OCORA

Open CCS On-board Reference Architecture

System Architecture

Beta Release

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0.10	▪ Version for final review	AL	2020-06-12
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1.00	▪ Release for OCORA Core Team Review	AL	2020-06-25
1.01	▪ Release for OCORA Steering Committee endorsement	AL	2020-06-30

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References

Reader's note: please be aware that the numbers in square brackets, e.g. [1], as per the list of referenced documents below; is used throughout this document to indicate the references.

The following references are used in this document:

[1] OCORA-10-001-Beta – Release Notes

[2] OCORA-10-003-Beta – Feedback Form

[3] OCORA-20-002-Beta – Technical Slide Deck

[4] OCORA-20-004-Beta – Technical Posters

[5] OCORA-30-001-Beta – Introduction to OCORA

[6] OCORA-30-002-Beta – Problem Statements

[7] OCORA-30-005-Beta – Alliances

[8] OCORA-30-006-Beta – High Level Methodology

[9] OCORA-30-007-Beta – High Level Tooling

[10] OCORA-30-010-Beta – Set of Requirements

[11] OCORA-40-001-Beta – System Architecture

[12] OCORA-40-002-Beta – System Architecture – Capella Model

[13] OCORA-40-003-Beta – UVCC Bus Evaluation

[14] OCORA-40-004-Beta – Computing Platform - Whitepaper

[15] OCORA-40-005-Beta – Functional Vehicle Adapter – Introduction and Overview

[16] OCORA-40-006-Beta – CCS-TCMS Interface – ETCS Functionality (SS119)

[17] OCORA-40-007-Beta – CCS-TCMS Interface – ATO Functionality (SS139)

[18] OCORA-40-008-Beta – (Cyber) Security – Overview

[19] OCORA-90-001-Beta – Question and Answers

[20] OCORA-90-002-Beta – Glossary

[21] EN 50126-1:2017-10 – Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process

[22] EN 50126-2:2017-10 – Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 2: Systems Approach to Safety

[23] EN 50128:2011-06 – Railway Applications – Communication, signalling and processing systems - Software for railway control and protection systems

[24] EN 50129:2018-11 – Railway applications - Communication, signalling and processing systems - Safety related electronic systems for signalling

[25] EN 50155: 2017 – Railway applications – Rolling stock – Electronic equipment

[26] EN 50159:2010-09 – Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems

[27] TSI CCS: 02016R0919 - EN - 16.06.2019 - 001.001 - 1: COMMISSION REGULATION (EU) 2016/919 of 27 May 2016 on the technical specification for interoperability relating to the 'control-command and signalling' subsystems of the rail system in the European Union, amended by Commission Implementing Regulation (EU) 2019/776 of 16 May 2019 L 139I

[28] RCA.Doc. 2, Beta.1, RCA Architecture Overview

[29] RCA.Doc.13, Gamma.1, Concept: Architectural approach and Systems-of-Systems Perspective

[30] RCA.Doc.35, Gamma.1, RCA System Architecture

[31] RCA.Doc.43, Gamma.1, Concept: Informal Architecture Overview

[32] ISO/IEC 7498-1:1994, Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model - Part 1.

[33] ERA_ERTMS_015560

[34] ERTMS User Group Document 97E2675B

[35] EN 15380-4 - Railway applications - Classification system for railway vehicles - Function groups

Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). We always reference to the latest available official version of the SUBSET, unless indicated differently.

1 Introduction

1.1 Document context and purpose

This document is published as part of the OCORA Beta release, together with the documents listed in the release notes [1]. It is the second release of this document which will be further developed in consecutive releases.

The document is provided in PDF format with searchable text and hyperlinks. The links are not only available for the directory, the table of figures, and the table of tables, but also for references to interface descriptions (green and red boxes) and all references to chapters / external documents. The latter are highlighted in blue to indicate the hyperlink functionality. Upon request, this document and all its graphics can be made available in the native data format (e.g. Word, PowerPoint, Visio).

The Alpha release of this document contained information about OCORA program aspects. Since this document focuses on architecture, content regarding the program has been moved to document [5] and [7]. Subsequent releases of this document (Gamma, etc.) and topic specific documentation will be developed in a modular and iterative approach, evolving within the progress of the OCORA collaboration.

This document is focusing on technical issues and possible solutions for the CCS on-board system. It is not addressing the need for a fair compensation framework in case of unbalance between cost of benefit or transfer of responsibility between the different actors.

This document aims to provide the reader:

- the system concept (chapter 2.1.2), containing information typically used for CENELEC phase 1 (refer to definitions in document [8]). This includes a clear definition of the scope, purpose, and content of the OCORA architecture.
- an identification and abstract description of all components (hardware & software) and building blocks, including all interfaces for selected building blocks.
- an introduction to digitalisation-specific topics, such as the cyber security, etc.
- proposition on various topics, such as the OCORA gateway, the connectivity with data centres, diagnostics, and maintenance, etc.

From all the topics discussed in this OCORA Beta release, the definition of the OSI layer 1 and 2 (according to the definitions in document [8]) of the universal vital command and control bus (UVCCB) is considered to be the most important message. An overview regarding the selected bus technology is provided in chapter 4.1.1 and information regarding the requirements used for evaluating the UVCCB and the respective evaluation can be found in document [20].

The Computing Platform - Whitepaper [14], the Functional Vehicle Adapter – Introduction and Overview [15], the CCS-TCMS Interface [16], [17], and the (Cyber) Security – Overview [18] provide further details of the OCORA architecture.

1.2 Why should I read this document and how to provide feedback?

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA technical concepts for on-board CCS. The reader will gain insights regarding the topics listed in chapter 1.1, will be able (and indeed is invited) to provide feedback to the OCORA collaboration and can, therefore, engage in shaping OCORA. Feedback to this document and to any other OCORA beta release documentation can be given by using the feedback form [2].

If you are a railway undertaking, you will find information provided in this document may be useful to compile tenders for OCORA compatible CCS building blocks, or for tendering complete CCS system, or also for CCS replacements for functional upgrades or for life-cycle reasons.

If you are an organization interested in developing CCS building blocks according to the OCORA standard, information provided in this document can be used as input for your development. Subsequent version of this document aims to provide information needed for CENELEC phase 2 – 5 (according to definitions in document [8]).

Before reading this document, it is recommended to read the Release Notes [1]. If you are interested in the context and the motivation that drives this specification document, we recommend to read the Introduction to OCORA [5], and the Problem Statements [6]. The reader should also be aware of the Question and Answers [19] and the Glossary [20].

Selected graphics provided in this document are available, in a larger scale, in the documents [3] and [4], and in Appendix F.

2 System concept

2.1 System under consideration

2.1.1 Scope

The system under consideration for the OCORA program is the "CCS On-Board" (green box) as identified in Figure 1 from a hardware point of view and in Figure 2 from a functional perspective. This scope applies for the system decomposition and for all RAMSS aspects and is used for CENELEC phase 1 – 5 and 8 – 12 (according to definitions in document [8]).

From a system architecture and design perspective, the focus is on the "OCORA Core" (red box) depicted identified in Figure 1 and in Figure 2. For the "Peripheral Devices" and the "Connectivity Devices" (outside the red box), OCORA will only provide interface specifications, high-level functional requirements, and non-functional requirements. These are all requirements and specifications needed to ensure "plug & play"-like exchangeability. Of course, these specifications are only developed by OCORA for the components not already sufficiently standardised and where no standard is being developed by other organizations.

To summarize: "Peripheral Devices" and "Connectivity Devices" are external systems in regard to the OCORA Core architecture, hence only interface specifications, high-level functional and non-functional requirements will be needed. From a RAMSS point of view, they are CCS On-Board components, and hence in scope for RAMS analysis.

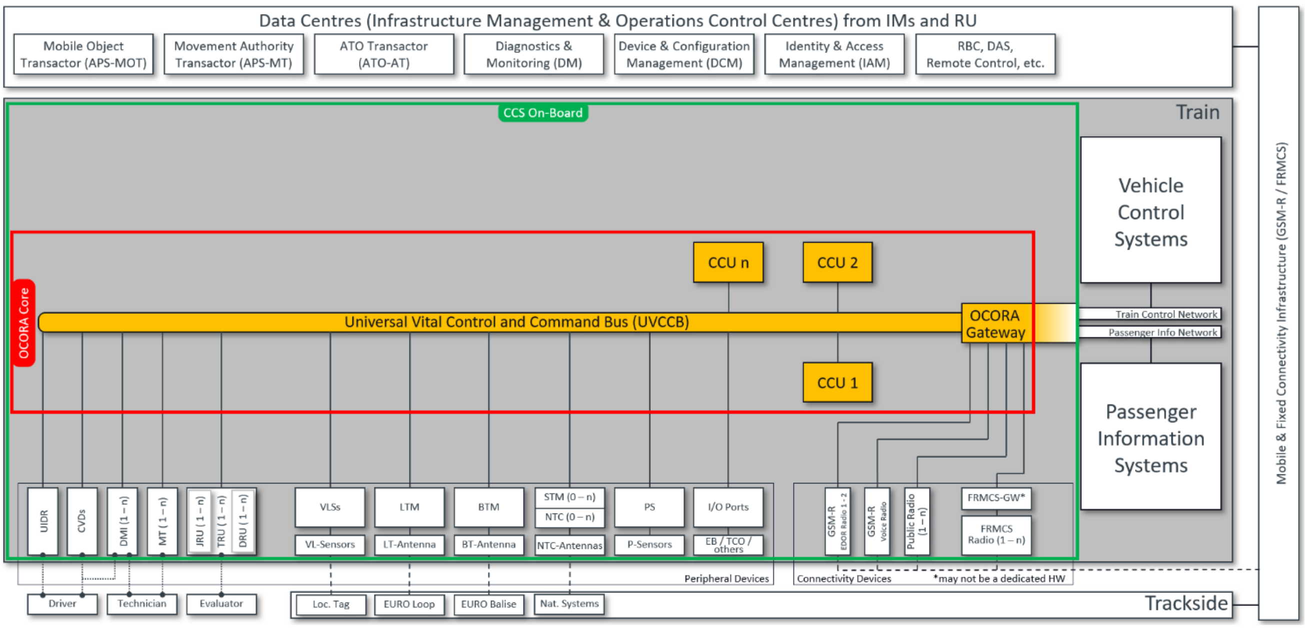

Figure 1 Scope – hardware view
(refer to Appendix F1 for large scale representation)

To define the architecture, OCORA has identified components for the "CCS On-Board" (blocks inside the green box).

Components are defined as a pieces of hardware and/or software, providing one or more functionality.

Components are grouped into building blocks. For the definition of building blocks, refer to chapter 3. Every component consists of sub-components. Currently, the OCORA architecture focuses just on the component and not on the sub-component level. Further decomposition will be addressed in subsequent releases. All components are described in more detail in chapter 4.

External systems and actors (blocks outside the green box) are interacting with the "CCS On-Board" and are described in more detail in chapter 2.1.3.

Solid lines in Figure 1 and in Figure 2 indicate wired connections, dotted lines represent user interactions, and dashed lines “over the air” communication. Large scale graphics can be found in Appendix F1.

As explained in document [5], OCORA aims to introduce “plug & play”-like exchangeability for the CCS on-board building blocks (refer to chapter 3 for a definition of building blocks). Since efforts to do so are quite extensive, and since OCORA want to leave as much room as possible to the industry to provide their (already existing) solutions, OCORA uses building blocks to group components. Building blocks can contain 1 to n component(s). It is the OCORA vision to provide “plug & play”-like exchangeability for all building blocks and not for all components identified in Figure 1 and in Figure 2. Refer to chapter 3 for the currently proposed OCORA building blocks.

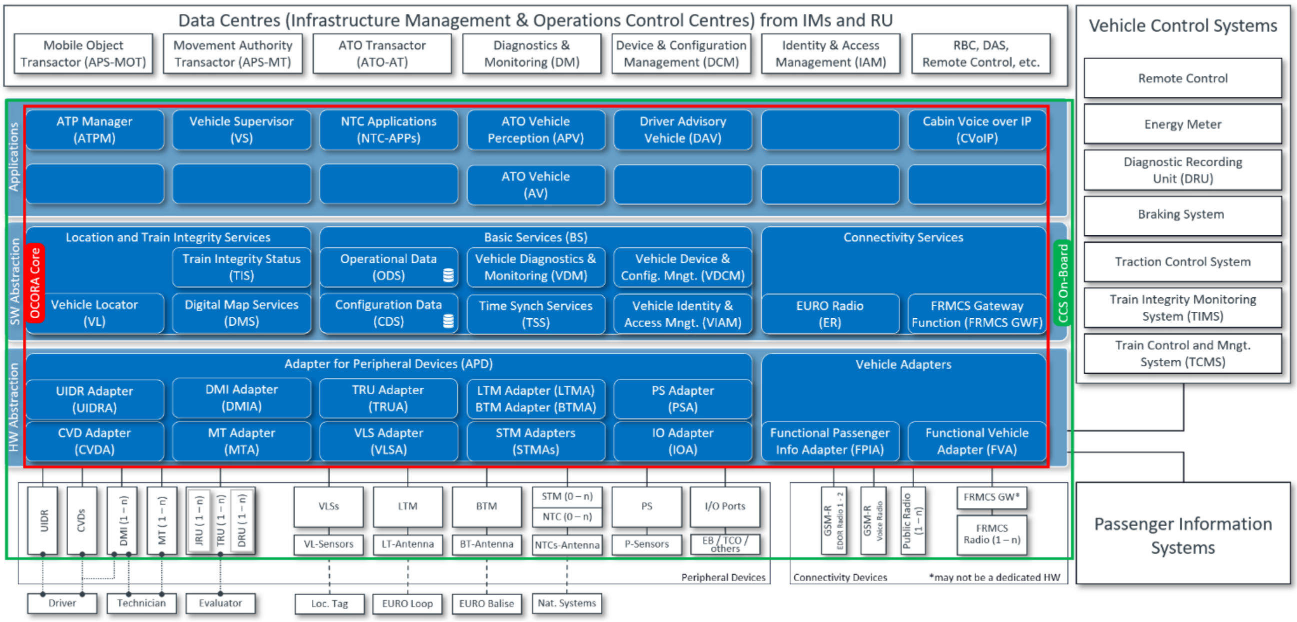

Figure 2 Scope – functional view
(refer to Appendix F2 for large scale representation)

The components within the “CCS On-Board” as identified in Figure 1 and in Figure 2 support ETCS L1 – L3, level National Train Controls (NTCs), ATO GoA1 – GoA4 over ETCS and/or over NTC, and the possibility to implement the NNTRs (Notified National Technical Rules) of the OCORA member states and others. The “empty boxes” in Figure 2 indicates that the architecture is open to implement functionality, not envisioned at this point in time. For this reason, an “Open Building Block” concept is introduced, that will be elaborated in later versions of this document. The UVCCB and the modular architecture provide the base for enabling this.

The configuration for a specific implementation is open and may include only a subset of the components represented in in Figure 1 and in Figure 2. But not only the number of deployed components can differ between implementations. The functionality of some of the hardware components (Figure 1) may vary also. For example: on one vehicle the CCU 1 could contain the ETCS functionality and CCU 2 the ATO functionality, while another supplier may decide to use CCU 1 for combined ETCS and ATO functionality and use CCU 2 as a fail-over unit to increase availability of the CCS on-board system. Yet another specific implementation may combine all safe functions on CCU 1 and all non-safe functions on CCU 2. To achieve this, the independence of software from hardware is paramount and therefore an important topic to OCORA. Refer to chapter 8 and document [14] for details on the computing platform, that supports the separation of hardware from software.

The components / building blocks identified in Figure 1 and in Figure 2 represent just a high-level view, abstracting many details. For example: The UVCCB, shown as a single block, is in fact a complex component with many sub-components and configuration options, depending on the needs of the RU/supplier (refer to Appendix A).

Last but not least, the representation in Figure 1 and Figure 2 show one possible deployment scenario. This especially in regard to the OCORA Gateway (OCORA-GW) and how the connectivity devices (GSM-R Radio, Public Radio, FRMCS Radio) and the train networks (TCN, PIN) are connected. For this aspect alone, many deployment scenarios exist that need further investigations (refer to Appendix C). Again, depending on the specific situation, one or the other scenario may make more or less sense. Nevertheless, OCORA aims to reduce the proposed scenarios to the most relevant ones. The connection between Passengers Information Systems and OCORA Core is, for instance, dependent on security requirements in the vehicle. It will be clarified in future release of this documentation.

All identified components, and external system are described further in subsequent chapters of this document. Chapter 2.1.1.1 provides a list and a short description of all hardware components, including references to more detailed information and chapter 2.1.1.2 provides the same for functional/software components.

To define the scope boundary to the necessary detail, all envisioned interfaces are identified in Figure 1 from a hardware point of view and in Figure 2 on a functional level. This, for the “CCS On-Board” scope (green numbers) as well as for the “OCORA Core” scope (red numbers). Chapter 5 provides a list and a short description of all those interfaces.

2.1.1.1 Hardware components

Figure 1 on page 12 and Appendix F1 depict the currently identified components, in scope of CCS on-board, from a hardware perspective. A high-level description including links to more detailed information for each of the components is provided in the subsequent tables of this chapter.

OCORA core hardware

The OCORA core hardware are the components within the “OCORA Core” scope. For these components, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements but also detailed design requirements. The OCORA core hardware is also considered for all RAMSS aspects.

The OCORA core hardware, together with the runtime environment (refer to chapter 8), provides the platform to run the OCORA core functionality.

OCORA Core Hardware		
Component	**High-Level Description**	**Link to Further Information**
UVCCB	**Universal Vital Control and Command Bus** The Universal Vital Command and Control Bus (UVCCB) is the CCS on-board bus/network allowing direct communication between all CCS on-board components connected to it and eventually with external systems, such as the TCMS. The UVCCB is the most central part of the OCORA architecture and is the basis for achieving modularity that results in “plug & play”-like exchangeability of all building blocks. The UVCCB is a TSN Ethernet based network with the use of SDTv2/v4 as safety layer. The bus/network is currently defined for OSI layer 1 to 2 (according to definitions in document [8]) but will be specified up to OSI layer 6 and 7 (according to definitions in document [8]) in subsequent versions of the OCORA specifications.	▪ Chapter 4.1.1 ▪ Document [13]
CCU (1 – n)	**CCS Computing Unit** The CCS Computing Unit (CCU) is the computing hardware for all OCORA core CCS functions. One CCU can contain multiple processor boards (e.g. to provide hardware level voting). The number and the functional behaviour of the CCUs can differ for the various implementations, depending on the RU’s need. For migration reasons, multiple CCUs may be needed or certain functions can be deployed on one node (e.g. safe functions) while others (e.g. non-safe) are deployed on a separate node. In some projects, additional CCUs may be used to increase availability and reliability by defining one or multiple CCU nodes as fail over or standby units. The CCU hardware is made accessible through the runtime environment. The CCU together with the runtime environment are building the computing platform (refer to chapter 8 for details).	▪ Chapter 4.1.2 ▪ Chapter 8 ▪ Document [14]
OCORA-GW	**OCORA Gateway** The OCORA Gateway (OCORA-GW) is a piece of hardware providing communication capabilities between the CCS bus (UVCCB) and the Train Control bus (if it exists) or the TCMS (if it exists) or the actuators and sensors residing outside the CCS domain but important to CCS. Depending on the vehicle, the OCORA Gateway covers multiple OSI layers (according to definitions in document [8]). This can include even layer 7 in some cases. The OCORA-GW provides a means of integrating the CCS system with various vehicle technologies, especially when deploying an OCORA based CCS system on existing fleets. However, even if the same bus technology is use for the CCS and vehicle systems, the OCORA-GW is still recommended for security and performance reasons.	▪ Chapter 4.1.3

Table 1 OCORA core hardware

Peripheral devices

The peripheral devices are components outside the "OCORA Core" scope. For these components, OCORA provides interface specifications, high-level functional requirements, and non-functional requirements only. Basically, all requirements and specifications needed to ensure "plug & play"-like exchangeability. Of course, these specifications are only developed for the building blocks not already standardised (well enough) or where no standard is being developed by other organizations. The peripheral devices are also considered for all RAMSS aspects.

The peripheral devices include all sensors and actuators needed for the CCS on-board system to function.

Peripheral Devices		
Component	**High-Level Description**	**Link to Further Information**
UIDR	**User Identification Reader** The User Identification Reader (UIDR) is used to automate the identification process for drivers and service technicians. RFID card readers may be the most common option used at this point in time. But as technology advances, fingerprint, face ID, etc. might become viable options. The OCORA specifications will be technology agnostic.	▪ Chapter 4.2.1
CVDs	**Cabin Voice Devices** The Cabin Voice Devices (CVDs) are the microphone and the loudspeaker(s) in the cabin, combined with some electronics, allowing to communicate over the UVCCB with the CVoIP application and ultimately with the GSM-R Voice Radio or the FRMCS Radio respectively. They are used for the communication between the driver and the operations control personnel or for communication between train staff. Today, these devices are only loosely integrated into the CCS domain, if at all. But with the upcoming migration from GSM-R to FRMCS options become available to share the new connectivity infrastructure between the CCS data and cabin voice. The OCORA concept foresees to have a cabin voice application running on one of the CCUs and providing voice communication through voice over IP (VoIP).	▪ Chapter 4.2.2
DMI (1 – n)	**Driver Machine Interface** At this point in time, this is the Driver Machine Interface (DMI) for all OCORA core CCS functions in need of user interaction. At a later stage, other functions may also be supported by the DMIs. The number of DMIs and the functions assigned to them can differ for the various implementations, depending on the RU's need. A typical OCORA implementation foresees one primary DMI for ETCS or the NTC system and an additional display for all other functions (e.g. ATO, Cabin Voice, etc.). In such configurations, the additional DMI may also be used to increase availability of the primary display functions through a switch-over mechanism. Mobile personal devices (e.g. Tablets) are another type of DMI that may be used for some applications.	▪ Chapter 4.2.3
MT (1 – n)	**Maintenance Terminal** The Maintenance Terminal (MT) is a laptop that can be connected to the UVCCB to perform maintenance tasks on all CCS on-board components. Maintenance tasks should include the monitoring and downloading of diagnostic data, executing service commands (e.g. reboot of a specific component) and installing updates (new software, configuration, etc).	▪ Chapter 4.2.4
TRU (1 – n)	**Train Recording Unit** The Train Recording Unit (TRU) includes the Juridical Recording Unit (JRU) and the Diagnostic Recording Unit (DRU). Currently, the JRU is mostly located in the CCS domain while the DRU is typically found in the Train Control domain. The JRU records data from the ETCS system while the DRU is recording data from other on-board systems, for instance the TCMS. In the future, other functions than ETCS will reside in the CCS domain (e.g. ATO). Those functions have also a need to record data. Hence, a DRU is proposed to be added to the CCS domain. Whether this is a specific hardware, in addition to the hardware available in the TCMS domain, or the DRU hardware can be combined needs to be explored further.	▪ Chapter 4.2.5
VLSs	**Vehicle Localisation Systems** The Vehicle Localisation Systems (VLSs) processes the data from the various Vehicle Localisation Sensors, performs the necessary sensor fusion, and provides the data to the VL through the UVCCB.	▪ Chapter 4.2.6

Peripheral Devices		
Component	**High-Level Description**	**Link to Further Information**
VL-Sensors	**Vehicle Localisation Sensors** The Vehicle Localisation Sensors (VL Sensors) provide raw data to determine speed, direction of travel, acceleration, position, and cold movement information to the Vehicle Localisation System (VLS). Depending on the RU's need and the progress of technology (e.g. GNSS, IMU) different type and quality of sensors may be used.	▪ Chapter 4.2.7
LTM	**Loop Transmission Module** The Loop Transmission Module (LTM) is used for ETCS L1 and L1LS systems to process the data from the Loop Transmission Antenna (LT-Antenna) and makes the data available on the UVCCB.	▪ Chapter 4.2.8
LT-Antenna	**Loop Transmission Antenna** The Loop Transmission Antenna (LT-Antenna) receives data through an RFID interface from the EURO Loop and provides the data to the Loop Transmission Module (LTM).	▪ Chapter 4.2.9
BTM	**Balise Transmission Module** The Balise Transmission Module (BTM) is used for ETCS L1 – L3 systems (including L0 and LNTC). It processes the data from the Balise Transmission Antenna (BT-Antenna) and makes the data available on the UVCCB, for the ETCS application (VS). Optionally, the BTM can also receive data from KER Balises and can make the data available, through the UVCCB, to the corresponding STM through the K interface describe in SUBSET-101.	▪ Chapter 4.2.10
BT-Antenna	**Balise Transmission Antenna** The Balise Transmission Antenna (BT-Antenna) receives data through an RFID interface from the EURO Balise and provides the data to the Balise Transmission Module (BTM). Optionally, the BT-Antenna can also receive data through an RFID interface from the KER Balises and can provide the data to the Balise Transmission Module (BTM).	▪ Chapter 4.2.11
STM	**Specific Transmission Module** The Specific Transmission Module (STM) provides the connection between the ETCS system (in case of OCORA the UVCCB) and the National Train Control System (NTC). The STM and the NTC are often closely integrated, hence the term STM is often used, when referring to the NTC system.	▪ Chapter 4.2.12
NTC	**National Train Control** The National Train Control (NTC) provides Automated Train Protection functionality on national level. It communicates with other OCORA components, namely the Automated Train Protection Manager (ATPM) and can also use the functionality of other components connected to the UVCCB (e.g. DMI, VLS, TCO, EB, etc.). Alternatively, it is also possible to implement the National Train Controls business logic as Applications on the OCORA computing platform (see NTC-APPs for more information). In this case, the NTC-APPs access through the UVCCB and the BTM the balise data in order to get the package 44 information.	▪ Chapter 4.2.13 ▪ Chapter 4.4.3
NTC-Antennas	**National Train Control Antennas** The National Train Control Antennas (NTC-Antennas) receive the data from the trackside installations of the respective national ATP system and provides the data to the NTC.	▪ Chapter 4.2.14
PS	**Perception Systems** The Perception System (PS) provides awareness information if needed for GoA3 and GoA4 operations. The Perception System processes the data from the various Perception Sensors (P Sensors), performs the necessary sensor fusion, and makes the data available on the UVCCB.	▪ Chapter 4.2.15
P-Sensors	**Perception Sensors** The Perception Sensors (P-Sensors) include all sensors to provide enough awareness of the environment (mainly the tracks) for safe GoA3 and GoA4 operations. The sensors are mostly cameras, but can also include vibration sensors, smoke detectors, etc.	▪ Chapter 4.2.16

Peripheral Devices		
Component	**High-Level Description**	**Link to Further Information**
I/O Ports	**Input/Output Ports** The I/O Ports provide access between the UVCCB and certain actuators and sensors. The status of the sensors is processed by this component and made available on the UVCCB and commands from the various CCS on-board components, sent through the UVCCB, are applied to the respective port.	▪ Chapter 4.2.17
EB / TCO / Others	**Emergency Brakes / Traction Cut-Off / Others** These are the devices triggering the Emergency Brake (EB) and the Traction Cut-Off (TCO) for ETCS, NTC-APP, APV, etc. Depending on the system configuration and RU's need, multiple EBs and TCOs can be connected and additional I/Os can be used to interact with "other" external systems, actuators, and sensors. Examples are: ▪ Cabin activation status ▪ ETCS isolation status ▪ Vehicle power status ▪ Dead Man Switch: to monitor the awareness of the driver ▪ CCS Cabinet Supervision: to monitor unauthorized access	▪ Chapter 4.2.18

Table 2 Peripheral devices

Connectivity devices

The connectivity devices are components outside the "OCORA Core" scope. For these components, OCORA only provides interface specifications, high-level functional requirements, and non-functional requirements. Basically, all requirements and specifications needed to ensure "plug & play"-like exchangeability. Of course, these specifications are only developed for the building blocks not already standardised (well enough) or where no standard is being developed by other organizations. The connectivity devices are also considered for all RAMSS aspects.

