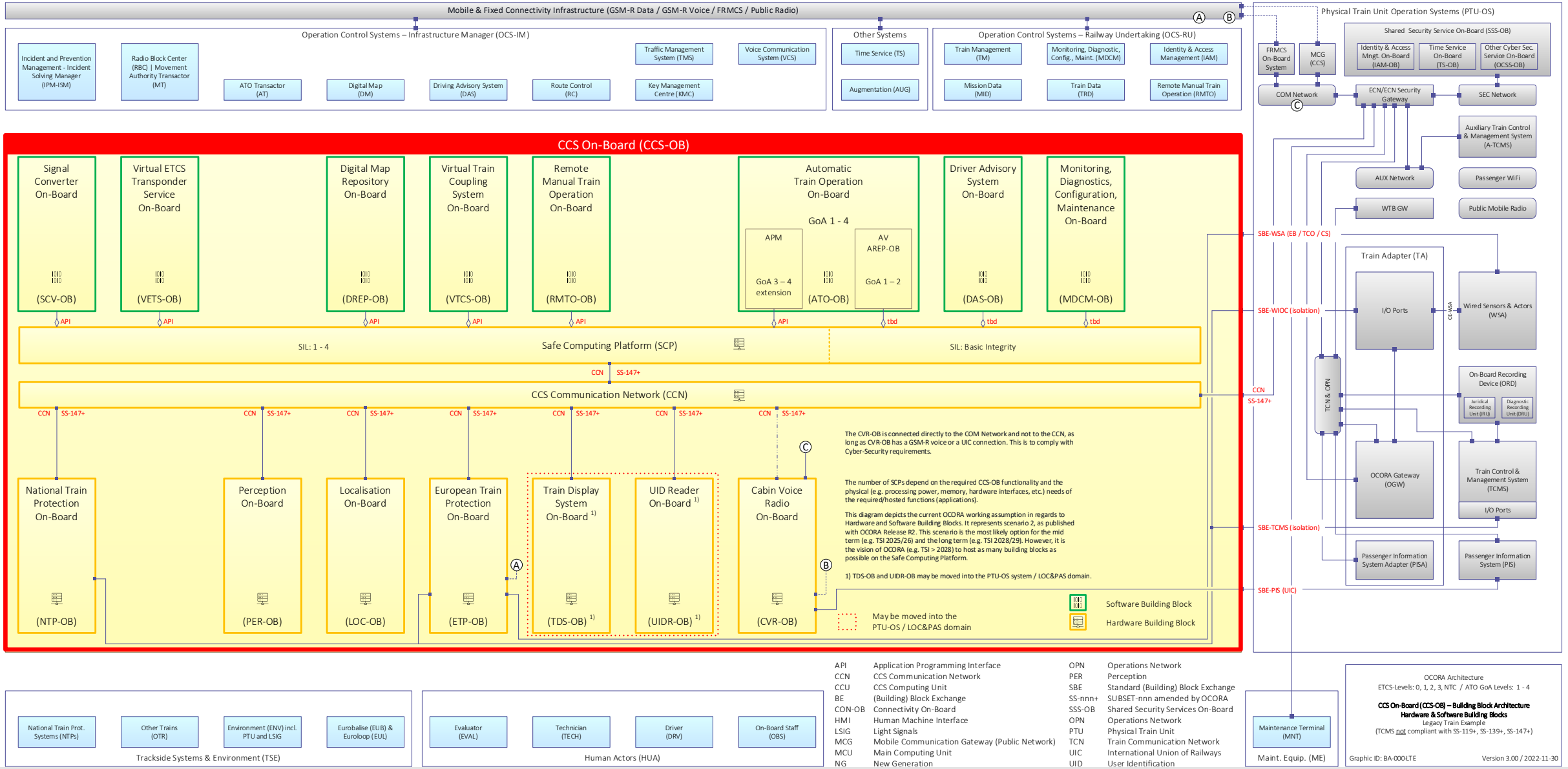
- **Exchangeability:** Building Blocks are individually exchangeable, by a third party integrator, with a building blocks of the same or of a different supplier without the involvement of any other building block supplier.
- **Migrateability:** Building blocks are individually migratable (introducing bug-fixes, improvements, new functionality), without affecting the other building blocks, unless changes on external interfaces are needed that are not backward compatible (note: backward in-compatible changes must be avoided, if possible).
- **Portability:** Software Building Blocks are portable. This means, that they runs un-changed, based on the generalized abstraction, on different (computing) platform implementations.
- **Evolvability:** Building blocks support the evolvement of the overall CCS.

Building Blocks also support the OOCRA vision for simplicity (reduced complexity) and for improved maintainability.

CCS-OB Building Blocks (New Generation Train)



CCS-OB Building Blocks (Legacy Train Example)

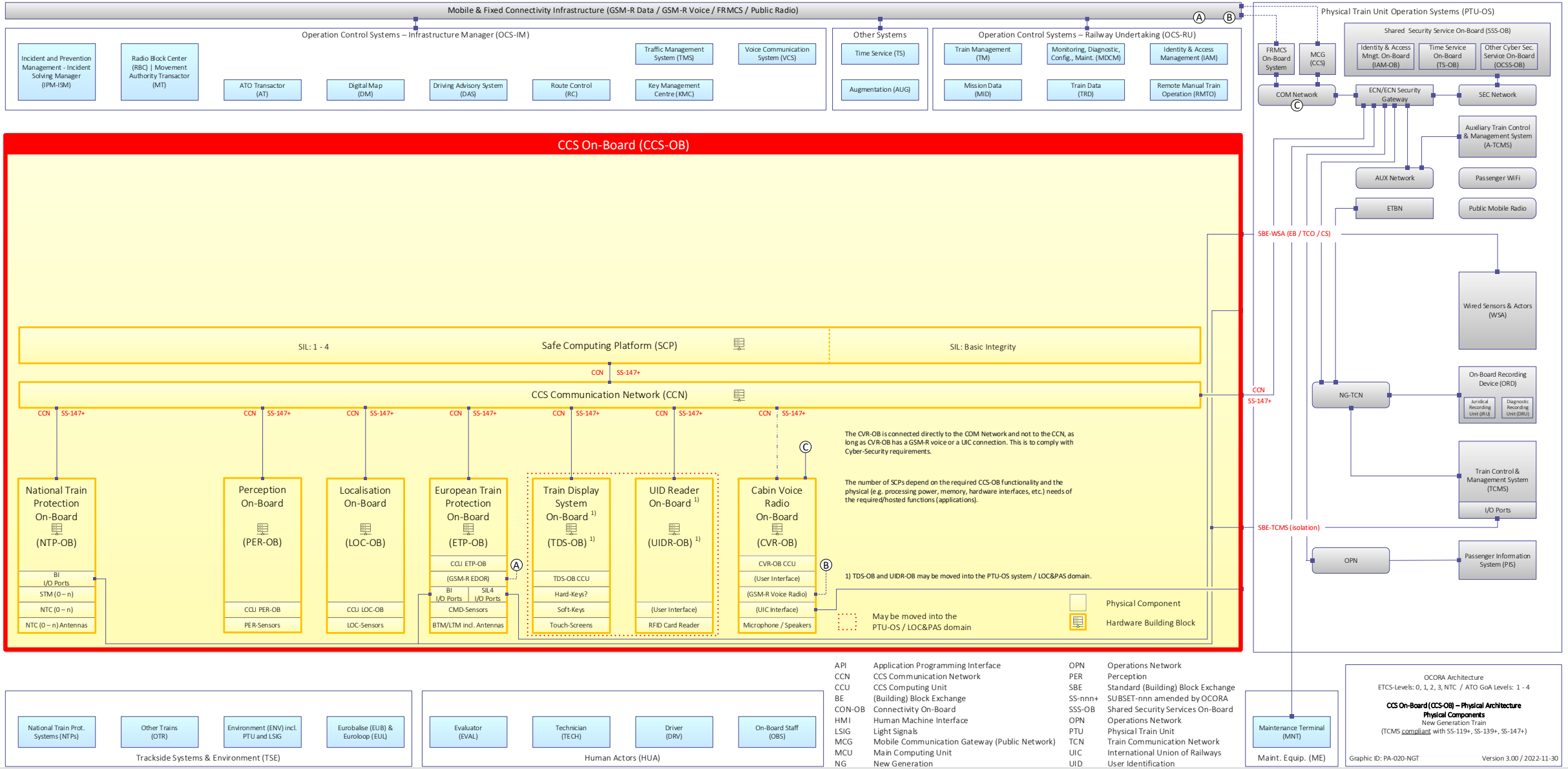


CCS On-Board (CCS-OB)

Physical Architecture – Hardware Block Diagram

OCORA-BWS02-030 / v3.00 / 08.12.2022

CCS-OB Hardware Block Diagram (New Generation Train)



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SSS-OB	Shared Security Services On-Board
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TCN	Train Communication Network
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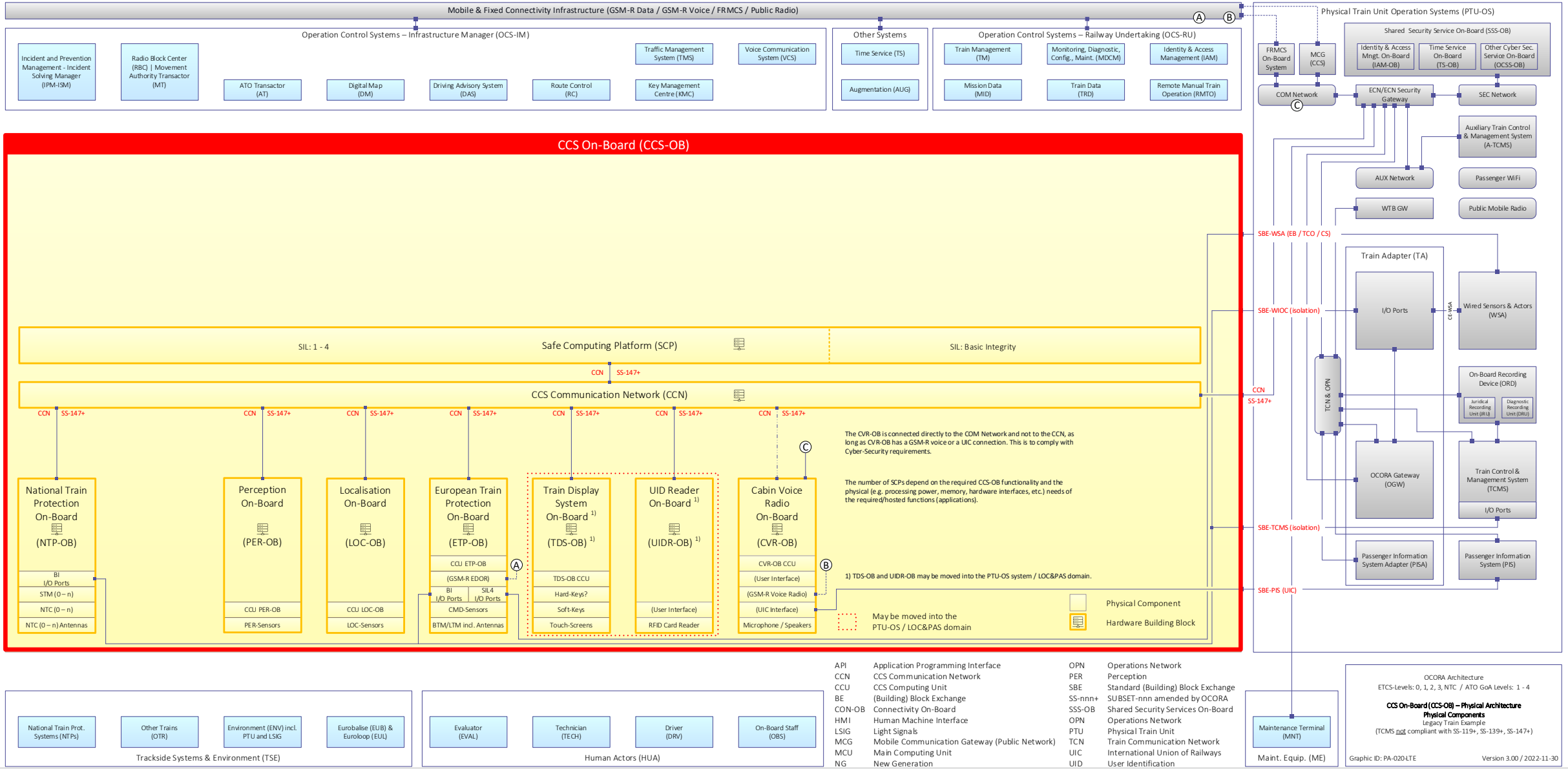
CCS-OB Hardware Block Diagram (Legacy Train Example)



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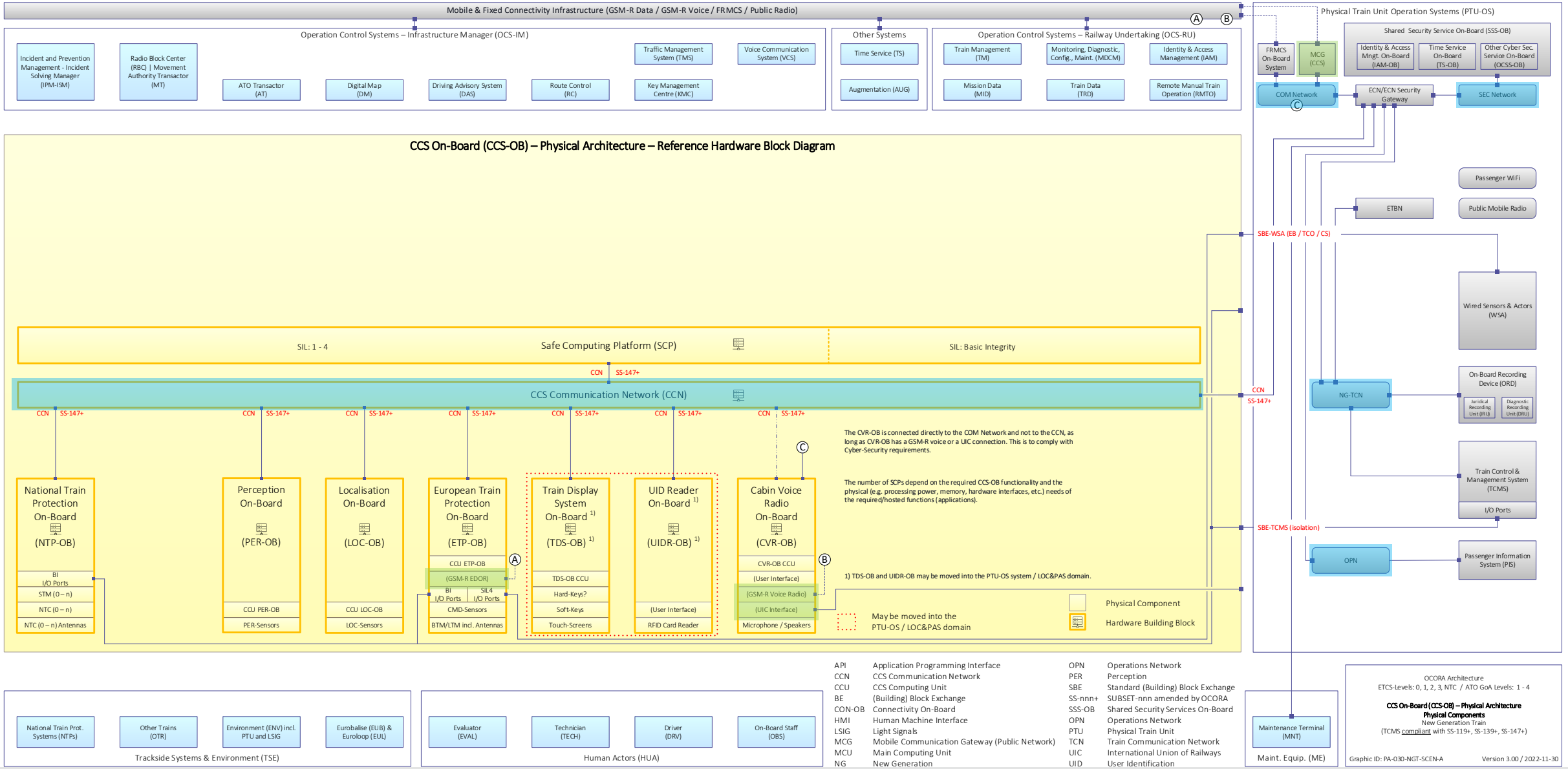
CCS On-Board (CCS-OB)

Physical Architecture – Train Integration Scenarios

OCORA-BWS02-030 / v3.00 / 08.12.2022

NG-TCN Train – Scenario A

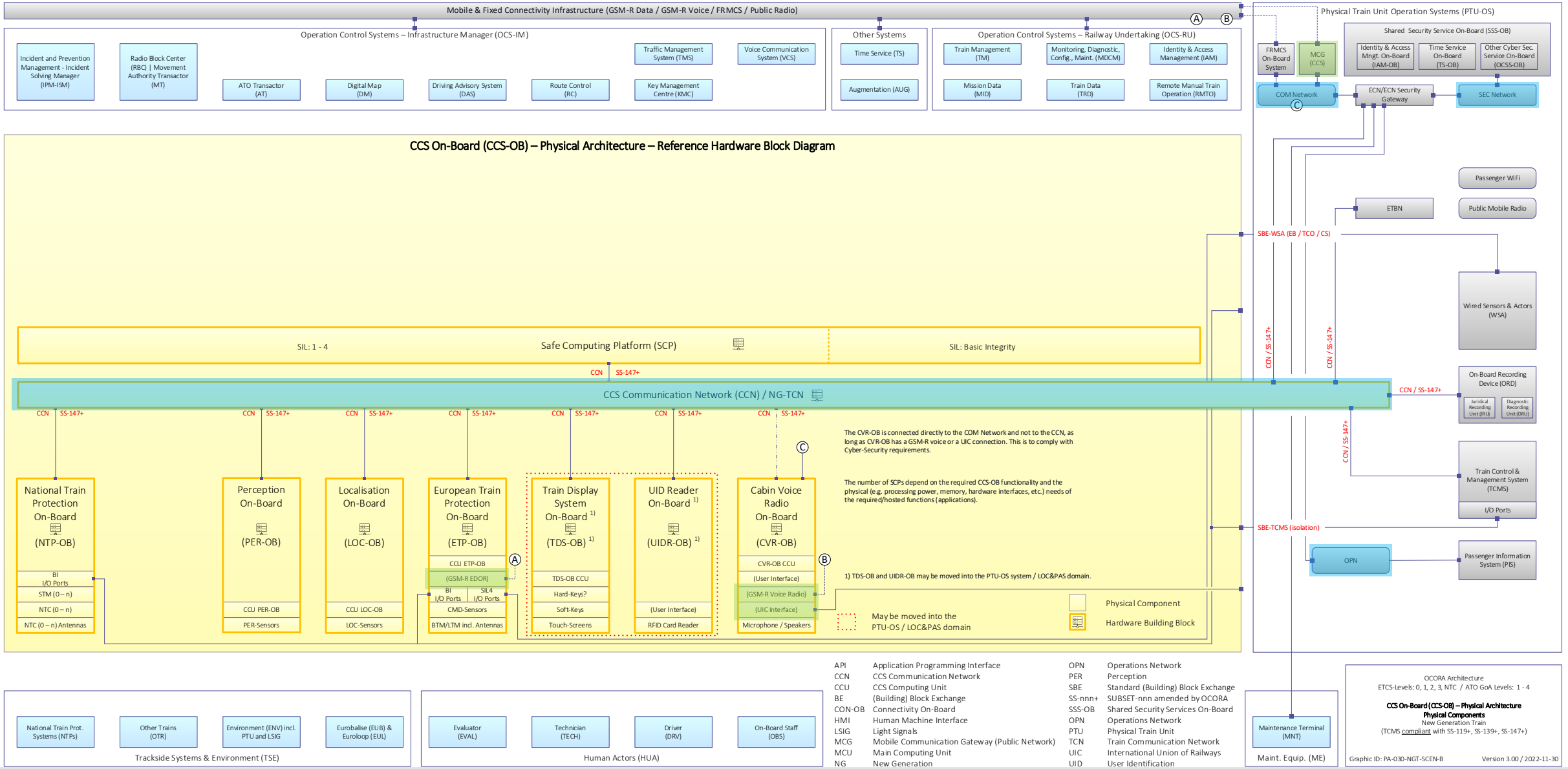
(CCN as **physically** separated network from Sec Net, Op Net, NG TCN and Com Net with support for legacy trackside infrastructure)



API	Application Programming Interface	OPN	Operations Network
CCN	CCS Communication Network	PER	Perception
CCU	CCS Computing Unit	SBE	Standard (Building) Block Exchange
BE	(Building) Block Exchange	SS-nnn+	SUBSET-nnn amended by OCORA
CON-OB	Connectivity On-Board	SSS-OB	Shared Security Services On-Board
HMI	Human Machine Interface	OPN	Operations Network
LSIG	Light Signals	PTU	Physical Train Unit
MCG	Mobile Communication Gateway (Public Network)	TCN	Train Communication Network
MCU	Main Computing Unit	UIC	International Union of Railways
NG	New Generation	UID	User Identification