The connectivity devices provide secure connectivity to the data centres for the CCS on-board domain. Eventually, other domains such as the train control or the passenger information may use this infrastructure for their communication needs. Refer to chapter 4.1.3 and Appendix C for a discussion of possible options.

Connectivity Devices		
Component	**High-Level Description**	**Link to Further Information**
GSM-R – EDOR Radio	**Global System for Mobile Communications Railway – EDOR Radio** The GSM-R EDOR Radio provides (cyber-)secure GSM-R data connectivity to trackside systems. Today, it is mainly used for the communication with the RBC in case of ETCS level 2 operations. The device will eventually be replaced by an FRMCS Radio.	▪ Chapter 4.3.1
GSM-R – Voice Radio	**Global System for Mobile Communications Railway – Voice Radio** The GSM-R Voice Radio provides GSM-R voice connectivity. Today, it is widely used for voice communication between the driver and the operations control centres or between train staff. The device will eventually be replaced by an FRMCS Radio in combination with the Cabin Voice over IP communication.	▪ Chapter 4.3.2
Public Radio (1 – n)	**Public Radio** The Public Radio provides connectivity between the train and off-board. The OCORA architecture foresees that multiple Public Radio modems can be connected, depending on the RU's need. Public Radio connections are mainly used for monitoring, diagnostic, and maintenance purposes during the transition phase to FRMCS. Separate modems can connect the train with the operations centre of its RU and/or with the train supplier. The Public Radio modem will eventually be replaced by the respective functionality of the FRMCS Radio.	▪ Chapter 4.3.3
FRMCS-GW	**Future Rail Mobile Communication System Gateway** The FRMCS Gateway (FRMCS-GW) provides the hardware resources to run FRMCS-GW Functions and connects to the FRMCS Radio(s).	▪ Chapter 4.3.4 ▪ Chapter 4.5.3.2 ▪ Chapter 4.5.3.2
FRMCS Radio (1 – n)	**Future Rail Mobile Communication System Radio** The FRMCS Radio represents a modem with one or more 3GPP and/or non-3GPP radio access technologies supported by the FRMCS system.	▪ Chapter 4.3.5

Table 3 Connectivity devices

2.1.1.2 Functional components

Figure 2 on page 12 and Appendix F2 and F3 on page 103 and 104 depict the currently identified components, in scope of CCS on-board, from a functional perspective. A high-level description including links to more detailed information for each of the components is provided in the subsequent tables of this chapter.

OCORA applications

The OCORA applications are functional application providing the actual (business) logic of a railway function. Most, if not all, OCORA applications are its own individual building block (refer to chapter 3.2). Hence, for these components, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements but also detailed design requirements. At the current stage, a set of applications are identified. However, more applications will be defined in subsequent versions of this document. But the OCORA platform also provides an API that allows new applications, not known at this point in time, to use the services of the platform and infrastructure of the vehicle. Hence, developing and deploying new functionality should be simplified. Such applications could be “automated routine test” or the development of an NTC application that uses balise data, package 44 (refer to chapter 4.4.3).

All OCORA applications run on the OCORA computing platform (refer to chapter 7).

OCORA Applications		
Component	**High-Level Description**	**Link to Further Information**
ATPM	**Automated Train Protection Manager** The Automated Train Protection Manager (ATPM) application, deployed on the OCORA computing platform, is a safe application in charge of managing the safety authority between installed ATP systems. It ensures that the proper ATP system is active and manages the switch-over from one ATP system to the other. Also, the ATPM includes the “STM control function” functionality defined in SUBSET-035.	▪ Chapter 4.4.1 ▪ Chapter 7.1
VS	**Vehicle Supervisor** The Vehicle Supervisor (VS) application, deployed on the OCORA computing platform, is a safe ETCS application (mandatory requirements are specified in SUBSET-026) in charge of calculating location specific speed limits (based on various inputs) and activating the braking system in case of speed limit overshoot. Location information is received from the Vehicle Locator (VL). In addition, information is received from the Balise Transmission Module (BTM) and the Loop Transmission Module (LTM) and processed adequately. In ETCS L2 and L3 mode, the VS interacts with the RBC or the APC-MT respectively. It receives the movement authority (MA) and reports the train position (TPR) to the respective system. The VS is agnostic to the communication technology used. Therefore, communication via GSM-R as well as via FRMCS or any future technology is possible. The VS also displays to the driver the necessary information (including cab signalling in ETCS L1, L2 and L3). It supports all ETCS modes and ETCS levels defined in the TSI-CCS.	▪ Chapter 4.4.2 ▪ Chapter 7.2
NTC-APPs	**National Train Control Applications** The National Train Controls Applications (NTC-APPs), deployed on the OCORA computing platform, are safe applications in charge of ensuring automated train protection based on national systems. NTC-APPs, implemented on the OCORA computing platform, must communicate, as a minimum, with the ATP Manager and can use their specific sensors and actuators. In addition, they can take advantage of the standard OCORA interfaces. E.g. location information can be received from the Vehicle Locator (VL), data can be recorded in the TRU, DMI can be used, the TCMS can be accessed through the Functional Vehicle Adapter (FVA), etc.	▪ Chapter 4.4.3 ▪ Chapter 7.3
AV	**ATO Vehicle** The ATO Vehicle (AV) application, deployed on the OCORA computing platform, is a non-safe application for automated train operations. A safe extension is needed for GoA3 and GoA4 operations. This is provided by the ATO Perception Vehicle (APV). The AV in GoA2 – GoA4 operates the vehicle automatically using information received through the interface SS126. It also communicates with the Vehicle Supervisor (VS) over the interface SS130 (between AV and ETCS-OB). Remark: AV is called ATO-OB in GoA2 Shift2Rail SUBSET-125.	▪ Chapter 4.4.4 ▪ Chapter 7.4

OCORA Applications		
Component	**High-Level Description**	**Link to Further Information**
APV	**ATO Perception Vehicle** The ATO Perception Vehicle (APV) application, deployed on the OCORA computing platform, is a safe application needed for automated train operations with GoA3 and GoA4. It is deployed in addition to ATO Vehicle (AV) and includes all safety-related functionality and data needed for GoA3 and GoA4 operations. To execute these tasks, it has interfaces to perception system, Digital Maps (DMS), etc. Based on the situation (type of danger and location information) it triggers speed reduction, service brakes, traction cut-off, and emergency brakes. Remark: APV is called "Incident Protection Management" (IPM) in GoA3 – GoA4 Shift2Rail discussions.	▪ Chapter 4.4.5 ▪ Chapter 7.5
DAV	**Driver Advisory Vehicle** The Driver Advisory Vehicle (DAV) application is an optional and non-safe application calculating an energy efficient speed profile to achieve the pre-planned and dynamically updated train timings. It generates detailed driver advice for adhering to the planned timings while driving energy efficient. The trackside Driver Advisory System (DAS) or the Traffic Management System (TMS) is responsible for conflict detection and calculation of new target train timings, that are forwarded to the DAV and evaluated accordingly. The typical integration of DAV application is defined EN 15380-4. The DAV can also operate standalone (e.g. without integration into the vehicle). The DAV is not needed if ATO Vehicle (AV) is installed, since the AV already includes the DAV functionality. The implementation of DAV application on OCORA computing platform is an open issue to be solved in subsequent versions of this document (unsafe information displayed on the driver DMI).	▪ Chapter 4.4.6
CVoIP	**Cabin Voice over IP** The Cab Voice over IP (CVoIP) application, deployed on the OCORA computing platform, implements the Cab Voice functionality. It uses the DMI to enable the train driver to initiate and receive voice communication between the train and the trackside operations control centres. For communication with the trackside operation control centres, the CVoIP is using the services provided by the FRMCS On-Board System or the GSM-R Voice Radio.	▪ Chapter 4.4.7

Table 4 CCS on-board components – OCORA Applications – functional view

Software abstraction / services

The software abstraction / services contain software components that mainly provide services to the OCORA applications and eventually to other applications. Some of these components build its own building block while others are grouped to building blocks (refer to chapter 3.2). For the identified building blocks that group these components, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements but also detailed design requirements. The components / building blocks currently identified for software abstractions / services are not comprehensive. Others may be added in subsequent versions of this documents.

The software abstraction / service components run on the OCORA computing platform or are an integral part of it (refer to chapter 7). This aspect will be further evaluated in subsequent versions of the OCORA architecture.

SW Abstraction / Services		
Component	**High-Level Description**	**Link to Further Information**
Location and Train Integrity Services		
VL	**Vehicle Locator** The Vehicle Locator (VL) is a safe service deployed on the OCORA computing platform. The VL uses localisation technology to safely and reliably provide position and speed information of the train to various applications. For ETCS implementations, it provides the actual position/direction and the current speed to the VS, where the actual position/direction and the current speed are aggregated with other data into a Train Position Report (TPR). Localisation data may be sent by the VL to APS-MOT, containing e.g. ETCS irrelevant data (not used by VS). The VL sends the full virtual track occupation of the train or only a part of it (only the front or rear position). The VL can use different localization technologies, from today's "balise + odometry" to additional sensor inputs such as GNSS or inertial measurement units. To access the respective sensors, the VL interacts with the Vehicle Localisation System (VLS).	▪ Chapter 4.5.1.1 ▪ Chapter 7.6
TIS	**Train Integrity Status** The Train Integrity Status (TIS) is a safe service deployed on the OCORA computing platform. To determine the train integrity, multiple options are possible: a) train integrity determination on the train (e.g. through the TCMS), b) second localisation unit at the end of the train with on-board determination of the train integrity, and c) second localisation unit at the end of the train with trackside determination of the train integrity. The TIS service ensures that all CCS applications that need to know the train's integrity status (including the coupler statuses, if applicable) are receiving the information through a standardized interface, independent of the option used. The train integrity status may also include the total safe train length (including the length over coupled compositions).	▪ Chapter 4.5.1.2 ▪ Chapter 7.7
DMS	**Digital Map Services** The Digital Map Service (DMS) is a safe service deployed on the OCORA computing platform. The DMS provides topology and topography data (a.k.a. map data) that are certified for the usage in safety-relevant on-board applications / services (e.g., VL, VS, APV) up to SIL4. The service guarantees that the map data fulfils the quality criteria stated by trackside, e.g. accurate, precise, reliable, complete, and up-to-date map data. The DMS uses its own on-board data storage that is updated, if required, through the interface RCA-5.	▪ Chapter 4.5.1.3
Basic Services		
ODS	**Operational Data Storage** The Operational Data Storage (ODS) is a data storage for saving quite dynamic data that is entered / provided during an operational day of a vehicle and has no relevance for long-time safeguarding. The operational data storage is separated from the ETCS components (e.g. VS) to make the data easily available to other applications that may need it (e.g. ATO Vehicle). The operational data storage contains data provided by the driver, the TCMS, and possibly the device and configuration management. Examples of Operational Data is the driver id, the train running number, etc. In subsequent versions of the OCORA specifications, the ODS will be specified in detail.	▪ Chapter 4.5.2.1

SW Abstraction / Services		
Component	**High-Level Description**	**Link to Further Information**
CDS	**Configuration Data Storage** The Configuration Data Storage (CDS) stores static and semi-static data needed for the CCS on-board system. The data storage is separated from the operational data and it is separated from the ETCS components (e.g. VS) to make the data easily available to other applications that may need it (e.g. VDM). The Configuration Data Storage contains data provided when commissioning a CCS on-board system for the first time and is changed whenever configurations of the vehicle change (e.g. additional sensors, additional DMI, etc.). The data is entered by service technicians through the local maintenance terminal or via the remote maintenance. In both cases this occurs through the Vehicle Device & Configuration Management (VDCM) component. In subsequent versions of the OCORA specifications, the CDS will be specified in detail.	▪ Chapter 4.5.2.2
TSS	**Time Synchronisation Service** The Time Synchronisation Service (TSS) provides a service that allows all on-board components to have its time in synched with each other and synched with the trackside systems (e.g. safe data centres). The time base is UTC and components in need to display the time can revert it to local time. This functionality is significant simplify diagnostic and analysis, for ATO operations, and other aspects.	▪ Chapter 4.5.2.3
VDM	**Vehicle Diagnostics & Monitoring** The Vehicle Diagnostics & Monitoring (VDM) service, deployed on the OCORA computing platform, collects data relevant for local (through the Maintenance Terminal or DMI) and remote diagnostic and monitoring. For local maintenance, it provides the relevant data upon request to the Maintenance Terminal or DMI in a standardized format. For remote diagnostics and monitoring the data can be send to multiple recipients (e.g. the RU of the vehicle, the IM the vehicle currently operates in, the vehicle provider, the CCS on-board provider etc.). The owner of the vehicle can define in the vehicle's configuration (refer to Configuration Data Storage) what data is forwarded to which recipient(s). While the TRUA provides the data for recording in the TRU, the VDM provides the data to other systems such as the centralized DMs or the Maintenance Terminals.	▪ Chapter 4.5.2.4
VDCM	**Vehicle Device & Configuration Management** The Vehicle Device & Configuration Management (VDCM) service, deployed on the OCORA computing platform, allows for local (through the Maintenance Terminal) and remote (through the centralized DCM services) configuration of the vehicle's devices (CCUs, Gateway, Peripherals, etc.). The component can process data received by the IMs (network related operational data) and the RU (vehicle related operational and configuration data). The service also allows the RU to execute commands (e.g. reboot of a specific component) and allows to install updates (e.g. new software).	▪ Chapter 4.5.2.5
VIAM	**Vehicle Identity & Access Management** The Vehicle Identity & Access Management (VIAM) is a service deployed on the OCORA computing platform. It integrates with the IAM System providing the central management for the identification, authentication and authorisation of devices and application to resources and functions of the CCS on-board and trackside systems. For the identification, the IAM System manages a unique ID for each entity (e.g. device, application). The granularity, on what level the system will be split into separate entities is not yet defined. It can reach from one single ID for the overall CCS on-board system to IDs for any single device connected to the UVCCB and to application, running on the OCORA Platform. For the authentication of a device or an application, the solution could be based on the Public Key Infrastructure (PKI) or Message Authentication Codes (MAC) using symmetrical encryption mechanisms like 3DES or AES. The access to resources and functions is centrally managed by roles and granted on a Need-to-Know principle to limit unauthorized access to resources and functions within the CCS on-board system.	▪ Chapter 4.5.2.6
Connectivity Services		
ER	**Euro Radio** The Euro Radio (ER) software component implements the Euro Radio protocol stack and the co-ordination function specified in Euroradio FIS, SUBSET-037.	▪ Chapter 4.5.3.1
FRMCS-GWF	**FRMCS Gateway Functions** The FRMCS Gateway Functions (FRMCS-GWF), deployed on the OCORA computing platform, or the OCORA Gateway, or the FRMCS Radio, is an on-board software gateway responsible for the coordination and management of the access to the FRMCS transport services offered by the FRMCS system. The FRCMS Gateway manages the application data flows, has a control plane interface for the applications, distributes the user plane data from data applications over the various radio units depending on the application's QoS requirements and possibly priorities between applications.	▪ Chapter 4.5.3.2

Table 5 CCS on-board components – SW Abstraction – functional view

Hardware abstraction

The hardware abstraction contains software components that allow abstracting the different type of train hardware towards the software abstraction / services and the applications. The goal of this software layer is to ensure that the interfaces towards the applications and software services remain the same, regardless of the underlying train hardware. It must be noted that OCORA aims at standardizing the interfaces to the respective peripheral devices. For the peripheral devices where OCORA can successfully standardize the interface, the need of having a respective adapter inside the "OCORA Core" scope may vanish.

These components are grouped to a single building block (refer to chapter 3.2). For this building block, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements, but also detailed design requirements.

The hardware abstractions components run on the OCORA computing platform or can run, in some cases, on the peripheral devices or the OCORA Gateway. The deployment possibilities of these components will be further evaluated in subsequent versions of the OCORA architecture.

HW Abstraction		
Component	**High-Level Description**	**Link to Further Information**
Adapter for Peripheral Devices (APD)		
UIDRA	**User Identification Reader Adapter** The User Identification Reader Adapter (UIDRA) is a software component, allowing to integrate different types (RFID, Barcode, etc.), brands or versions of User Identification Readers while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand or version of reader used. In case of changing the type, brand, or version of reader in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.	▪ Chapter 4.6.1.1
CVDA	**Cabin Voice Device Adapter** The Cabin Voice Device Adapter (CVDA) is a software component, allowing to integrate different types, brands or versions of Cabin Voice Devices while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand or version of Cabin Voice Devices used. In case of changing the type, brand, or version of a Cabin Voice Device in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.	▪ Chapter 4.6.1.2
DMIA	**Driver Machine Interface Adapter** The Driver Machine Interface Adapter (DMIA) is a software component, allowing to integrate different numbers, types, brands, or versions of Driver Machine Interfaces while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the number, type, brand or version of User Interface Devices used. In case of changing the number, type, brand, or version of a Driver Machine Device in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.	▪ Chapter 4.6.1.3
MTA	**Maintenance Terminal Adapter** The Maintenance Terminal Adapter (MTA) is a software component, allowing to connect different numbers, types, brands, or versions of Maintenance Terminals while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the number, type, brand, or version of Maintenance Terminals used. Remark: this component may not be needed and may drop-out of the architecture in subsequent versions of this document.	▪ Chapter 4.6.1.4
TRUA	**Train Recording Unit Adapter** The Train Recording Unit Adapter (TRUA) is a software component, allowing to integrate different numbers, types, brands, or versions of Train Recording Units (TRUs) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the number, type, brand or version of TRUs used. In case of changing the number, type, brand, or version of TRUs in a CCS on-board system or if modifications to the recorded data and its format needs to be made, only this component and the component delivering additional data needs to be updated. No change to any other components, especially not to safety related components, is needed.	▪ Chapter 4.6.1.5

HW Abstraction		
Component	**High-Level Description**	**Link to Further Information**
VLSA	**Vehicle Localisation System Adapter** The Vehicle Localisation System Adapter (VLSA) is a software component, allowing to connect different types, brands, or versions of Vehicle Localisation Systems (VLS) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the VLS used. In case of changing the type, brand, or version of a VLS in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.	▪ Chapter 4.6.1.6
LTMA	**Loop Transmission Module Adapter** The Loop Transmission Module Adapter (LTMA) is a software component, allowing to connect different types, brands, or versions of Loop Transmission Modules (LTM) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brands, or versions of the LTM used. In case of changing the type, brand, or version of an LTM in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.	▪ Chapter 4.6.1.7
BTMA	**Balise Transmission Module Adapter** The Balise Transmission Module Adapter (BTMA) is a software component, allowing to connect different types, brands, or versions of Balise Transmission Modules (BTM) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the BTM used. In case of changing the type, brand, or version of a BTM in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.	▪ Chapter 4.6.1.8
STMAs	**Specific Transmission Module Adapters** The Specific Transmission Module Adapters (STMAs) are software component, allowing to connect different types, brands, or versions of Specific Transmission Modules (STMs) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the STM used. For every STM integrated, an additional STMA component is deployed. In case of changing the type, brand, or version of an STM in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed. to be completed.	▪ Chapter 4.6.1.9
PSA	**Perception System Adapter** The Perception System (PMA) is a software component, allowing to connect different types, brands, or versions of Perception Systems (PS) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand or version of the PS used. In case of changing the type, brand, or version of a PS in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.	▪ Chapter 4.6.1.10
IOA	**Input / Output Adapter** The Input / Output Adapter (IOA) is a software component, allowing to connect different types, brands, or versions of Input / Output Ports (IO) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the IOs used. In case of changing the type, brand, or version of an IO in a CCS on-board system, only this component needs to be updated. No change to any other components, especially not to safety related components, is needed. Through this component, EB, TCO, etc. are controlled. Therefore, this component is to be considered safety critical.	▪ Chapter 4.6.1.11

HW Abstraction		
Component	**High-Level Description**	**Link to Further Information**
Vehicle Adapters		
FVA	**Functional Vehicle Adapter** The Functional Vehicle Adapter (FVA) is a piece of software deployed on the OCORA computing platform, or on the OCORA Gateway. Its job is to provide an OCORA unified and standardized interface towards the CCS applications and services for vehicle functions and vehicle information needed by the OCORA on-board applications and services. Although the TSI-CCS SUBSET-034, -119, and -139 are defining the interface to the TCMS system, vehicle from different suppliers and especially from different generations have still different interfaces implemented. This adapter allows to map, on a functional level, the commands sent, and the information received from a specific TCMS into the OCORA standard. In addition, the FVA can also be used to integrate vehicles through wired connections. Also, the standardized interface to the CCS applications evolves in multiple iterations as outlined in chapter 3. Remark: Sometimes the FVA is also called Train Interface Unit (TIU). However, the TIU is not clearly defined. Sometimes it refers to the functional level of the interface with the vehicle, while in other context a piece of hardware is meant. To avoid confusion, OCORA does not use the term TIU.	▪ Chapter 4.6.2.1 ▪ Chapter 7.8 ▪ Document [15], [16], [17]
FPIA	**Functional Passenger Info Adapter** The Functional Passenger Information Adapter (FPIA) is a non-safe piece of software deployed on the OCORA computing platform, or on the OCORA Gateway. Its job is to provide an OCORA unified and standardized interface towards the Passenger Information System (PIS), allowing the PIS to receive CCS of interest to the PIS.	▪ Chapter 4.6.2.2

Table 6 CCS on-board components – HW Abstraction – functional view

2.1.2 Context

Information about the context in which the OCORA architecture is being developed, can be found in document [5], and [6]. The technical context is described in chapter 2.1.3.

2.1.3 Environment

The environment consists of all actors and systems that interact with the CCS on-board system and the environment conditions in which the CCS on-board system operates.

2.1.3.1 Actors

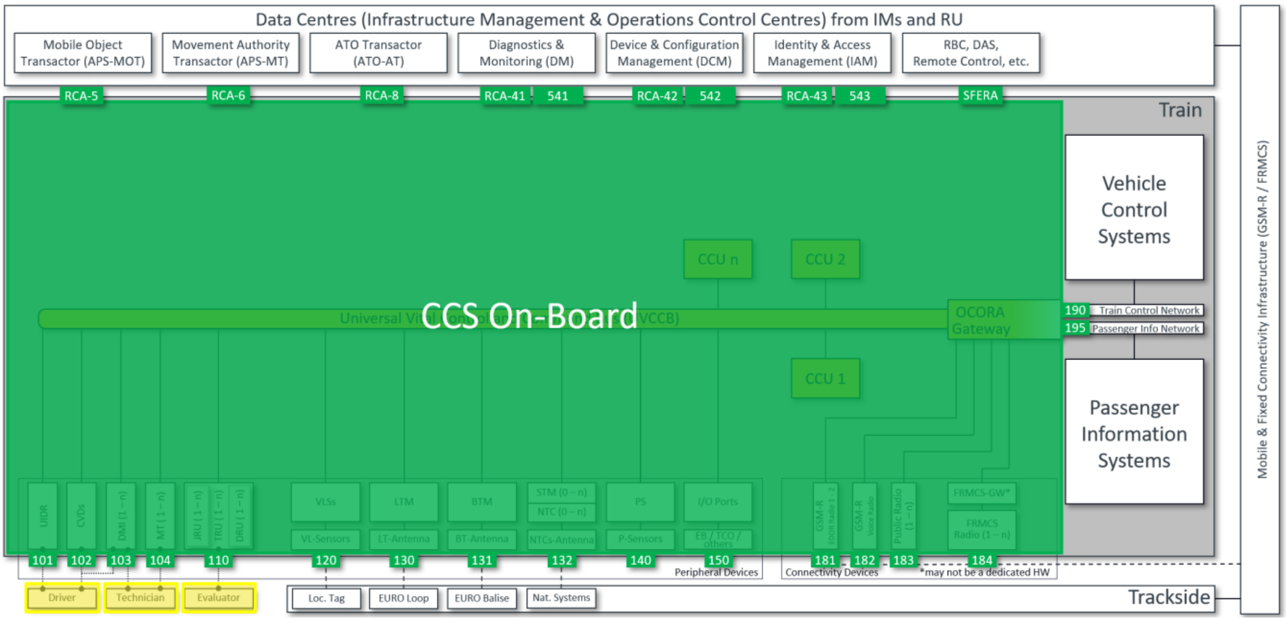

Figure 3 CCS On-Board Actors (yellow boxes)

The actors are the users of the CCS on-board system. The actors currently identified, including their roles, are listed in the following table. Refer to Figure 3 or to Appendix F1 on page 102 to locate the actors in the OCORA architecture.