NG-TCN Train – Scenario B

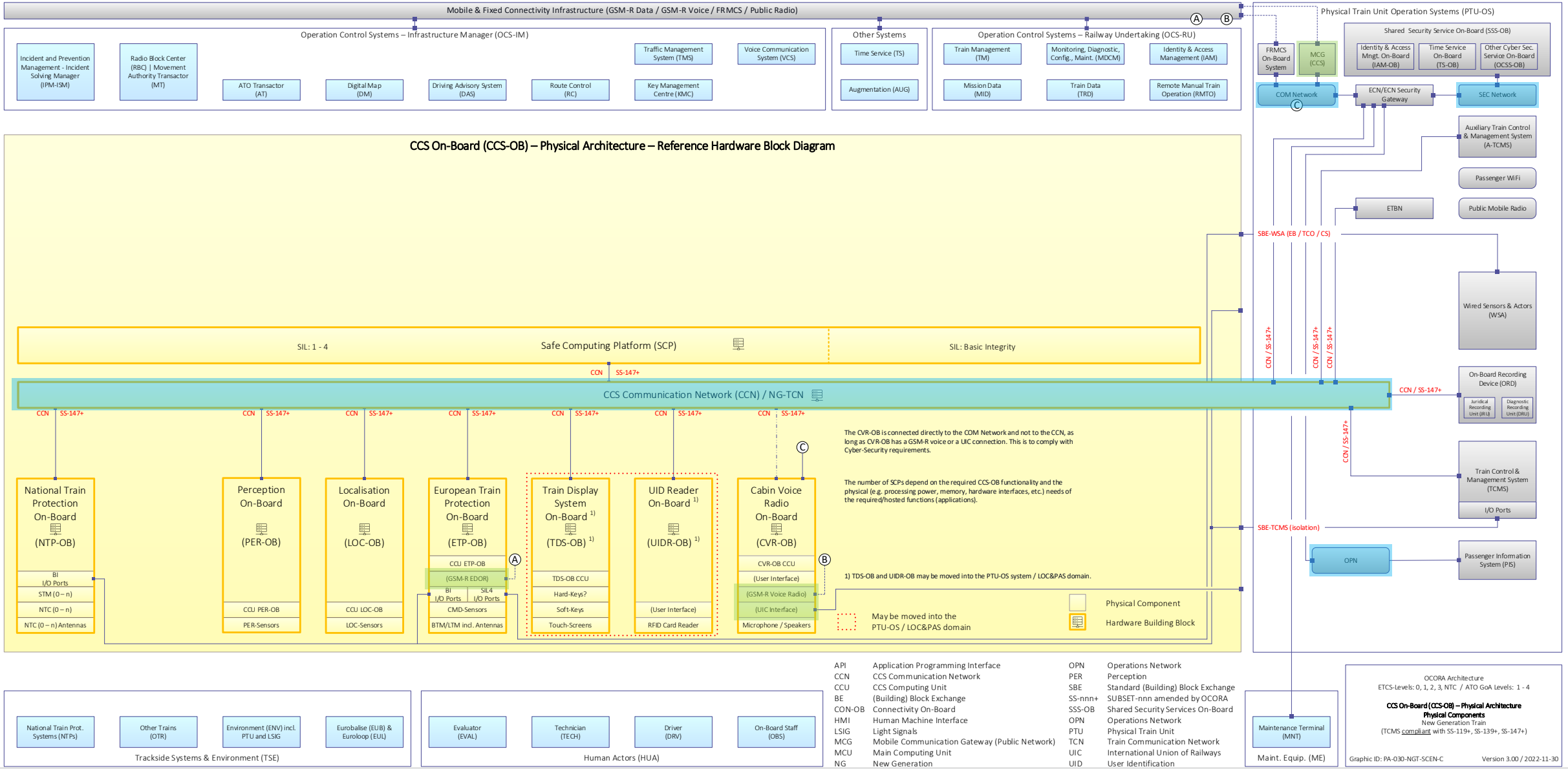
(CCN as **logically** separated network from NG TCN and physically separated from Sec Net, Op Net and Com Net with support for legacy trackside infrastructure)



API	Application Programming Interface
CCN	CCS Communication Network
CCU	CCS Computing Unit
BE	(Building) Block Exchange
CON-OB	Connectivity On-Board
HMI	Human Machine Interface
LSIG	Light Signals
MCG	Mobile Communication Gateway (Public Network)
MCU	Main Computing Unit
NG	New Generation
OPN	Operations Network
PER	Perception
SBE	Standard (Building) Block Exchange
SS-nnn+	SUBSET-nnn amended by OCORA
SSS-OB	Shared Security Services On-Board
OPN	Operations Network
PTU	Physical Train Unit
TCN	Train Communication Network
UIC	International Union of Railways
UID	User Identification

NG-TCN Train – Scenario C

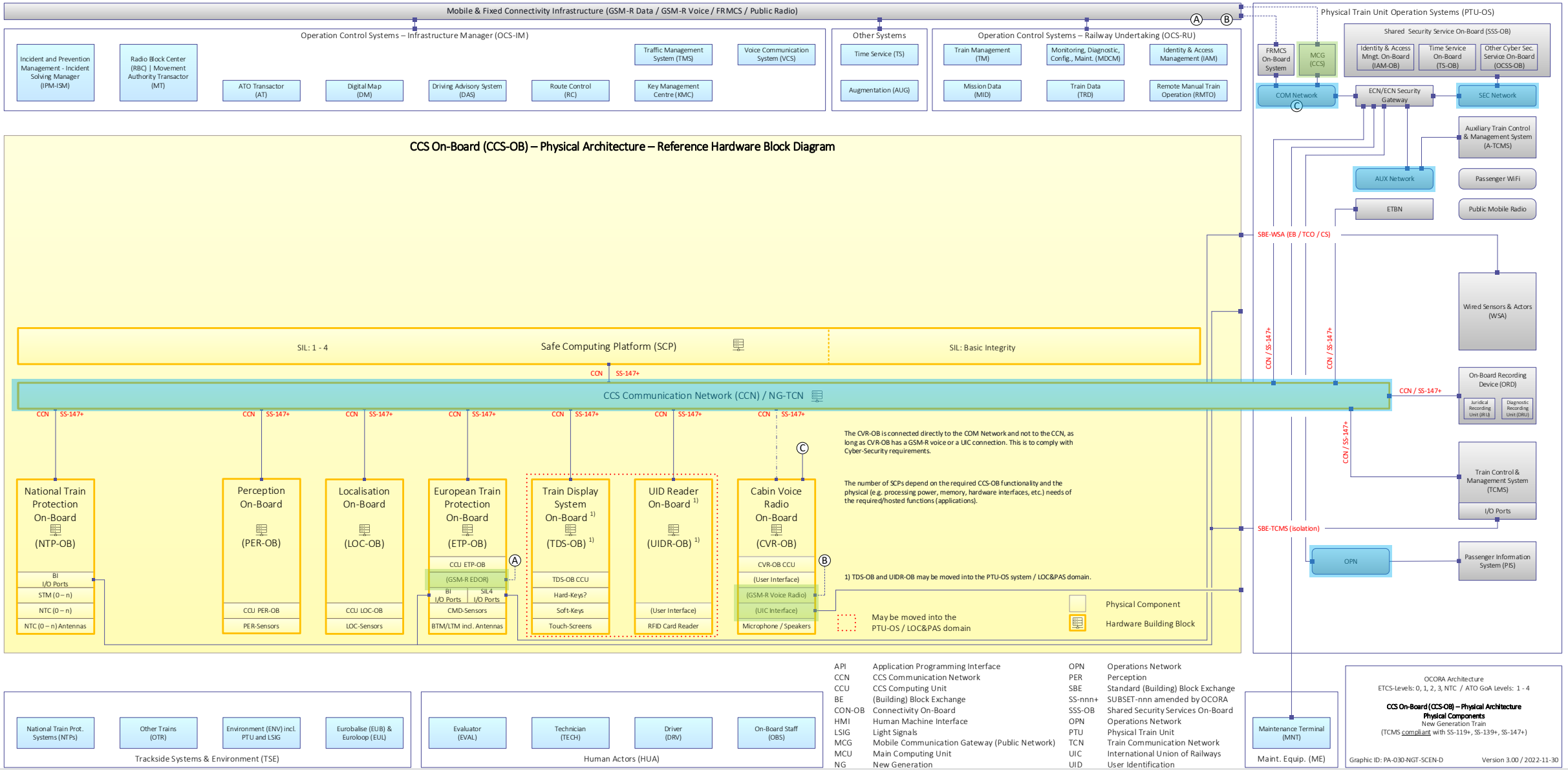
(Common CCN and TCMS network **logically** separated from A-TCMS and physically separated from Sec Net, Op Net and Com Net with support for legacy trackside infrastructure)



API	Application Programming Interface
CCN	CCS Communication Network
CCU	CCS Computing Unit
BE	(Building) Block Exchange
CON-OB	Connectivity On-Board
HMI	Human Machine Interface
LSIG	Light Signals
MCG	Mobile Communication Gateway (Public Network)
MCU	Main Computing Unit
NG	New Generation
OPN	Operations Network
PER	Perception
SBE	Standard (Building) Block Exchange
SS-nnn+	SUBSET-nnn amended by OCORA
SSS-OB	Shared Security Services On-Board
OPN	Operations Network
PTU	Physical Train Unit
TCN	Train Communication Network
UIC	International Union of Railways
UID	User Identification

NG-TCN Train – Scenario D

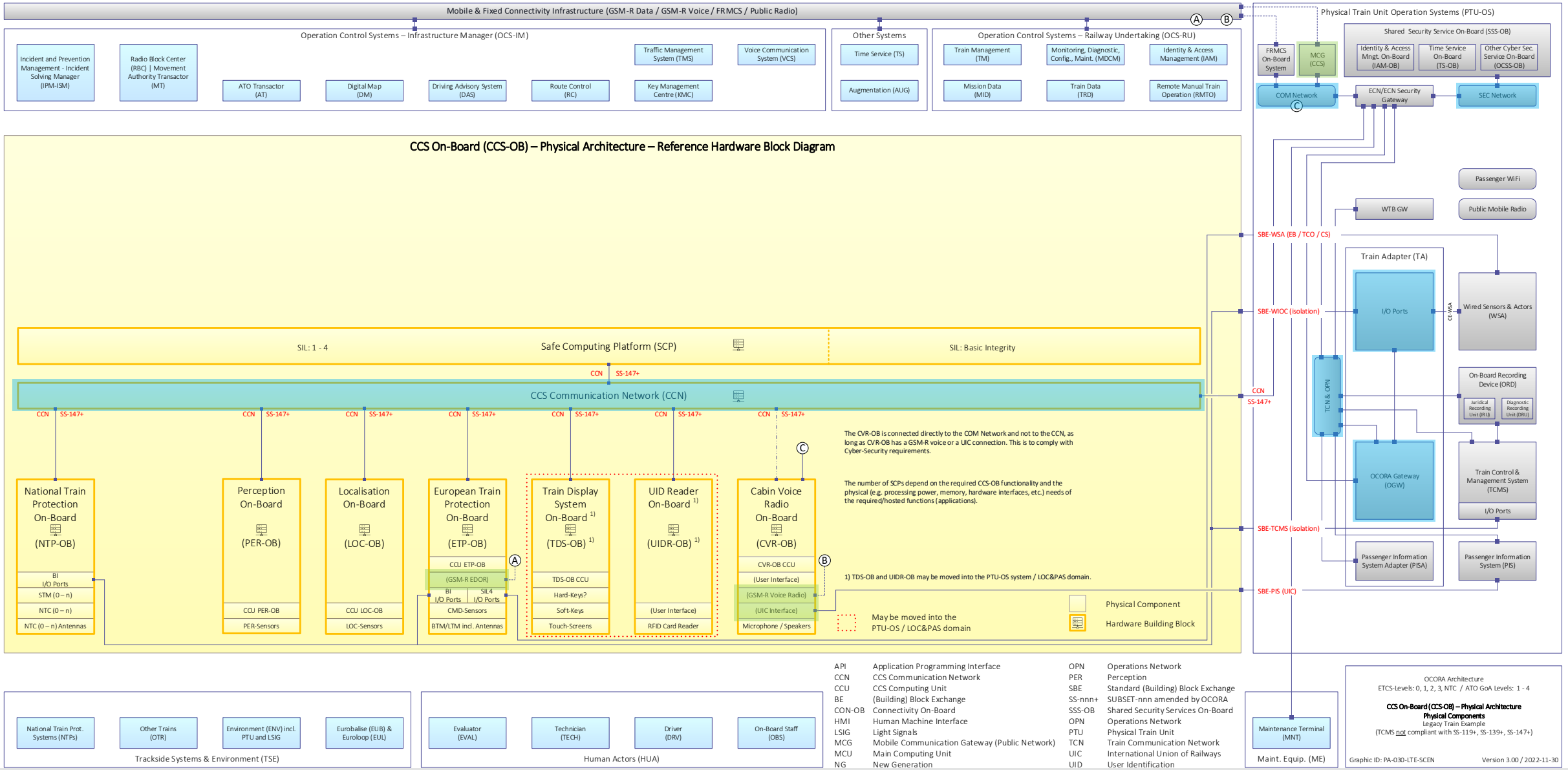
(Common CCN and TCMS network **physically** separated from A-TCMS, Sec Net, Op Net and Com Net with support for legacy trackside infrastructure)



API	Application Programming Interface
CCN	CCS Communication Network
CCU	CCS Computing Unit
BE	(Building) Block Exchange
CON-OB	Connectivity On-Board
HMI	Human Machine Interface
LSIG	Light Signals
MCG	Mobile Communication Gateway (Public Network)
MCU	Main Computing Unit
NG	New Generation
OPN	Operations Network
PER	Perception
SBE	Standard (Building) Block Exchange
SS-nnn+	SUBSET-nnn amended by OCORA
SSS-OB	Shared Security Services On-Board
OPN	Operations Network
PTU	Physical Train Unit
TCN	Train Communication Network
UIC	International Union of Railways
UID	User Identification

Legacy Train

(CCN **physically** separated from Sec Net and Com Net using the OCORA GW connecting to the TCMS / PIS Networks. Support for legacy trackside infrastructure)

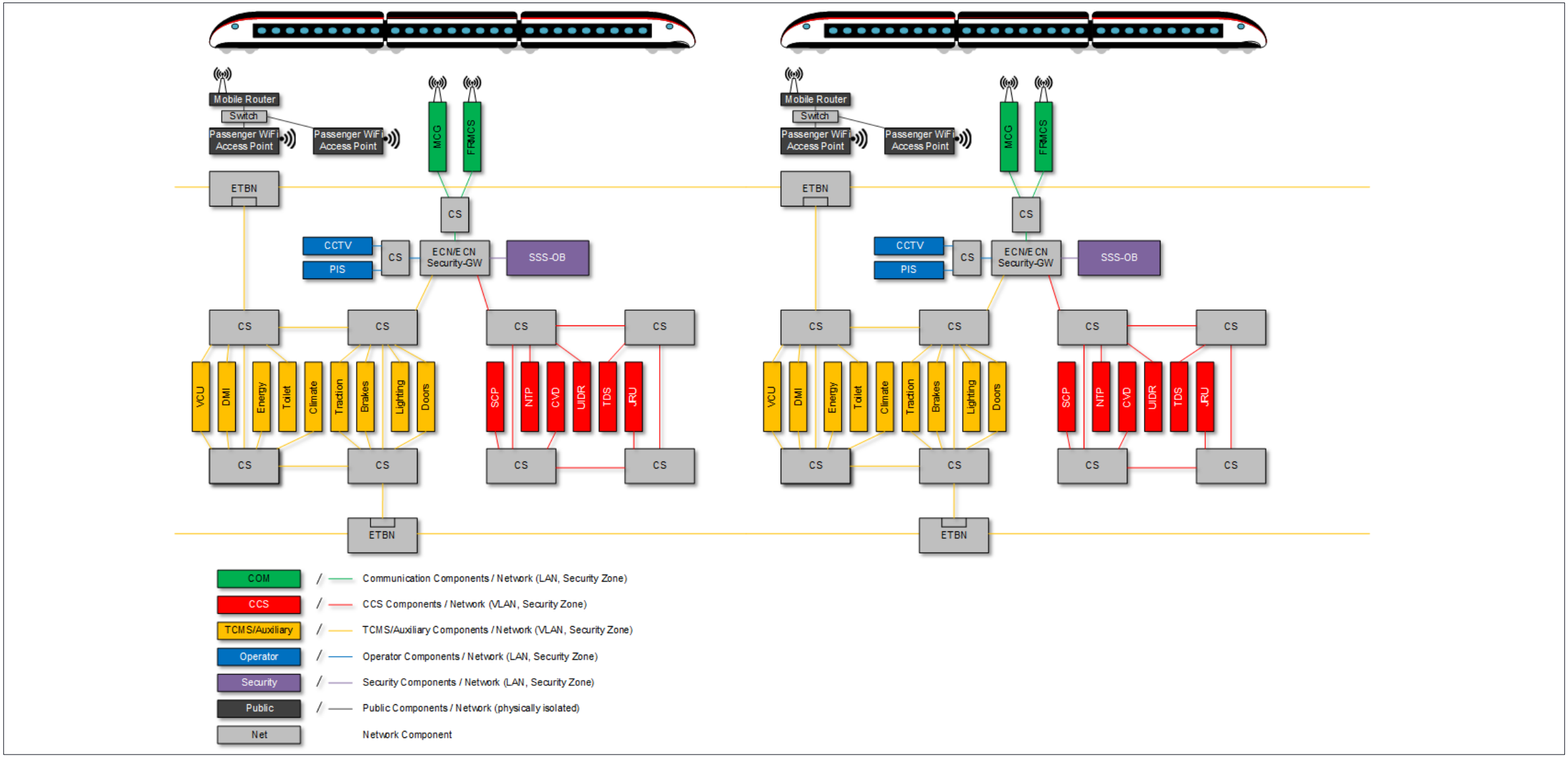


CCS On-Board (CCS-OB)

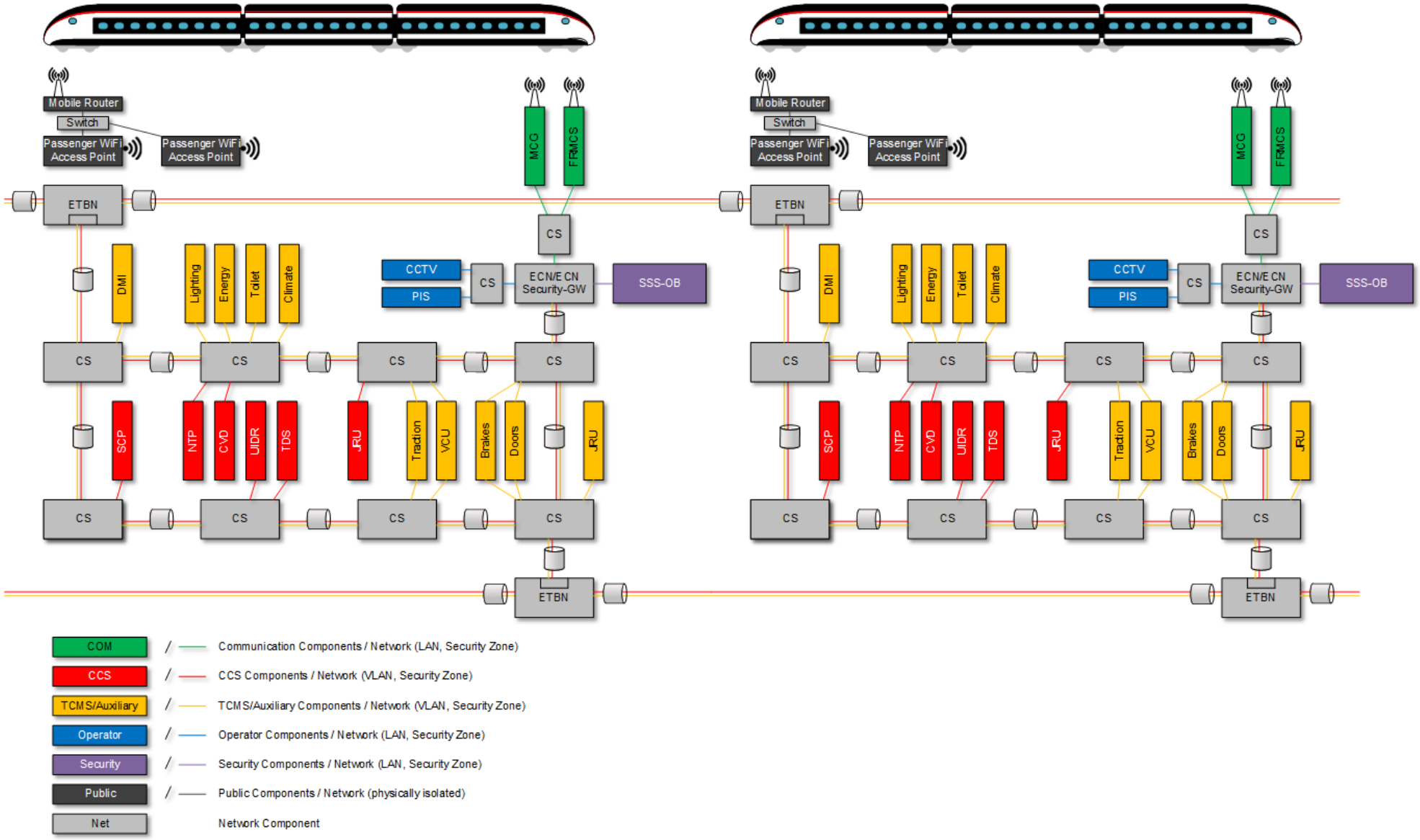
Physical Architecture – Network Topology Scenarios

OCORA-BWS02-030 / v3.00 / 08.12.2022

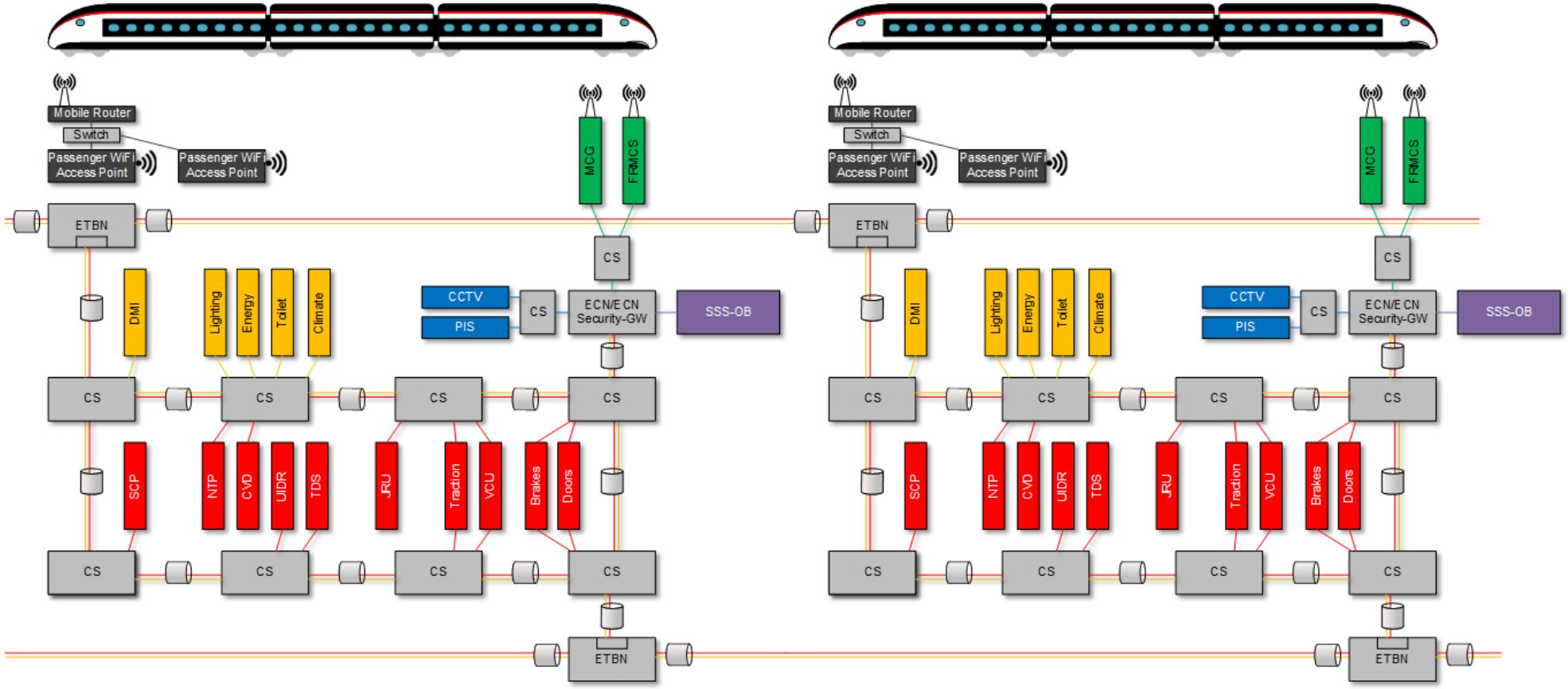
Scenario A: CCN as **physically** separated network



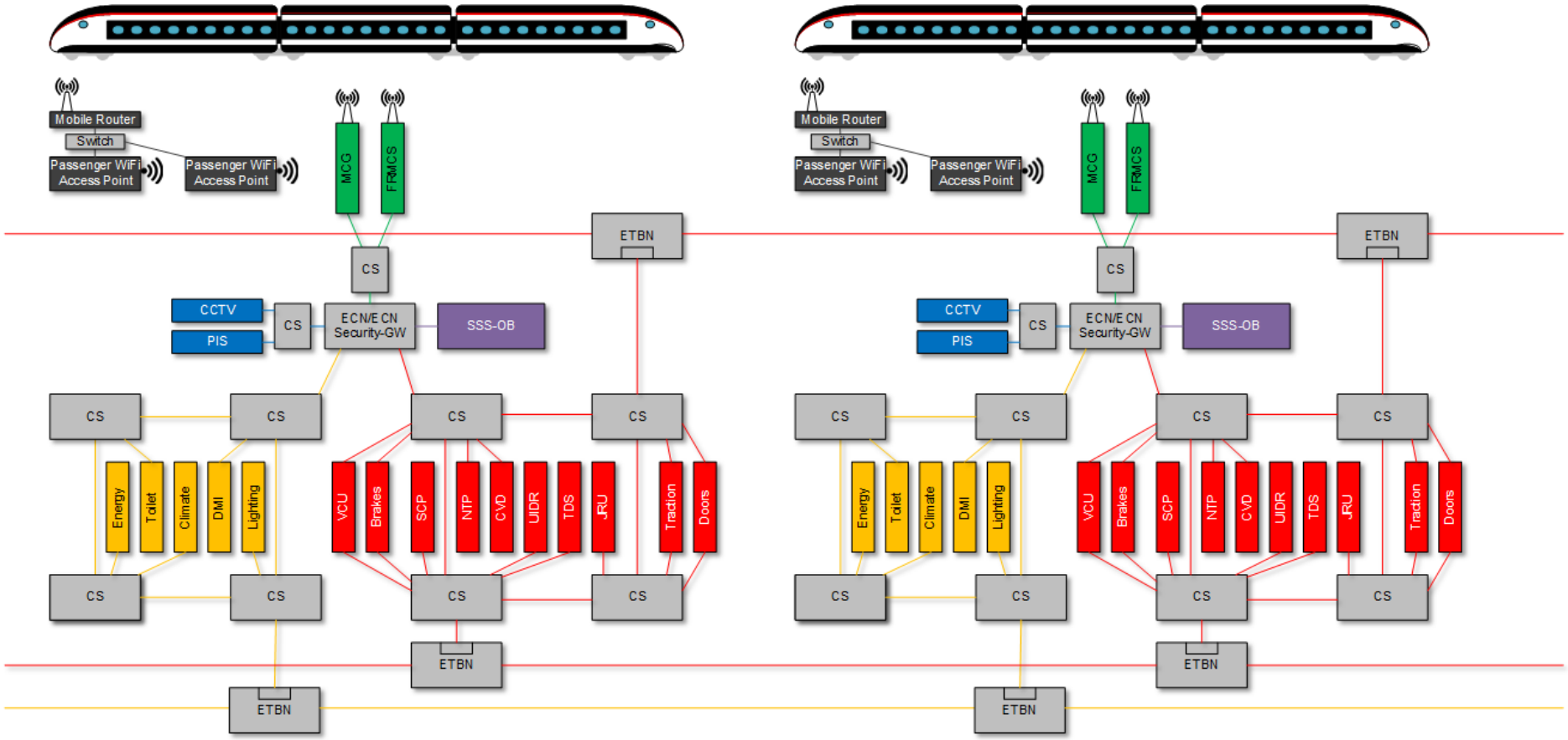
Scenario B: CCN as **logically** separated network



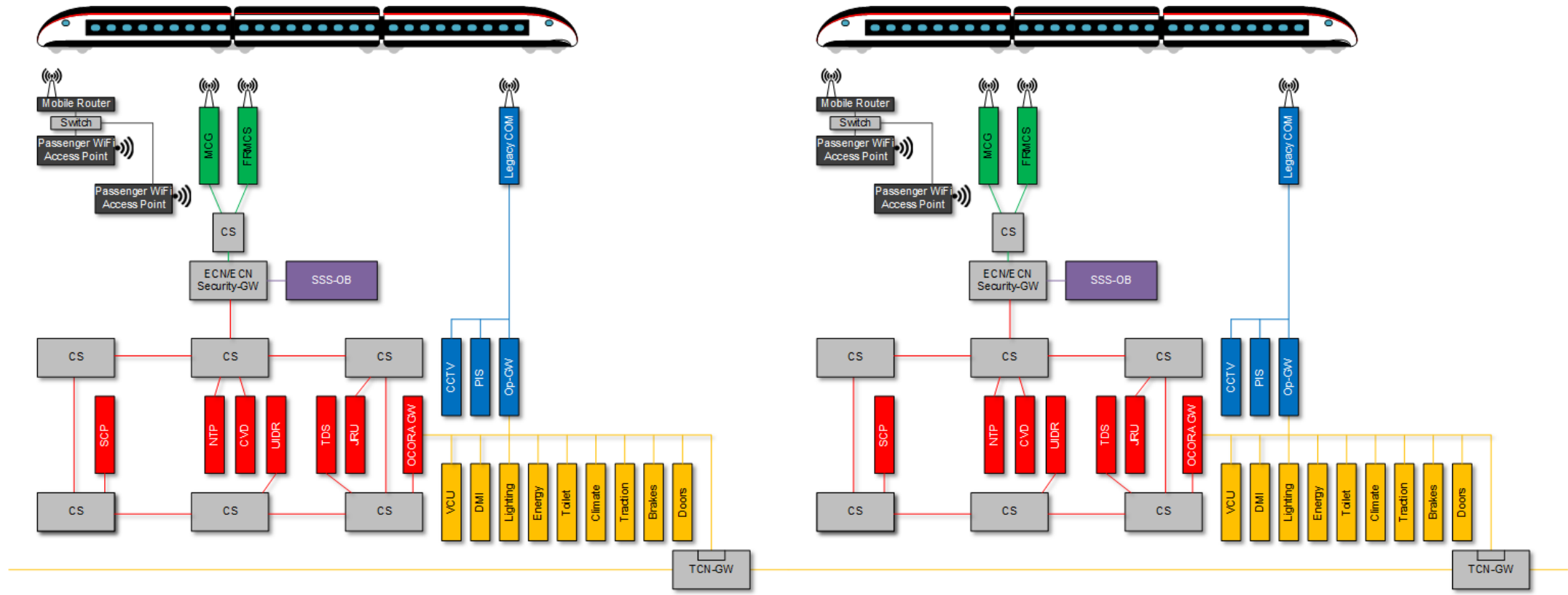
Scenario C: Common critical control network **logically** separated



Scenario D: Common critical control network **physically** separated



Legacy Train – Integration with OCORA-GW



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

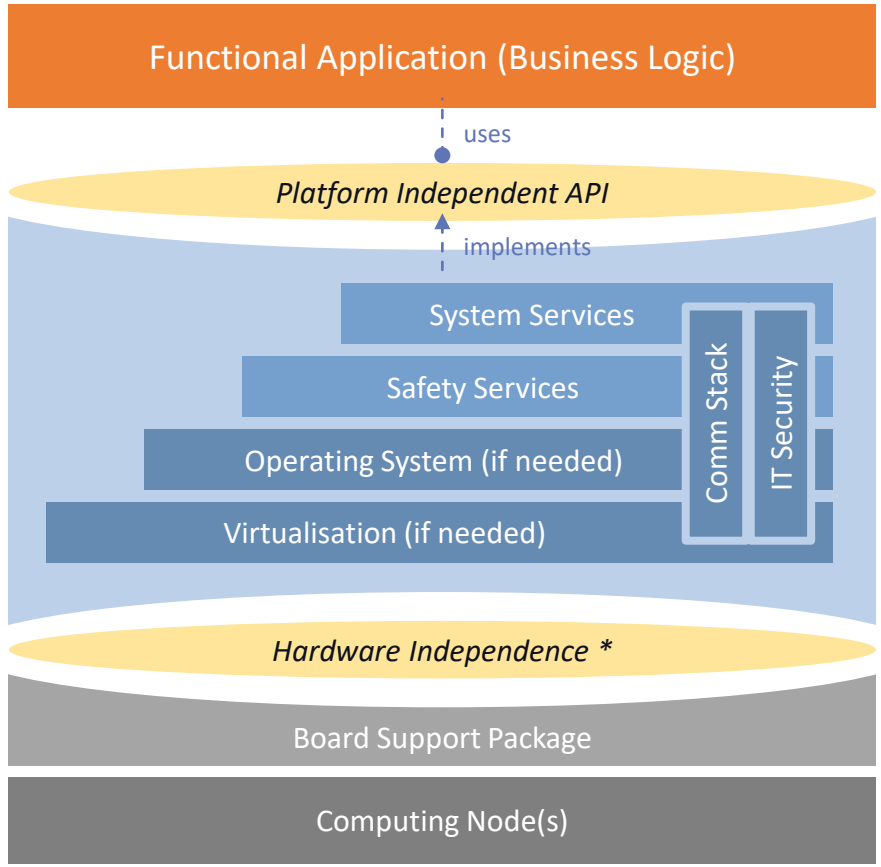
Remark: The network architecture of retrofit vehicles is only an example. Legacy architectures are always vehicle dependent and therefore the CCS integration is project specific.

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

Safe Computing Platform (SCP)

OCORA-BWS02-030 / v3.00 / 08.12.2022

Computing Platform – High Level Architecture



Runtime environment

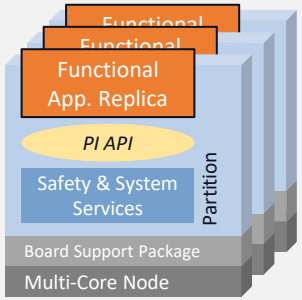
Hardware

Computing Platform

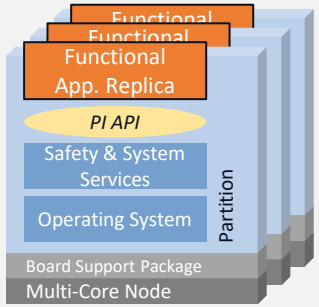
* It is to be discussed to which extent hardware independence can or should be enforced

Computing Platform – Deployment Options

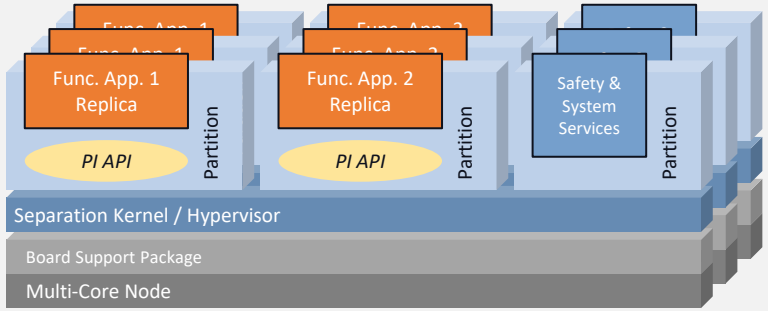
Option A:
Hardware without operating system



Option B:
Hardware with operating system

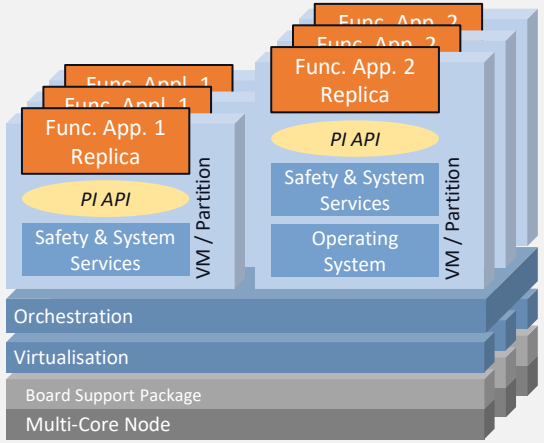


Option C:
Separation kernel / hypervisor based system



Likely options for ***onboard*** deployments

Option D:
Orchestrated virtualisation environment



Likely option for ***trackside*** deployments

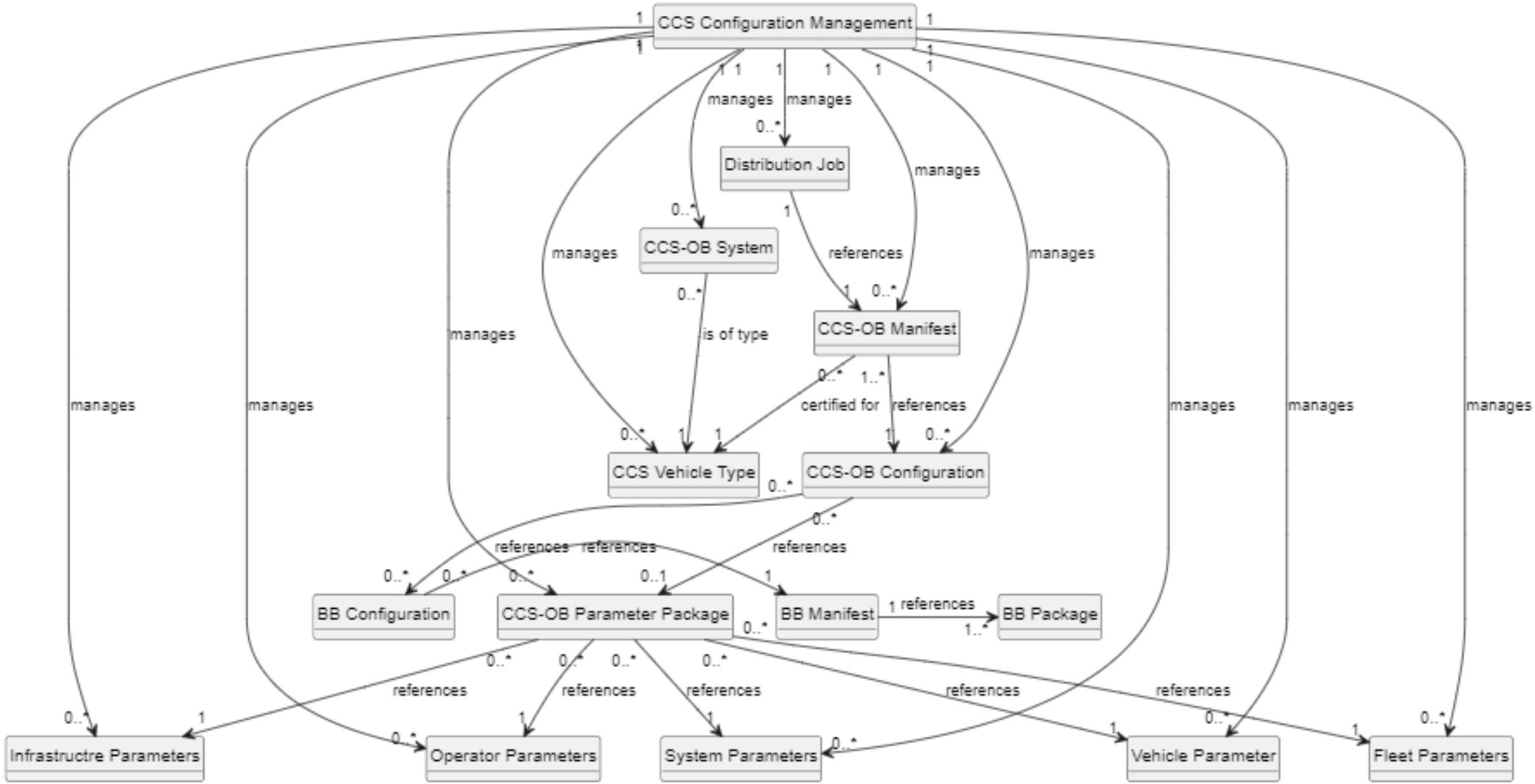
Platform options where applications are programmed against PI API

Approaches depicted in the diagram are non-exhaustive. The industry may propose different state-of-the-art solutions.