Actor	Role
Driver	The person who operates the vehicle and may hold a user identification card. Refer also to interfaces: 101 102 103
Technician	The person who performs preventive and corrective maintenance tasks. Refer also to interfaces: 103 104
Evaluator	The person evaluating data stored in the TRU. Refer also to interfaces: 110

Table 7 Actors and roles

2.1.3.2 External systems

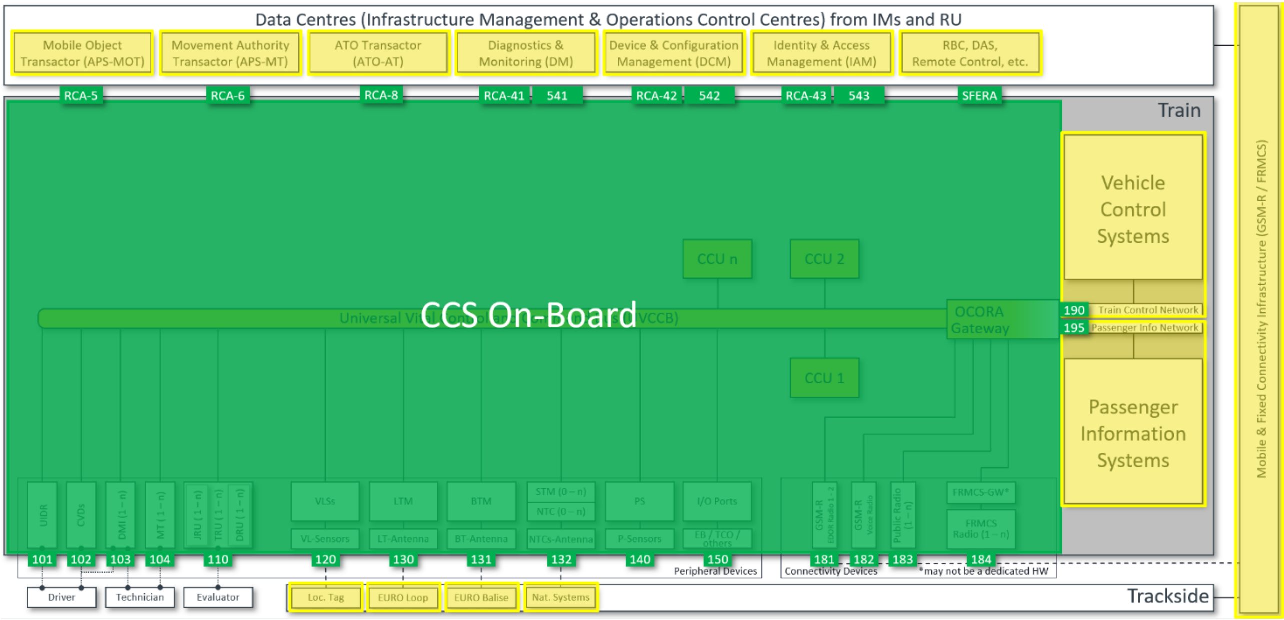

Figure 4 CCS On-Board External Systems (yellow boxes)

External systems are all systems that interact with the CCS on-board system. This includes the track side equipment, the mobile & fixed connectivity infrastructure, and the data centres form the IMs and the RU. The external systems currently identified, including a brief description and link to the interface description are listed in the Table 8. Refer to Figure 4 or to Appendix F1 on page 102 to locate the external systems in the OCORA architecture.

In addition to the external systems described in Table 8, there are also mechanical systems (e.g. cabinets) and electrical systems (e.g. UPSs) interacting with the CCS on-board system. These systems will be considered in more detail in subsequent versions of the OCORA documentation.

External System	High-Level Description	Link to Interface Description
Trackside Equipment		
Loc. Tag	**Location Tag** The location tags can be any kind of tag installed on trackside infra-structure elements, providing the Vehicle Localisation System the ability to determine the absolute position of the vehicle. These tags can be bar codes, RFID tags, etc. The EURO Balise is a such a tag, but with the additional ability to transfer static and dynamic data to the vehicle.	120
EURO Loop	**EURO Loop** A transponder loop mounted along the track, which can communi-cate with a train passing along, compliant to the ERTMS/ETCS spe-cifications.	130
EURO Balise	**EURO Balise** A transponder, mounted on the track, which can communicate with a train passing over it, compliant to the ERTMS/ETCS specifications.	131
National Systems	Any kind of national Automated Train Protection (ATP) system.	140
Mobile & Fixed Connectivity Infrastructure		
This includes all communication infrastructure needed by the vehicle.		181 182 183 184
Train / Vehicle		
Train Control Network	Any kind of Train Control Network/Bus/Cables and its connected systems.	190 390 490

External System	High-Level Description	Link to Interface Description
Passenger Information Network	Any kind of Passenger Information Network and its connected systems. This does not include the network for passenger internet services.	195 395 495
Data Centres (Infrastructure Management & Operations Control Centres) from IMs and RU		
APS-MOT	**Advanced Protection System - Mobile Object Transactor** RCA definition as per document [35]: The APS-MOT is used to communicate with the (safe) mobile devices. It includes the following information: ▪ Management of the devices ▪ Provides information to the Device, which it needs to localize itself. ▪ Position of the Device ▪ Requests to warn the Moveable Object	RCA-5
APS-MT	**Advanced Protection System - Movement Authority Transactor** RCA definition as per document [35]: The APS-MT communicates with the registered ETCS capable vehicles. Among others, it translates the movement permissions to ETCS Movement Authorities and send them to the vehicle. Only radio-based ETCS is supported. In the other direction it will receive the train position reports from the vehicle and forward them to OA.	RCA-6
ATO-AT	**ATO Transactor** RCA definition as per document [35]: ATO-AT implements the communication with all registered ATO vehicles and provides the standardized interface.	RCA-8
DM	**Diagnostics & Monitoring** RCA definition as per document [35]: Diagnostics & Monitoring (DM) collects monitoring and diagnostics information from all systems like central systems, trackside assets or the vehicles. The information is on one side used to derive the capacity limitation and an estimated duration of the capacity limitation that is used in TMS to reschedule Capacity Plan. On the other side the information is forwarded to a monitoring system of the IM, which triggers the corrective maintenance actions. It must be noted that there is the need for a DM system operated by the IM of the network and a DM operated by the RU of the vehicle, hence the two interfaced identified. More detailed information will be provided in subsequent versions of this document.	RCA-41 541
DCM	**Device & Configuration Management** RCA definition as per document [35]: The Device & Configuration Management (DCM) is used to register, setup, and manipulate devices. This includes updating the configuration data and the software version. Safety criticality: DCM is safety critical in so far, that part of the configuration is safety critical. Not the whole DCM needs to be on highest safety levels. It must be noted that there is the need for a DCM system operated by the IMs of the networks and a DCM operated by the RU of the vehicle, hence the two interfaced identified. More detailed information will be provided in subsequent versions of this document.	RCA-42 542
IAM	**Identity & Access Management** RCA definition as per document [35]: The Identity & Access Management (IAM) authenticates and authorizes users and technical systems and grants or denies access to the system. Therefore, it will need to store the credentials to authenticate the entities. Supports the implementation of an ISO27001 / IEC 62443 compatible architecture. It must be noted that there is the need for an IAM system operated by the IM of the network and an IAM operated by the RU of the vehicle, hence the two interfaced identified. More detailed information will be provided in subsequent versions of this document.	RCA-43 543

External System	High-Level Description	Link to Interface Description
DAS	**Driver Advisory System** The Driver Advisory System (DAS) application, is a non-safe application. It generates, together with the Driver Advisory Vehicle (DAV) application, detailed driver advice for adhering to the planned timings while driving energy efficient. The DAS is responsible for conflict detection and calculation of new target train timings, that are forwarded to the Driver Advisory Vehicle (DAV) application. The DAV is responsible to calculating an energy efficient speed profile to achieve the pre-planned and dynamically updated train timings. The DAS communicates with the DAV, using the SFERA specification.	SFERA
RBC	**Radio Block Centre** [1] The Radio Block Centre (RBC) is a specialised computing device with Safety integrity level 4 (SIL) for generating Movement Authorities (MA) and transmitting it to trains. It gets information from Signalling control and from the trains in its section. It hosts the specific geographic data of the railway section and receives cryptographic keys from trains passing in. According to conditions the RBC will attend the trains with MA until leaving the section. RBC have defined interfaces to trains but have no regulated interfaces to Signalling Control and only follow national regulation.	SUBSET-026

Table 8 External systems

[1] https://en.wikipedia.org/wiki/European_Train_Control_System

2.1.3.3 Environmental conditions

The environment conditions, in which the different components of the CCS on-board system operate, depend on the location the component is installed. The possible installation locations are defined in EN 50155: 2017, appendix C. Figure 5 depicts the foreseen installation locations and Table 9 provides explanations regarding these locations.

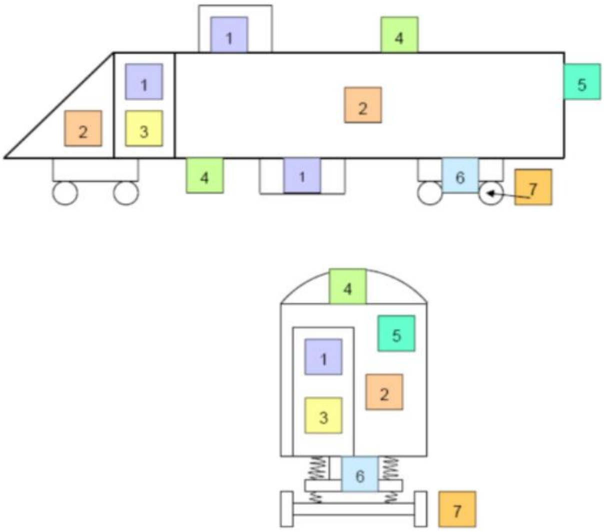

Figure 5 Typical location positions for on-board rolling stock (EN 50155: 2017)

Location ID (see Figure 5)	Definition	Examples	Examples of consequences on requirements
1	closed electrical operating area	▪ interior vehicle cubicle (weather-protected) ▪ exterior vehicle cubicle (weather-protected) ▪ either under-frame or upper-roof	▪ Operating temperatures and/or shock levels ▪ depending on the location of the installation.
2	cabin and interiors	▪ passenger vehicle compartment ▪ driver cabin	▪ low IP code required (air with low dust and chemical contamination
3	closed electrical operating area; forced filtered ventilation with outside air	▪ machinery compartment	▪ higher operating temperature in case of engine/power converter compartment or ▪ resistance to fuels and fluids
4	outdoor static applications	▪ under car body, roof (non-weather protected)	▪ non weather-protected location higher IP code ▪ resistance to light (UV) ▪ resistance to ozone for rubber and plastic parts
5	outdoor dynamic applications	▪ inter-vehicle	▪ non weather-protected location higher IP degree ▪ resistance to light (UV) ▪ resistance to ozone for rubber and plastic parts ▪ higher mechanical resistance
6	outdoor highly dynamic applications	▪ bogie	▪ non weather-protected location higher IP code ▪ resistance to light (UV) ▪ resistance to ozone for rubber and plastic parts ▪ higher mechanical resistance ▪ high vibration and shock constraints ▪ resistance to fuel and fluids
7	outdoor highly dynamic applications	▪ axles	▪ non weather-protected location higher IP code ▪ resistance to light (UV) ▪ resistance to ozone for rubber and plastic parts ▪ higher mechanical resistance ▪ very high vibration and shock constraints ▪ resistance to fuels and fluids

Table 9 Explanation of typical location positions for on-board rolling stock (EN 50155: 2017)

The definitions of the environmental conditions applicable for OCORA components will be provided in a subsequent version of the OCORA documentation.

2.1.4 Purpose

The purpose of the OCORA program is to:

provide an open and modular CCS on-board reference architecture, allowing for “plug & play”-like exchangeability of the defined pre-certified building blocks, supporting maximum independency, and the acceptance of global standards.

Refer to document [5], and [6], for details about the motivation that drives this purpose and to [10] for OCORA objectives.

The technical purpose of the CCS on-board system is to:

- prevent accidents such as collision between trains, derailment due to overspeed, damage by reason of indication negligence, etc.
- allow for Automated Train Operations (ATO) at all Grads of Autonomy levels (GoA 1 - 4) and in combination with different Automated Train Protection (ATP) systems (ETCS and/or NTC).

Refer to chapter 2.1.1 for details about the scope.

2.2 RAMSS performance and requirements of similar and/or previous systems

This chapter will be provided as part of a subsequent release of this documentation.

2.3 RAMSS performance and requirements for CCS on-board system

2.3.1 Reliability

This chapter will be provided as part of a subsequent release of this documentation.

2.3.2 Availability

This chapter will be provided as part of a subsequent release of this documentation.

2.3.3 Maintainability

This chapter will be provided as part of a subsequent release of this documentation.

2.3.4 Safety

This chapter will be provided as part of a subsequent release of this documentation.

2.3.5 Security

Refer to chapter 9.

2.4 RAMSS policies and targets from railway undertakings

This chapter will be provided as part of a subsequent release of this documentation.

2.5 Safety legislation

This chapter will be provided as part of a subsequent release of this documentation.

2.6 Impacts from further regulations

This chapter will be provided as part of a subsequent release of this documentation.

2.7 Assumptions and justifications

This chapter will be provided as part of a subsequent release of this documentation.

3 Building block identification

Modularity with the purpose of having “plug & play”-like exchangeability as defined in the OCORA context (see red box below), requires very detailed interface descriptions as well as harmonized requirement specifications (functional and non-functional) for all building blocks. Defining these interfaces and requirements to the level needed for the OCORA desired “plug & play”-like exchangeability, requires a substantial deployment of scarce human resources. Therefore, the granularity of the decomposition needs to be a result of a well-balanced analysis of the effort against the business needs (expected benefits).

In order to limit these efforts for modularization and to provide to the supplier industry as much room as possible to re-use their current products, OCORA is not aiming at “plug & play”-like exchangeability for all components identified in chapter 2.1.1. Instead, components are combined in building blocks that need to fulfil the exchangeability criteria. The definition of a building block is as follows.

> A building block is a top-level unit of the CCS on-board system (hardware and/or software), having well defined capabilities (tasks to be performed to achieve a predefined result) and interfaces towards other building blocks of the CCS system. Building blocks consist of 1 – n component(s) and are regression free modifiable / adaptable and therefore portable / replaceable. As a result, every building block is “plug & play”-like exchangeable without impacting other building blocks. OCORA building blocks shall be an optimal balance between "number of interfaces between building blocks" and "desire to exchange building blocks at a low granularity".

While OCORA aims primarily for “plug & play”-like exchangeability at a building block level, exchangeability at a lower level is always welcome. This is facilitated through the use of standardised COTS components within the building blocks. Therefore, OCORA strongly recommends to use / demand for standardised COTS components, wherever possible and reasonable.

As mentioned before, efforts for modularisation with “plug & play”-like exchangeability, as envisioned by OCORA, are considerable and therefore result in a long timeline. To support projects currently in the tender phase, OCORA plans to evolve the modularity in a phased approach. By doing so, these projects can take advantage of the first iteration OCORA architecture and can evolve, at the given time, to the final OCORA architecture with all its benefits. Currently, two iterations are planned to support this phased approach. But more iterations may be introduced, depending on the progress of the OCORA specification work and the RU’s timelines for tendering new CCS on-board systems.

3.1 Building blocks identification for first iteration

In this iteration, the CCS on-board system is not decomposed into building blocks as planned for the OCORA final iteration. The CCS on-board system basically remains as per SUBSET-026 with just the ETCS Kernel and the ATO application being separated from the rest of the CCS on-board system. This allows to eventually replace a “first iteration system” with a “first iteration system” of another supplier or even with a system following the specifications of the OCORA final iteration. This of course, without necessarily involving the original supplier of the train or of the CCS system. Figure 6 shows the corresponding system decomposition from a hardware and Figure 7 from a functional point of view.

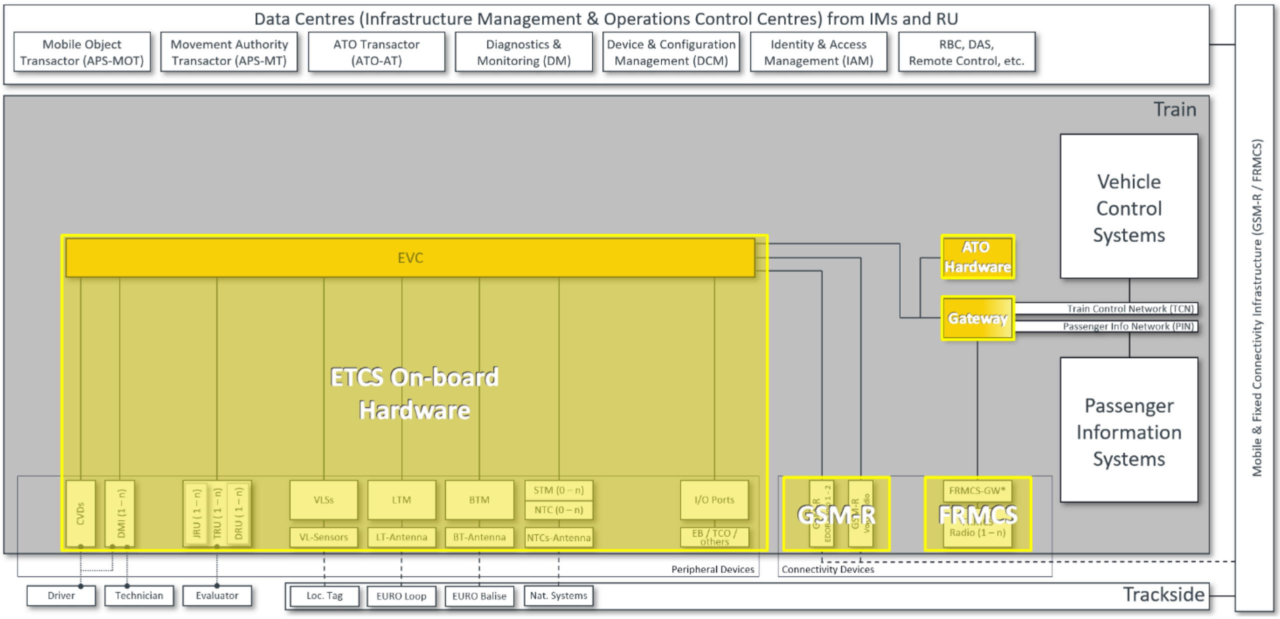

Figure 6 Hardware building blocks (first iteration)

For this first iteration, the identified building blocks are depicted in Figure 6 The interface descriptions and the OCORA requirements of these building blocks must be followed. Otherwise, integration is not possible and individual exchangeability throughout the lifetime of the train is not ensured.

The UVCCB is not depicted as a separate building block. But OCORA strongly encourages to use the defined UVCCB already in implementations, following this first iteration.

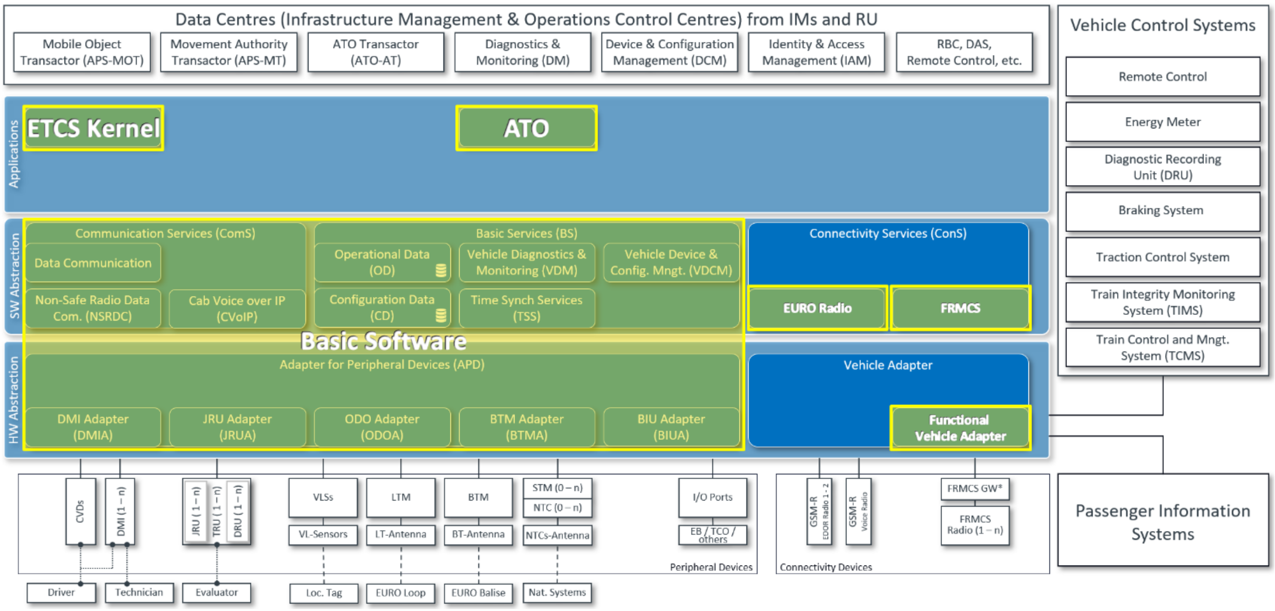

Figure 7 Functional building blocks (first iteration)

As for the hardware, the grouped CCS building blocks (yellow fields) depicted in Figure 7 are considered to be monolithic functional blocks and need to be purchased as a whole from one single supplier. The interface descriptions and the OCORA requirements of these building blocks must be followed. Otherwise, integration is not possible and individual exchangeability throughout the lifetime of the train is not ensured.

For the first iteration, a separation of hardware from software in the way envisioned for the final iteration and as outlined in chapter 5 is not foreseen. As a result, ATO functionality needs to be deployed on a separate hardware and needs to be purchased as a hardware-software bundle.

This first iteration does not only consider ATO to be integrated into a CCS on-board system but does also envision the migration from GSM-R to FRMCS. But the architecture regarding FRMCS integration needs to evolve with the final iteration and the TOBA architecture and will therefore be available in a later version of this document.

For the integration of the ERTMS game changer (FRMCS and ATO), the ETCS Kernel needs to be modified to ensure the integration with standard interfaces.

3.2 Building block identification for final iteration

This iteration builds on the first iteration and especially reuses the functional level of the interface specifications between the CCS and the TCMS (refer to [16] and [17]). However, it must be assumed that, based on the experience of the first iteration, adjustments will be made to these specifications and extensions will be introduced (e.g. to support train integrity functionality).

In this final iteration, the CCS on-board system is decomposed into additional building blocks. The proposed decomposition has been evaluated using the design principles as stated in Appendix A. This proposal is tentative and may change in subsequent versions of the OCORA architecture documentation. Figure 8 shows the proposed system decomposition from a hardware and Figure 9 from a functional point of view.

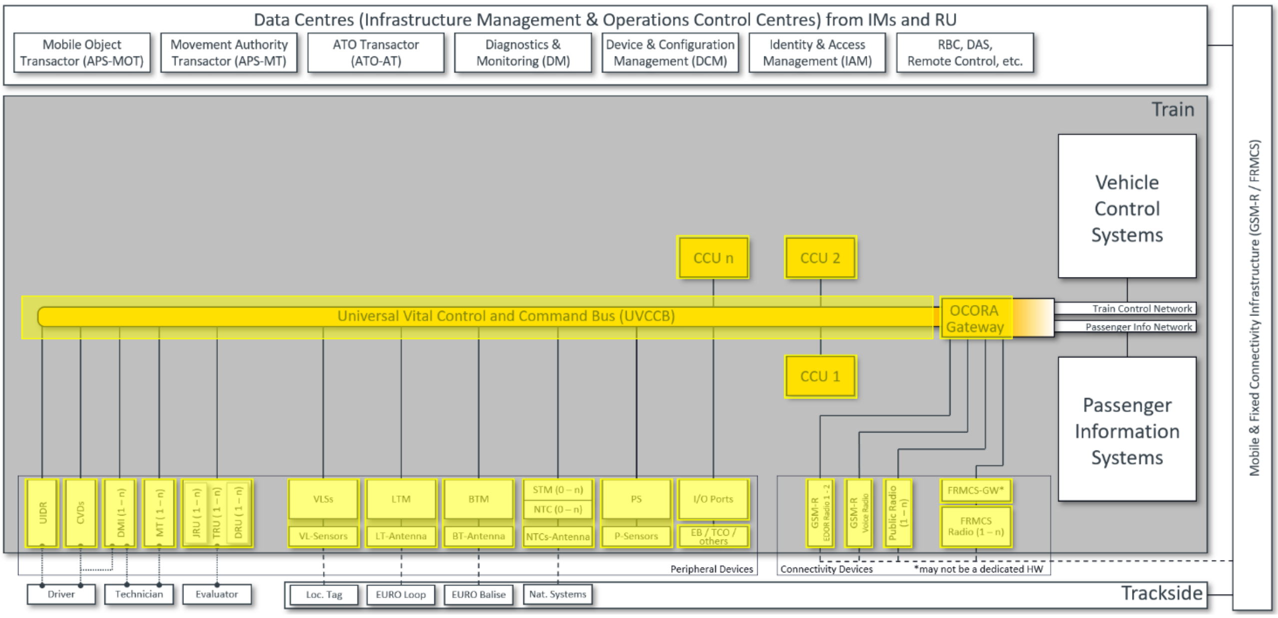

Figure 8 Hardware building blocks (final iteration)

In this final iteration, the grouped CCS building blocks (yellow fields) depicted in Figure 8 are considered to be monolithic blocks. For the peripheral devices and connectivity devices, this includes the software running on them.

The interface descriptions and the OCORA requirements of the building blocks must be followed. Otherwise, integration is not possible and individual exchangeability throughout the lifetime of the train is not ensured.

Refer to chapter 4.1, 4.2, and 4.3 for a more detailed description of the identified hardware components.