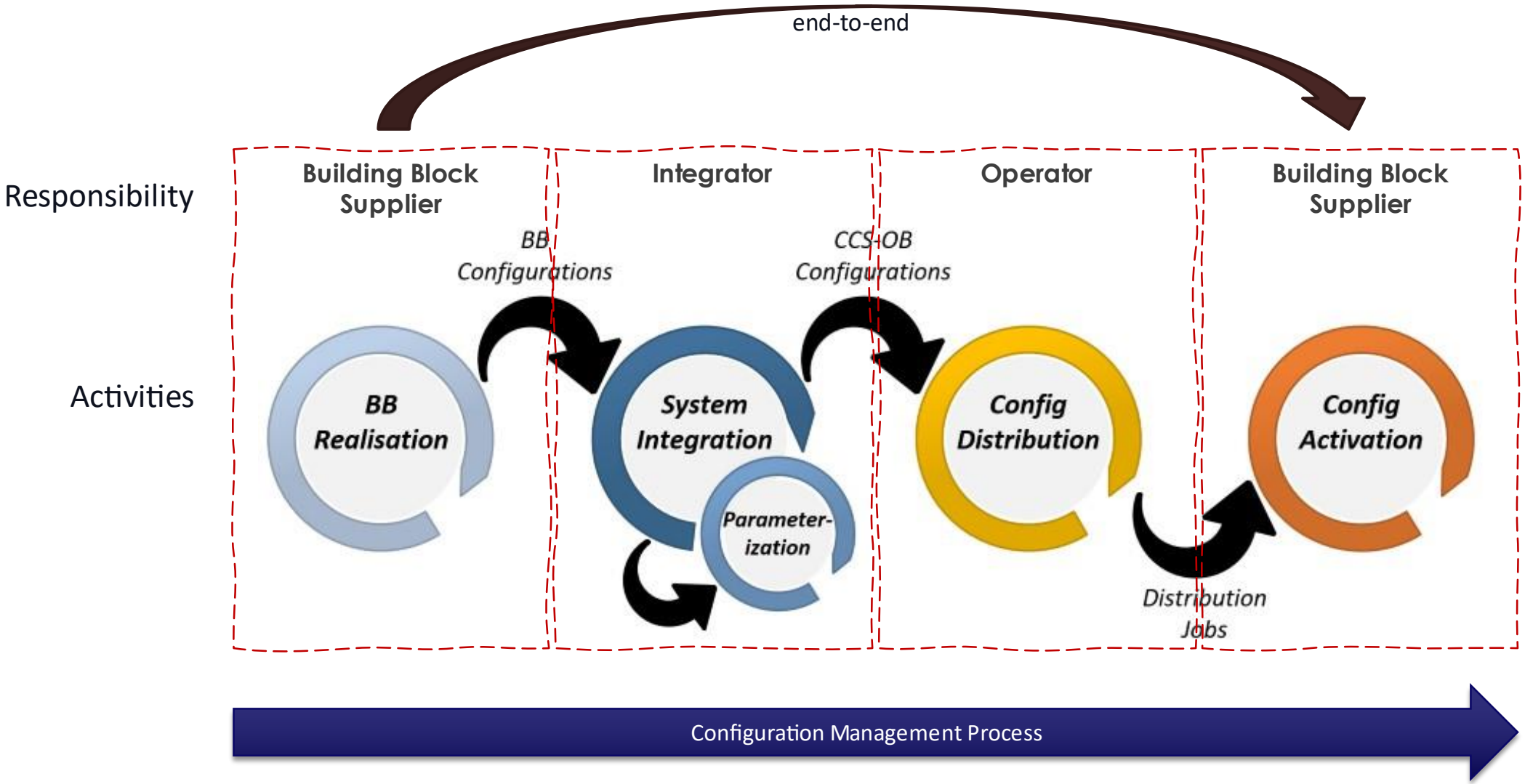
Configuration Management Concept

OCORA-BWS02-030 / v3.00 / 08.12.2022

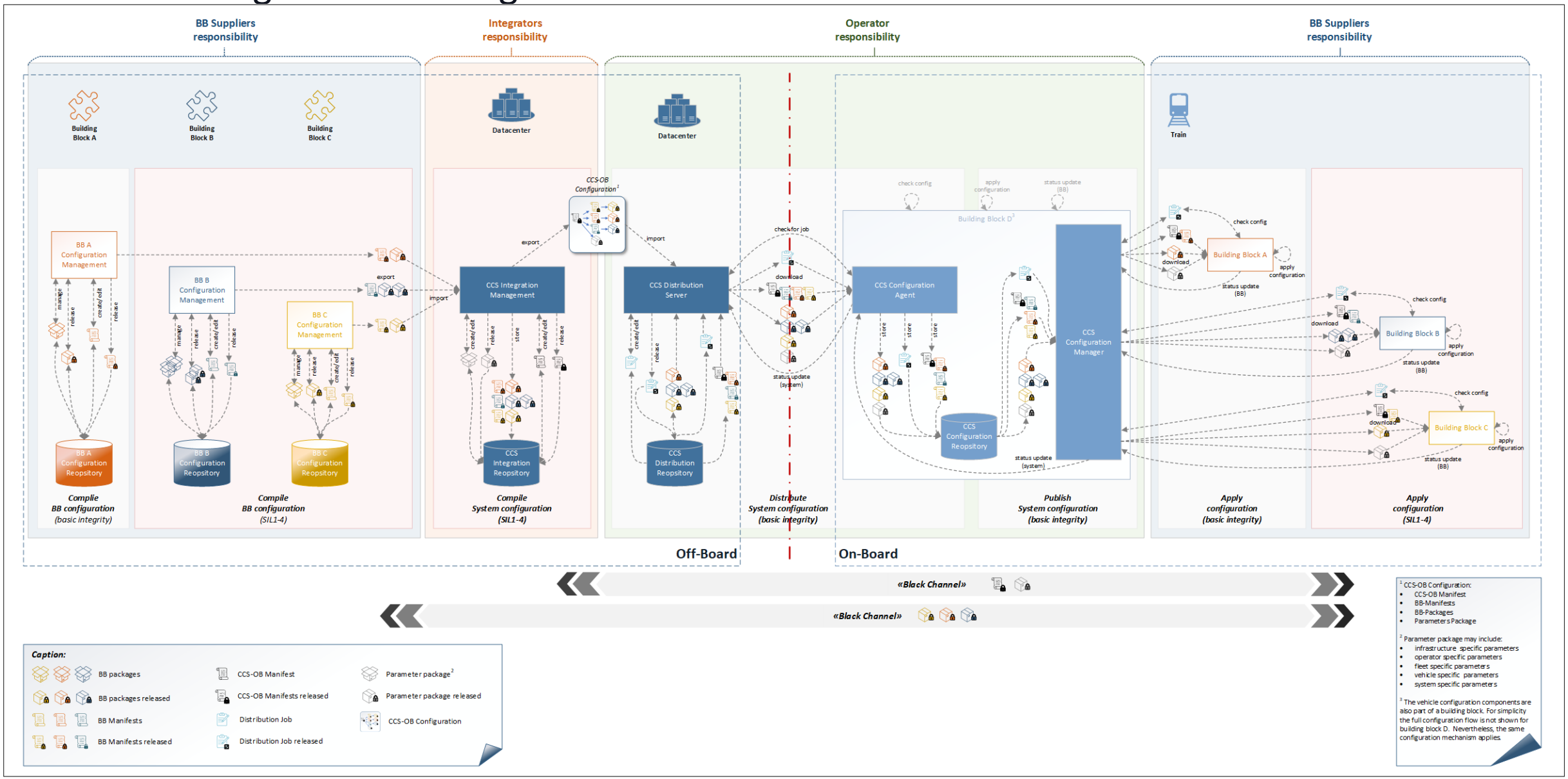
Entity Relationship Diagram



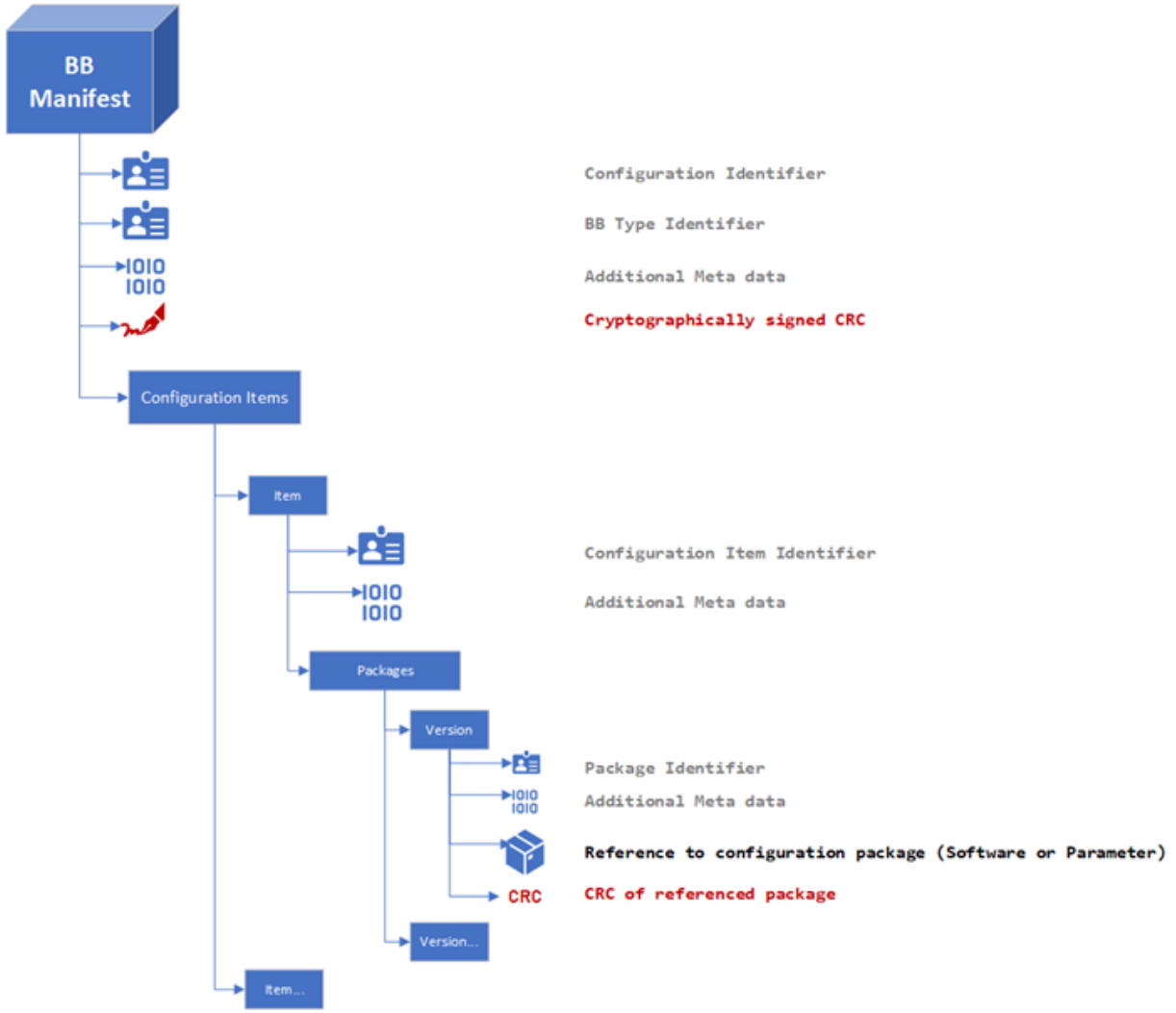
Configuration Management Stakeholders & Activities



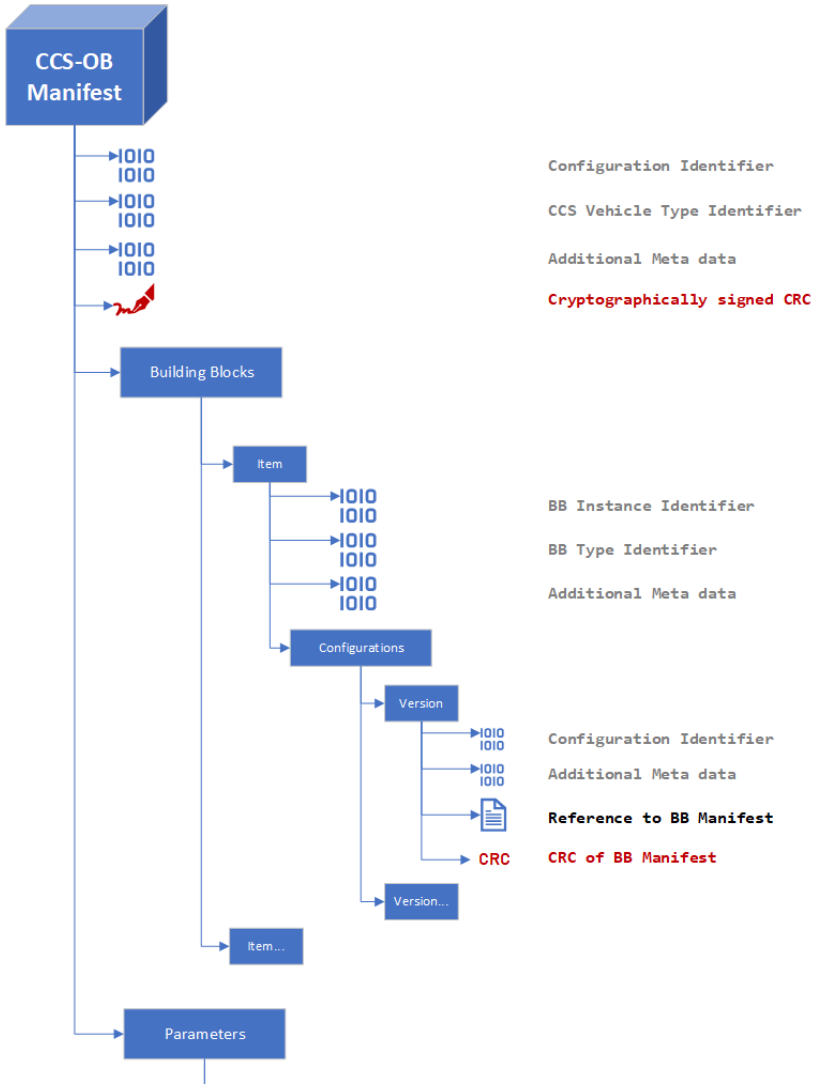
Detailed Configuration Management Process

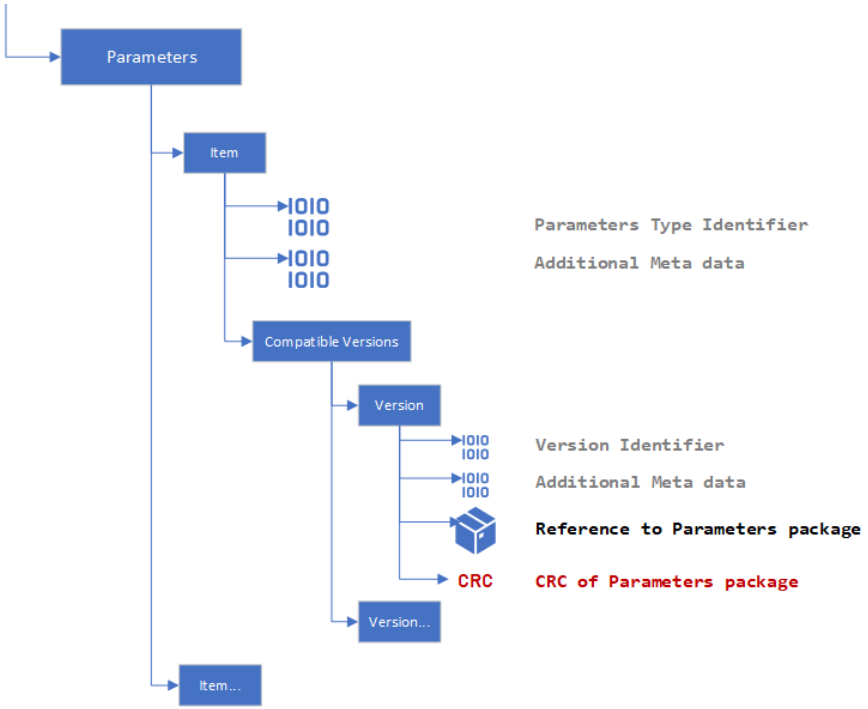


Building Block Manifest

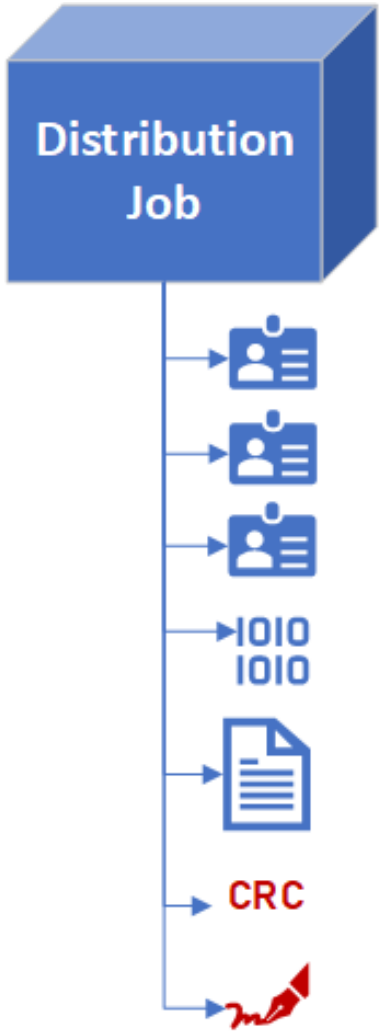


CCS-OB Manifest





Distribution Job



Job Identifier

CCS Vehicle Type Identifier

CCS Vehicle Identifier

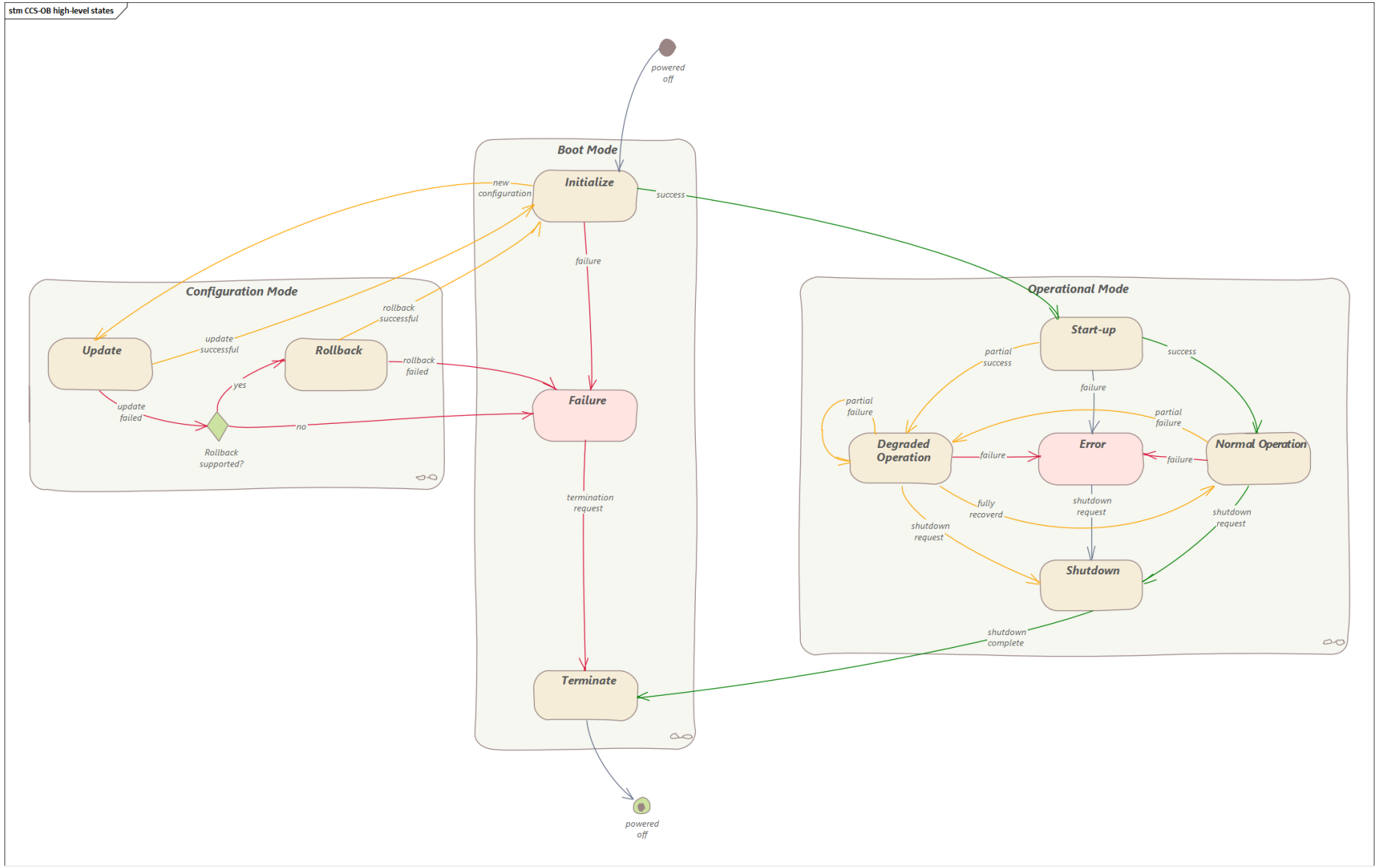
Additional Meta data

Reference to CCS-OB Manifest

CRC of CCS-OB Manifest

Cryptographically signed CRC

Building Blocks Modes & States



Functional Vehicle Adapter (FVA)

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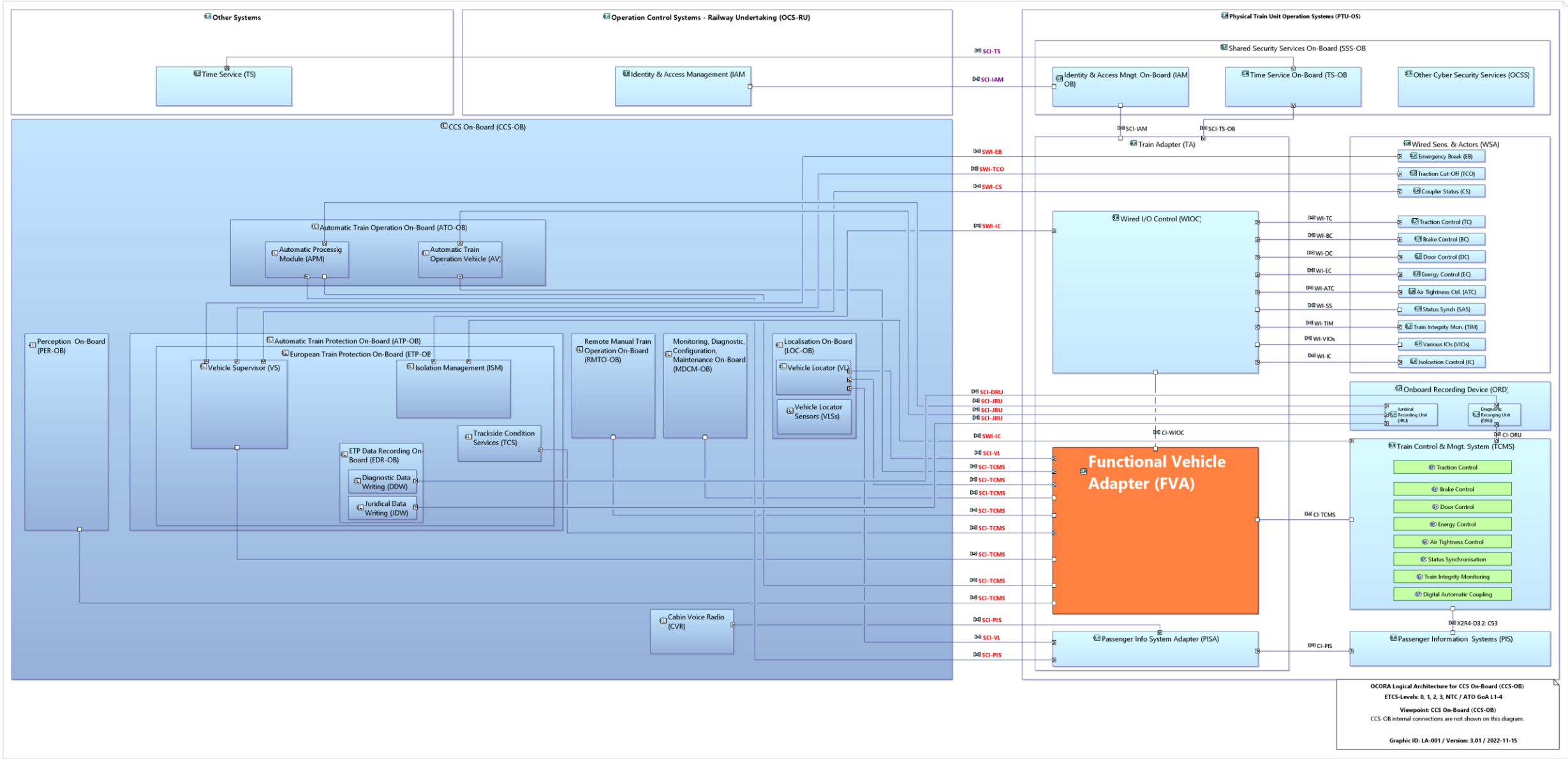
Legacy Train Example – Focus FVA Actors and External Interfaces



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

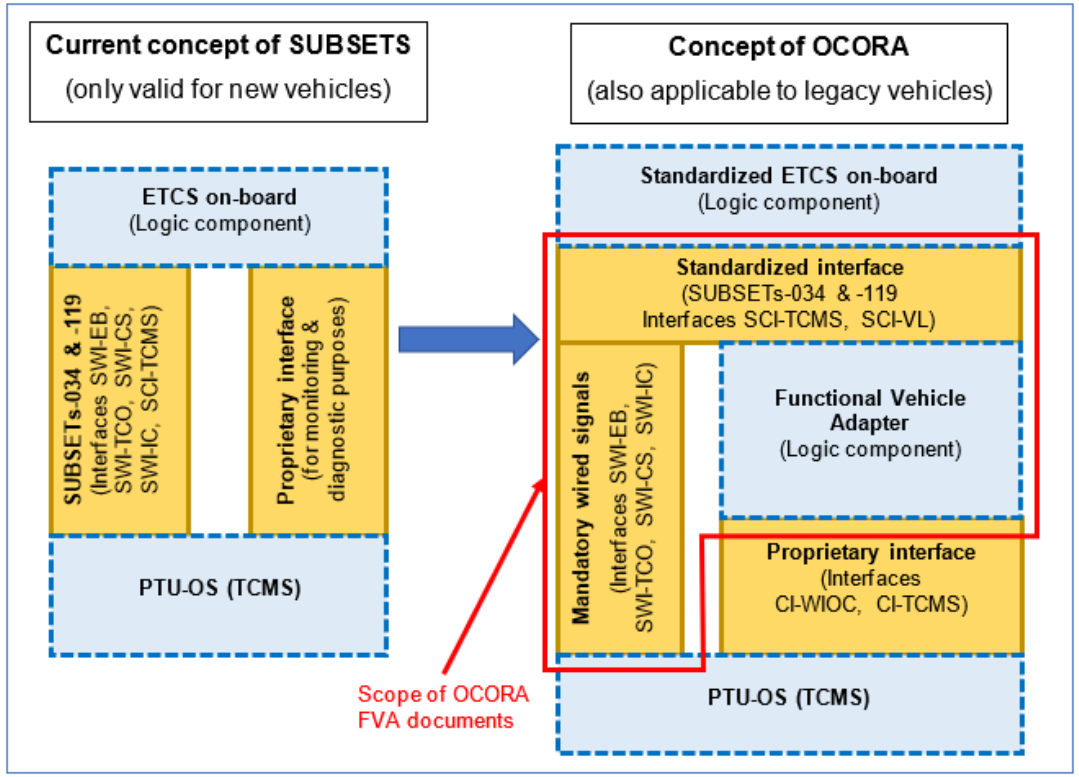
1) May be moved into the PTU-OS / LOC&PAS domain.

SS-nnn Respective subset contains information for the interface

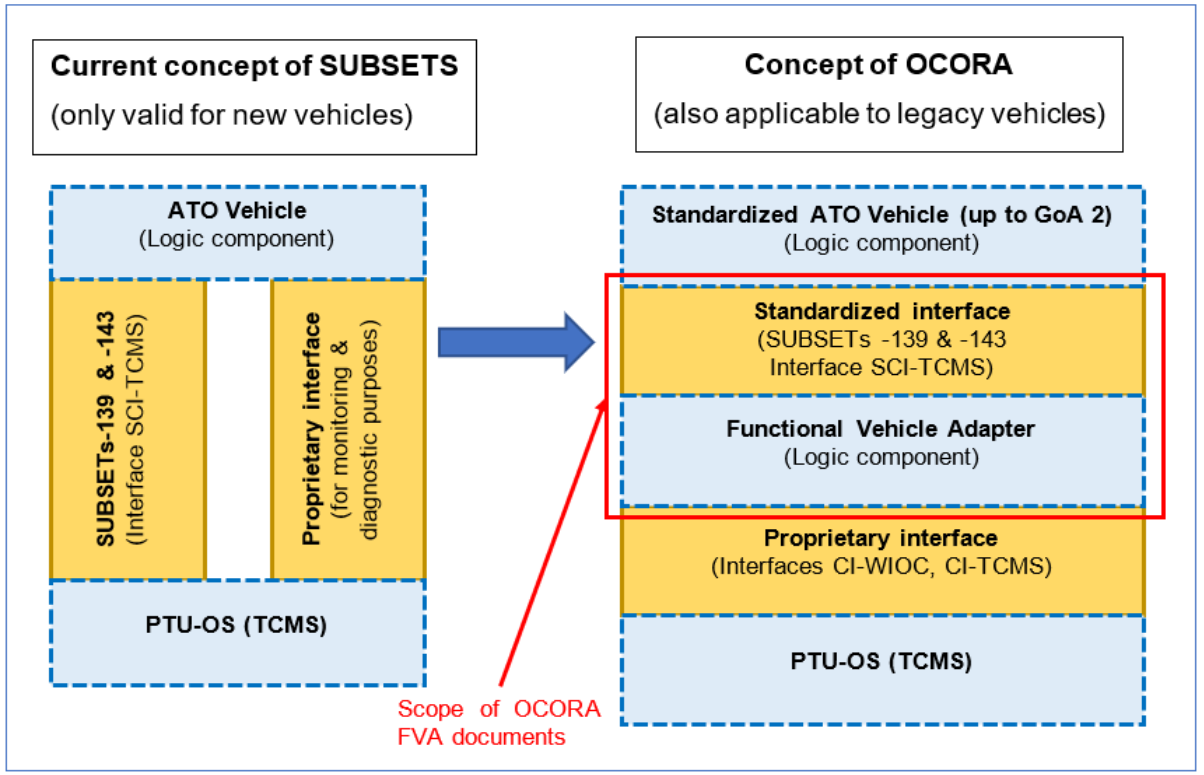
SS-nnn* Respective subset does not address the interface but should contain the information in the future.

OCORA – Functional Vehicle Adapter

ETCS



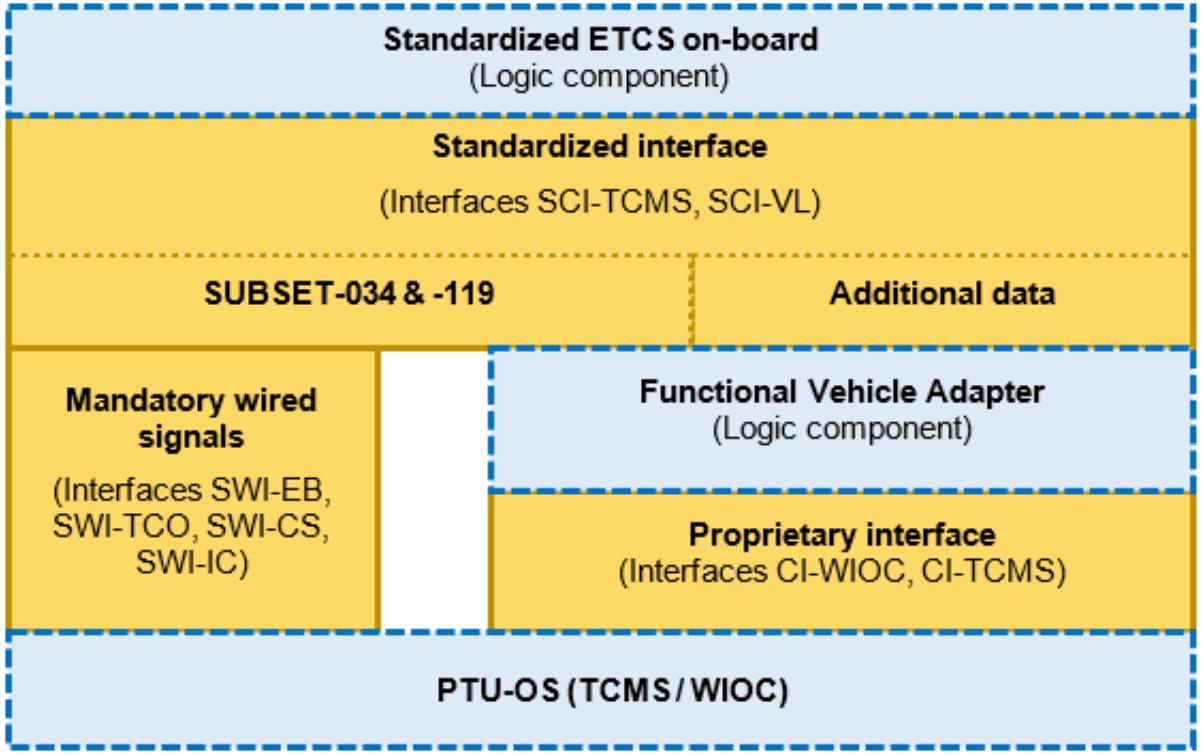
ATO



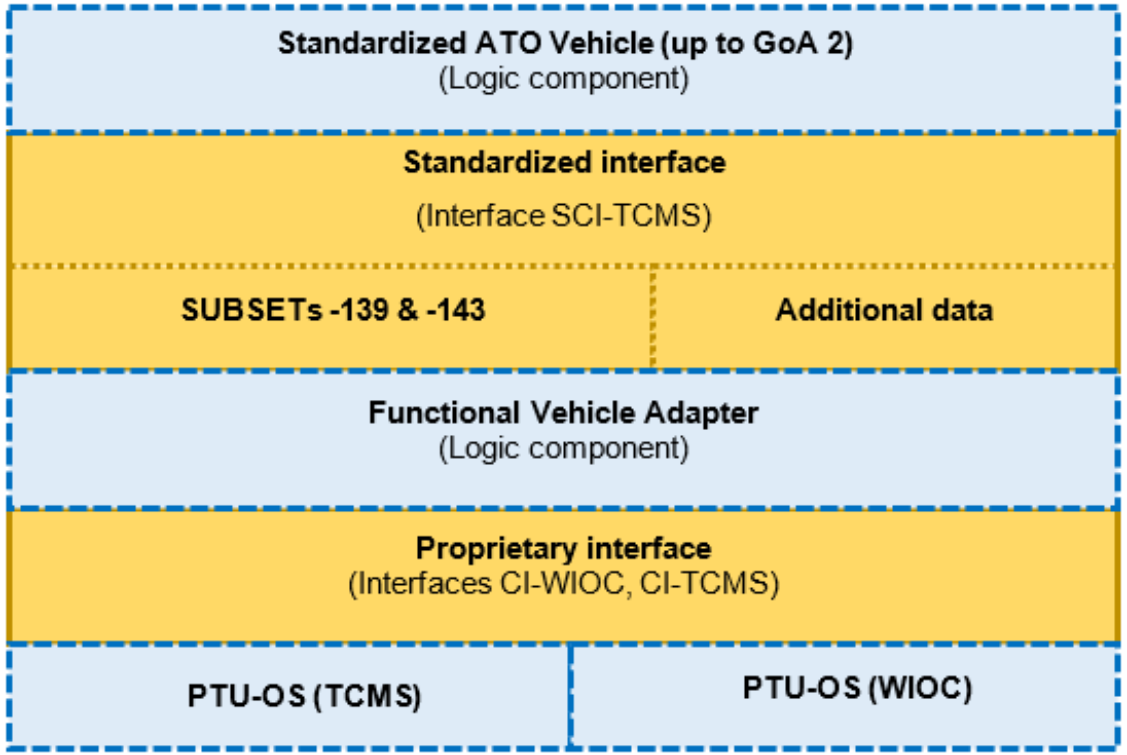
Details in Document: OCORA-TWS04-010 – Functional Vehicle Adapter - Introduction

OCORA – Functional Vehicle Adapter: Extensions

ETCS



ATO



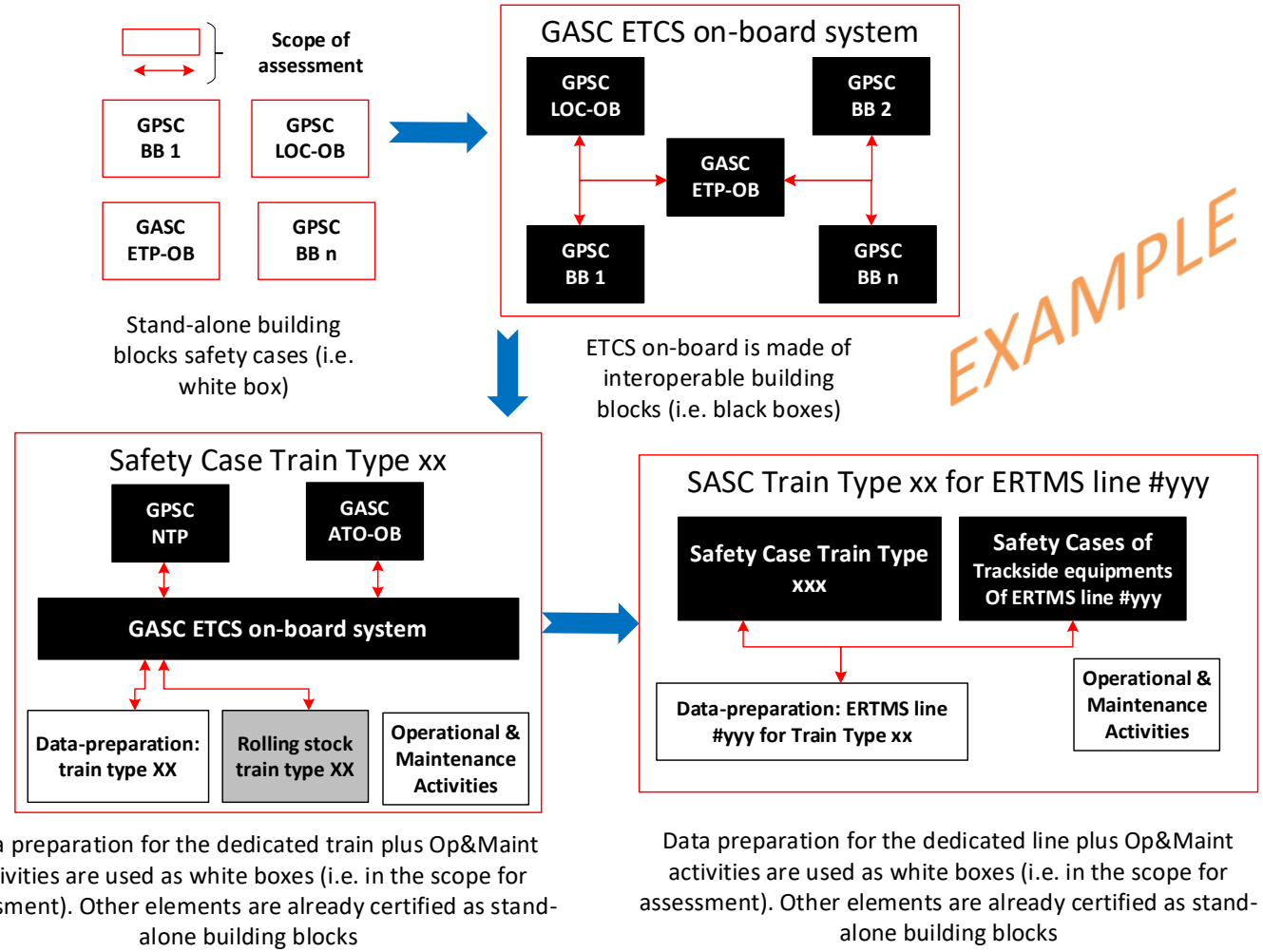
Details in Documents: OCORA-TWS04-013 – Design Guideline

Modular Safety

OCORA-BWS02-030 / v3.00 / 08.12.2022

OCORA – Modular Safety

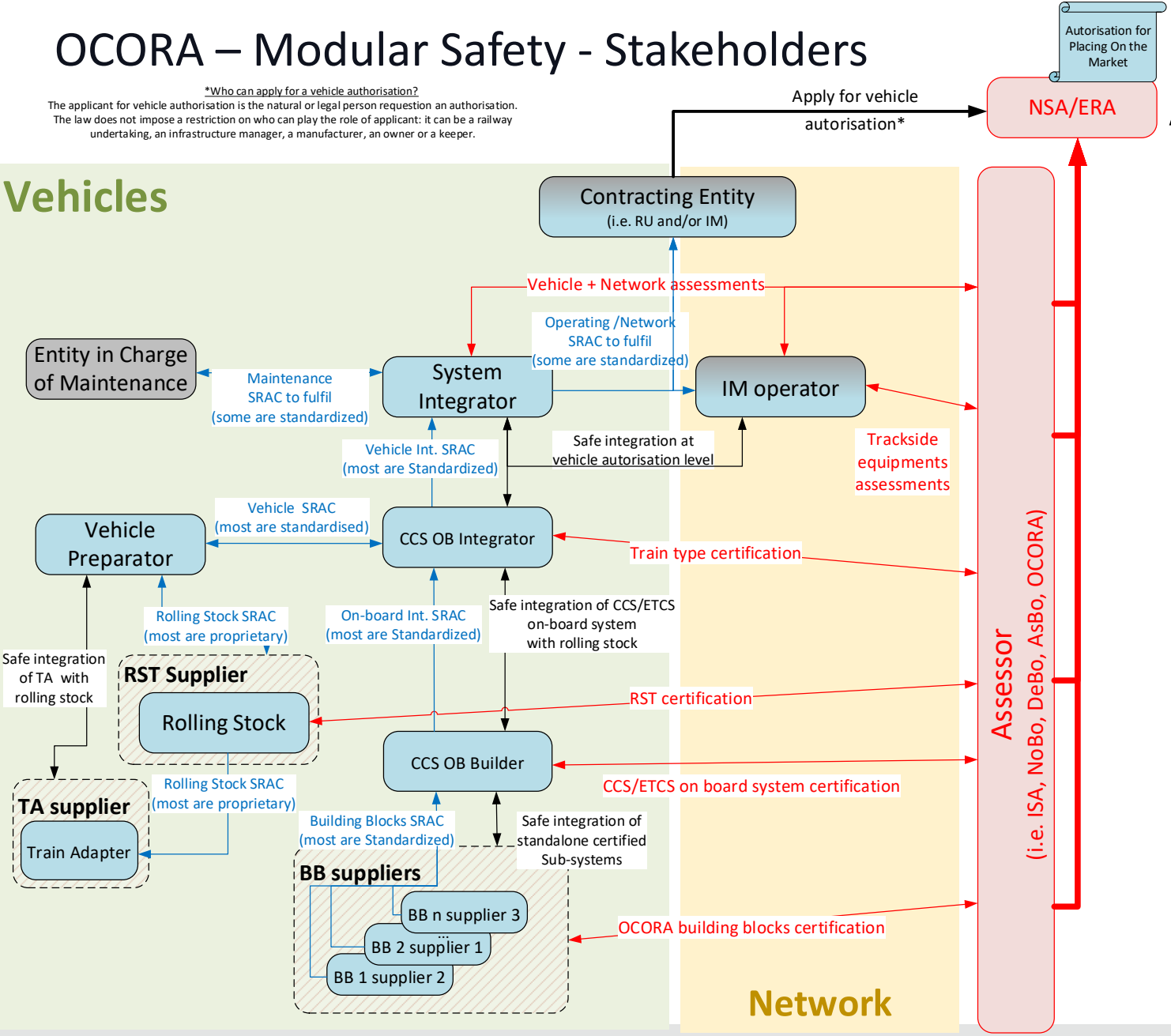
- Modular Safety defines the hierarchy between safety cases from building blocks to specific application(s).
- One of the main goal is to reduce the certification efforts from BB to specific application(s); initial and re-certification by limiting the "Domino's effect (propagation of modifications at all upper 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 R3
  - Harmonised and generic set of SRAC/AC



Data preparation for the dedicated train plus Op&Maint activities are used as white boxes (i.e. in the scope for assessment). Other elements are already certified as stand-alone building blocks

Data preparation for the dedicated line plus Op&Maint activities are used as white boxes (i.e. in the scope for assessment). Other elements are already certified as stand-alone building blocks

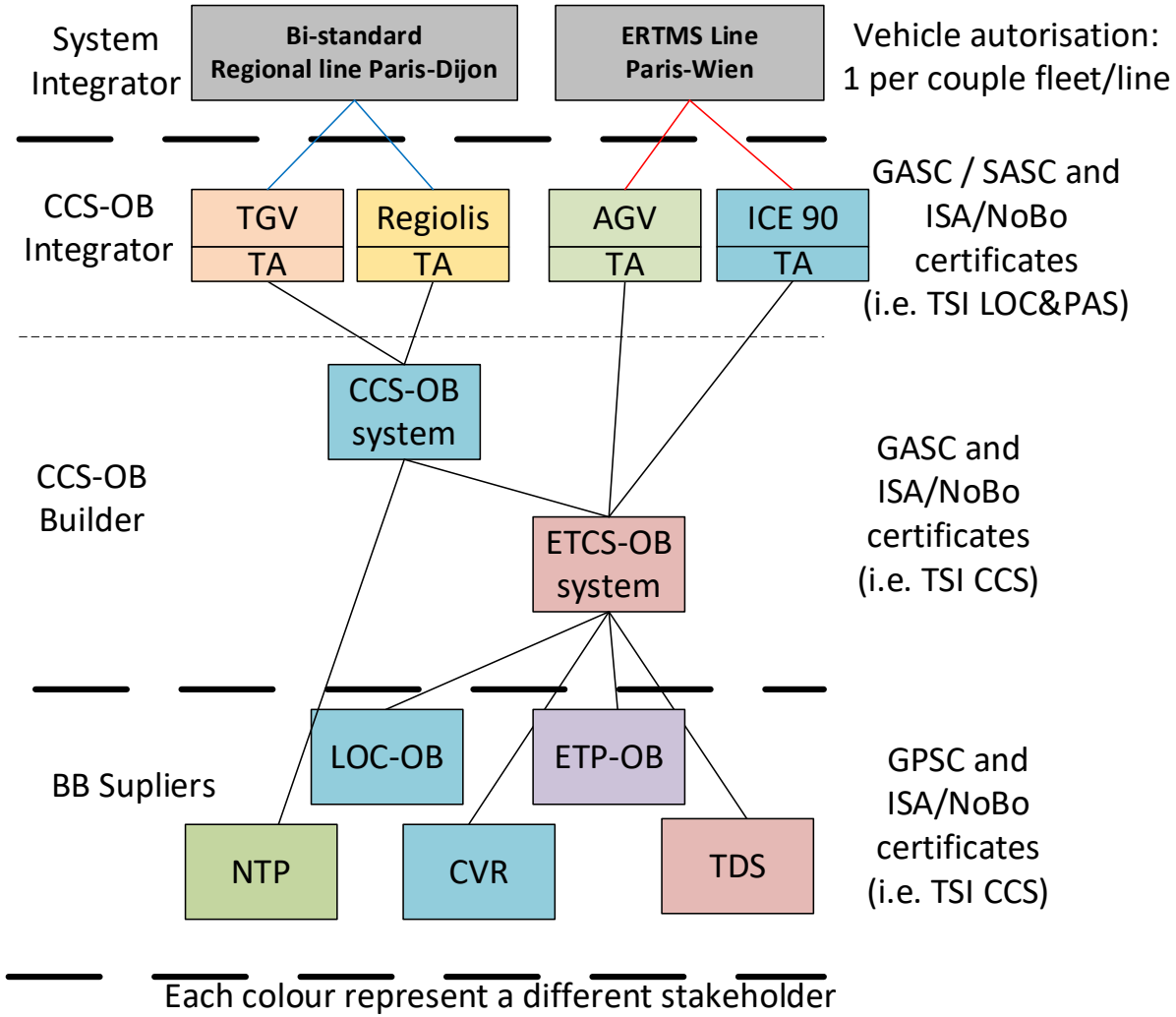
OCORA – Modular Safety - Stakeholders



- **BB suppliers** shall create the building the BB and ensuring their certification (NoBo, OCORA, ISA…)
- **CCS-OB Builder** shall ensure the *safe integration* of the different BB and ensure its certification (NoBo, OCORA, ISA…)
- **TA Supplier** shall provide the train adapter according to the Vehicle Environment and ensure its certification (NoBo, OCORA, ISA…)
- **Vehicle Preparator** shall perform the *safe integration* of the TA in the Vehicle Environment
- **CCS-OB Integrator** shall perform the *safe integration* of the CCS-OB system in the prepared vehicle and ensure its certification (NoBo, OCORA, ISA/AsBo…)
- **System Integrator** in collaboration with the IM shall perform the *safe integration* of the full Vehicle in the selected network and ensure its certification (NoBo, DeBo, AsBo…)
- **Contracting Entity** shall realise the call for tenders for all stakeholders and the handle the final Authorisation for Placing on the Market with the NSA/ERA

safe integration scope of activities is defined into:
era_1209-063_clarification_note_on_safe_integration_en