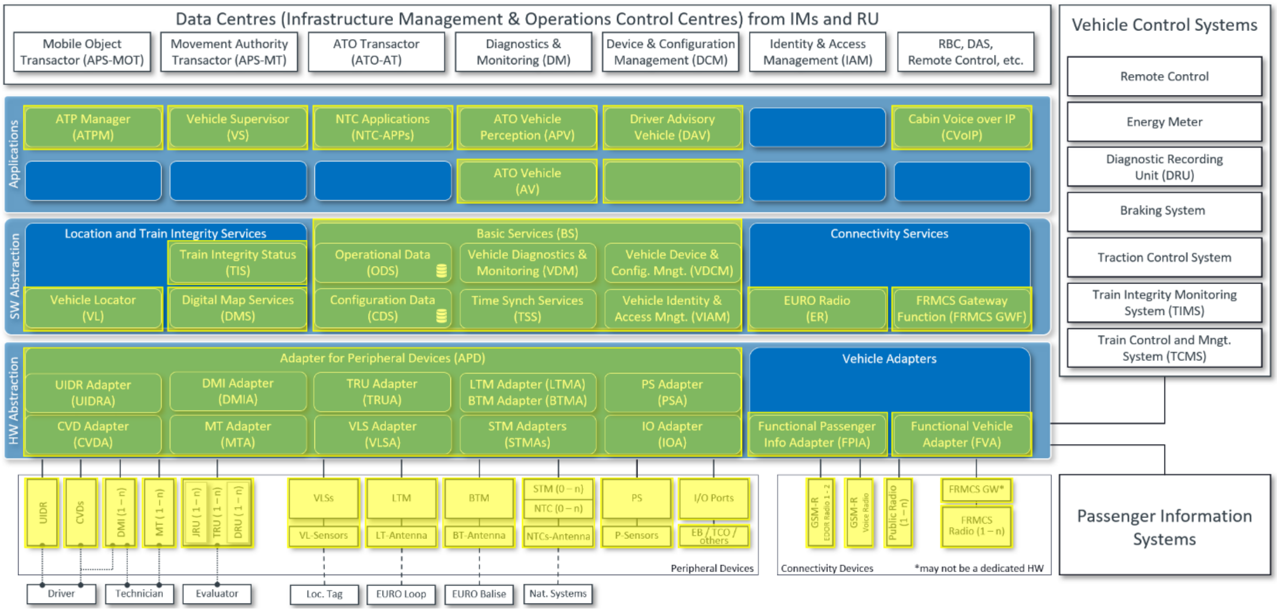

Figure 9 Functional building blocks (final iteration)

In this final iteration, the grouped CCS building blocks (yellow fields) depicted in Figure 9 are considered to be monolithic functional blocks. For the peripheral devices and connectivity devices, this includes the hardware on which the software runs.

The interface descriptions and the OCORA requirements of the building blocks must be followed. Otherwise, integration is not possible and individual exchangeability throughout the lifetime of the train is not ensured.

For the final iteration, a separation of CCU hardware from software is envisioned as outlined in chapter 5. As a result, there is no dependency between CCU hardware and applications / services anymore. The “Runtime Environment” (refer to chapter 5) act as hardware abstracter and may be bundled within the hardware.

Refer to chapter 4.4, 4.5, and 4.6 for a more detailed description of the identified functional components.

4 Component description

4.1 OCORA core hardware

The OCORA core hardware are the components within the "OCORA Core" scope. For these components, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements but also detailed design requirements. The OCORA core hardware is also considered for all RAMSS aspects.

The OCORA core hardware, together with the runtime environment (refer to chapter 8), provides the platform to run the OCORA core functionality.

4.1.1 Universal Vital Command and Control Bus (UVCCB)

The Universal Vital Command and Control Bus (UVCCB) is the CCS on-board bus/network allowing direct communication between all CCS on-board components connected to it and eventually with external systems, such as the TCMS. The UVCCB is the most central part of the OCORA architecture and is the basis for achieving modularity that results in "plug & play"-like exchangeability of all building blocks. The UVCCB is a TSN Ethernet based network with the use of SDTv2/v4 as safety layer. The bus/network is currently defined for OSI layer 1 to 2 (according to definitions in document [8]) but will be specified up to OSI layer 6 and 7 (according to definitions in document [8]) in subsequent versions of the OCORA specifications.

The UVCCB is installed on every OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the UVCCB component in the OCORA architecture.

Every CCS on-board device with high RAMS requirements has two TSN capable Ethernet ports. Refer to Appendix B for network topology scenarios.

On layer 3 to 6 at least IPv4, UDP, TCP and TRDP must be supported in order to be able to communicate directly to the TCMS. For communication between CCS on-board devices, other protocols on session layer are possible (e.g. OPC-UA Pub/Sub or DDS-RTPS).

Information regarding the requirements used for evaluating the UVCCB and the respective evaluation can be found in document [13].

Further details, especially the integration of the UVCCB with the NG-TCN and further investigations on OSI layer 3 to 6 (according to definitions in document [8]) will be provided in subsequent versions of the OCORA architecture documentation.

4.1.2 CCS Computing Unit (CCU)

The CCS Computing Unit (CCU) is the computing hardware for all OCORA core CCS functions. One CCU can contain multiple processor boards (e.g. to provide hardware level voting). The number and the functional behaviour of the CCUs can differ for the various implementations, depending on the RU's need. For migration reasons, multiple CCUs may be needed or certain functions can be deployed on one node (e.g. safe functions) while others (e.g. non-safe) are deployed on a separate node. In some projects, additional CCUs may be used to increase availability and reliability by defining one or multiple CCU nodes as fail over or standby units. The CCU hardware is made accessible through the runtime environment. The CCU together with the runtime environment are building the computing platform (refer to chapter 8 for details).

At least one CCU is installed on every OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the CCU component in the OCORA architecture.

Further details regarding the CCU hardware will be provided in subsequent versions of the OCORA architecture documentation.

4.1.3 OCORA Gateway (OCORA-GW)

The OCORA Gateway (OCORA-GW) is a piece of hardware providing communication capabilities between the CCS bus (UVCCB) and the Train Control bus (if it exists) or the TCMS (if it exists) or the actuators and sensors residing outside the CCS domain but important to CCS. Depending on the vehicle, the OCORA Gateway covers multiple OSI layers (according to definitions in document [8]). This can include even layer 7 in some cases. The OCORA-GW provides a means of integrating the CCS system with various vehicle technologies, especially when deploying an OCORA based CCS system on existing fleets. However, even if the same bus technology is use for the CCS and vehicle systems, the OCORA-GW is still recommended for security and performance reasons.

The OCORA-GW is installed on every OCORA based CCS on-board system whilst and where no standardized and common TCMS-CCS network/bus is available. In case there is not TCMS the OCORA-GW can integrate directly with the EB and TCO. Refer to Appendix F1 on page 102 to locate the OCORA-GW component in the OCORA architecture.

The GSM-R and the FRMCS Radio may also be connected to the Gateway, providing connectivity for the CCS Systems with the RBC (for ETCS L2/L3 networks), with ATO trackside (ATO-AT) and with the RCA compliant CCS Data Centres respectively. For communication over public radio networks (remote diagnostics and maintenance), a corresponding modem might be connected to the Gateway. Furthermore, the Passenger Information bus may, depending on security requirements, also be connected with the Gateway, ensuring communication between the CCS Systems and the Passenger Information Systems. The FRMCS Radio, connected to the Gateway, may eventually provide communication services for the CCS Systems, the Train Control Systems, and the Passenger Information Systems.

In addition to the connectivity services outlined above, the Gateway may also provide IT Security Services (if not provided by the on-board radio – discussion and assessment ongoing) to protect the CCS System from cyber-attacks. Depending on the cyber security strategy, this service may also be shared with the Train Control Systems, and the Passenger Information Systems. Additional IT Security Services also clearly segregate the different train born systems (CCS, Train Control, Passenger Information) from each other.

OCORA aims at defining a standardized CCS System with standardized interfaces. To integrate with the different current and future Train Control and Passenger Information systems without modifying the standardized CCS System, corresponding adapters might be needed to convert standardized OCORA communication protocols and messages to the specific protocols and messages of the respective Train Control and Passenger Information Systems. The Gateway may provide the environment to run the necessary adapters. Once there is a standardized TCMS and PIS interface defined, the need for adapters vanishes and the Gateway may be reduced to a router or switch, hosting the needed firewalls (if not part of the on-board radio) and supporting the “plug & play”-like exchangeability of the UVCCB without reassessment of the TCMS segment in case of changes. For the interface with the vehicle TCMS, this is specified in document [16] and [17].

While OCORA foresees in its architecture the Gateway for integrating with the specific Train Control and Passenger Information Systems, the implementation of the Gateway remains a vehicle specific integration task. Depending on the specific situation, the OCORA Gateway may be simple or quite complex. In any case, the OCORA Gateway, drawn as a single box in Appendix F1 on page 102, is composed of multiple subcomponents. Some of these sub-components will be part of most OCORA Gateway deployments while others are only needed for some integrations. The purpose, the requirements, and the decomposition of the OCORA Gateway will be discussed in more detail in the OCORA Gamma release.

Currently, the scope and functionality of the OCORA Gateway is not well defined. The OCORA gateway functionality and requirement will be refined in a later stage in liaison and coherence with UIC TOBA, S2R Connecta project, and cyber-security railway platforms.

To sharpen the scope and functionality of the OCORA gateway from an OCORA perspective, the following possible scenarios are evaluated against a weighted set of criteria. Refer to Appendix C for a detailed explanation of the different scenarios.

Scenario ID	Description	Radio connected to				Security integrated in	
		TCN	UVCCB	PIN	OCORA-GW	Radio	OCORA-GW
1	▪ The Radio is connected to the **Train Control Network** ▪ All Busses use the TCB for Trackside communication ▪ **Security** is integrated into **Radio**	x				x	
2	▪ The Radio is connected to the **Train Control Network** ▪ All Busses use the TCB for Trackside communication ▪ **Security** is integrated into **OCORA-GW**	x					x
3	▪ The Radio is connected to the **UVCCB** ▪ All Busses use the UVCCB for Trackside communication ▪ **Security** is integrated into **Radio**		x			x	
4	▪ The Radio is connected to the **UVCCB** ▪ All Busses use the UVCCB for Trackside communication ▪ **Security** is integrated into **OCORA-GW**		x				x
5	▪ The Radio is connected to the **Passenger Information Network** ▪ All Busses use the PIB for Trackside communication ▪ **Security** is integrated into **Radio**			x		x	
6	▪ The Radio is connected to the **Passenger Information Network** ▪ All Busses use the PIB for Trackside communication ▪ **Security** is integrated into **OCORA-GW**			x			x
7	▪ The Radio is **integrated** into the **OCORA-GW** ▪ All Busses use the GW for Trackside communication ▪ Security is integrated into OCORA-GW				x		x
8	▪ The Radio is **connected** to the **OCORA-GW** ▪ All Busses use the GW for Trackside communication ▪ Security is integrated into OCORA-GW				x		x
9	▪ Each Bus has its own Radio	x	x	x		x	
10	▪ Only CCS Communicates over the OCORA-GW	x		x	x		x

Table 10 Possible scenarios for connecting the connectivity to CCS on-board

At this point in time a first list of evaluation criteria is available (see table below). It consists of the OCORA design principles, the RAMS aspects, and the market readiness.

Design principle	Weight	1	2	3	4	5	6	7	8	9	10
Modularity											
Replaceability											
Modifiability											
Adaptability											
Portability											
Security											
Reliability											
Availability											
Maintainability											
Safety											
Market Readiness											

Table 11 Evaluation of OCORA Gateway scenarios

Further details, especially the evaluation of the OCORA Gateway scenarios (Table 11), will be provided in subsequent versions of the OCORA architecture documentation.

4.2 Peripheral devices

The peripheral devices are components outside the "OCORA Core" scope. For these components, OCORA provides interface specifications, high-level functional requirements, and non-functional requirements only. Basically, all requirements and specifications needed to ensure "plug & play"-like exchangeability. Of course, these specifications are only developed for the building blocks not already standardised (well enough) or where no standard is being developed by other organizations. The peripheral devices are also considered for all RAMSS aspects.

The peripheral devices include all sensors and actuators needed for the CCS on-board system to function.

4.2.1 User Identification Reader (UIDR)

The User Identification Reader (UIDR) is used to automate the identification pro cess for drivers and service technicians. RFID card readers may be the most common option used at this point in time. But as technology advances, fingerprint, face ID, etc. might become viable options. The OCORA specifications will be technology agnostic.

The UIDR is an optional deployment on OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the UIDR component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.2 Cab Voice Devices (CVDs)

The Cabin Voice Devices (CVDs) are the microphone and the loudspeaker(s) in the cabin, combined with some electronics, allowing to communicate over the UVCCB with the CVoIP application and ultimately with the GSM-R Voice Radio or the FRMCS Radio respectively. They are used for the communication between the driver and the operations control personnel or for communication between train staff. Today, these devices are only loosely integrated into the CCS domain, if at all. But with the upcoming migration from GSM-R to FRMCS options become available to share the new connectivity infrastructure between the CCS data and cabin voice. The OCORA concept foresees to have a cabin voice application running on one of the CCUs and providing voice communication through voice over IP (VoIP).

The CVDs are an optional deployment on OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the CVD components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.3 Driver Machine Interface (DMI)

At this point in time, this is the Driver Machine Interface (DMI) for all OCORA core CCS functions in need of user interaction. At a later stage, other functions may also be supported by the DMIs. The number of DMIs and the functions assigned to them can differ for the various implementations, depending on the RU's need. A typical OCORA implementation foresees one primary DMI for ETCS or the NTC system and an additional display for all other functions (e.g. ATO, Cabin Voice, etc.). In such configurations, the additional DMI may also be used to increase availability of the primary display functions through a switch-over mechanism. Mobile personal devices (e.g. Tablets) are another type of DMI that may be used for some applications.

At least one DMI is installed on every OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the DMI components in the OCORA architecture.

OCORA plans to build on top of the European Driver's Desk (EUDD) specification work when developing the OCORA DMI specifications. It is an aim of OCORA to support a better interchangeability of the DMIs, than in the present market scenario.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.4 Maintenance Terminal (MT)

The Maintenance Terminal (MT) is a laptop that can be connected to the UVCCB to perform maintenance tasks on all CCS on-board components. Maintenance tasks should include the monitoring and downloading of diagnostic data, executing service commands (e.g. reboot of a specific component) and installing updates (new software, configuration, etc).

Multiple MTs can be connected to every OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the MT components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.5 Train Recording Unit (TRU)

The Train Recording Unit (TRU) includes the Juridical Recording Unit (JRU) and the Diagnostic Recording Unit (DRU). Currently, the JRU is mostly located in the CCS domain while the DRU is typically found in the Train Control domain. The JRU records data from the ETCS system while the DRU is recording data from other on-board systems, for instance the TCMS. In the future, other functions than ETCS will reside in the CCS domain (e.g. ATO). Those functions have also a need to record data. Hence, a DRU is proposed to be added to the CCS domain. Whether this is a specific hardware, in addition to the hardware available in the TCMS domain, or the DRU hardware can be combined needs to be explored further.

At least one TRU is installed on every OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the TRU components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.6 Vehicle Localisation Systems (VLSs)

The Vehicle Localisation Systems (VLSs) processes the data from the various Vehicle Localisation Sensors, performs the necessary sensor fusion, and provides the data to the VL through the UVCCB.

At least one VLS is installed on every OCORA based CCS on-board system. The sensors connected to it may differ from one installation to the other. The architecture allows to install multiple VLSs to support different type of sensors, if needed (e.g. separate VLS for IMU sensors). Refer to Appendix F1 on page 102 to locate the VLS component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.7 Vehicle Localisation Sensors (VL-Sensors)

The Vehicle Localisation Sensors (VL Sensors) provide raw data to determine speed, direction of travel, acceleration, position, and cold movement information to the Vehicle Localisation System (VLS). Depending on the RU's need and the progress of technology (e.g. GNSS, IMU) different type and quality of sensors may be used.

VL Sensors are installed on every OCORA based CCS on-board system, but the configuration of the sensors may differ from one installation to the other. Refer to Appendix F1 on page 102 to locate the VL-Sensor component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.8 Loop Transmission Module (LTM)

The Loop Transmission Module (LTM) is used for ETCS L1 and L1LS systems to process the data from the Loop Transmission Antenna (LT-Antenna) and makes the data available on the UVCCB.

The LTM is installed on every OCORA based CCS on-board system in need Euroloop functionality. Refer to Appendix F1 on page 102 to locate the LTM component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.9 Loop Transmission Antenna (LT-Antenna)

The Loop Transmission Antenna (LT-Antenna) receives data through an RFID interface from the EURO Loop and provides the data to the Loop Transmission Module (LTM).

The LT-Antenna is installed on every OCORA based CCS on-board system in need of Euroloop functionality. Refer to Appendix F1 on page 102 to locate the LT-Antenna component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.10 Balise Transmission Module (BTM)

The Balise Transmission Module (BTM) is used for ETCS L1 – L3 systems (including L0 and LNTC). It processes the data from the Balise Transmission Antenna (BT-Antenna) and makes the data available on the UVCCB, for the ETCS application (VS). Optionally, the BTM can also receive data from KER Balises and can make the data available, through the UVCCB, to the corresponding STM through the K interface describe in SUBSET-101.

The BTM is installed on every OCORA based CCS on-board system in need of ETCS functionality. Refer to Appendix F1 on page 102 to locate the BTM component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.11 Balise Transmission Antenna (BT-Antenna)

The Balise Transmission Antenna (BT-Antenna) receives data through an RFID interface from the EURO Balise and provides the data to the Balise Transmission Module (BTM). Optionally, the BT-Antenna can also receive data through an RFID interface from the KER Balises and can provide the data to the Balise Transmission Module (BTM).

The BT-Antenna is installed on every OCORA based CCS on-board system in need of ETCS functionality. Refer to Appendix F1 on page 102 to locate the BT-Antenna component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.12 Specific Transmission Module (STM)

The Specific Transmission Module (STM) provides the connection between the ETCS system (in case of OCORA the UVCCB) and the National Train Control System (NTC). The STM and the NTC are often closely integrated, hence the term STM is often used, when referring to the NTC system.

Multiple STMs can be connected to the UVCCB. They are installed on OCORA based CCS on-board system on an as needed basis. Refer to Appendix F1 on page 102 to locate the STM components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.13 National Train Control (NTC)

The National Train Control (NTC) provides Automated Train Protection functionality on national level. It communicates with other OCORA components, namely the Automated Train Protection Manager (ATPM) and can also use the functionality of other components connected to the UVCCB (e.g. DMI, VLS, TCO, EB, etc.). Alternatively, it is also possible to implement the National Train Controls business logic as Applications on the OCORA computing platform (see NTC-APPs for more information). In this case, the NTC-APPs access through the UVCCB and the BTM the balise data in order to get the package 44 information.

Multiple NTCs can be connected via the respective STM to the UVCCB. They are installed on OCORA based CCS on-board system on an as needed basis. Refer to Appendix F1 on page 102 to locate the NTC components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.14 National Train Control Antenna (NTC-Antenna)

The National Train Control Antennas (NTC-Antennas) receive the data from the trackside installations of the respective national ATP system and provides the data to the NTC.

The NTC-Antennas can be connected via the respective NTC and STM to the UVCCB. They are installed on OCORA based CCS on-board system on an as needed basis. Refer to Appendix F1 on page 102 to locate the NTC-Antenna components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.15 Perception System (PS)

The Perception System (PS) provides awareness information if needed for GoA3 and GoA4 operations. The Perception System processes the data from the various Perception Sensors (P Sensors), performs the necessary sensor fusion, and makes the data available on the UVCCB.

The PS is installed on OCORA based CCS on-board system, if needed for ATO GoA3 – GoA4 operations. Refer to Appendix F1 on page 102 to locate the PS component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.16 Perception System Sensors (P-Sensors)

The Perception Sensors (P-Sensors) include all sensors to provide enough awareness of the environment (mainly the tracks) for safe GoA3 and GoA4 operations. The sensors are mostly cameras, but can also include vibration sensors, smoke detectors, etc.

The P-Sensors are installed on OCORA based CCS on-board system, supporting ATO GoA3 – GoA4. Refer to Appendix F1 on page 102 to locate the P-Sensor components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.17 I/O Ports

The I/O Ports provide access between the UVCCB and certain actuators and sensors. The status of the sensors is processed by this component and made available on the UVCCB and commands from the various CCS on-board components, sent through the UVCCB, are applied to the respective port.

The I/O Ports are installed on every OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the I/O Ports component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.2.18 Emergency Brake (EB) / Traction Cut-Off (TCO) / Others

These are the devices triggering the Emergency Brake (EB) and the Traction Cut-Off (TCO) for ETCS, NTC-APP, APV, etc. Depending on the system configuration and RU's need, multiple EBs and TCOs can be connected and additional I/Os can be used to interact with "other" external systems, actuators, and sensors. Examples are:

- *Cabin activation status*
- *ETCS isolation status*
- *Vehicle power status*
- *Dead Man Switch: to monitor the awareness of the driver*
- *CCS Cabinet Supervision: to monitor unauthorized access*

At least one EB and TCO devices are installed on every OCORA based CCS on-board system. Refer to Appendix F1 on page 102 to locate the EB and TCO components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.3 Connectivity devices

The connectivity devices are components outside the "OCORA Core" scope. For these components, OCORA only provides interface specifications, high-level functional requirements, and non-functional requirements. Basically, all requirements and specifications needed to ensure "plug & play"-like exchangeability. Of course, these specifications are only developed for the building blocks not already standardised (well enough) or where no standard is being developed by other organizations. The connectivity devices are also considered for all RAMSS aspects.

The connectivity devices provide secure connectivity to the data centres for the CCS on-board domain. Eventually, other domains such as the train control or the passenger information may use this infrastructure for their communication needs. Refer to chapter 4.1.3 and Appendix C for a discussion of possible options.

4.3.1 GSM-R - EDOR Radio

The GSM-R EDOR Radio provides (cyber-)secure GSM-R data connectivity to trackside systems. Today, it is mainly used for the communication with the RBC in case of ETCS level 2 operations. The device will eventually be replaced by an FRMCS Radio.

The GSM-R EDOR Radio is installed on every OCORA based CCS on-board system supporting ETCS L2 or higher, as long as FRMCS is not widely deployed. Refer to Appendix F1 on page 102 to locate the GSM-R EDOR Radio component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.3.2 GSM-R - Voice Radio

The GSM-R Voice Radio provides GSM-R voice connectivity. Today, it is widely used for voice communication between the driver and the operations control centres or between train staff. The device will eventually be replaced by an FRMCS Radio in combination with the Cabin Voice over IP communication.

The Voice Radio is installed on OCORA based CCS on-board system on an as needed basis. Refer to Appendix F1 on page 102 to locate the GSM-R Voice Radio component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.3.3 Public Radio

The Public Radio provides connectivity between the train and off-board. The OCORA architecture foresees that multiple Public Radio modems can be connected, depending on the RU's need. Public Radio connections are mainly used for monitoring, diagnostic, and maintenance purposes during the transition phase to FRMCS. Separate modems can connect the train with the operations centre of its RU and/or with the train supplier. The Public Radio modem will eventually be replaced by the respective functionality of the FRMCS Radio.

Multiple Public Radios can be installed on OCORA based CCS on-board system on an as needed basis. Refer to Appendix F1 on page 102 to locate the Public Radio component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.3.4 FRMCS Gateway (FRMCS-GW)

The FRMCS Gateway (FRMCS-GW) provides the hardware resources to run FRMCS-GW Functions and connects to the FRMCS Radio(s).

Refer to Appendix F1 to locate the FRMCS Radio component in the OCORA architecture. However, it must be noted that the FRMCS Gateway may not be a dedicated piece of hardware. The FRMCS-GW Functionality could also be deployed on the FRMCS Radio, the OCORA Gateway, or on a CCU.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.3.5 Future Rail Mobile Communication System (FRMCS) Radio

The FRMCS Radio represents a modem with one or more 3GPP and/or non-3GPP radio access technologies supported by the FRMCS system.

Multiple FRMCS Radio modules may be installed on every OCORA based CCS on-board system supporting cabin voice and/or ETCS L2 or higher level, once FRMCS is available. Refer to Appendix F1 to locate the FRMCS Radio components in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.4 OCORA applications

The OCORA applications are functional application providing the actual (business) logic of a railway function. Most, if not all, OCORA applications are its own individual building block (refer to chapter 3.2). Hence, for these components, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements but also detailed design requirements. At the current stage, a set of applications are identified. However, more applications will be defined in subsequent versions of this document. But the OCORA platform also provides an API that allows new applications, not known at this point in time, to use the services of the platform and infrastructure of the vehicle. Hence, developing and deploying new functionality should be simplified. Such applications could be "automated routine test" or the development of an NTC application that uses balise data, package 44 (refer to chapter 4.4.3).

All OCORA applications run on the OCORA computing platform (refer to chapter 7).

4.4.1 Automatic Train Protection Manager (ATPM)

The Automated Train Protection Manager (ATPM) application, deployed on the OCORA computing platform, is a safe application in charge of managing the safety authority between installed ATP systems. It ensures that the proper ATP system is active and manages the switch-over from one ATP system to the other. Also, the ATPM includes the "STM control function" functionality defined in SUBSET-035.

The ATPM is deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the ATPM component in the OCORA architecture and to chapter 7.1 for information about the ATPM interfaces.

In today's ETCS implementations, the ATPM is part of the monolithic ETCS OBU (STM control function). Since the purpose of the OCORA architecture includes the ability to deploy one or multiple ATP systems on the OCORA platform (e.g. through NTC-APPs or by connecting STMs) without the need to deploy an ETCS, it is essential that the ATPM is a separate component.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.4.2 Vehicle Supervisor (VS)

The Vehicle Supervisor (VS) application, deployed on the OCORA computing platform, is a safe ETCS application (mandatory requirements are specified in SUBSET-026) in charge of calculating location specific speed limits (based on various inputs) and activating the braking system in case of speed limit overshoot. Location information is received from the Vehicle Locator (VL). In addition, information is received from the Balise Transmission Module (BTM) and the Loop Transmission Module (LTM) and processed adequately. In ETCS L2 and L3 mode, the VS interacts with the RBC or the APC-MT respectively. It receives the movement authority (MA) and reports the train position (TPR) to the respective system. The VS is agnostic to the communication technology used. Therefore, communication via GSM-R as well as via FRMCS or any future technology is possible. The VS also displays to the driver the necessary information (including cab signalling in ETCS L1, L2 and L3). It supports all ETCS modes and ETCS levels defined in the TSI-CCS.

The VS application is deployed on every OCORA based CCS on-board system in need of ETCS functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the VS component in the OCORA architecture and to chapter 7.2 for information about the VS interfaces.