Key roles



Case of two independent systems made of building blocks from different suppliers

- Different *reference systems* can be created:
  - ETCS-OB
  - CCS-OB
- The *reference systems* can be reused in any type of train thanks to the Train Adapters
- No re-certification is required for them => cross acceptance rules defined by OCORA are respected
- A reference system at train and then at system levels can be created and reuse as basis for all other vehicles equipped with the CCS/ETCS-OB system. Certifications focuses on the different conditions of use (to be defined post OCORA R3)
- That mutualises projects resources at RU's level on similar fleets and ease the process to get the Authorisation for Placing on the Market
- For the next certifications steps (during the lifetime), a generic and systematic approach defined by OCORA, based on CSM-RA will then help any stakeholder to handle easier (I.e. less delay and costs than today) the evolutions at any level

OCORA – Modularity & Integration Tasks

➔ System Integrator

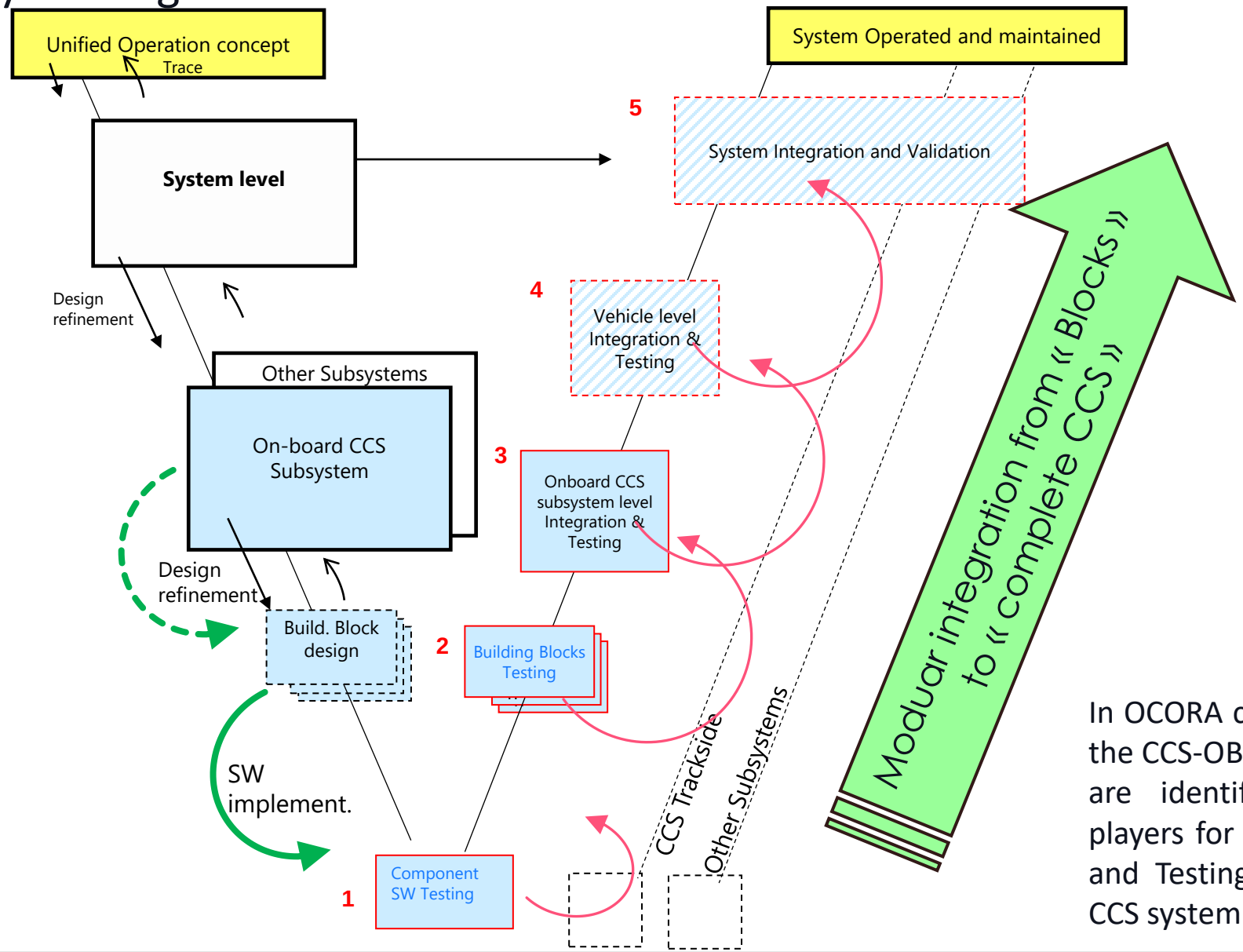
➔ CCS-OB Integrator

➔ CCS-OB Builder

➔ Building Blocks Suppliers

Scope of OCORA

1, 2..: integration steps



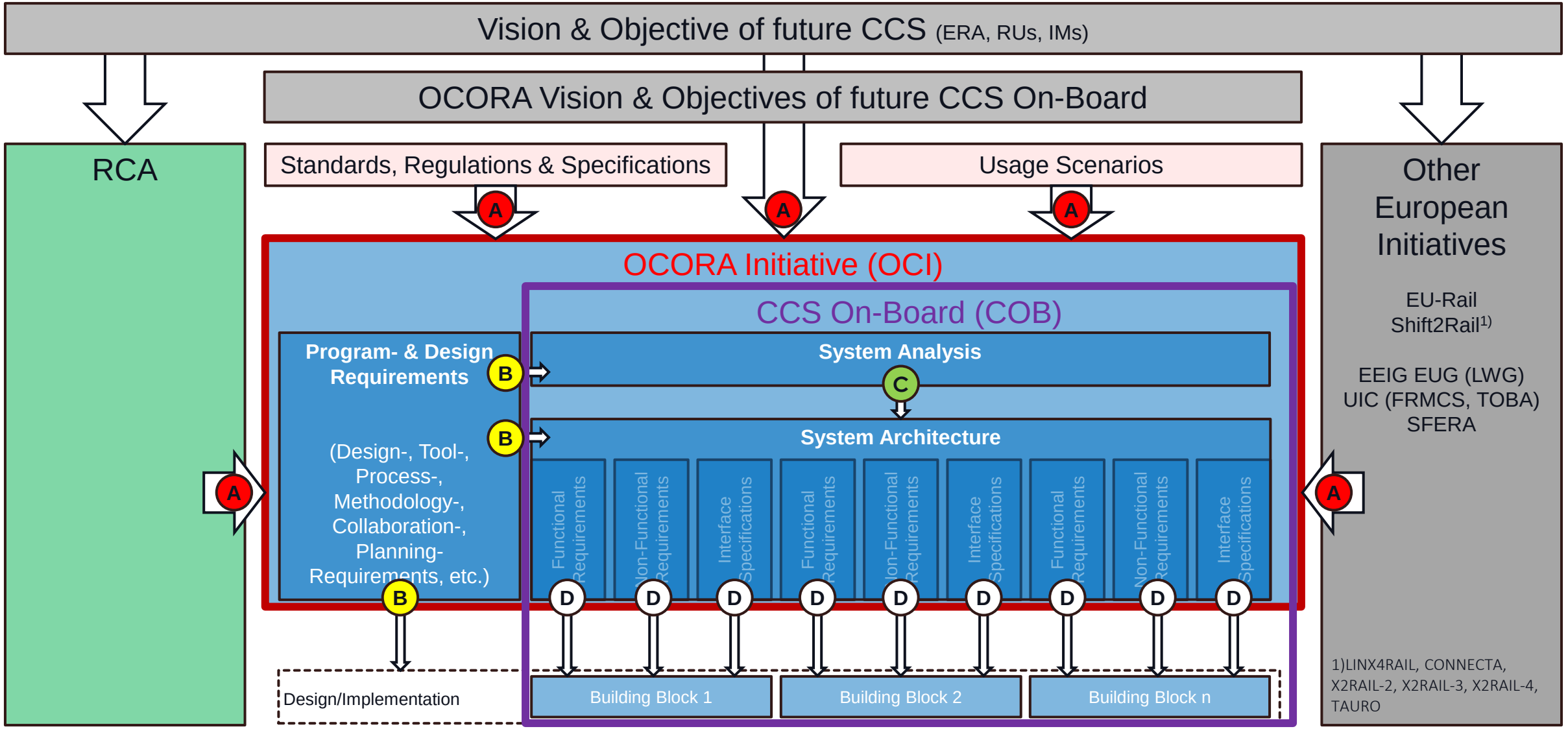
In OCORA compliant projects, the CCS-OB builder/integrator are identified as the key players for Safety, Integration and Testing of the on-board CCS system.

Methodology & Tooling

OCORA-BWS02-030 / v3.00 / 08.12.2022

OCORA Requirements Engineering

Structuring the Requirements



OCORA Requirements Engineering

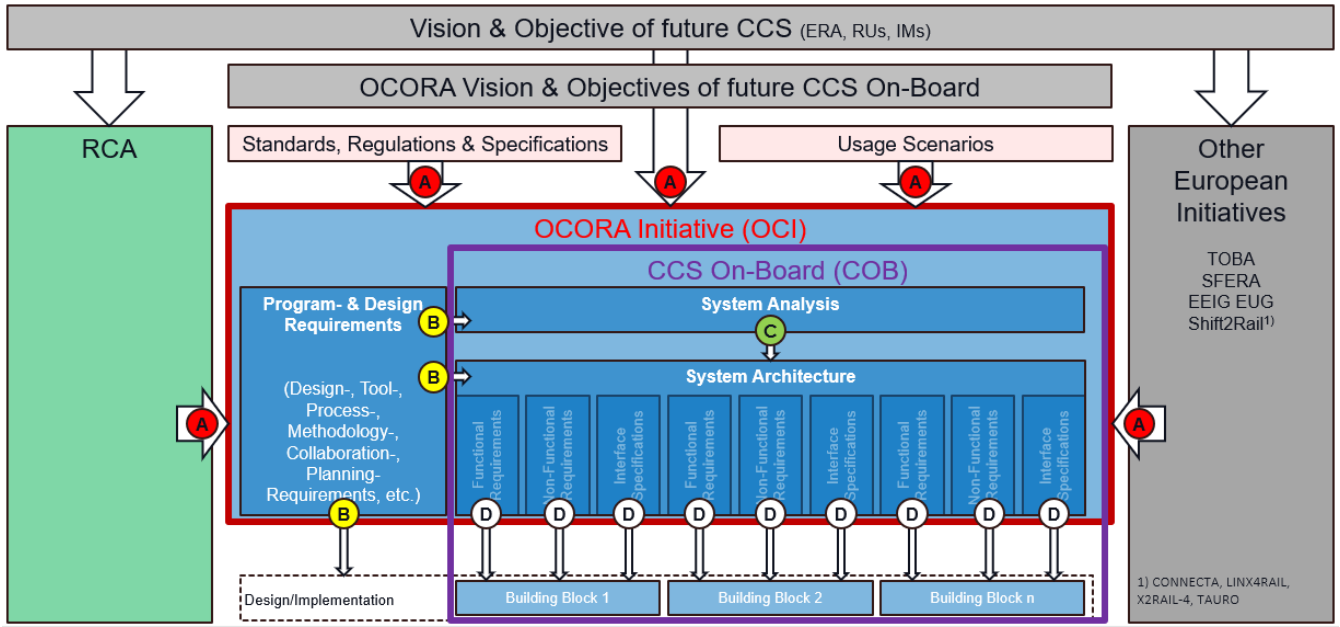
Requirement Definitions

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

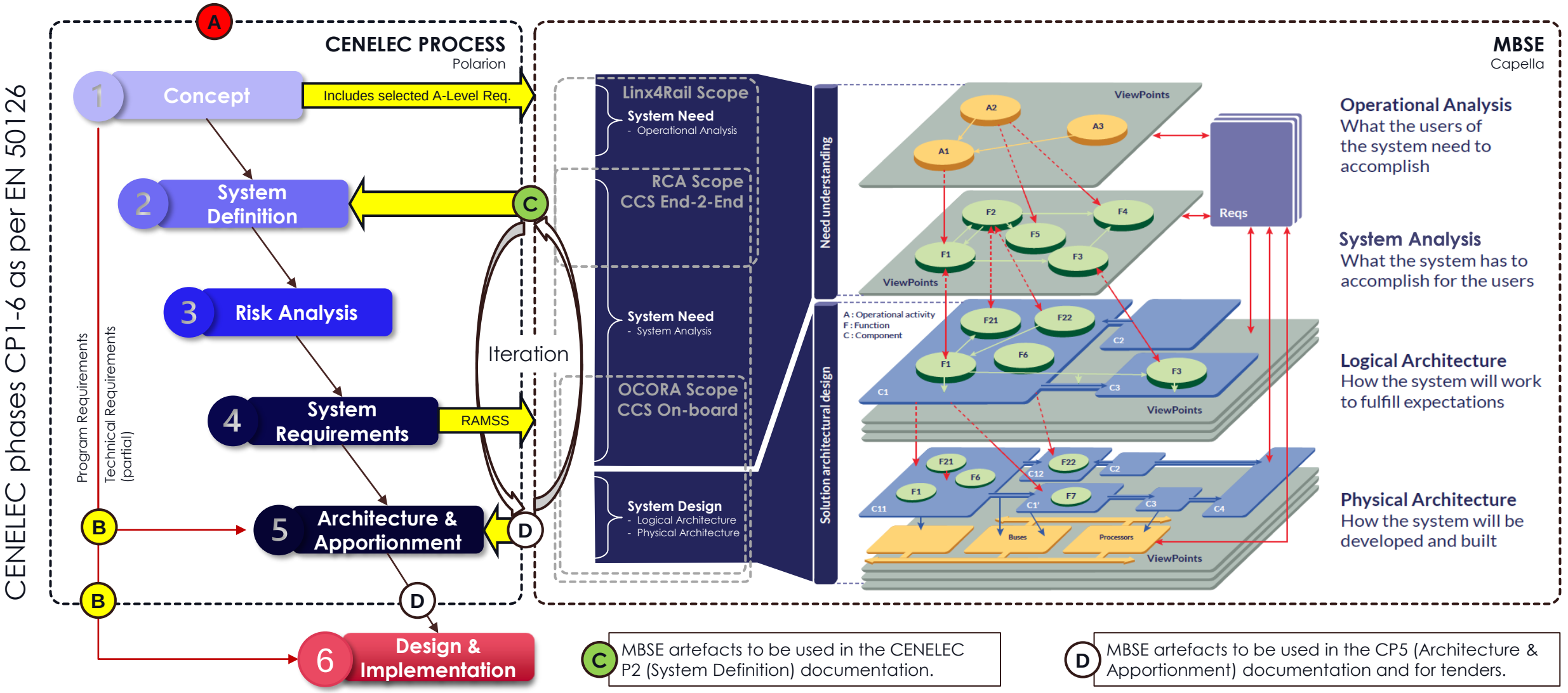
B **Program- & Design Requirements:** The OCORA program defines tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.

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.



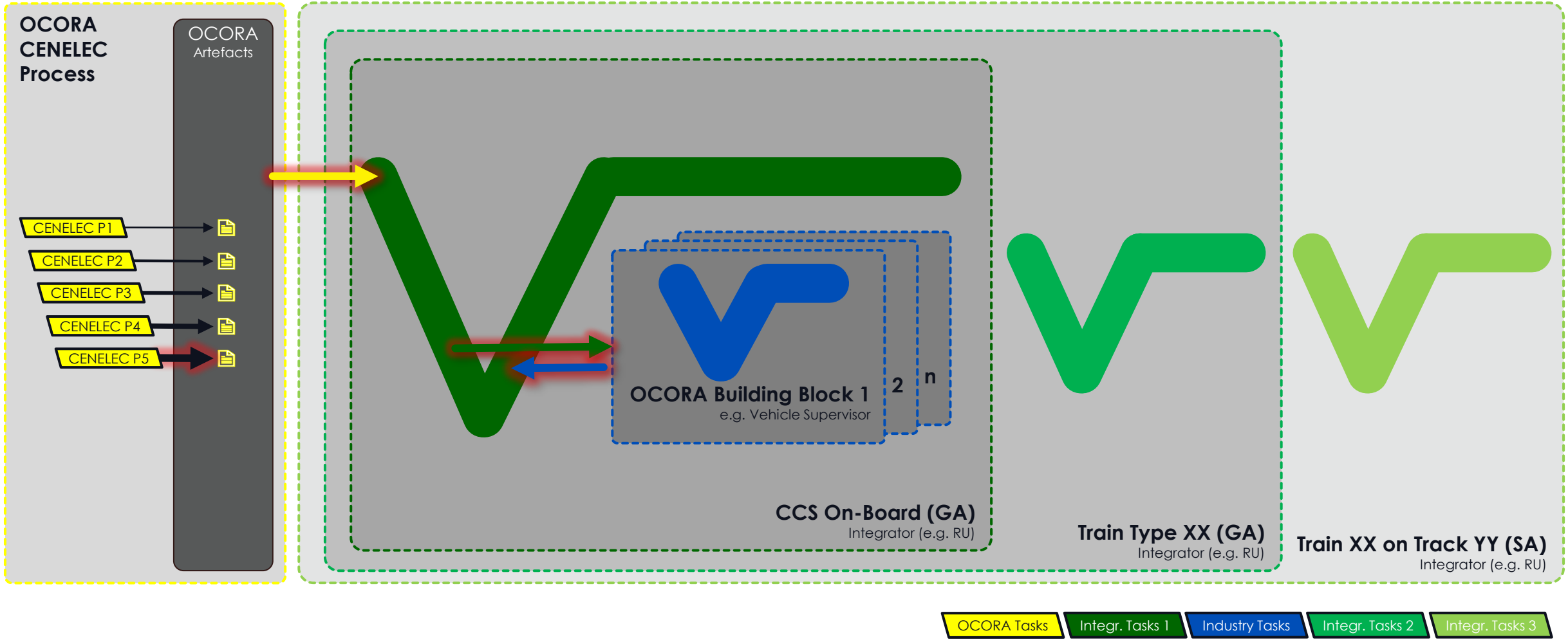
Interaction between CENELEC Process and MBSE



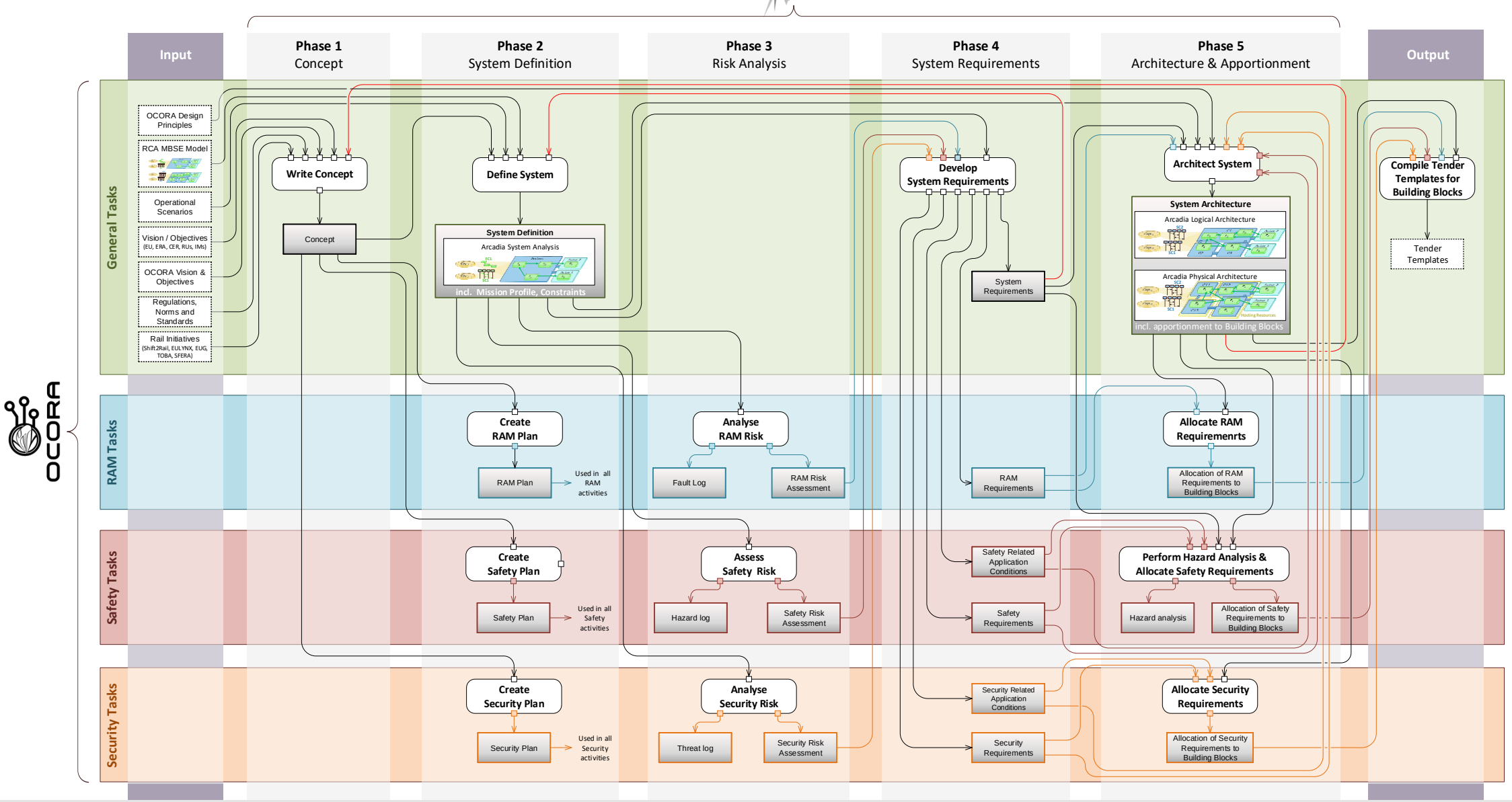
C MBSE artefacts to be used in the CENELEC P2 (System Definition) documentation.

D MBSE artefacts to be used in the CP5 (Architecture & Apportionment) documentation and for tenders.

OCORA in Context of the relevant CENELEC Projects



OCORA CENELEC Process

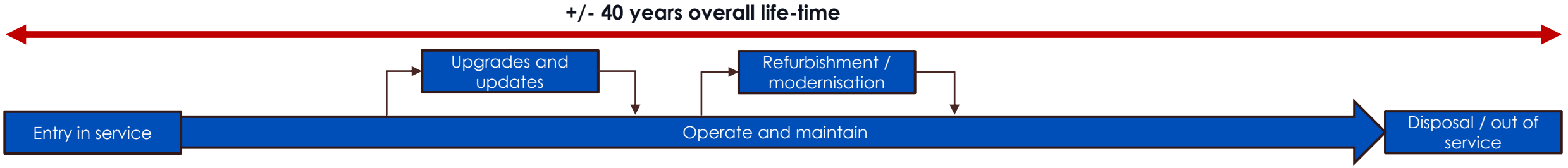


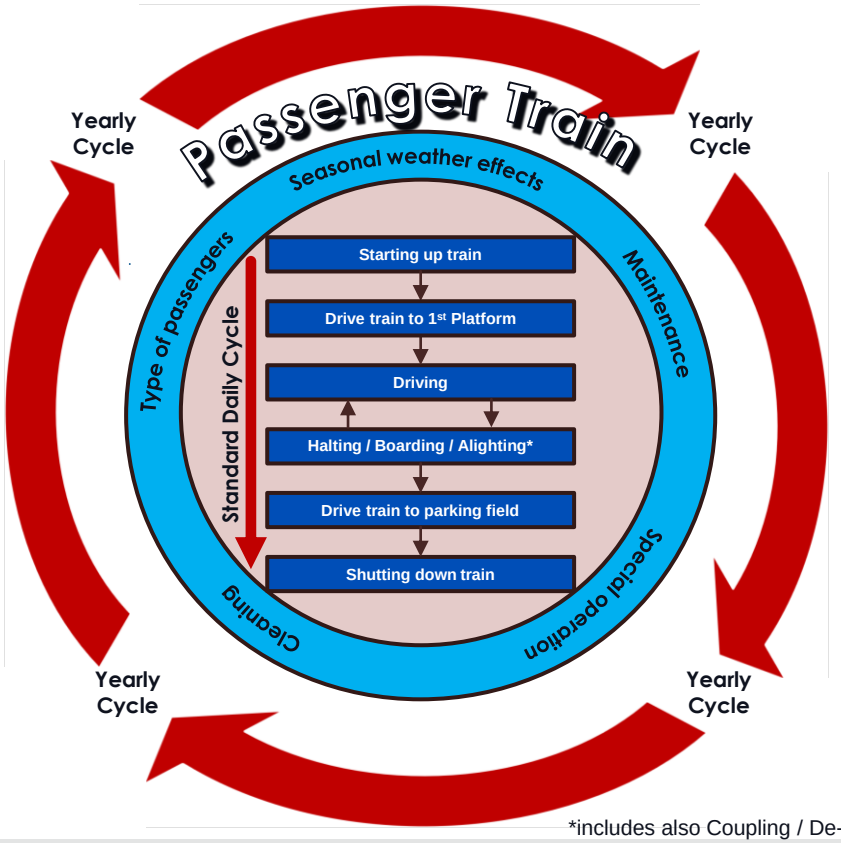
Operational Concept

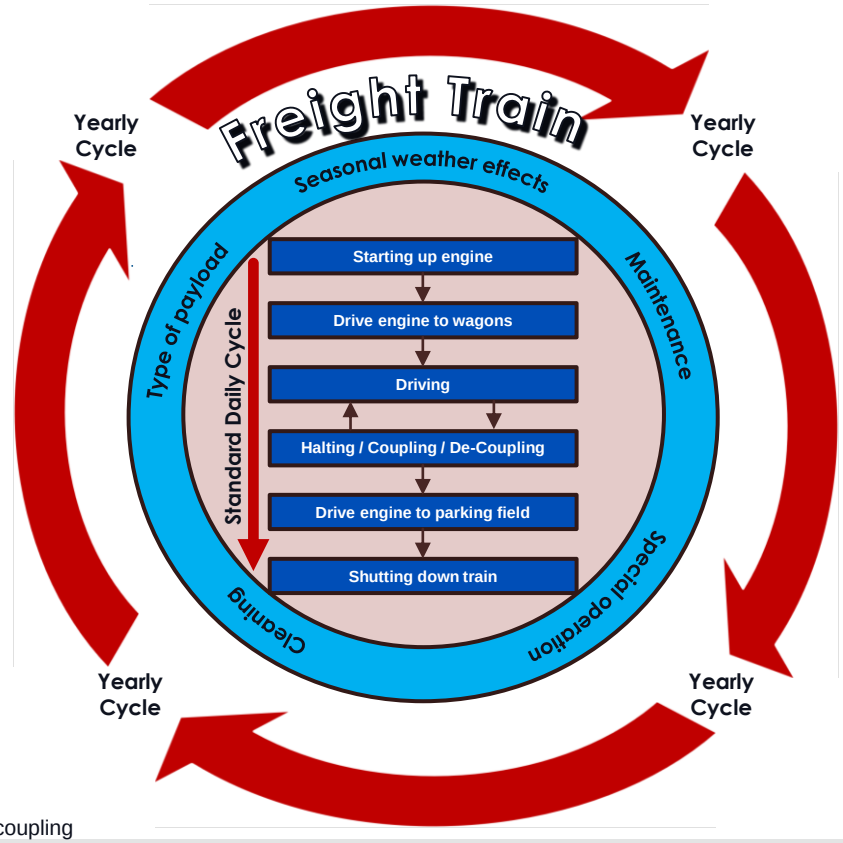
OCORA-BWS02-030 / v3.00 / 08.12.2022

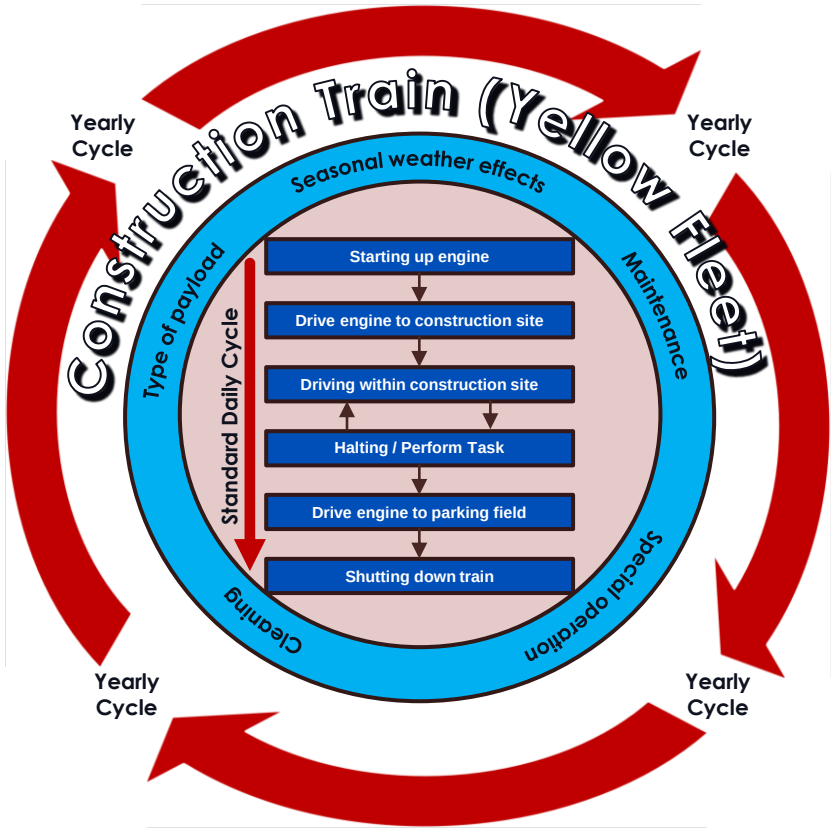
Operational Concept Overview

Live Cycle of Passenger, Freight, and Construction Trains







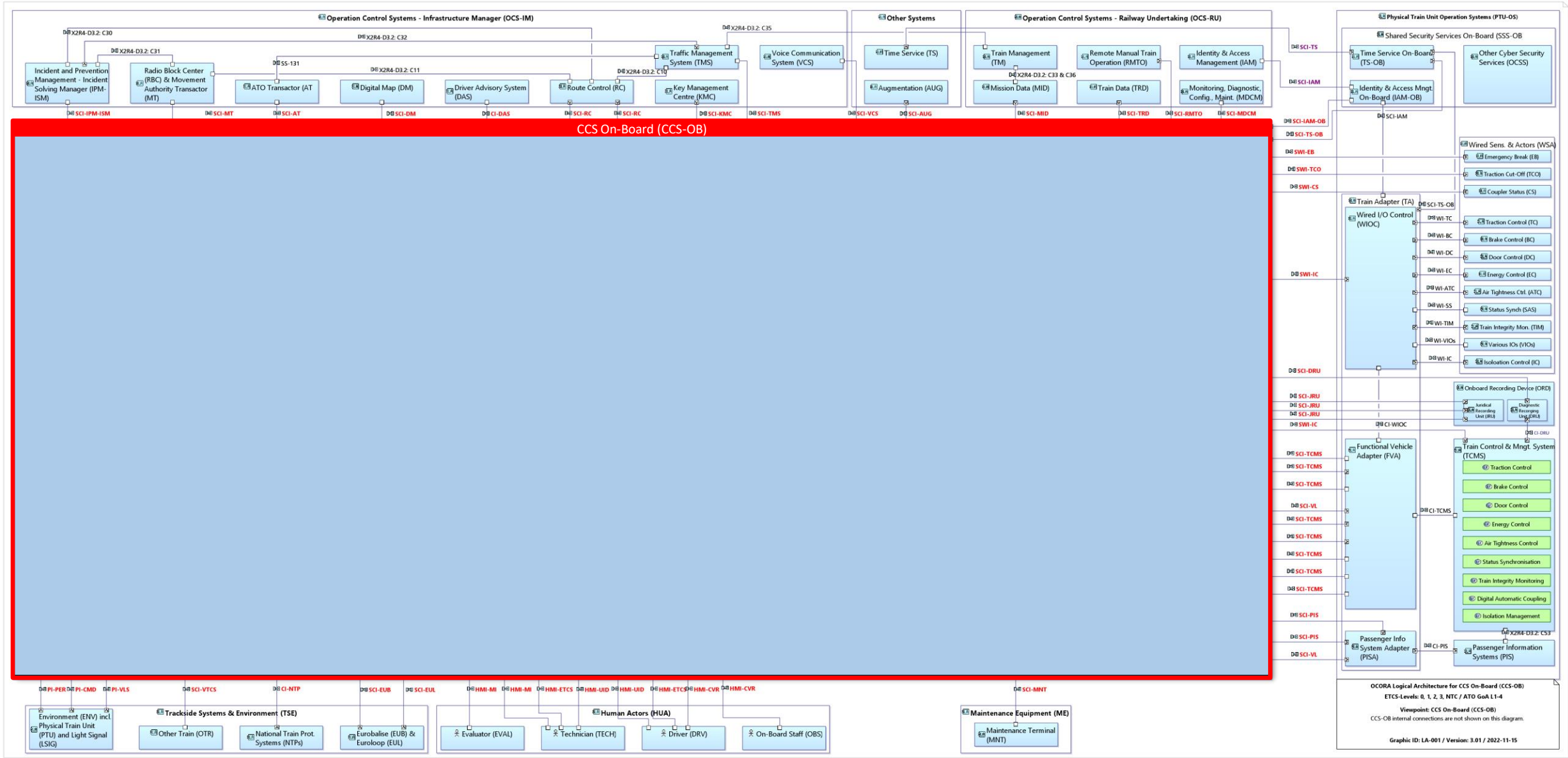


*includes also Coupling / De-coupling

OCORA Release R2 Style Graphics

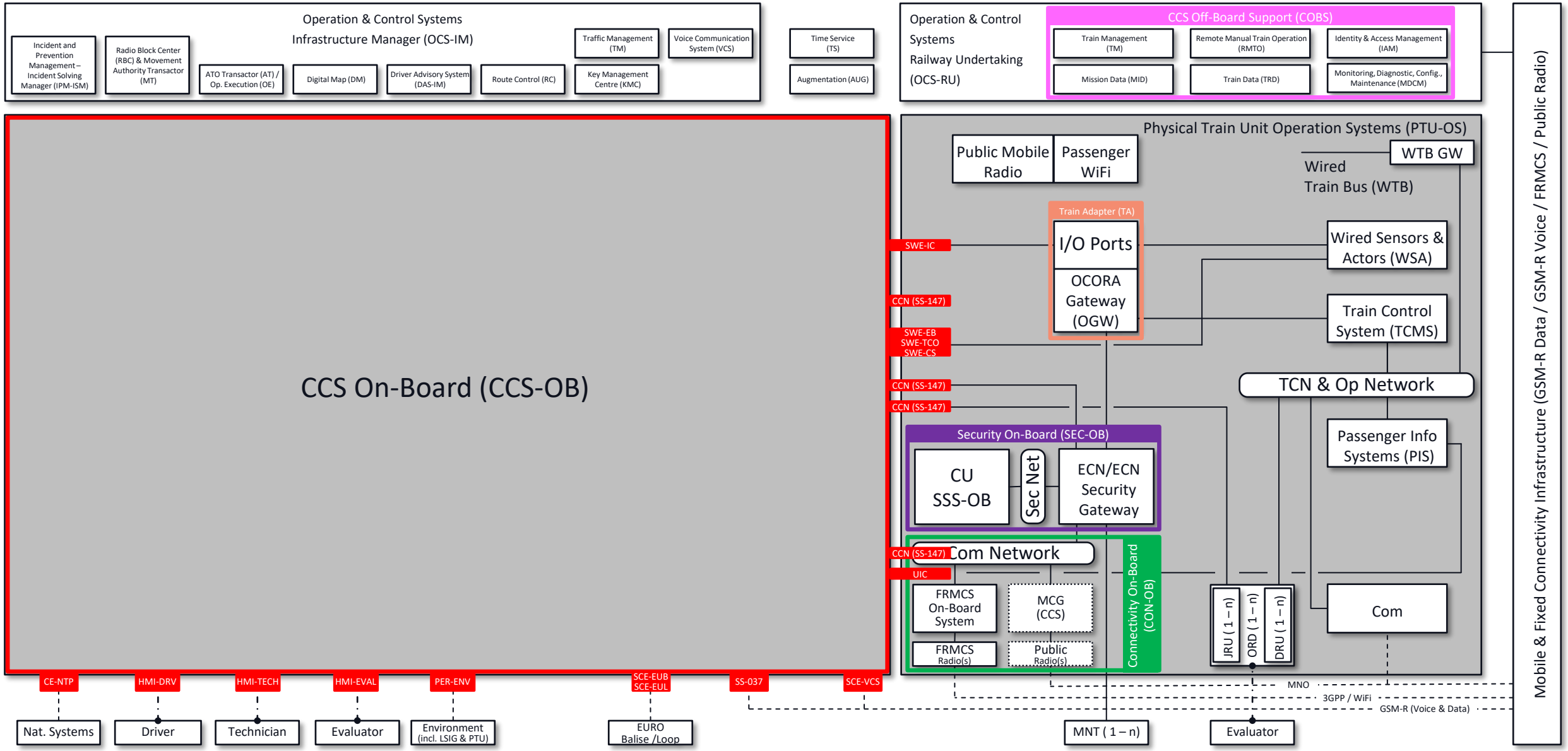
OCORA-BWS02-030 / v3.00 / 08.12.2022

External Logical Interfaces (Legacy Train Example)



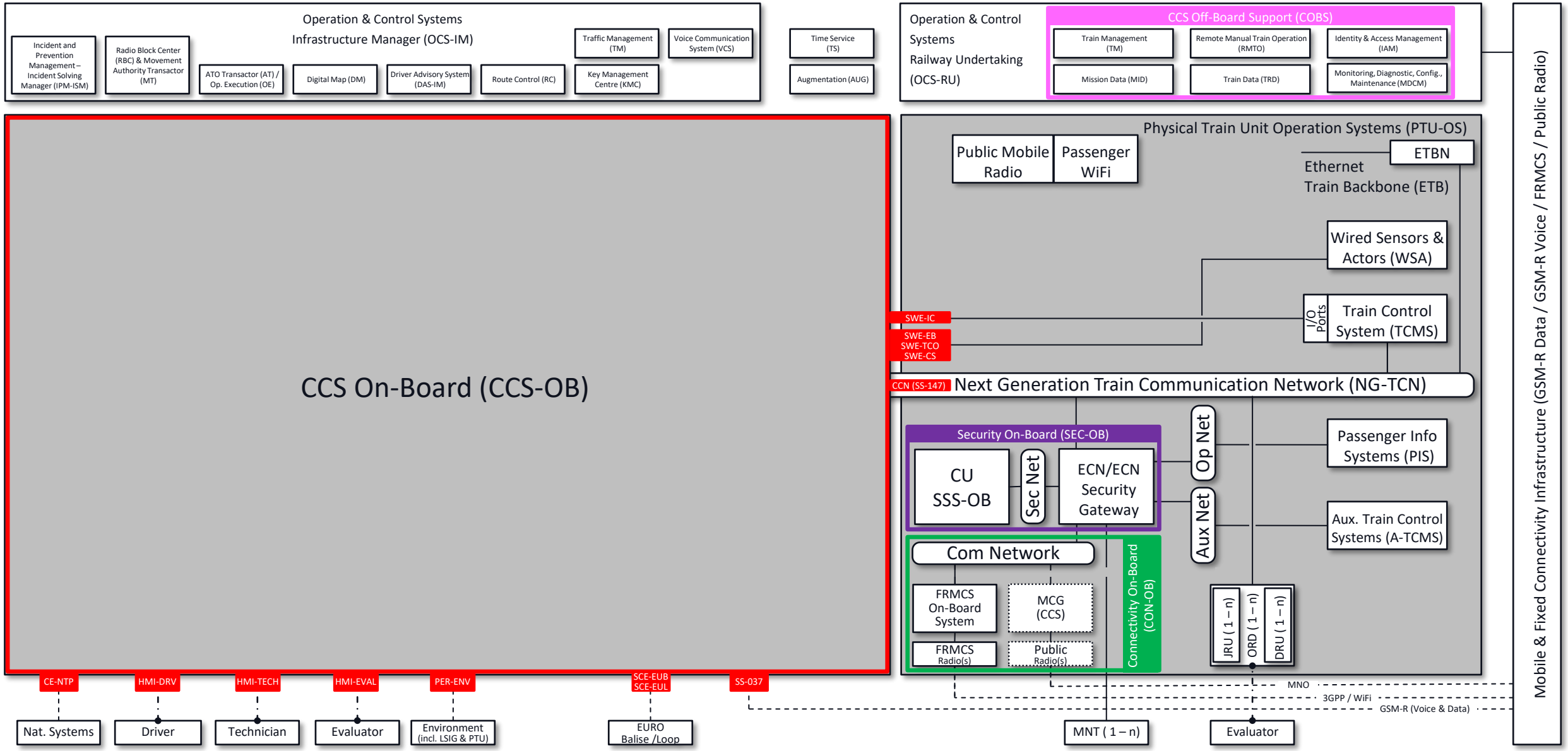
1) May be moved into the PTU-OS / LOC&PAS domain.