In today's ETCS implementations, the VS is part of the monolithic ETCS OBU. Since the purpose of the OCORA architecture includes the ability to deploy one or multiple ATP systems on the OCORA platform without the need to deploy an ETCS, it is essential that the VS is a separate component, containing just the minimum functionality needed to perform the supervision of the vehicle during ETCS operations. Appendix B contains, on a very high-level, a first proposed split of functionality between the VS, VL, and the ATPM, based on SUBSET-026, chapter 4.5. The OCORA architecture team is aware that splitting the functionality only based on the SUBSET-026, chapter 4.5 is not sufficient, because the subset does not provide all requirements. SUBSET-026 is providing the mandatory requirement specifications only. A more detailed separation and a first version of a complete VS model, identifying additional requirement to SUBSET-026, can be expected in subsequent OCORA documentation releases.

Isolating the VS- from the VL- and ATPM-functionality has the positive side-effect that the complexity of the VS is reduced and a stable component with little need for changes can be developed. A very important aspect, since the VS is requiring a safe implementation and already many changes for the CCS on-board are foreseeable. For example, it is expected that changes will be introduced, and more functionality will be added to CCS on-board in the upcoming TSI-CCS revisions and through the introduction of new functionalities (game changers).

New functionalities (game changers) with potential impact on the VS are:

- FRMCS
- ATO
- Train integrity detection for ETCS L3 mode

It is the goal of the OCORA architecture team to build a VS model that is mostly agnostic to these changes, and where not possible, does already consider the changes in the design.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.4.3 National Train Control Applications (NTC-APPs)

The National Train Controls Applications (NTC-APPs), deployed on the OCORA computing platform, are safe applications in charge of ensuring automated train protection based on national systems. NTC-APPs, implemented on the OCORA computing platform, must communicate, as a minimum, with the ATP Manager and can use their specific sensors and actuators. In addition, they can take advantage of the standard OCORA interfaces. E.g. location information can be received from the Vehicle Locator (VL), data can be recorded in the TRU, DMI can be used, the TCMS can be accessed through the Functional Vehicle Adapter (FVA), etc.

Multiple NTC-APPs can be deployed on OCORA based CCS on-board system, depending on the requirements of the rail network, the RU wants to operate in. Refer to Appendix F2 and F3 on page 103 and 104 to locate the NTC-APPs in the OCORA architecture and to chapter 7.3 for information about the NTC-APPs interfaces.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.4.4 ATO Vehicle (AV)

The ATO Vehicle (AV) application, deployed on the OCORA computing platform, is a non-safe application for automated train operations. A safe extension is needed for GoA3 and GoA4 operations. This is provided by the ATO Perception Vehicle (APV). The AV in GoA2 – GoA4 operates the vehicle automatically using information received through the interface SS126. It also communicates with the Vehicle Supervisor (VS) over the interface SS130 (between AV and ETCS-OB). Remark: AV is called ATO-OB in GoA2 Shift2Rail SUBSET-125.

The AV application is deployed on every OCORA based CCS on-board system in need of ATO functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the AV component in the OCORA architecture and to chapter 7.4 for information about the AV interfaces.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.4.5 ATO Perception Vehicle (APV)

The ATO Perception Vehicle (APV) application, deployed on the OCORA computing platform, is a safe application needed for automated train operations with GoA3 and GoA4. It is deployed in addition to ATO Vehicle (AV) and includes all safety-related functionality and data needed for GoA3 and GoA4 operations. To execute these tasks, it has interfaces to perception system, Digital Maps (DMS), etc. Based on the situation (type of danger and location information) it triggers speed reduction, service brakes, traction cut-off, and emergency brakes. Remark: APV is called "Incident Protection Management" (IPM) in GoA3 – GoA4 Shift2Rail discussions.

The APV application is deployed on every OCORA based CCS on-board system in need of ATO GoA3 or GoA4 functionality. Refer Appendix F2 and F3 on page 103 and 104 to locate the APV component in the OCORA architecture and to chapter 7.5 for information about the APV interfaces.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.4.6 Driver Advisory Vehicle (DAV)

The Driver Advisory Vehicle (DAV) application is an optional and non-safe application calculating an energy efficient speed profile to achieve the pre-planned and dynamically updated train timings. It generates detailed driver advice for adhering to the planned timings while driving energy efficient. The trackside Driver Advisory System (DAS) or the Traffic Management System (TMS) is responsible for conflict detection and calculation of new target train timings, that are forwarded to the DAV and evaluated accordingly. The typical integration of DAV application is defined EN 15380-4. The DAV can also operate standalone (e.g. without integration into the vehicle). The DAV is not needed if ATO Vehicle (AV) is installed, since the AV already includes the DAV functionality. The implementation of DAV application on OCORA computing platform is an open issue to be solved in subsequent versions of this document (unsafe information displayed on the driver DMI).

The DAV application can be deployed on OCORA based CCS on-board system, depending on the requirements of the rail network, the RU wants to operate in. Refer to Appendix F2 and F3 on page 103 and 104 to locate the DAV component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.4.7 Cab Voice over IP (CVoIP)

The Cab Voice over IP (CVoIP) application, deployed on the OCORA computing platform, implements the Cab Voice functionality. It uses the DMI to enable the train driver to initiate and receive voice communication between the train and the trackside operations control centres. For communication with the trackside operation control centres, the CVoIP is using the services provided by the FRMCS On-Board System or the GSM-R Voice Radio.

The CVoIP application can be deployed on OCORA based CCS on-board system, once FRMCS service is available on the vehicle. Refer to Appendix F2 and F3 on page 103 and 104 to locate the CVoIP component in the OCORA architecture.

In case GSM-R Radio is used for voice communication, the CVoIP can provide a VoIP to PCM conversion and the GSM-R control mechanisms, enabling the Cab Voice over IP communicating the GSM-R Radio.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5 SW abstraction / services

The software abstraction / services contain software components that mainly provide services to the OCORA applications and eventually to other applications. Some of these components build its own building block while others are grouped to building blocks (refer to chapter 3.2). For the identified building blocks that group these components, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements but also detailed design requirements. The components / building blocks currently identified for software abstractions / services are not comprehensive. Others may be added in subsequent versions of this documents.

The software abstraction / service components run on the OCORA computing platform or are an integral part of it (refer to chapter 7). This aspect will be further evaluated in subsequent versions of the OCORA architecture.

4.5.1 Location and train integrity services

4.5.1.1 Vehicle Locator (VL)

The Vehicle Locator (VL) is a safe service deployed on the OCORA computing platform. The VL uses localisation technology to safely and reliably provide position and speed information of the train to various applications. For ETCS implementations, it provides the actual position/direction and the current speed to the VS, where the actual position/direction and the current speed are aggregated with other data into a Train Position Report (TPR). Localisation data may be sent by the VL to APS-MOT, containing e.g. ETCS irrelevant data (not used by VS). The VL sends the full virtual track occupation of the train or only a part of it (only the front or rear position). The VL can use different localization technologies, from today's "balise + odometry" to additional sensor inputs such as GNSS or inertial measurement units. To access the respective sensors, the VL interacts with the Vehicle Localisation System (VLS).

The VL service is deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the VL component in the OCORA architecture and to chapter 7.6 for information about the VL interfaces.

In today's ETCS implementations, the VL is part of the monolithic ETCS OBU. Since the VL can be used for multiple purpose applications/services (Virtual Balise Readers, Fail-Safe odometry, TIMS, Enhanced Passenger Information, Enhanced Traffic Management and Operation, Vehicle Control applications), it is essential that the VL is a separate component, containing just the functionality needed to perform the vehicle localisation. The separation of the VL from the ETCS system allows also the VL to be used for localization purposes in installations where no ETCS is available but ATO functionality is desired in conjunction with an NTC system/lateral signalling. Appendix D contains, on a very high-level, a first proposed split of functionality between the VS, VL, and the ATPM, based on SUBSET-026, chapter 4.5. The OCORA architecture team is aware that splitting the functionality only based on the SUBSET-026, chapter 4.5 is not sufficient, because the subset does not provide all requirements. SUBSET-026 is providing the mandatory requirement specifications only. A more detailed separation and a first version of a complete VL model, identifying additional requirement to SUBSET-026, can be expected in subsequent OCORA documentation releases.

Another reason for splitting the functions apart is the different technological lifecycles between VS and VL. New localization technologies shall be introduced more quickly in the future without the need to modify the VS functionality.

Isolating the VL- from the VS- and ATPM-functionality has the positive effect that the complexity of the VL is reduced. A very important aspect, since the VL is requiring a safe implementation and already many changes for the CCS on-board are foreseeable. For example, it is expected that changes will be introduced, and more functionality will be added to CCS on-board in the upcoming TSI-CCS revisions and through the introduction of new functionalities (game changers).

New functionalities (game changers) with potential impact on the VL are:

- FRMCS
- ATO
- Train integrity detection for ETCS L3

It is the goal of the OCORA architecture team to build a VL model that is mostly agnostic to these changes, and where not possible, does already consider the upcoming changes in the design.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.1.2 Train Integrity Status (TIS)

The Train Integrity Status (TIS) is a safe service deployed on the OCORA computing platform. To determine the train integrity, multiple options are possible: a) train integrity determination on the train (e.g. through the TCMS), b) second localisation unit at the end of the train with on-board determination of the train integrity, and c) second localisation unit at the end of the train with trackside determination of the train integrity. The TIS service ensures that all CCS applications that need to know the train's integrity status (including the coupler statuses, if applicable) are receiving the information through a standardized interface, independent of the option used. The train integrity status may also include the total safe train length (including the length over coupled compositions).

The TIS service is deployed on every OCORA based CCS on-board system in need of ETCS L3 functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the TIS component in the OCORA architecture and to chapter 7.7 for information about the TIS interfaces.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.1.3 Digital Map Services (DMS)

The Digital Map Service (DMS) is a safe service deployed on the OCORA computing platform. The DMS provides topology and topography data (a.k.a. map data) that are certified for the usage in safety-relevant on-board applications / services (e.g., VL, VS, APV) up to SIL4. The service guarantees that the map data fulfils the quality criteria stated by trackside, e.g. accurate, precise, reliable, complete, and up-to-date map data. The DMS uses its own on-board data storage that is updated, if required, through the interface RCA-5.

The DMS is foreseen to be deployed on every OCORA based CCS on-board system in need of GoA3 – GoA4 functionality or if the VLS has a need for it. Refer to Appendix F2 and F3 on page 103 and 104 to locate the DMS component in the OCORA architecture.

Examples of possible digital map objects/attributes are (with reference to the RCA topology concept): track edge, track node, track edge point (balise, track radius, gradient, cant, speed profile marker), and track edge section (tunnel, platform edge).

Example of service usage: The Vehicle Locator (VL) service uses the digital map service (DMS) to place sensor measurements into a common reference frame such that this data can be interlinked as part of a fusion algorithm. For example, a position determined by balise and relative path measurement (odometer) is geo-referenced and fused with an absolute GNSS position before being mapped back to a position on the track edge to improve the accuracy and confidence of the actual train position.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.2 Basic Services (BS)

4.5.2.1 Operational Data Storage (ODS)

The Operational Data Storage (ODS) is a data storage for saving quite dynamic data that is entered / provided during an operational day of a vehicle and has no relevance for long-time safeguarding. The operational data storage is separated from the ETCS components (e.g. VS) to make the data easily available to other applications that may need it (e.g. ATO Vehicle). The operational data storage contains data provided by the driver, the TCMS, and possibly the device and configuration management. Examples of Operational Data is the driver id, the train running number, etc. In subsequent versions of the OCORA specifications, the ODS will be specified in detail.

The ODS component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the ODS component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.2.2 Configuration Data Storage (CDS)

The Configuration Data Storage (CDS) stores static and semi-static data needed for the CCS on-board system. The data storage is separated from the operational data and it is separated from the ETCS components (e.g. VS) to make the data easily available to other applications that may need it (e.g. VDM). The Configuration Data Storage contains data provided when commissioning a CCS on-board system for the first time and is changed whenever configurations of the vehicle change (e.g. additional sensors, additional DMI, etc.). The data is entered by service technicians through the local maintenance terminal or via the remote maintenance. In both cases this occurs through the Vehicle Device & Configuration Management (VDCM) component. In subsequent versions of the OCORA specifications, the CDS will be specified in detail.

The CDS component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the CDS component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.2.3 Time Synch Services (TSS)

The Time Synchronisation Service (TSS) provides a service that allows all on-board components to have its time in synched with each other and synched with the trackside systems (e.g. safe data centres). The time base is UTC and components in need to display the time can revert it to local time. This functionality is significant simplify diagnostic and analysis, for ATO operations, and other aspects.

The TSS is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the TSS component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.2.4 Vehicle Diagnostic & Monitoring (VDM)

The Vehicle Diagnostics & Monitoring (VDM) service, deployed on the OCORA computing platform, collects data relevant for local (through the Maintenance Terminal or DMI) and remote diagnostic and monitoring. For local maintenance, it provides the relevant data upon request to the Maintenance Terminal or DMI in a standardized format. For remote diagnostics and monitoring the data can be send to multiple recipients (e.g. the RU of the vehicle, the IM the vehicle currently operates in, the vehicle provider, the CCS on-board provider etc.). The owner of the vehicle can define in the vehicle's configuration (refer to Configuration Data Storage) what data is forwarded to which recipient(s). While the TRUA provides the data for recording in the TRU, the VDM provides the data to other systems such as the centralized DMs or the Maintenance Terminals.

The VDM service is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the VDM component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.2.5 Vehicle Device & Configuration Management (VDCM)

The Vehicle Device & Configuration Management (VDCM) service, deployed on the OCORA computing platform, allows for local (through the Maintenance Terminal) and remote (through the centralized DCM services) configuration of the vehicle's devices (CCUs, Gateway, Peripherals, etc.). The component can process data received by the IMs (network related operational data) and the RU (vehicle related operational and configuration data). The service also allows the RU to execute commands (e.g. reboot of a specific component) and allows to install updates (e.g. new software).

The VDCM service is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the VDCM component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.2.6 Vehicle Identity & Access Management (VIAM)

The Vehicle Identity & Access Management (VIAM) is a service deployed on the OCORA computing platform. It integrates with the IAM System providing the central management for the identification, authentication and authorisation of devices and application to resources and functions of the CCS on-board and trackside systems. For the identification, the IAM System manages a unique ID for each entity (e.g. device, application). The granularity, on what level the system will be split into separate entities is not yet defined. It can reach from one single ID for the overall CCS on-board system to IDs for any single device connected to the UVCCB and to application, running on the OCORA Platform. For the authentication of a device or an application, the solution could be based on the Public Key Infrastructure (PKI) or Message Authentication Codes (MAC) using symmetrical encryption mechanisms like 3DES or AES. The access to resources and functions is centrally managed by roles and granted on a Need-to-Know principle to limit unauthorized access to resources and functions within the CCS on-board system.

The VIAM service is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the VIAM component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.3 Connectivity services

4.5.3.1 Euro Radio (ER)

The Euro Radio (ER) software component implements the Euro Radio protocol stack and the co-ordination function specified in Euroradio FIS, SUBSET-037.

The ER component is to be deployed on every OCORA based CCS on-board system in need of ETCS functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the ER component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.5.3.2 FRMCS Gateway Functions (FRMC-GWF)

The FRMCS Gateway Functions (FRMCS-GWF), deployed on the OCORA computing platform, or the OCORA Gateway, or the FRMCS Radio, is an on-board software gateway responsible for the coordination and management of the access to the FRMCS transport services offered by the FRMCS system. The FRCMS Gateway manages the application data flows, has a control plane interface for the applications, distributes the user plane data from data applications over the various radio units depending on the application's QoS requirements and possibly priorities between applications.

The FRMCS-GWF component is to be deployed on every OCORA based CCS on-board system in need of FRMCS services. Refer to Appendix F2 and F3 on page 103 and 104 to locate the FRMCS component in the OCORA architecture.

Any on-board application using the FRMCS on-board system to transmit voice, video, or data, is using the OBAPP interface through the FRMCS Application Client for Authorisation and through the FRMCS Service Client for the Service Session. For applications not supporting the OBAPP interface, a proxy function offering the functionality of the FRMCS Application Client and the FRMCS Service Client to the application could be used. Figure 10 below depicts the different options for the implementation of the Proxy Function.

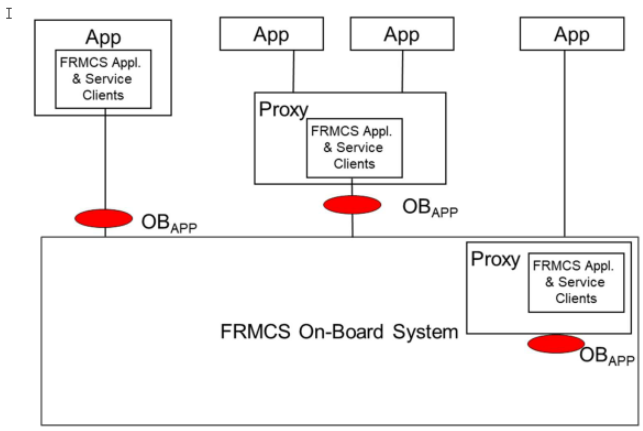

Figure 10 FRMCS implementation options
(Source: TOBA 7510-0.2.0 Section 7.7.2.4)

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6 Hardware abstraction

The hardware abstraction contains software components that allow abstracting the different type of train hardware towards the software abstraction / services and the applications. The goal of this software layer is to ensure that the interfaces towards the applications and software services remain the same, regardless of the underlying train hardware. It must be noted that OCORA aims at standardizing the interfaces to the respective peripheral devices. For the peripheral devices where OCORA can successfully standardize the interface, the need of having a respective adapter inside the "OCORA Core" scope may vanish.

These components are grouped to a single building block (refer to chapter 3.2). For this building block, OCORA not only provides interface specifications, high-level functional requirements, and non-functional requirements, but also detailed design requirements.

The hardware abstractions components run on the OCORA computing platform or can run, in some cases, on the peripheral devices or the OCORA Gateway. The deployment possibilities of these components will be further evaluated in subsequent versions of the OCORA architecture.

4.6.1 Adapter for Peripheral Devices (APD)

4.6.1.1 User Identification Reader Adapter (UIDRA)

The User Identification Reader Adapter (UIDRA) is a software component, allowing to integrate different types (RFID, Barcode, etc.), brands or versions of User Identification Readers while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand or version of reader used. In case of changing the type, brand, or version of reader in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.

The UIDRA component is foreseen to be deployed on every OCORA based CCS on-board system, in need of a User Identification Reader. Refer to Appendix F2 and F3 on page 103 and 104 to locate the UIDRA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.2 Cabin Voice Devices Adapter (CVDA)

The Cabin Voice Device Adapter (CVDA) is a software component, allowing to integrate different types, brands or versions of Cabin Voice Devices while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand or version of Cabin Voice Devices used. In case of changing the type, brand, or version of a Cabin Voice Device in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.

The CVDA component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the CVDA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.3 DMI Adapter (DMIA)

The Driver Machine Interface Adapter (DMIA) is a software component, allowing to integrate different numbers, types, brands, or versions of Driver Machine Interfaces while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the number, type, brand or version of User Interface Devices used. In case of changing the number, type, brand, or version of a Driver Machine Device in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.

The DMIA component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the DMIA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.4 Maintenance Terminal Adapter (MTA)

The Maintenance Terminal Adapter (MTA) is a software component, allowing to connect different numbers, types, brands, or versions of Maintenance Terminals while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the number, type, brand, or version of Maintenance Terminals used. Remark: this component may not be needed and may drop-out of the architecture in subsequent versions of this document.

At this time, the MTA component is foreseen to be deployed on every OCORA based CCS on-board system. However, and as mentioned above, this component may not be needed and may drop-out of the architecture in subsequent versions of this document. Refer to Appendix F2 and F3 on page 103 and 104 to locate the DMIA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.5 TRU Adapter (TRUA)

The Train Recording Unit Adapter (TRUA) is a software component, allowing to integrate different numbers, types, brands, or versions of Train Recording Units (TRUs) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the number, type, brand or version of TRUs used. In case of changing the number, type, brand, or version of TRUs in a CCS on-board system or if modifications to the recorded data and its format needs to be made, only this component and the component delivering additional data needs to be updated. No change to any other components, especially not to safety related components, is needed.

The TRUA component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the TRUA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.6 VLS Adapter (VLSA)

The Vehicle Localisation System Adapter (VLSA) is a software component, allowing to connect different types, brands, or versions of Vehicle Localisation Systems (VLS) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the VLS used. In case of changing the type, brand, or version of a VLS in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.

The VLSA component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the VLSA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.7 Loop Transmission Module Adapter (LTMA)

The Loop Transmission Module Adapter (LTMA) is a software component, allowing to connect different types, brands, or versions of Loop Transmission Modules (LTM) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brands, or versions of the LTM used. In case of changing the type, brand, or version of an LTM in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.

The LTMA component is foreseen to be deployed on every OCORA based CCS on-board system in need of Euroloop functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the LTMA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.8 Balise Transmission Module Adapter (BTMA)

The Balise Transmission Module Adapter (BTMA) is a software component, allowing to connect different types, brands, or versions of Balise Transmission Modules (BTM) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the BTM used. In case of changing the type, brand, or version of a BTM in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.

The BTMA component is foreseen to be deployed on every OCORA based CCS on-board system in need of ETCS functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the BTMA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.9 Specific Transmission Modul Adapters (STMAs)

The Specific Transmission Module Adapters (STMAs) are software component, allowing to connect different types, brands, or versions of Specific Transmission Modules (STMs) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the STM used. For every STM integrated, an additional STMA component is deployed. In case of changing the type, brand, or version of an STM in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed. to be completed.

The STMA components are foreseen to be deployed on every OCORA based CCS on-board system in need of STM functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the STMAs component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.10 Perception System Adapter (PSA)

The Perception System (PMA) is a software component, allowing to connect different types, brands, or versions of Perception Systems (PS) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand or version of the PS used. In case of changing the type, brand, or version of a PS in a CCS on-board system, only this component needs to be updated. No change to any other component, especially not to safety related components, is needed.

The PSA component is foreseen to be deployed on every OCORA based CCS on-board system in need of ATO GoA3 – GoA4 functionality. Refer to Appendix F2 and F3 on page 103 and 104 to locate the PSA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.1.11 I/O Adapter (IOA)

The Input / Output Adapter (IOA) is a software component, allowing to connect different types, brands, or versions of Input / Output Ports (IO) while ensuring that the interfaces and the behaviour towards the OCORA applications and services remain always the same, regardless of the type, brand, or version of the IOs used. In case of changing the type, brand, or version of an IO in a CCS on-board system, only this component needs to be updated. No change to any other components, especially not to safety related components, is needed.

The IOA component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the IOA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.2 Vehicle adapters

4.6.2.1 Functional Vehicle Adapter (FVA)

The Functional Vehicle Adapter (FVA) is a piece of software deployed on the OCORA computing platform, or on the OCORA Gateway. Its job is to provide an OCORA unified and standardized interface towards the CCS applications and services for vehicle functions and vehicle information needed by the OCORA on-board applications and services. Although the TSI-CCS SUBSET-034, -119, and -139 are defining the interface to the TCMS system, vehicle from different suppliers and especially from different generations have still different interfaces implemented. This adapter allows to map, on a functional level, the commands sent, and the information received from a specific TCMS into the OCORA standard. In addition, the FVA can also be used to integrate vehicles through wired connections. Also, the standardized interface to the CCS applications evolves in multiple iterations as outlined in chapter 3. Remark: Sometimes the FVA is also called Train Interface Unit (TIU). However, the TIU is not clearly defined. Sometimes it refers to the functional level of the interface with the vehicle, while in other context a piece of hardware is meant. To avoid confusion, OCORA does not use the term TIU.

The FVA component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the FVA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

4.6.2.2 Functional Passenger Information Adapter (FPIA)

The Functional Passenger Information Adapter (FPIA) is a non-safe piece of software deployed on the OCORA computing platform, or on the OCORA Gateway. Its job is to provide an OCORA unified and standardized interface towards the Passenger Information System (PIS), allowing the PIS to receive CCS of interest to the PIS.

The FPIA component is foreseen to be deployed on every OCORA based CCS on-board system. Refer to Appendix F2 and F3 on page 103 and 104 to locate the FPIA component in the OCORA architecture.

Further details will be provided in subsequent versions of the OCORA architecture documentation.

5 External interfaces of the “CCS On-Board” scope

This chapter identifies and describes all interfaces for the “CCS On-Board” scope. The content in this chapter represents the current state of work. The chapter will evolve over subsequent versions of this document.

5.1 Mechanical interfaces

Information will be provided in subsequent versions of this document.

5.2 Electrical interfaces

Information will be provided in subsequent versions of this document.

5.3 Communication interfaces

The following pictures identify all communication interface for the “CCS On-Board” scope. The table following the graphics provides a high-level description for every interface.