External Physical Component Exchange (Legacy Train Example)



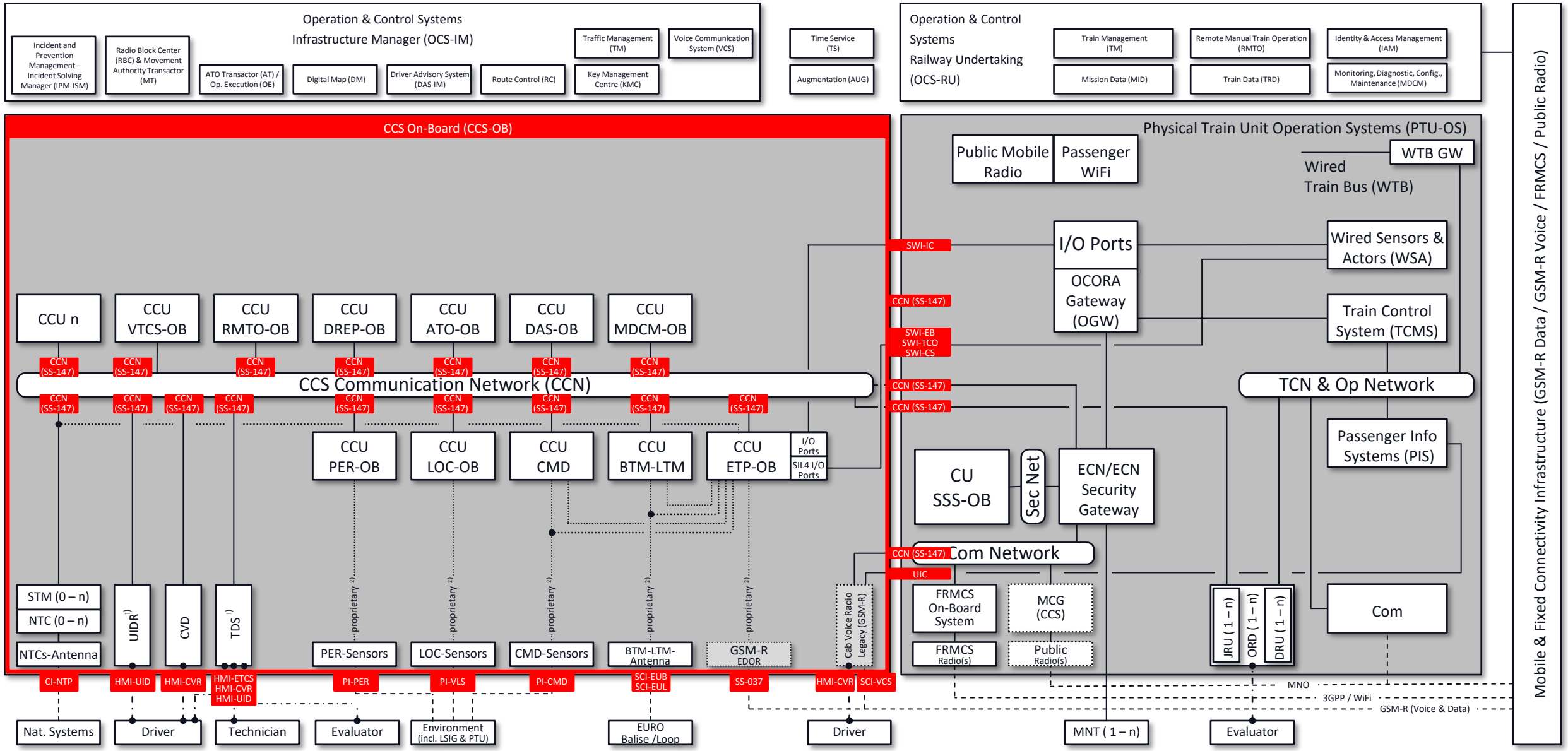
Remark: solid lines indicate wired connections, dashed lines "over the air" communication, dotted lines represent proprietary connections, and dashed-dotted lined represent user interactions.

External Physical Component Exchange (New Generation Train)



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

Reference Hardware Block Diagram (Legacy Train Example / no Safe Computing Platform)

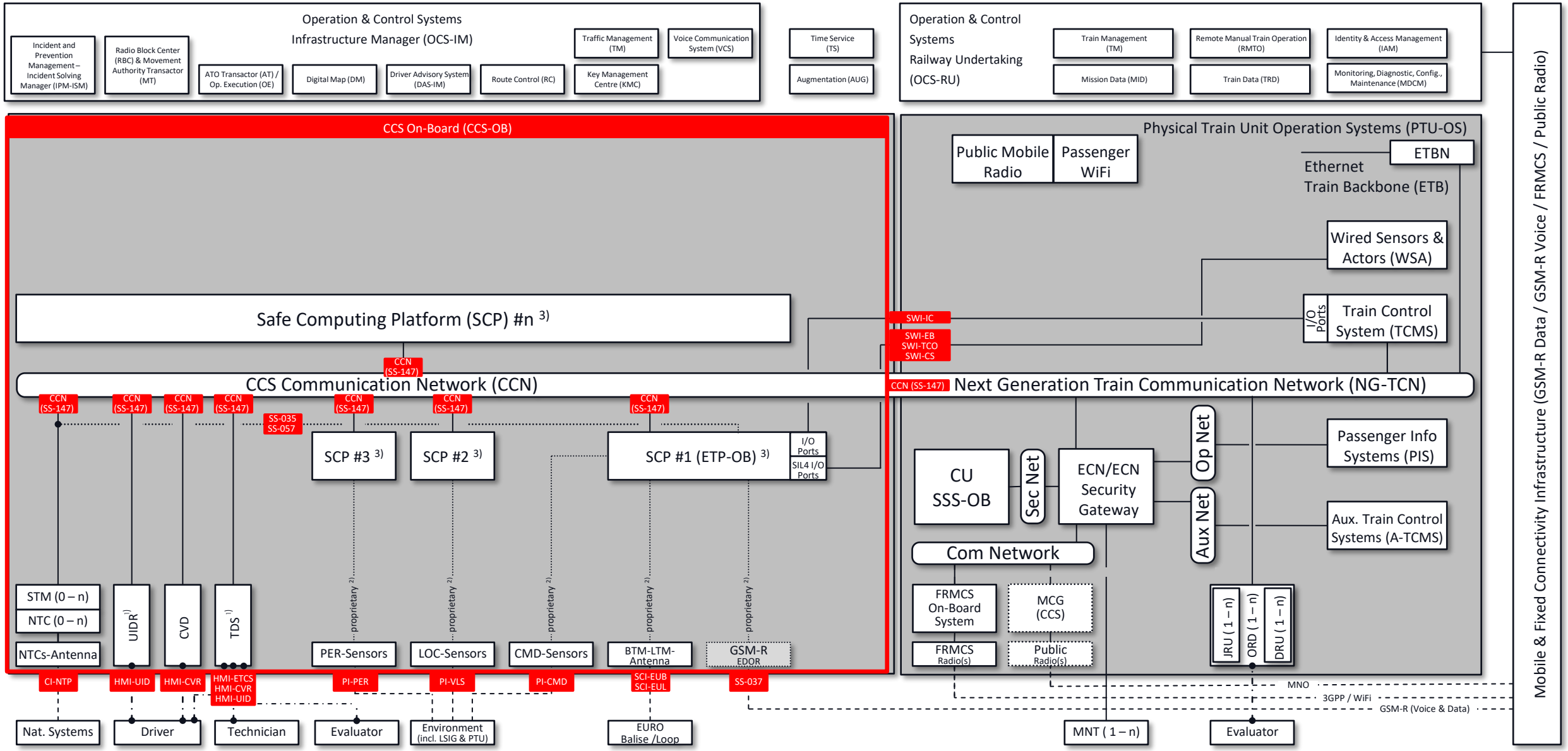


Remark: solid lines indicate wired connections, dashed lines "over the air" communication, dotted lines represent proprietary connections, and dashed-dotted lined represent user interactions.

1) TDS & UIDR 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.

Reference Hardware Block Diagram (Legacy Train Example / with Safe Computing Platform)



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

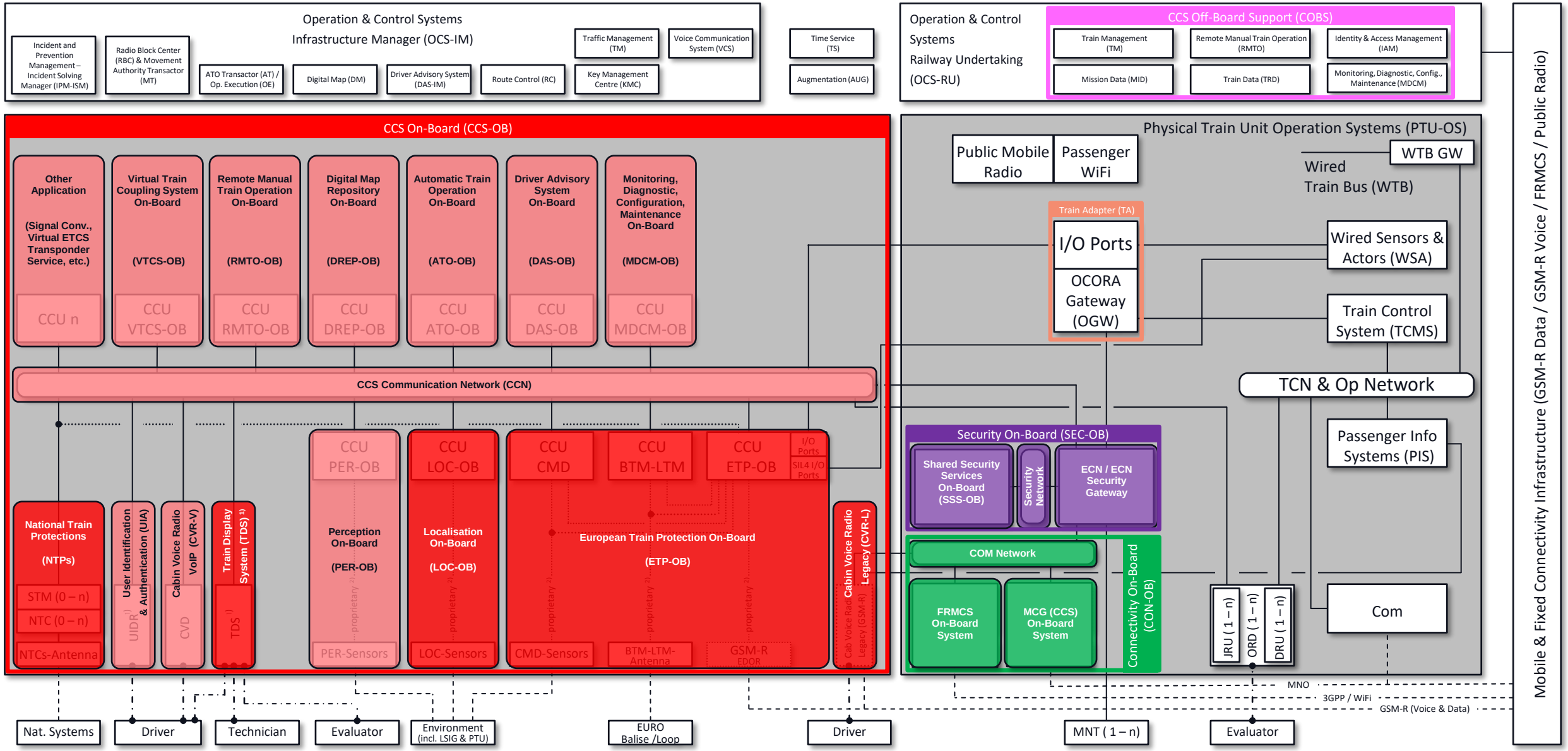
1) TDS & UIDR may be moved into the PTU-OS / LOC&PAS domain.

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.

3) The number of SCPs depend on the required CCS-OB functionality and the physical needs of the required/hosted functions (applications).

Scenario 1

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



Current CCS-OB Functionality

Future CCS-OB Functionality

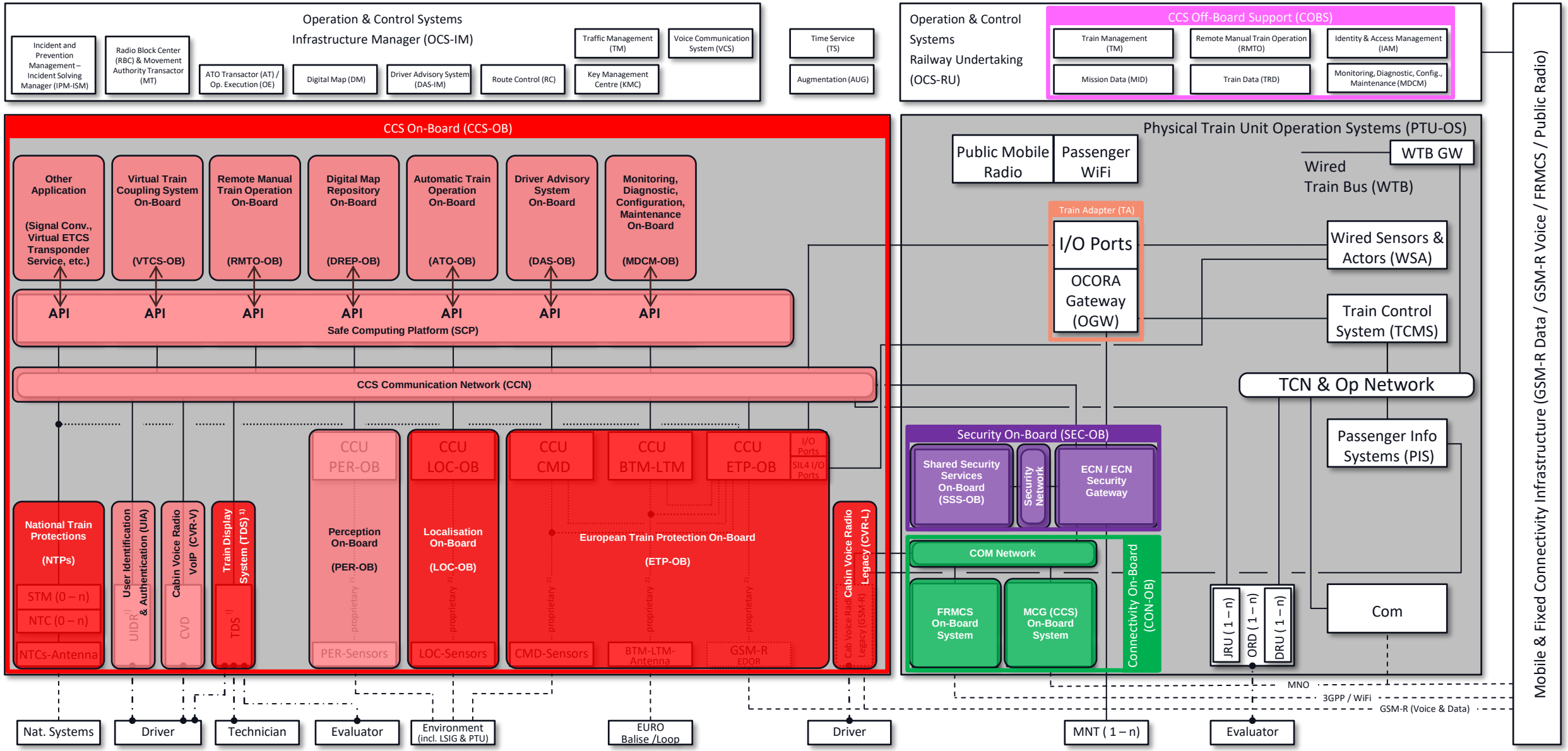
Remark: solid lines indicate wired connections, dashed lines "over the air" communication, dotted lines represent proprietary connections, and dashed-dotted lined represent user interactions.

1) TDS & UIDR 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.

Scenario 2

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



Current CCS-OB Functionality

Future CCS-OB Functionality

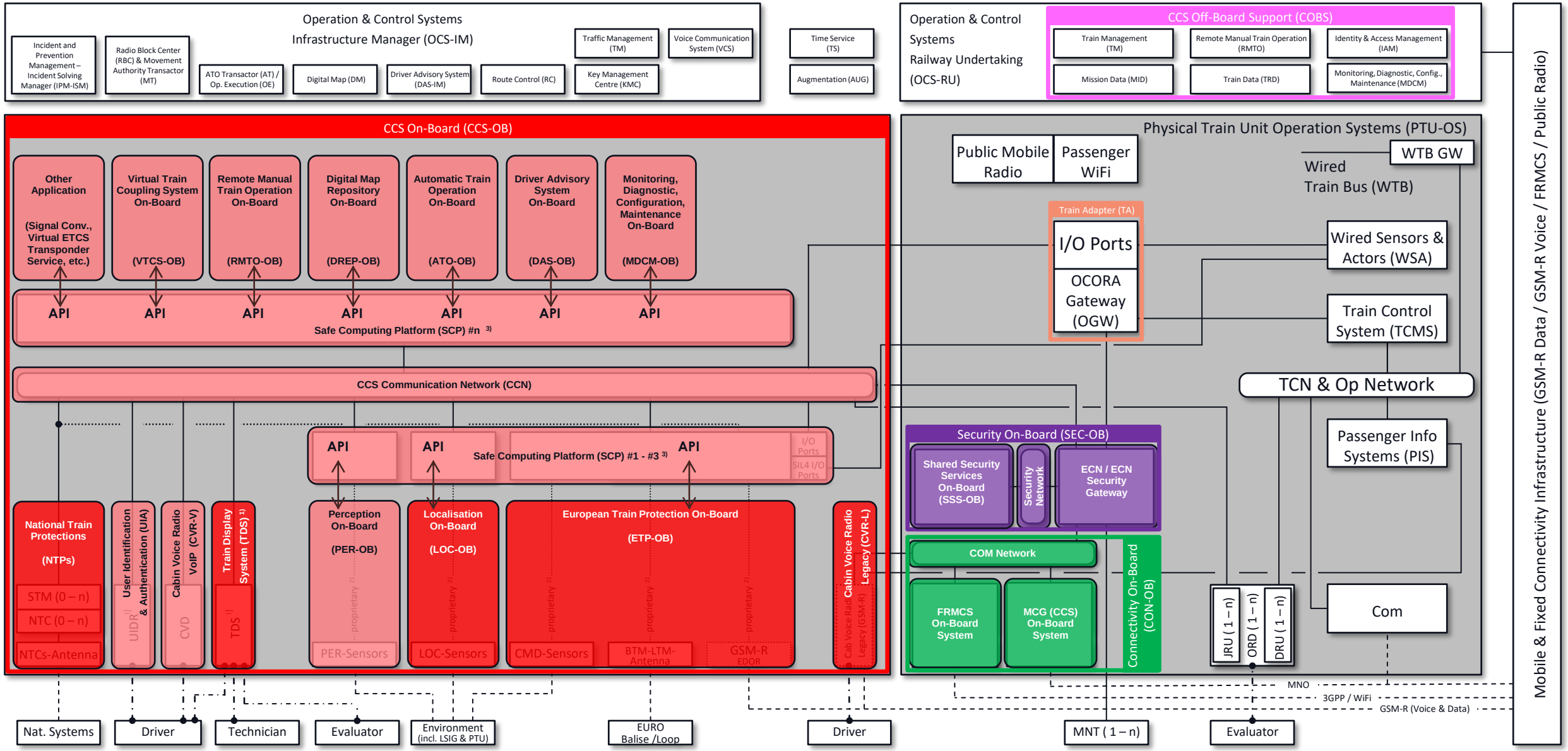
Remark: solid lines indicate wired connections, dashed lines "over the air" communication, dotted lines represent proprietary connections, and dashed-dotted lined represent user interactions.

1) TDS & UIDR 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.

Scenario 3

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



Current CCS-OB Functionality | Future CCS-OB Functionality

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

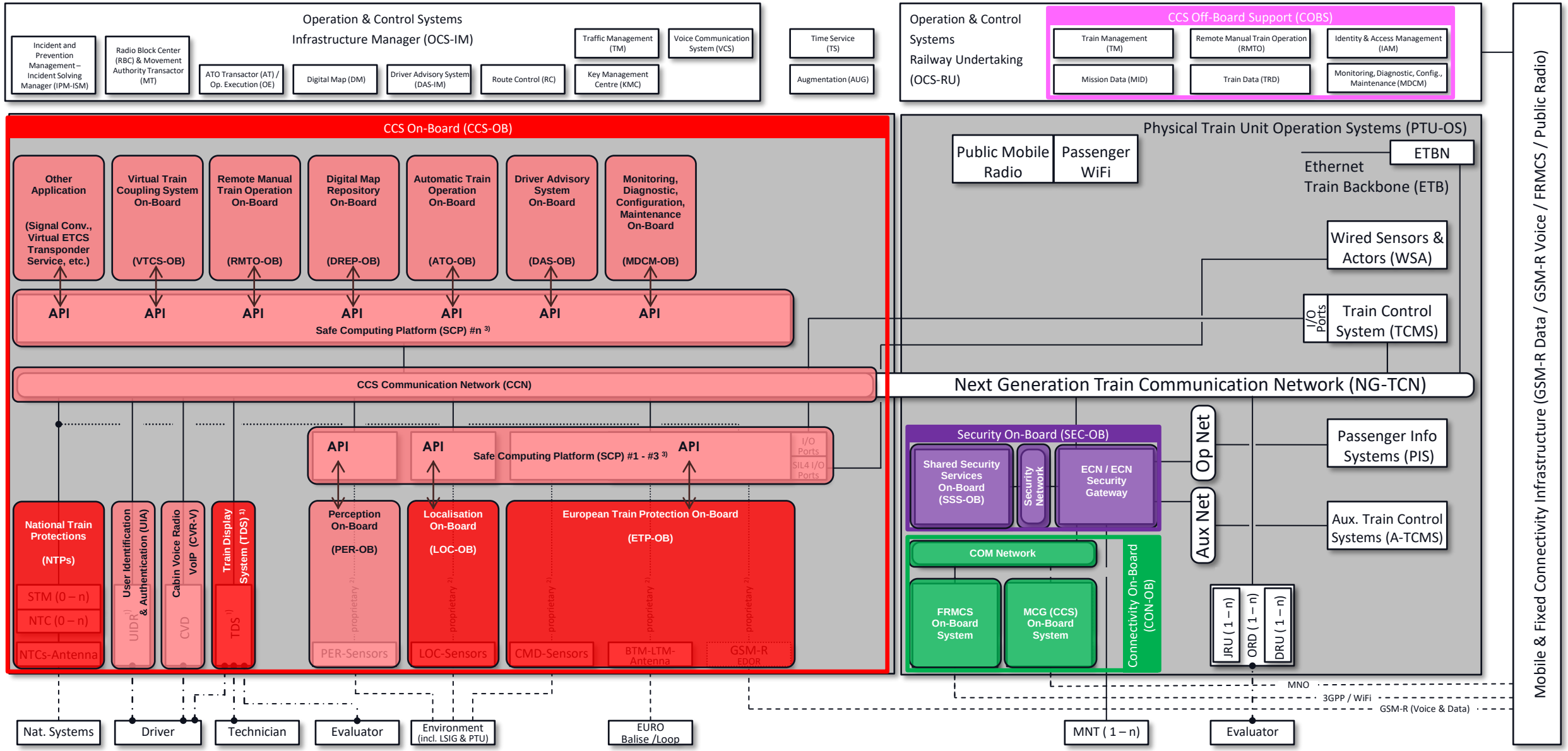
1) TDS & UIDR may be moved into the PTU-OS / LOC&PAS domain.

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.

3) The number of SCPs depend on the required CCS-OB functionality and the physical needs of the required/hosted functions (applications).

Scenario 4

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



Current CCS-OB Functionality | Future CCS-OB Functionality

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

1) TDS & UIDR 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.

3) The number of SCPs depend on the required CCS-OB functionality and the physical needs of the required/hosted functions (applications).