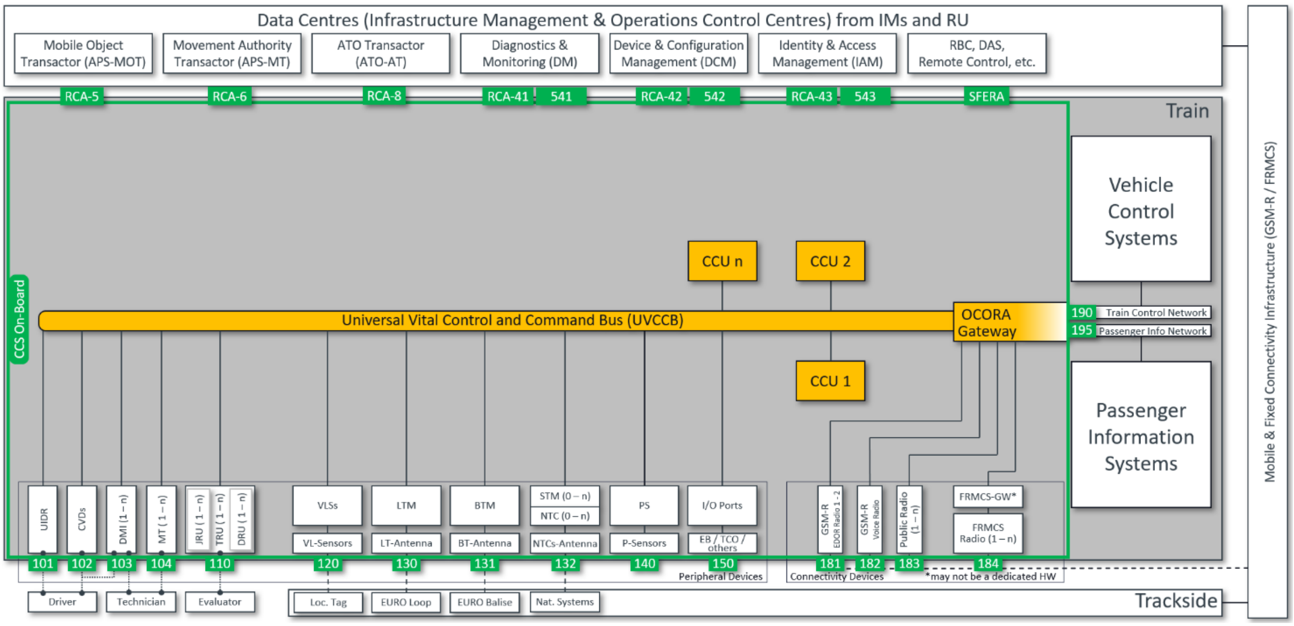

Figure 11 “CCS On-Board” hardware with external communication IFs

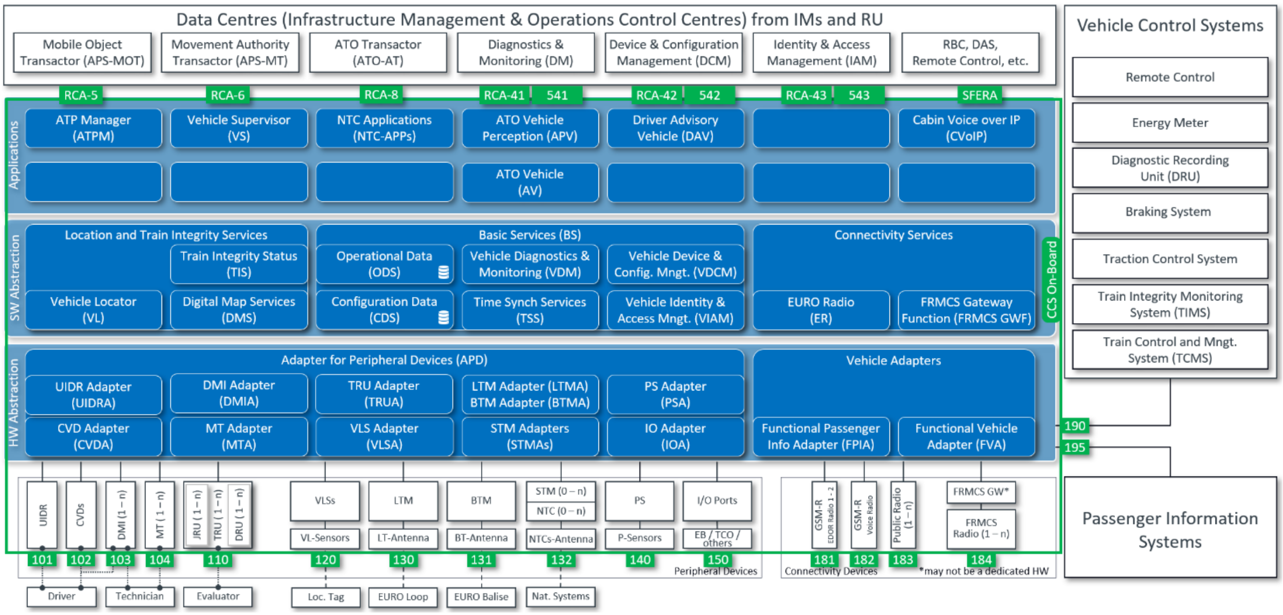

Figure 12 “CCS On-Board” functional components with external communication IFs

Interface ID	High-Level Description
101	This is the interface between the User Identification Reader (refer to chapter 4.2.1) and the Driver or the Driver’s UID card (refer to chapter 2.1.3.1). OCORA does not aim to standardize this interface.
102	This is the interface between the Cabin Voice Devices (refer to chapter 4.2.2) such as loudspeaker and microphone and the Driver (refer to chapter 2.1.3.1). OCORA does not aim to standardize this interface.
103	This is the interface between the Driver Machine Interface (refer to chapter 4.2.3) and the Driver or the Technician (refer to chapter 2.1.3.1). Standardization efforts for ETCS functionality are ongoing by the ERA (refer to document ERA_ERTMS_015560). The document must be extended to include ATO requirements (not in scope of OCORA). Standardization of the user interfaces for Voice Radio, Diagnostics, Monitoring, Configuration, NTCs, and Driver Advisory Vehicle are not existing and OCORA does not plan, at this point in time, to work on those standards.
104	This is the interface between the Maintenance Terminals (refer to chapter 4.2.4) and the Technician (refer to chapter 2.1.3.1). OCORA does not aim to standardize this interface.
110	This is the interface between the Train Recording Units (refer to chapter 4.2.5) and the Evaluator (refer to chapter 2.1.3.1). SUBSET-027 defines the data stored in the JRU and SUBSET-140 is being prepared for ATO data storage. However, the DRU data is not standardized and the access to the JRU and DRU is not standardized. OCORA may consider standardizing the JRU output format to facilitate data evaluation with a vendor independent evaluation software and integration into standardised remote monitoring.
120	These are the interface between the Vehicle Location Sensors (refer to chapter 4.2.7) and their environment that can include a trackside mounted Location Tag (refer to chapter 2.1.3.2). OCORA does not aim to standardize these interfaces. OCORA expects various technologies to be used.

Interface ID	High-Level Description
130	This is the interface between the Loop Transmission Antenna (refer to chapter 4.2.9) and the EURO Loop (refer to chapter 2.1.3.2). SUBSET-044 specifies this interface.
131	This is the interface between the Balise Transmission Antenna (refer to chapter 4.2.11) and the EURO Balise (refer to chapter 2.1.3.2). SUBSET-036 specifies this interface.
132	This is the interface between the National Systems Antenna (refer to chapter 4.2.14) and the National Systems (refer to chapter 2.1.3.2). This is a specific interface of the existing ATP systems and is therefore not relevant for OCORA.
140	These are the interface between the Perception Sensors (refer to chapter 4.2.16) and their environment. OCORA does not aim to standardize these interfaces. But standards may be needed at some point in time.
150	These are the interface between the Emergency Brake device / Traction Cut-off device / other devices (refer to chapter 4.2.18) and the respective vehicle infrastructure. This are existing discrete interfaces. OCORA does not aim to standardize these interfaces.
181	This is the interface between the GM-R EDOR Radio (refer to chapter 4.3.1) and the "Mobile & Fixed Connectivity Infrastructure" (refer to chapter 2.1.3.2). This interface is defined in the GSM-R specifications (EIRENE FRS v8.0.0 / SRS v16.0.0), developed under the EIRENE project and maintained by the UIC. SUBSET-037 specifies this interface on functional level.
182	This is the interface between the GM-R Voice Radio (refer to chapter 4.3.2) and the "Mobile & Fixed Connectivity Infrastructure" (refer to chapter 2.1.3.2). This interface is defined in the GSM-R specifications (EIRENE FRS v8.0.0 / SRS v16.0.0), developed under the EIRENE project and maintained by the UIC.
183	This is the interface between the Public Radio (refer to chapter 4.3.3) and the "Mobile & Fixed Connectivity Infrastructure" (refer to chapter 2.1.3.2). This interface is standardized through the LTE and 5G Standards developed by the 3rd Generation Partnership Project (3GPP).
184	This is the interface between the FRMCS Radio (refer to chapter 4.3.5) and the "Mobile & Fixed Connectivity Infrastructure" (refer to chapter 2.1.3.2). The FRMCS FRS and SRS are in progress at UIC in corporation with the TOBA working-group, which covers the specifications for the FRMCS on-board equipment. SUBSET-037 specifies this interface on functional level.
190	This is the interface between the OCORA Gateway (refer to chapter 4.1.3), if it exists and the "Train Control Network" (refer to chapter 2.1.3.2) with its Train Control System (TCMS). If the OCORA Gateway is not needed on a specific vehicle, then this interface is between the CCS on-board system and the TCMS. On a functional level (OSI layer 7, according to definitions in document [8]), this is the interface between the Functional Vehicle Adapter and the TCMS or whatever system exists on the train side. Refer to interface 390 (chapter 6.3) and interface 490 (chapter 6.4) where the technical communication level (OSI 1-6, according to definitions in document [8]) is clearly separated from the functional level (OSI layer 7, according to definitions in document [8]). This is a specific interface of the respective train. Standards exists or are being developed with SUBSET-034, SUBSET-119, SUBSET-139, and SUBSET-143. But these standards are relevant for modern vehicles with a TCMS only. The TCMS side of the gateway is vendor specific for all retrofit projects. OCORA does not aim at standardizing this interface but foresees the OCORA-GW to adapt to any kind of vehicle. Also, OCORA is working together with the organization (S2R) that aims at standardizing this interface for modern vehicles.

Interface ID	High-Level Description
195	This is the interface between the OCORA Gateway (refer to chapter 4.1.3), if it exists and the "Passenger Information Network" (refer to chapter 2.1.3.2) with its Passenger Information Systems (PISs). If the OCORA Gateway is not needed on a specific vehicle, then this interface is between the CCS on-board system and the PIS. Refer to interface 395 (chapter 6.3) and interface 495 (chapter 6.4) where the technical communication level (OSI layer 1-6, according to definitions in document [8]) is clearly separated from the functional level (OSI layer 7, according to definitions in document [8]). OCORA may consider providing a standard for this interface at a later stage. The interface allows the PIS to get information from the CCS on-board system, such as speed, location, etc.
RCA-5	This is the interface between the Vehicle Locator (refer to chapter 4.5.1.1) and the Advanced Protection System's Mobile Object Transactor (refer to chapter 2.1.3.2). This information is used by the VL to send localisation data to the APS-MOT, containing e.g. ETCS irrelevant data (not used by VS). This interface is being standardized by RCA.
RCA-6	This is the interface between the Vehicle Supervisor (refer to chapter 4.4.2) and the Advanced Protection System's Movement Authority Transactor (refer to chapter 2.1.3.2) or the Radio Block Center, depending on the system provided by the infrastructure manager. SUBSET-026, chapter 7 & 8 define this interface.
RCA-8	This is the interface between the ATO Vehicle (refer to chapter 4.4.4) and the ATO Transactor (refer to chapter 2.1.3.2). SUBSET-126 is being prepared by S2R to specify this interface.
RCA-41	This is the interface between Vehicle Diagnostic & Monitoring (refer to chapter 4.5.2.4) and the Diagnostic & Monitoring system (refer to chapter 2.1.3.2) of the infrastructure manager, the vehicle currently operates in. This interface is defined by RCA. Refer to document [28].
541	This is the interface between Vehicle Diagnostic & Monitoring (refer to chapter 4.5.2.4) and the Diagnostic & Monitoring system (refer to chapter 2.1.3.2) of the railway undertaking. OCORA aims at providing a standard for this interface.
RCA-42	This is the interface between Vehicle Device & Configuration Management (refer to chapter 4.5.2.5) and the Device & Configuration Management system (refer to chapter 2.1.3.2) of the infrastructure manager, the vehicle currently operates in. This interface is defined by RCA. Refer to document [28].
542	This is the interface between Vehicle Device & Configuration Management (refer to chapter 4.5.2.5) and the Device & Configuration Management system (refer to chapter 2.1.3.2) of the railway undertaking. OCORA aims at providing a standard for this interface.
RCA-43	This is the interface between Vehicle Identity & Access Management (refer to chapter 4.5.2.6) and the Identity & Access Management system (refer to chapter 2.1.3.2) of the infrastructure manager, the vehicle currently operates in. This interface is defined by RCA. Refer to document [28].
543	This is the interface between Vehicle Identity & Access Management (refer to chapter 4.5.2.6) and the Identity & Access Management system (refer to chapter 2.1.3.2) of the railway undertaking. OCORA aims at providing a standard for this interface.
SFERA	This is the interface between Driver Advisory Vehicle (refer to chapter 4.4.6) and the Driver Advisory System (refer to chapter 2.1.3.2) of the railway undertaking. SFERA aims at providing a standard for this interface.

Table 12 External communication IFs of the "CCS On-Board" scope

6 External interfaces of the “OCORA Core” scope

This chapter identifies and describes all interfaces for the “OCORA Core” scope. The content in this chapter represents the current state of work. The chapter will evolve over subsequent versions of this document.

6.1 Mechanical interfaces

Information will be provided in subsequent versions of this document.

6.2 Electrical interfaces

Information will be provided in subsequent versions of this document.

6.3 Communication interfaces (OSI layers 1-6)

The following picture identifies all communication interface for OSI layers 1-6 (according to definitions in document [8]) for the “OCORA Core” scope. The table following the graphic provides a high-level description for every interface.

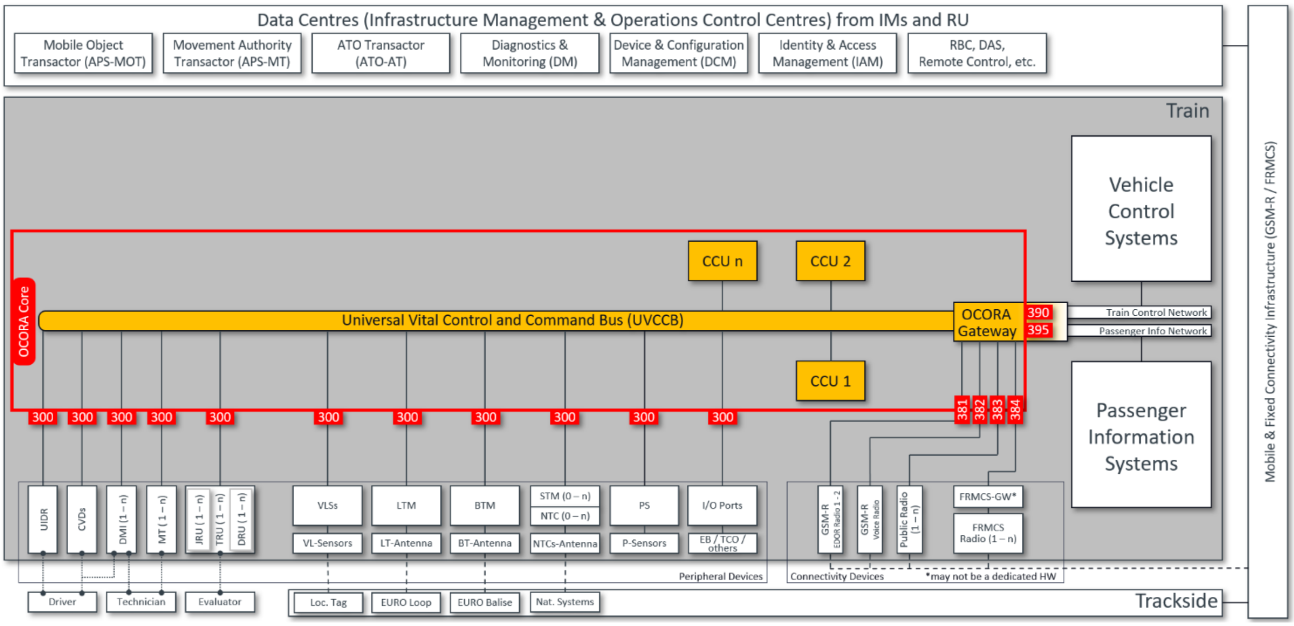

Figure 13 “OCORA Core” hardware with external communication IFs (OSI layers 1-6)

Interface ID	High-Level Description
300	This is the interface, the Universal Vital Command and Control Bus (refer to chapter 4.1.1) provides to the CCUs (refer to chapter 4.1.2), the OCORA Gateway (refer to chapter 4.1.3), all the peripheral devices (refer to chapter 4.2), and possibly to the connectivity devices (refer to chapter 4.3). The interface is currently defined for OSI layer 1 to 2 (according to definitions in document [8]) but will be specified up to OSI layer 6 and 7 (according to definitions in document [8]) in subsequent versions of the OCORA specifications.
381	This is the interface between the OCORA Gateway (refer to chapter 4.1.3) or the UVCCB (refer to Appendix B and Appendix C) and the GSM-R EDOR Radio (refer to chapter 4.3.1). OCORA aims to define the standard to be used for OCORA compliant CCS on-board systems. Further details will be provided in subsequent versions of this document.
382	This is the interface between the OCORA Gateway (refer to chapter 4.1.3) or the UVCCB (refer to Appendix B and Appendix C) and the GSM-R Voice Radio (refer to chapter 4.3.2). OCORA aims to define the standard to be used for OCORA compliant CCS on-board systems. Further details will be provided in subsequent versions of this document.
383	This is the interface between the OCORA Gateway (refer to chapter 4.1.3) or the UVCCB (refer to Appendix B and Appendix C) and the Public Radio (refer to chapter 4.3.3). OCORA aims to define the standard to be used for OCORA compliant CCS on-board systems. Further details will be provided in subsequent versions of this document.
384	This is the interface between the OCORA Gateway (refer to chapter 4.1.3) or the UVCCB (refer to Appendix B and Appendix C) and the FRMCS Gateway (refer to chapter 4.3.4) or the FRMCS Radio (refer to chapter 4.3.4). OCORA aims to define, together with UIC TOBA, the standard to be used for OCORA compliant CCS on-board systems. Further details will be provided in subsequent versions of this document.
390	This interface is identical with the technical communication part (OSI layer 1-6, according to definitions in document [8]) of the interface 190 (refer to chapter 5.3) and is assigned to the “OCORA Core” scope rather than to the “CCS On-Board” scope. It is the interface between the OCORA Gateway (refer to chapter 4.1.3), if it exists and the “Train Control Network” (refer to chapter 2.1.3.2) with its Train Control System (TCMS). If the OCORA Gateway is not needed on a specific vehicle (use of same network between TCMS and CCS), then this interface does not exist or corresponds to interface 300 respectively. This is a specific interface of the respective train. Standards exists or are being developed with SUBSET-119 and SUSET-143. But these standards are relevant for modern vehicles only. OCORA does not aim at standardizing this interface but foresees the OCORA-GW to adapt to any kind of vehicle. Also, OCORA is working together with the organization (S2R) that aims at standardizing this interface for modern vehicles.
395	This interface is identical with the technical communication part (OSI layer 1-6, according to definitions in document [8]) of the interface 195 (refer to chapter 5.3) and is assigned to the “OCORA Core” scope rather than to the “CCS On-Board” scope. This is the interface between the OCORA Gateway (refer to chapter 4.1.3), if it exists and the “Passenger Information Network” (refer to chapter 2.1.3.2) with its Passenger Information Systems (PISs). If the OCORA Gateway is not needed on a specific vehicle (use of same network between PIS and CCS), then this interface does not exist or corresponds to interface 300 respectively.

Table 13 External communication IFs of the “OCORA Core” scope

6.4 Functional interfaces (OSI layers 7)

The following picture identifies all functional interface for OSI layer 7 (according to definitions in document [8]) for the “OCORA Core” scope. The table following the graphic provides a high-level description for every interface.

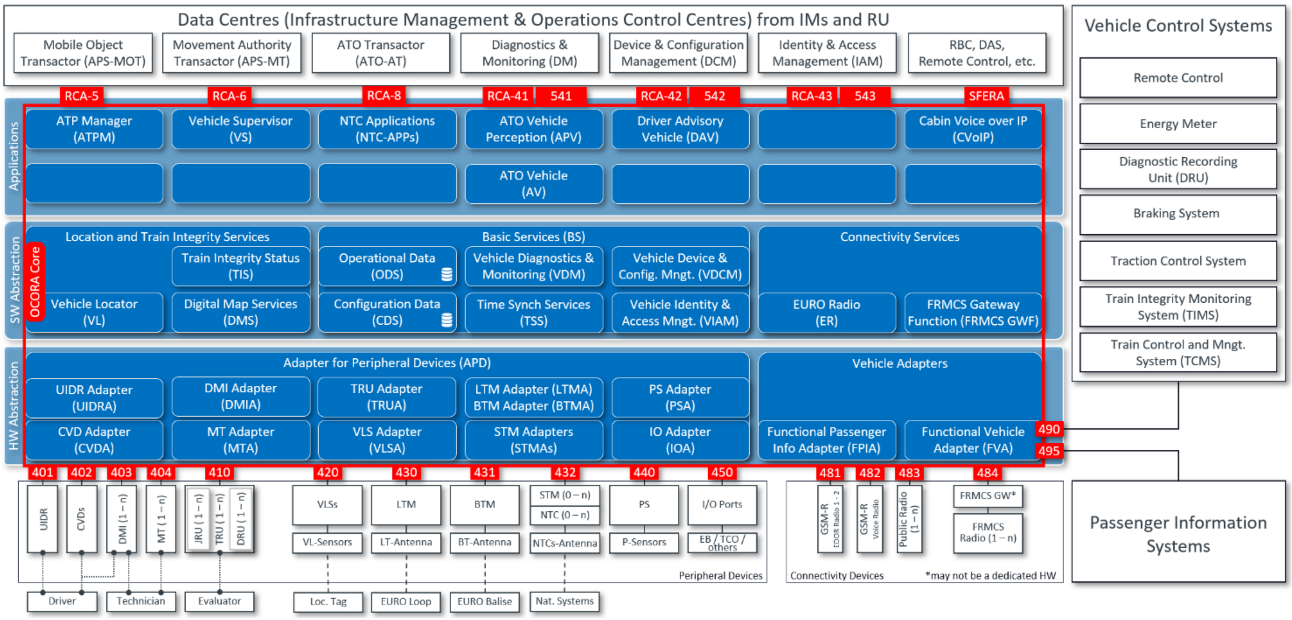

Figure 14 “OCORA Core” functional components with external communication IFs (OSI layers 7)

Interface ID	High-Level Description
401	This is the functional interface between the User Identification Reader Adapter (UIDRA) and the User Identification Reader (UIDR). OCORA aims to provide a standard for this interface.
402	This is the functional interface between the Cabin Voice Device Adapter (CVDA) and the Cabin Voice Devices (CVDs). OCORA aims to provide a standard for this interface.
403	This is the functional interface between the Driver Machine Interface Adapter (DMIA) and the Driver Machine Interfaces (DMIs). SUBSET-121 aims at providing a standard. OCORA aims to define this interface exhaustively.
404	This is the functional interface between the Maintenance Terminal Adapter (MTA) and the Maintenance Terminals (MTs). OCORA aims to provide a standard for this interface.
410	This is the functional interface between the Train Recording Unit Adapter (TRUA) and the Train Recording Unit (TRU). SUBSET-027 defines this interface for the Juridical Recording Unit (JRU) and work on SUSET-140 is in progress for other data (e.g. ATO). OCORA may want to extend this interface to allow standardized data recording for other components.
420	This is the functional interface between the Vehicle Location System Adapter (VLSA) and the Vehicle Location Systems (VLAs). A proposal from the European Economic Interest groups (ERTMS User Group) exists (Document 97E2675B) for standardizing part of this interface. OCORA aims to define this interface exhaustively.

Interface ID	High-Level Description
430	This is the functional interface between the Loop Transmission Module Adapter (LTMA) and the Loop Transmission Modul (LTM). SUBSET-026, chapter 7 and chapter 8 contain the data to be transferred over this interface. OCORA plans to standardize this interface, based on the existing specifications.
431	This is the functional interface between the Balise Transmission Module Adapter (BTMA) and the Balise Transmission Modul (BTM). SUBSET-026, chapter 7 and chapter 8 contain the data to be transferred over this interface. In addition, SUBSET-101 contains the data to communicate with the Specific Transmission Module (STM). OCORA plans to standardize this interface, based on the existing specifications.
432	This is the functional interface between the Specific Transmission Module Adapters (STMAs) and the Specific Transmission Modules (STMs). SUBSET-035 and SUBSET-058 contains the data to be transferred over this interface. In addition, SUBSET-101 contains the data to communicate with the Balise Transmission Module (BTM). OCORA plans to standardize this interface, based on the existing specifications.
440	This is the functional interface between the Perception System Adapter (PSA) and the Perception System (PS). Various organisations are working on this topic. OCORA does not plan to work on this interface for the time being but aims at standardizing this interface at the given time.
450	This is the functional interface between I/O Adapter (IOA) and the I/O Ports. SUBSET-034, SUBSET-119 and proposed SUBSET-139 contain information regarding this interface. OCORA plans to standardize this interface, based on the existing specifications.
481	This is the functional interface (in a technical sense) between the connectivity services and the GSM-R EDOR Radio. It is not clear at this point in time, if this interface is needed.
482	This is the functional interface (in a technical sense) between the connectivity services and the GSM-R Voice Radio. It is not clear at this point in time, if this interface is needed.
483	This is the functional interface (in a technical sense) between the connectivity services and the Public Radio. It is not clear at this point in time, if this interface is needed.
484	This is the functional interface (in a technical sense) between the connectivity services and the FRMCS Gateway Function or between the FRMCS Gateway Function and the FRMCS Radio. UIC / TOBA is currently working on this topic.
490	This interface is identical with the functional part (OSI layer 7, according to definitions in document [8]) of the interface 190 (refer to chapter 5.3) and is assigned to the "OCORA Core" scope rather than to the "CCS On-Board" scope. It is the functional interface between the Functional Vehicle Adapter (FVA) (refer to chapter 4.6.2.1) and the TCMS. This is a specific interface of the respective train. Standards exists or are being developed with SUBSET-119 and SUSET-143. But these standards are relevant for modern vehicles only. OCORA does not aim at standardizing this interface but foresees the FVA to adapt to any kind of vehicle. Also, OCORA is working together with the organization (S2R) that aims at standardizing this interface for modern vehicles.
495	This interface is identical with the functional part (OSI layer 7, according to definitions in document [8]) of the interface 195 (refer to chapter 5.3) and is assigned to the "OCORA Core" scope rather than to the "CCS On-Board" scope. This is the functional interface between the Functional Passenger Info Adapter (FPIA) (refer to chapter 4.6.2.2) and the Passenger Information Systems (PISs). OCORA may consider providing a standard for this interface. The interface allows the PIS to get information from the CCS on-board system, such as speed, location, etc.
RCA-5	This interface is identical to interface RCA-5 assigned to the "CCS On-Board" scope.
RCA-6	This interface is identical to interface RCA-6 assigned to the "CCS On-Board" scope.

Interface ID	High-Level Description
RCA-8	This interface is identical to interface RCA-8 assigned to the “CCS On-Board” scope.
RCA-41	This interface is identical to interface RCA-41 assigned to the “CCS On-Board” scope.
541	This interface is identical to interface 541 assigned to the “CCS On-Board” scope.
RCA-42	This interface is identical to interface RCA-42 assigned to the “CCS On-Board” scope.
542	This interface is identical to interface 542 assigned to the “CCS On-Board” scope.
RCA-43	This interface is identical to interface RCA-43 assigned to the “CCS On-Board” scope.
543	This interface is identical to interface 543 assigned to the “CCS On-Board” scope.
SFERA	This interface is identical to interface SFERA assigned to the “CCS On-Board” scope.

Table 14 External functional IFs of the “OCORA Core” scope

7 Building block interfaces – identification & description

This chapter identifies and describes, on a high-level, all interfaces for selected OCORA building blocks. Every building block is treated separately in the subsequent chapters while Appendix F3 provides a complete view of all building block interfaces currently identified. The content in this chapter represents the current state of work. It is a starting point for the MBSE modelling work and serves to trigger discussion with the respective subject matter experts (ATO, VS, VL, VLS, etc.). The chapter will evolve over subsequent versions of this document.

7.1 Automated Train Protection Manager (ATPM) – functional interfaces

The Automated Train Protection Manager (ATPM) application, deployed on the OCORA computing platform, is a safe application in charge of managing the safety authority between installed ATP systems. It ensures that the proper ATP system is active and manages the switch-over from one ATP system to the other. Also, the ATPM includes the “STM control function” functionality defined in SUBSET-035.

The following figure depicts the ATPM with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

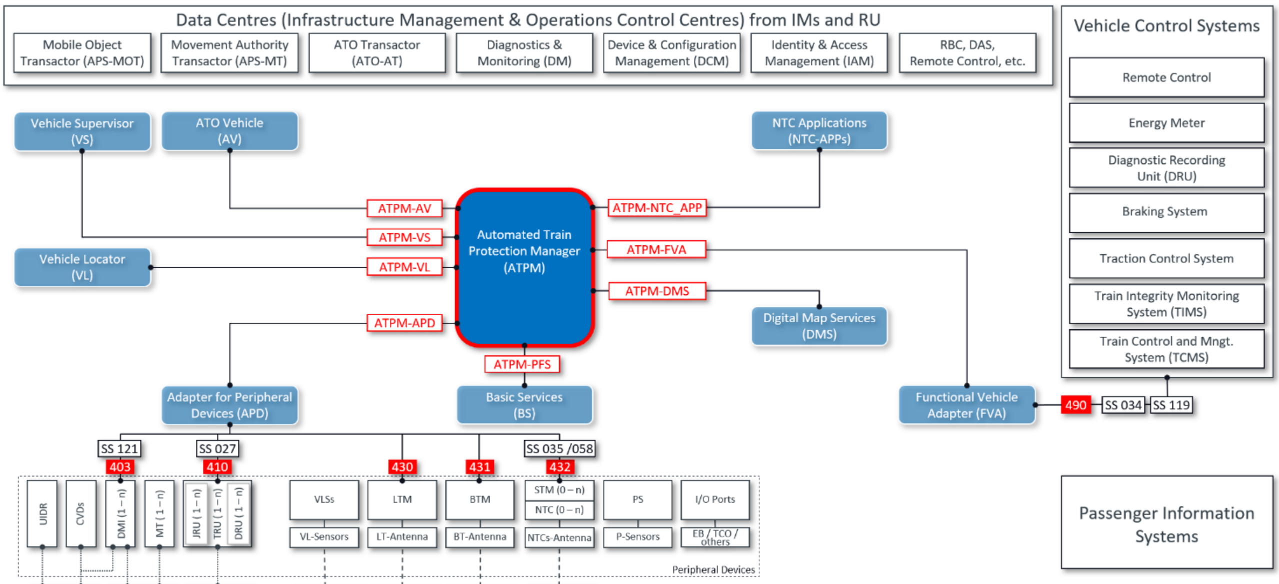

Figure 15 Automated Train Protection Control (ATPM) – context diagram (tentative)

Interface ID	High-Level Description
ATPM-AV	This interface allows the ATPM to tell the AV what mode and level of the ATP systems is active. It needs to be investigated if this information is of interested to the AV. Otherwise the interface can be dropped.
ATPM-VS	This interface allows the ATPM to assign or remove the responsibility for the ATP to/from the VS.
ATPM-VL	This interface allows the VL to tell the ATPM what position the train is currently at. This might be useful to allow the ATPM to automatically define, together with the DMS, the mode and level for the ATP system.
ATPM-APD	This interface allows the ATPM to communicate with the various peripheral devices.
ATPM-BS	This interface allows the ATPM to communicate with the BS.
ATPM-DMS	This interface allows the ATPM to receive date from the DMS. This might be useful to allow the ATPM to automatically define, together with the DMS, the mode and level for the ATP system.
ATPM-FVA	This interface allows the ATPM to know that status of the cabin (active / inactive)
ATPM-NTC_APP	This interface allows the ATPM to assign or remove the responsibility for the automated train protection to/from the NTC-APPs.

Table 15 Automated Train Protection Management (ATPM) – functional interfaces (tentative)

7.2 Vehicle Supervisor (VS) – functional interfaces

The Vehicle Supervisor (VS) application, deployed on the OCORA computing platform, is a safe ETCS application (mandatory requirements are specified in SUBSET-026) in charge of calculating location specific speed limits (based on various inputs) and activating the braking system in case of speed limit overshoot. Location information is received from the Vehicle Locator (VL). In addition, information is received from the Balise Transmission Module (BTM) and the Loop Transmission Module (LTM) and processed adequately. In ETCS L2 and L3 mode, the VS interacts with the RBC or the APC-MT respectively. It receives the movement authority (MA) and reports the train position (TPR) to the respective system. The VS is agnostic to the communication technology used. Therefore, communication via GSM-R as well as via FRMCS or any future technology is possible. The VS also displays to the driver the necessary information (including cab signalling in ETCS L1, L2 and L3). It supports all ETCS modes and ETCS levels defined in the TSI-CCS.

The following figure depicts the VS with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

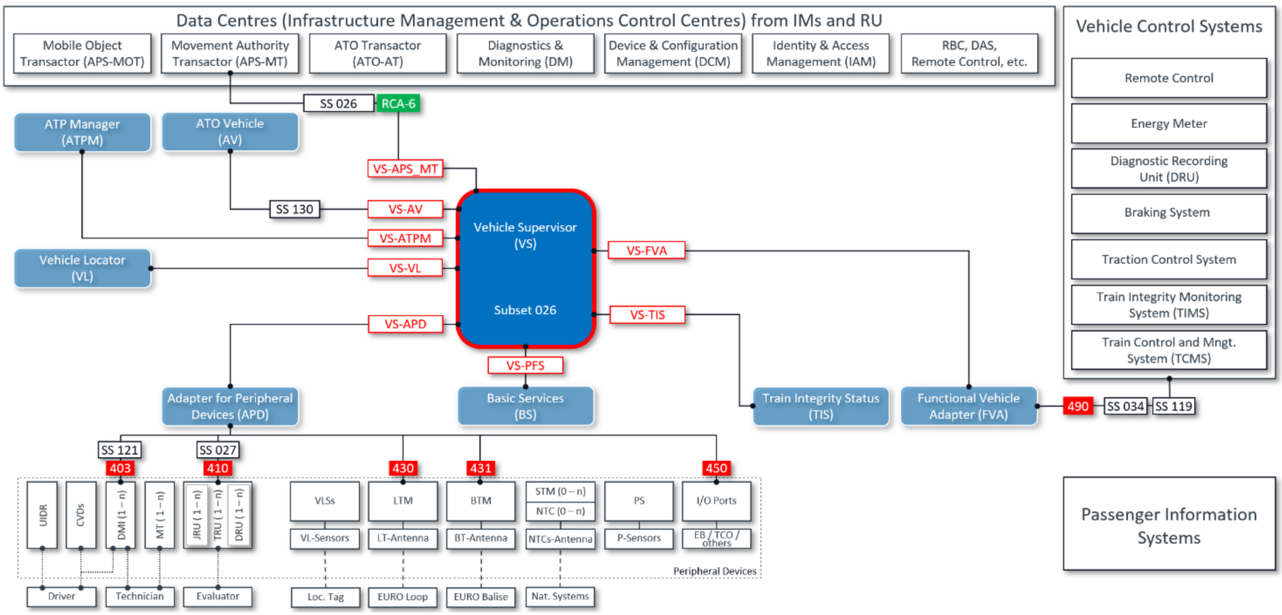

Figure 16 Vehicle Supervisor (VS) – context diagram (tentative)

Interface ID	High-Level Description
VS-APS_MT	This interface corresponds to the specifications of the interface RCA-6.
VS-AV	This interface allows communication between the VS and AV according to the specification in SUBSET-130.
VS-ATPM	This interface allows the ATPM to assign or remove the responsibility for the ATP to/from the VS.
VS-VL	This interface allows to exchange information between VS and VL.
VS-APD	This interface allows the VS to communicate with the various peripheral devices.
VS-BS	This interface allows the VS to communicate with the BS.
VS-TIS	This interface allows the VS to receive the train integrity status from the TIS. This is needed in ETCS L3 mode to report the train integrity status to the APS-MT.
VS-FVA	This interface allows the VS to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).

Table 16 Vehicle Supervisor (VS) – functional interfaces (tentative)

7.3 National Train Control Applications (NTC-APPs) – functional interfaces

The National Train Controls Applications (NTC-APPs), deployed on the OCORA computing platform, are safe applications in charge of ensuring automated train protection based on national systems. NTC-APPs, implemented on the OCORA computing platform, must communicate, as a minimum, with the ATP Manager and can use their specific sensors and actuators. In addition, they can take advantage of the standard OCORA interfaces. E.g. location information can be received from the Vehicle Locator (VL), data can be recorded in the TRU, DMI can be used, the TCMS can be accessed through the Functional Vehicle Adapter (FVA), etc.

The following figure depicts the NTC with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

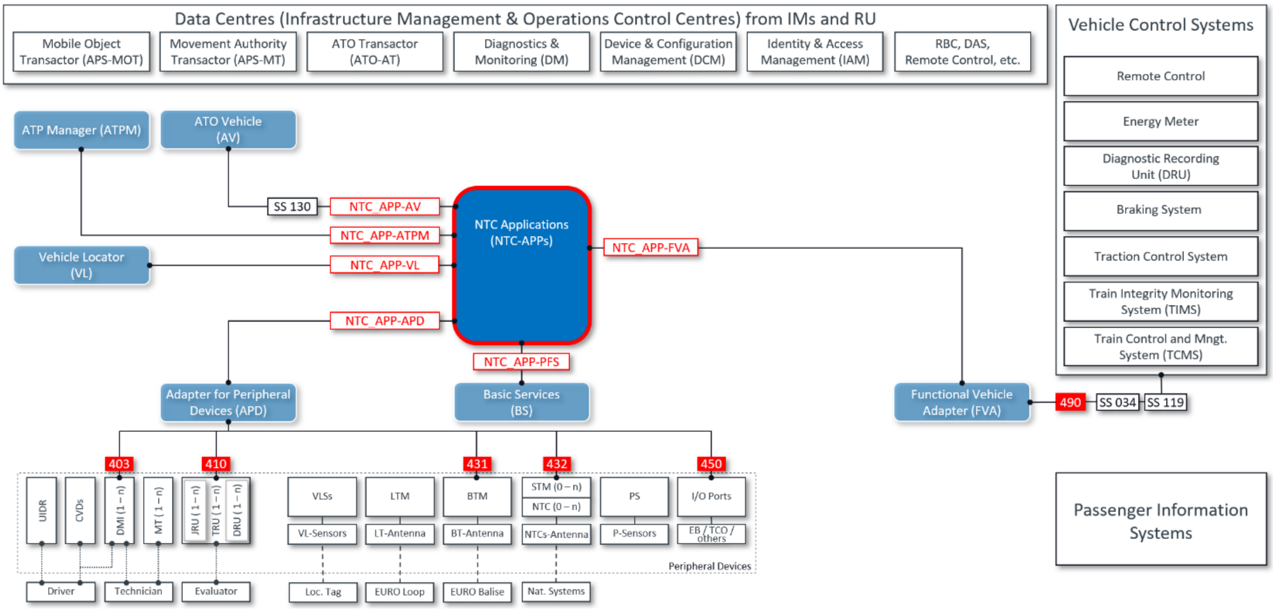

Figure 17 National Train Control Applications (NTC APPs) – context diagram (tentative)

Interface ID	High-Level Description
NTC_APP-AV	This interface allows communication between the NTC_APPs and AV, similar to the communication between VS and AV.
NTC_APP-ATPM	This interface allows the ATPM to assign or remove the responsibility for the ATP to/from the NTC-APPs.
NTC_APP-VL	This interface allows the NTC-APPs to receive information from the VL.
NTC_APP-APD	This interface allows the NTC-APPs to communicate with the various peripheral devices.
NTC_APP-BS	This interface allows the NTC-APPs to communicate with the BS.
NTC_APP-FVA	This interface allows the NTC-APPs to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).

Table 17 National Train Control Applications (NTC-APPs) – functional interfaces (tentative)

7.4 ATO Vehicle (AV) – functional interfaces

The ATO Vehicle (AV) application, deployed on the OCORA computing platform, is a non-safe application for automated train operations. A safe extension is needed for GoA3 and GoA4 operations. This is provided by the ATO Perception Vehicle (APV). The AV in GoA2 – GoA4 operates the vehicle automatically using information received through the interface SS126. It also communicates with the Vehicle Supervisor (VS) over the interface SS130 (between AV and ETCS-OB). Remark: AV is called ATO-OB in GoA2 Shift2Rail SUBSET-125.

The following figure depicts the AV with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

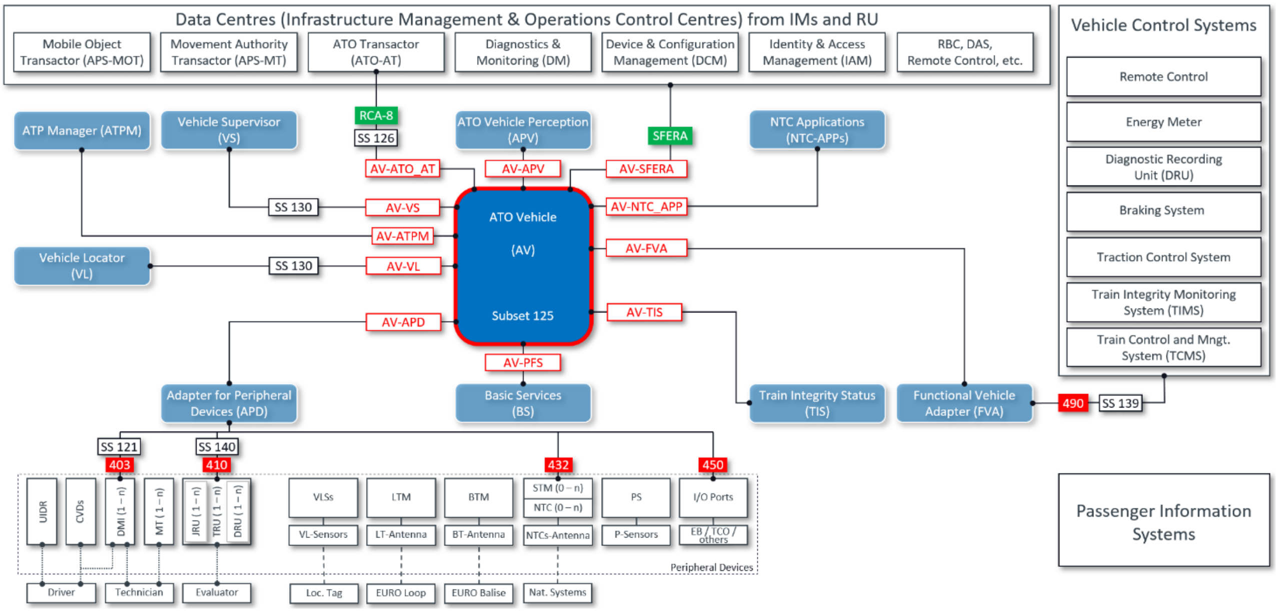

Figure 18 ATO Vehicle (AV) – context diagram (tentative)

Interface ID	High-Level Description
AV-ATO_AT	This interface corresponds to the specifications of the interface RCA-8.
AV-VS	This interface allows communication between the VS and AV according to the specification in SUBSET-130.
AV-ATPM	This interface allows the ATPM to tell the AV what mode and level of the ATP systems is active. It needs to be investigated if this information is of interested to the AV. Otherwise the interface can be dropped.
AV-VL	This interface allows to exchange information between AV and VL.
AV-APD	This interface allows the AV to communicate with the various peripheral devices.
AV-BS	This interface allows the AV to communicate with the BS.
AV-TIS	This interface allows the AV to receive the train integrity status from the TIS. This “replaces” the driver’s view into the mirror, if this is not the responsibility of the train driver (GoA 1-2) or if the train driver does not exist.
AV-FVA	This interface allows the VL to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).
AV-NTC_APP	This interface allows communication between the NTC_APPs and AV, similar to the communication between VS and AV.
AV-SFERA	This interface allows communication between the AV and DAS, similar to the communication between AV and ATO-AT but for “AOT over NTC”. This interface corresponds to the specifications of the SFERA interface.
AV-APV	This interface allows the APV to inform the AV about a perception status and AV can report the current GoA level to APV.

Table 18 ATO Vehicle (AV) – functional interfaces (tentative)

7.5 ATO Perception Vehicle (APV) – functional interfaces

The ATO Perception Vehicle (APV) application, deployed on the OCORA computing platform, is a safe application needed for automated train operations with GoA3 and GoA4. It is deployed in addition to ATO Vehicle (AV) and includes all safety-related functionality and data needed for GoA3 and GoA4 operations. To execute these tasks, it has interfaces to perception system, Digital Maps (DMS), etc. Based on the situation (type of danger and location information) it triggers speed reduction, service brakes, traction cut-off, and emergency brakes. Remark: APV is called "Incident Protection Management" (IPM) in GoA3 – GoA4 Shift2Rail discussions.

The following figure depicts the APV with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

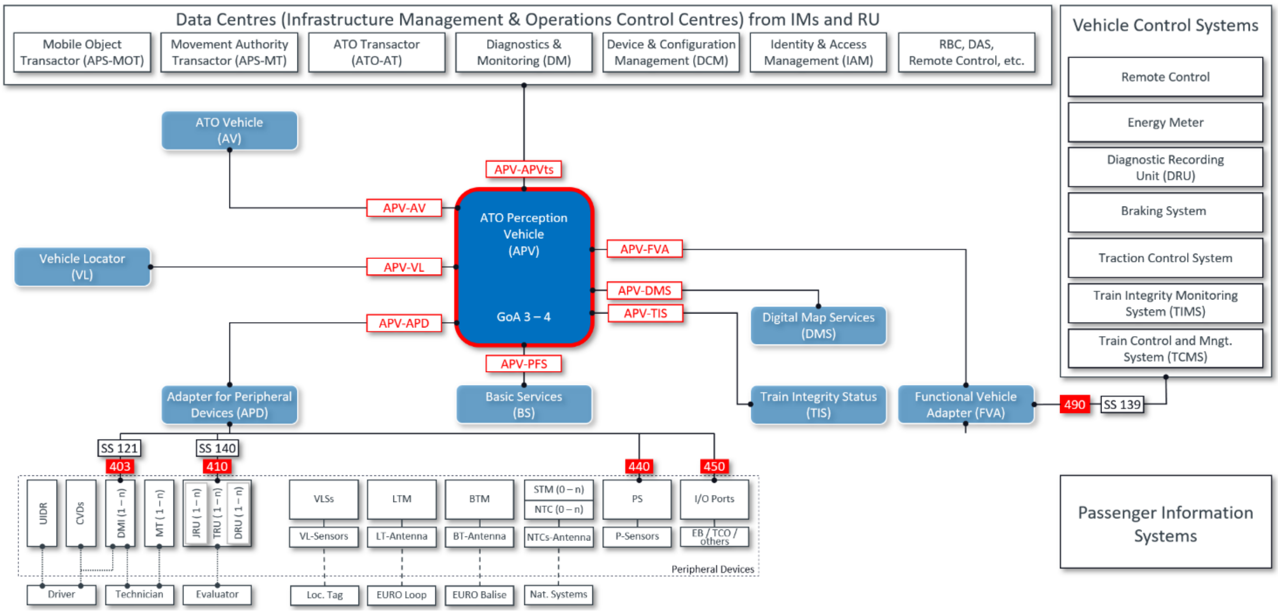

Figure 19 ATO Perception Vehicle (APV) – context diagram (tentative)

Interface ID	High-Level Description
APV-AV	This interface allows the APV to inform the AV about a perception status and AV can report the current GoA level to APV.
APV-VL	This interface allows the APV to receive information from the VL.
APV-APD	This interface allows the AVP to communicate with the various peripheral devices.
APV-BS	This interface allows the APV to communicate with the BS.
APV-TIS	This interface allows the APV to receive the train integrity status from the TIS to make sure the APV has as much awareness information as possible.
APV-DMS	This interface allows the APV to retrieve DMS data. This is needed to make decisions on how to react on a certain perception status.
APV-FVA	This interface allows the APV to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).
APV-APVts	This interface allows the APV to inform the AV about a perception status and AV can report the current GoA level AV is using.

Table 19 ATO Perception Vehicle (APV) – functional interfaces (tentative)

7.6 Vehicle Locator (VL)

The Vehicle Locator (VL) is a safe service deployed on the OCORA computing platform. The VL uses localisation technology to safely and reliably provide position and speed information of the train to various applications. For ETCS implementations, it provides the actual position/direction and the current speed to the VS, where the actual position/direction and the current speed are aggregated with other data into a Train Position Report (TPR). Localisation data may be sent by the VL to APS-MOT, containing e.g. ETCS irrelevant data (not used by VS). The VL sends the full virtual track occupation of the train or only a part of it (only the front or rear position). The VL can use different localization technologies, from today's "balise + odometry" to additional sensor inputs such as GNSS or inertial measurement units. To access the respective sensors, the VL interacts with the Vehicle Localisation System (VLS).

The following figure depicts the VL with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

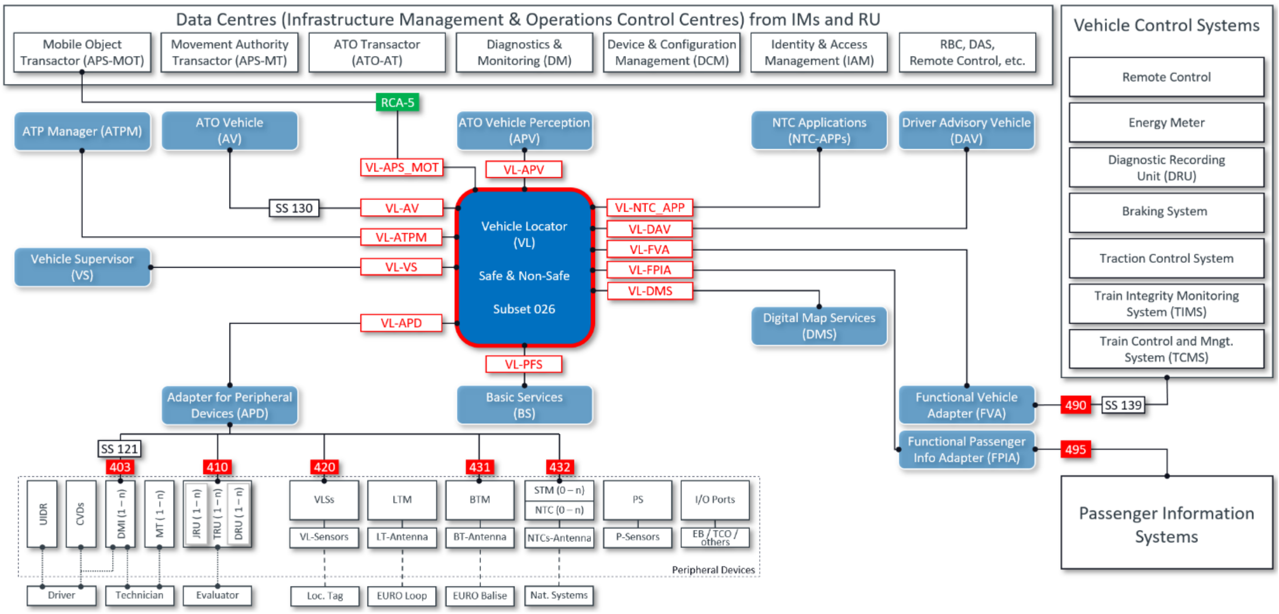

Figure 20 Vehicle Locator (VL) – context diagram (tentative)

Interface ID	High-Level Description
VL-APS_MOT	This information is used by the VL to send localisation data to the APS-MOT, containing e.g. ETCS irrelevant data (not used by VS). This interface corresponds to the specifications of the interface RCA-5.
VL-AV	This interface allows to exchange information between VL and AV.
VL-ATPM	This interface allows the VL to tell the ATPM what position the train is currently at. This might be useful to allow the ATPM to automatically define, together with the DMS, the mode and level for the ATP system.
VL-VS	This interface allows to exchange information between VL and VS.
VL-APD	This interface allows the VL to communicate with the various peripheral devices.
VL-BS	This interface allows the VL to communicate with the BS.
VL-DMS	This interface allows the VL to access the DMS.
VL-FPIA	This interface allows the VL to make location, current speed, etc. available to the FPIA to be forwarded to the passenger information systems.
VL-FVA	This interface allows the VL to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).
VL-DAV	This interface allows the VL to inform the DAV about location, current speed, etc.
VL-NTC_APP	This interface allows the NTC-APPs to access location, speed, etc. data.
VL-APV	This interface allows the VL to inform the APV about location, current speed, etc. This may be interesting to the APV to make the proper decisions.

Table 20 Vehicle Locator (VL) – functional interfaces (tentative)

7.7 Train Integrity Status (TIS)

The Train Integrity Status (TIS) is a safe service deployed on the OCORA computing platform. To determine the train integrity, multiple options are possible: a) train integrity determination on the train (e.g. through the TCMS), b) second localisation unit at the end of the train with on-board determination of the train integrity, and c) second localisation unit at the end of the train with trackside determination of the train integrity. The TIS service ensures that all CCS applications that need to know the train's integrity status (including the coupler statuses, if applicable) are receiving the information through a standardized interface, independent of the option used. The train integrity status may also include the total safe train length (including the length over coupled compositions).

The following figure depicts the TIS service with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

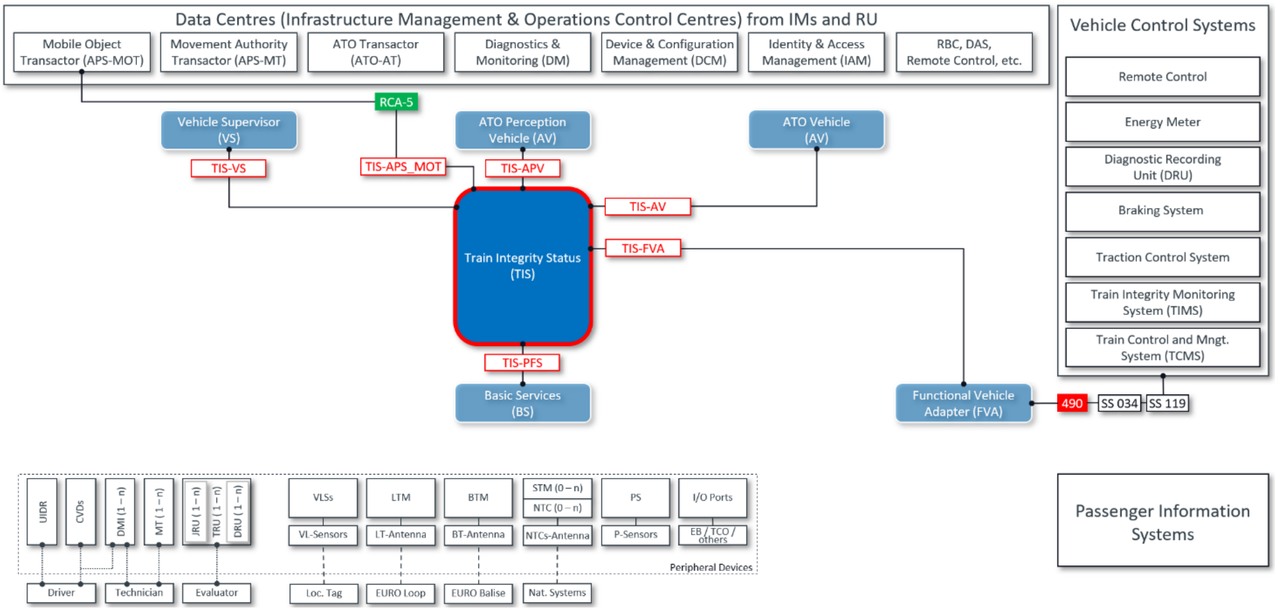

Figure 21 Train Integrity Status (TIS) – context diagram (tentative)

Interface ID	High-Level Description
TIS-APS_MOT	This interface is to inform the train from trackside about the integrity status. This for the situation where the integrity is determined at trackside (e.g. train end-tag evaluation, axel counters). This interface corresponds to the specifications of interface the interface RCA-5.
TIS-VS	This interface allows the VS to receive the train integrity status from the TIS. This is needed in ETCS L3 mode to report the train integrity status to the APS-MT.
TIS-BS	This interface allows the VL to communicate with the BS.
TIS-FVA	This interface allows the VL to communicate via an OCORA standardized interface (FVA) with the vehicle (e.g. TCMS) to receive the integrity status, if determined on-board.
TIS-AV	This interface allows the AV to receive the train integrity status from the TIS. This "replaces" the driver's view into the mirror, if this is not the responsibility of the train driver (GoA 1-2) or if the train driver does not exist.
TIS-APV	This interface allows the APV to receive the train integrity status from the TIS to make sure the APV has as much awareness information as possible.

Table 21 Train Integrity Status (TIS) – functional interfaces (tentative)

7.8 Functional Vehicle Adapter (FVA)

The Functional Vehicle Adapter (FVA) is a piece of software deployed on the OCORA computing platform, or on the OCORA Gateway. Its job is to provide an OCORA unified and standardized interface towards the CCS applications and services for vehicle functions and vehicle information needed by the OCORA on-board applications and services. Although the TSI-CCS SUBSET-034, -119, and -139 are defining the interface to the TCMS system, vehicle from different suppliers and especially from different generations have still different interfaces implemented. This adapter allows to map, on a functional level, the commands sent, and the information received from a specific TCMS into the OCORA standard. In addition, the FVA can also be used to integrate vehicles through wired connections. Also, the standardized interface to the CCS applications evolves in multiple iterations as outlined in chapter 3. Remark: Sometimes the FVA is also called Train Interface Unit (TIU). However, the TIU is not clearly defined. Sometimes it refers to the functional level of the interface with the vehicle, while in other context a piece of hardware is meant. To avoid confusion, OCORA does not use the term TIU.

The following figure depicts the FVA with its interfaces and the interacting building blocks. A high-level description of all identified interfaces is presented in the table below. It must be noted, that this is only a starting point for the MBSE modelling work and serves to trigger discussions with respective subject matter experts. Therefore, changes must be expected in upcoming versions of this document.

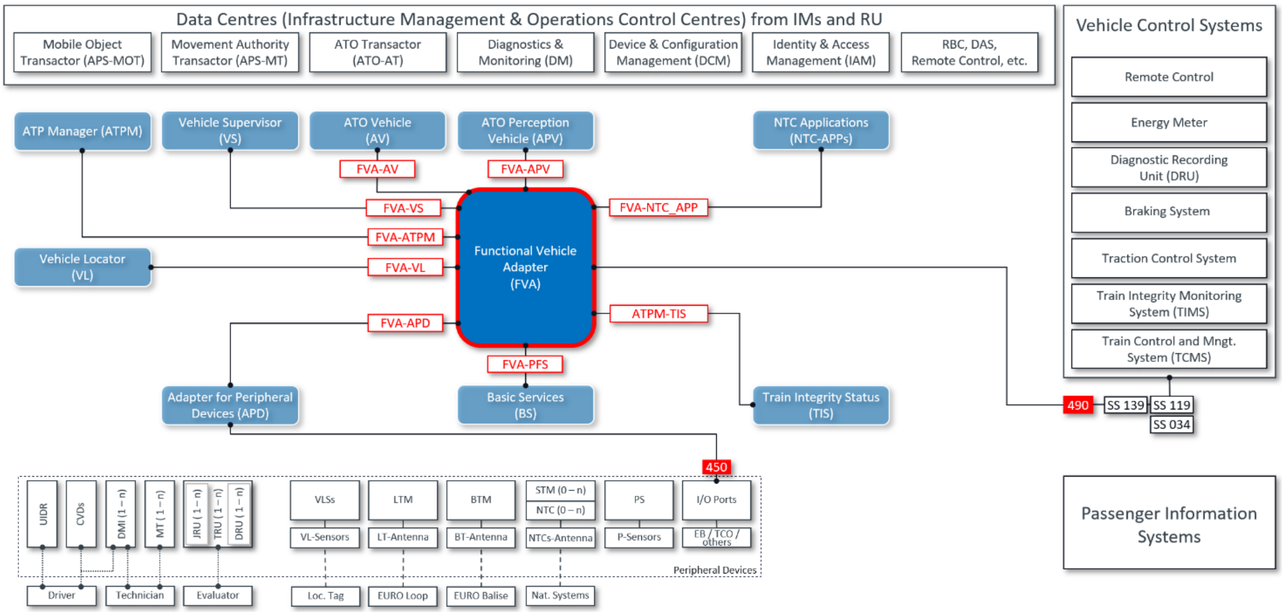

Figure 22 Functional Vehicle Adapter (FVA) – context diagram (tentative) for final iteration

Interface ID	High-Level Description
FVA-AV	This interface allows the AV to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).
FVA-VS	This interface allows the VS to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).
FVA-ATPM	This interface allows the ATPM to know that status of the cabin (active / inactive)
FVA-VL	This interface allows the VL to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).
FVA-APD	This interface allows the FVA to communicate with the various peripheral devices.
FVA-BS	This interface allows the FVA to communicate with the BS.
FVA-TIS	This interface allows the TIS to communicate with the vehicle (e.g. TCMS) to receive the integrity status, if determined on-board.
490	This interface corresponds to the specifications of the interface 490.
FVA-NTC_APP	This interface allows the NTC-APP to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).
FVA-APV	This interface allows the APV to communicate, via an OCORA standardized interface, through the FVA, with the vehicle (e.g. TCMS).

Table 22 Functional Vehicle Adapter (FVA) – functional interfaces (tentative)

8 Computing platform

8.1 Context

The computing platform provides the infrastructure required for operating OCORA's modular, software-component-based, distributed functional CCS on-board applications. Safety and non-safety critical applications shall be able to coexist on the same platform and may even run on the same computing hardware.

8.2 Motivation

The incentive to postulate an open, standardised computing platform is directly derived from the OCORA problem statements, key principles, objectives, and design statements as described in [5], [6], and Appendix A.

Todays deployed CCS on-board systems are proprietary, monolithic vendor specific solutions, creating undesired vendor lock-ins resulting in very high cost of ownership. High-priced changes and extensions stall advancements and impede new game-changing technologies.

Safety functions implemented by CCS on-board systems demand adherence to railway specific standards during development, operation, and maintenance of the entire systems. The stringent homologation processes imposed by CENELEC (standards such as EN50126, EN50128, EN50129) is exorbitantly expensive and time consuming when applied to proprietary, monolithic products in every (type of) rolling stock.

OCORA aims to mitigate the problem by breaking down the CCS on-board system into different layers and components with defined, open interfaces that can be developed, tested, and certified independently.

The proposed computing platform provides a communication focused abstraction layer; a construction kit for building functional applications, agnostic of the underlying operating system, board support package, hypervisor, and hardware.

Today's monolithic solutions block innovative new application development due to

- lacking support for new functions, sensors, and actuators
- lacking ability to cope with increased/different processing requirements (like real-time/non-real-time)
- lacking support for calculation intense machine learning algorithms that require GPU hardware processing.

The OCORA computing platform pursues to address these issues by abstracting the underlying hardware, board support package and operating system. An open, unified platform independent API shall open the door to platform agnostic application development while entrusting the computing platform internals to experienced vendors.

Industrial and technological readiness are essential, when deploying new CCS components. To meet this target, a computing platform that is deployed on a large scale must have been extensively tested in field (e.g. to ensure reliability in operation). It will take several computing platform iterations to achieve all OCORA goals (e.g. full hardware independency may not be achieved in the first computing platform generation). Along the journey, applications' portability will be indispensable to leverage implementation and certification effort across the evolving computing platform generations.

8.3 High-level computing platform architecture

The notion of a Platform Independent API is key to the proposed computing platform architecture. It allows vendors to offer solutions readily available on the market as well as new solutions currently in their product pipelines. New and innovative approaches to Safety and Fault Tolerance may be introduced as they become available on the market, promoting a solution agnostic and future-proof evolution of the computing platform whilst functional applications implementing the business logic of CCS on-board functions remain portable.

A second abstraction considers the different life-cycle profiles of software and hardware. A CCS on-board system comprises of different hardware modules: on one hand the computing nodes that run the CCS on-board functional applications and on the other hand all peripheral devices and the external systems (accessed via the OCORA Gateway).

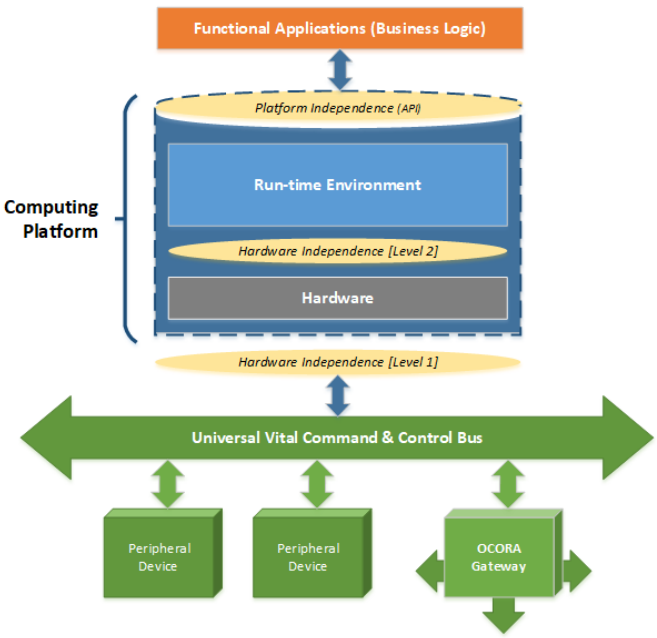

Figure 23 Creating hardware independence

8.3.1 Platform Independence

In OCORA's distributed component based eco-system, a Platform Independent API provides the software layer that lies between the computing platform and the functional applications. It enables the various OCORA components to communicate and share data. Taking advantage of the Universal Vital Control & Command bus, the API simplifies the development of such a distributed system by letting software developers focus on the specific purpose of their applications rather than the mechanics of passing information between applications, peripheral devices, and external systems (via the OCORA gateway).

The Platform Independent API abstracts the application from the details of the operating system, network transport, and low-level data formats. The same concepts and APIs may be accessible from different programming languages allowing applications to exchange information across operating systems, languages, and processor architectures. Low-level details like data wire format, discovery, connections, reliability, protocols, QoS management, etc. are all managed by the computing platform.

In a component-based architecture communication is the "glue" holding everything together and as such becomes a crucial part of the solution: failing inter-component communication may result in complete system failure.

Safety critical (SIL-4) CCS functional applications must comply with the safety requirements according to CENELEC EN 50126, EN 50128, EN 50129 and EN 50159. In conclusion, the computing platform must comply with the same standards, providing a fully transparent safety and fault tolerance layer.

Applications implemented against the Platform Independent API shall be portable between different computing platform implementations and/or versions. To be able to achieve portability, functional applications may only contain business logic related safety code (like for example the computation of the braking curves), all other safety and fault tolerance aspects are to be handled transparently within the computing platform.

8.3.2 Hardware independence

Hardware independence is key to overcome monolithic vendor specific solutions that create undesired vendor lock-ins. OCORA's computing platform addresses hardware independence on two levels:

Level 1: The introduction on the Universal Vital Control & Command bus provides standardised access to peripheral devices and external systems (via the OCORA gateway). Communication is handled by dedicated platform communication services accessible to applications via the Unified Platform Independent API.

Level 2: The computing platform comprises a software part (Run-time Environment) and a hardware part consisting of one ore multiple computing nodes. Computing-node hardware independence is strongly related to the proposed industry solution. In case outright level 2 hardware independence cannot be achieved, potential platform suppliers shall support and maintain compatible, directly procurable computing-node hardware modules of at least two independent hardware manufactures during the entire lifetime of the computing platform.

8.4 Design paradigms and platform approaches

The computing platform architecture shall follow the below design paradigms:

- ***Clear separation of concern between the functional applications and the platform:*** Notably, functional applications shall handle only business logic, while all other required functions to maintain the application's life-cycle (incl. mechanisms for safety, fault tolerance, persistence, communication, and application management) shall be handled by the computing platform;
- ***Satisfy railway norms such as EN 50126, EN 50128 and EN 50129 in their application for up to SIL4:*** provide functional applications with the safe, reliable, deterministic, and real-time performance as well as the level of availability required.
- ***Provide a mechanism for Safe and Secure Communication with external entities:*** (peripheral devices and external systems via the OCORA Gateway)
- ***Provide mechanisms to sufficiently isolate functional applications***, in particular when involving different SIL levels, that are running on the same physical platform.
- ***Implement a harmonized Platform Independent API:*** possibly common between on-board and track-side implementations
- ***Follow a modular safety concept:*** to minimize homologation efforts
- ***Maximize usage of COTS hardware components:*** to be able to choose the hardware according to the required performance, availability, processor architecture, etc. and to minimize vendor lock-in and leverage advances in other sectors.
- ***Consider utilizing virtualization techniques or similar means of abstraction of compute resources:*** for better evolvability, scalability, the support of mixed SIL constellations and a more flexible mapping of applications to compute resources.

The computing platform's exact internal architecture is intentionally entrusted to the industry e.g. potential platform vendors. Depending on existing solutions but whilst respecting above mentioned design paradigms, vendors may propose completely different approaches.

The below diagram shows three possible options on how the internals of the computing platform could look like. The presented options are intended to illustrate the idea only.

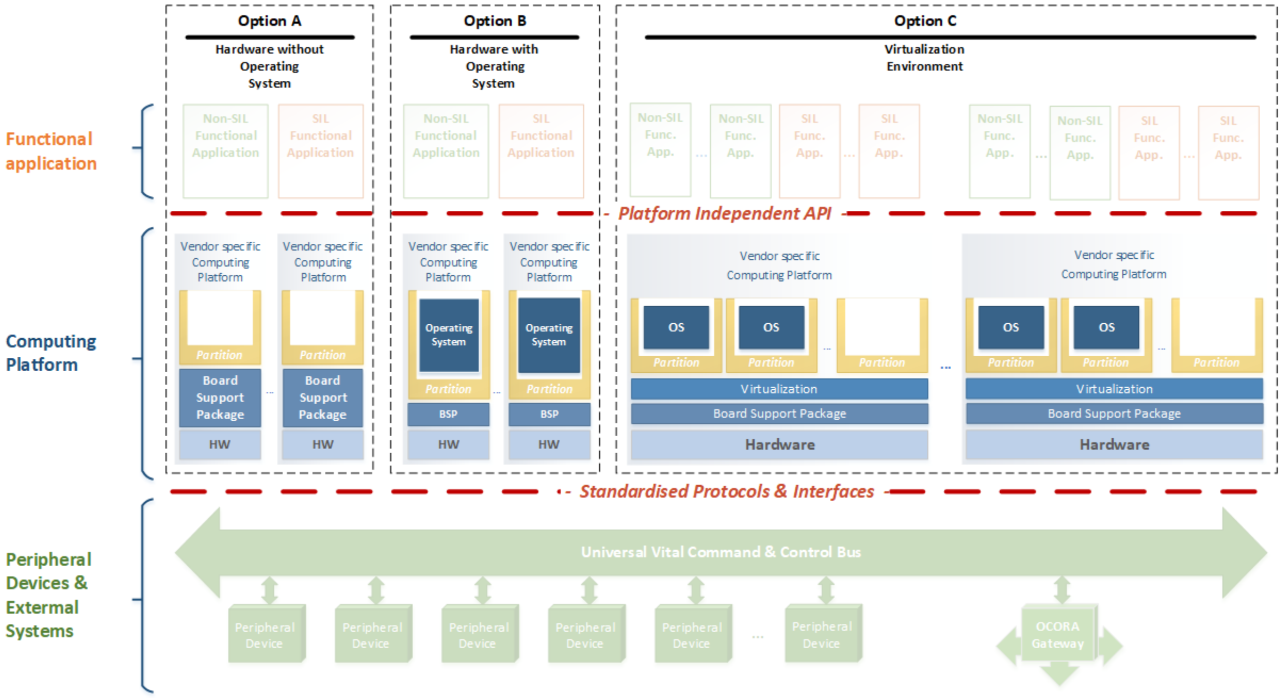

Figure 24 Platform approaches

The *Functional Application* is a functional module of the over-all-system. It has its own task (business logic). It interfaces with the computing platform via a unified platform independent API and runs in a *Partition*.

Partitions are execution environments with guaranteed memory address space isolation and limited processor (or core) execution time. Propagation of software errors among partitions is assured to be impossible. To be consistent, the concept of a *Partition* is also applied to systems without virtualisation. They comply by default with afore mentioned partition characteristics.

Option A: The computing platform is implemented on fully embedded hardware, using a board support package and no Operating System. Such a platform could be composed of multiple similar computing-nodes.

Option B: The computing platform uses hardware, board support package and some operating system. Again, such a platform could comprise several computing-nodes.

Option C: The computing platform uses a virtualization environment that allows running multiple partitions on the same hardware. Partitions are execution environments that may contain their own operating system. If required, such a platform could also make use of several computing-nodes using virtualization.

All afore mentioned options shall be considered as a non-exhaustive list of possible platform approaches. A joint OCORA/RCA initiative has initiated discussions regarding synergies between the CCS on-board computing platform and the RCA track-side safe data centre. In a first step, the group has compiled a whitepaper [14] that shall help industry discussions with the goals to narrow down the most promising platform approaches as well as to evaluate the concept of having a common unified platform independent API for on-board and track-side functional applications.

9 Cyber security

The advancing communication of components results in increased interfaces and points of contact between systems that are required for a modern railway operator. These days there are no adequate and commonly used security solutions in place to protect against unauthorized access or to completely prevent unauthorized interventions and attacks. This results in a steadily growing attack surface for internal and external attacks on safety-relevant systems of a railway operator.

Therefore, OCORA is required to also consider security aspects of CCS on-board solutions. In European cooperation security experts will develop a set of well-defined security requirements as an addition for the OCORA requirement catalog. This will be achieved by developing a process to define new security requirements and by revisions of already existing ones through workshops.

The two main objectives of the OCORA security workstream is the creation of security architectural principles and security requirements as an addition for the OCORA requirement catalog and that cyber security thoughts get integrated in the OCORA architecture like zoning, principles, and levels. The workstream will also include opinions and results from other security work groups.

Further information on cyber security is published in document [10] and [18]. The cyber security topic will be discussed in more detail in subsequent versions of the OCORA documents and with other relevant Cyber-security platforms like ER-ISAC and UIC P666 project.

Appendix A System architecture guidelines

A1 Prerequisites for system decomposition

The overall goals of the system decomposition are to enable:

1. “Plug & play”-like exchangeability of CCS building blocks, i.e. (software) applications to be updated, upgraded, removed, added, or exchanged without the need for hardware changes or (re)certification of other than the (software) application affected.
2. Fast, simple and – whenever feasible from a point of view of system performance, cyber security, and operational effort – remote replacement, update, or upgrade of software.
3. Simplified and – where possible – automated safety case development and certification; component oriented (modular) certification.
4. Compatibility alignment on application level between CCS on-board building blocks and between train borne and trackside.
5. Modular testing, acceptance, and certification.

A2 Decomposition principles and rules

The decomposition of the CCS on-board in single building blocks is a key task and needs to be achieved according to a set of decomposition rules and principles that follow the OCORA design principles listed in document [5].

> A building block is a top-level unit of the CCS on-board system (hardware and/or software), having well defined capabilities (tasks to be performed to achieve a predefined result) and interfaces towards other building blocks of the CCS system. Building blocks consist of 1 – n component(s) and are regression free modifiable / adaptable and therefore portable / replaceable. As a result, every building block is “plug & play”-like exchangeable without impacting other building blocks. OCORA building blocks shall be an optimal balance between "number of interfaces between building blocks" and "desire to exchange building blocks at a low granularity".

Top level requirements for decomposing the on-board CCS are:

1. Decomposition shall be based on the lowest reasonable granularity to enable the maximum level of value for money. Building blocks shall have narrow interfaces (low coupling) and must allow for regression free testing.
2. Since the function requiring the highest safety integrity level defines the safety integrity level required of all other functions in the same application or service, mixing of functions requiring different safety integrity levels in one application or service shall be prevented.
3. CCS on-board functions not needed in the future (e.g. GSM-R), shall be isolated. This allows easy removal, once the functionality is not needed anymore.
4. Single building blocks are strictly isolated and connected by testable FFFIS.
5. Physical distribution of building blocks over a train must be possible (e.g. maximum cable length requirements, antenna positioning, etc.)
6. Functionality not needed in all CCS on-board implementations are isolated in separate building blocks, allowing to deploy functionality on an as needed basis.
7. Strategy for product selection (e.g. off the shelf products, make or buy, RU's IT strategy, procurement strategy, different or multiple suppliers, etc.) is considered.
8. Coherence and consistency of life-cycle management on a building block level must be achieved. This is to achieve an independent life-cycle management for each of the building blocks.

A3 Architecture design guidelines

The OCORA architecture design principles formulated in document [5] can be operationalised in to the system architecture design guidelines that are applied in this document.

System architecture design guidelines	OCORA architecture design principles						
	openness	modularity	exchangeability	migrateability	evolvability	portability	security
1. The CCS on-board shall be decomposed according to the rules defined in Appendix A1.	x	x	x	x	x	x	
2. Functions shall be realised in software (applications and services) and should not be bound to a specific hardware.	x	x	x	x	x	x	
3. System design shall enable software to be updated, upgraded, removed, added, or exchanged without the need for hardware changes or (re)certification of other than the software affected. Means to ensure backward compatibility must be provided.	x	x	x	x	x	x	x
4. Core ETCS functionality shall be isolated from other on-board functions and the core ETCS functionality shall be decomposed according to the rules defined in Appendix A1.	x	x	x	x	x	x	
5. CCS on-board functionality foreseeable to become obsolete in the future shall be isolated to ensure easy decommissioning, once the respective functionality is not needed anymore.	x	x	x	x	x	x	
6. Whilst and where no standardized and common TCMS-CCS network/bus is available, the CCS on board shall communicate with vehicle functions through a gateway.	x	x	x	x	x	x	x
7. Open standards are used wherever possible and reasonable.	x	x	x	x	x	x	x
8. The re-use of software is maximized (same software for various deployments).	x	x	x	x	x	x	
9. A service-oriented architecture on application level shall avoid duplication of code. Therefore, common applications or application services will be identified.	x	x	x	x	x	x	
10. The architecture/design provides support for automated testing.		x	x	x	x	x	
11. The on-board CCS system is optimized regarding the optimal number of building blocks.	x	x					
12. Hardware is separated from software, allowing to handle the different life cycle profiles.	x	x	x	x	x	x	
13. The architecture considers that a competitive market for the different building blocks can develop.	x	x	x	x	x	x	

Table 23 System architecture design guidelines

Appendix B CCS on-board – network topology scenarios

This appendix provides initial ideas for the CCS on-board network topology, including an initial set of scenarios to interconnect the different on-board networks and to connect and integrate the connectivity devices. These scenarios are the basis for further discussions around the connectivity and the OCORA Gateway (OCORA-GW) and will be adapted as the architecture evolves. Refer also to Appendix C for a discussion of OCORA-GW scenarios, focussing on cyber-security aspects.

B1 Scenario 1 – OCORA-GW

In this scenario, the OCORA-GW is the central element between the different onboard networks, provides the connectivity to the trackside systems, and acts as a firewall between all connected networks. Different types of networks can be connected through the OCORA-GW.

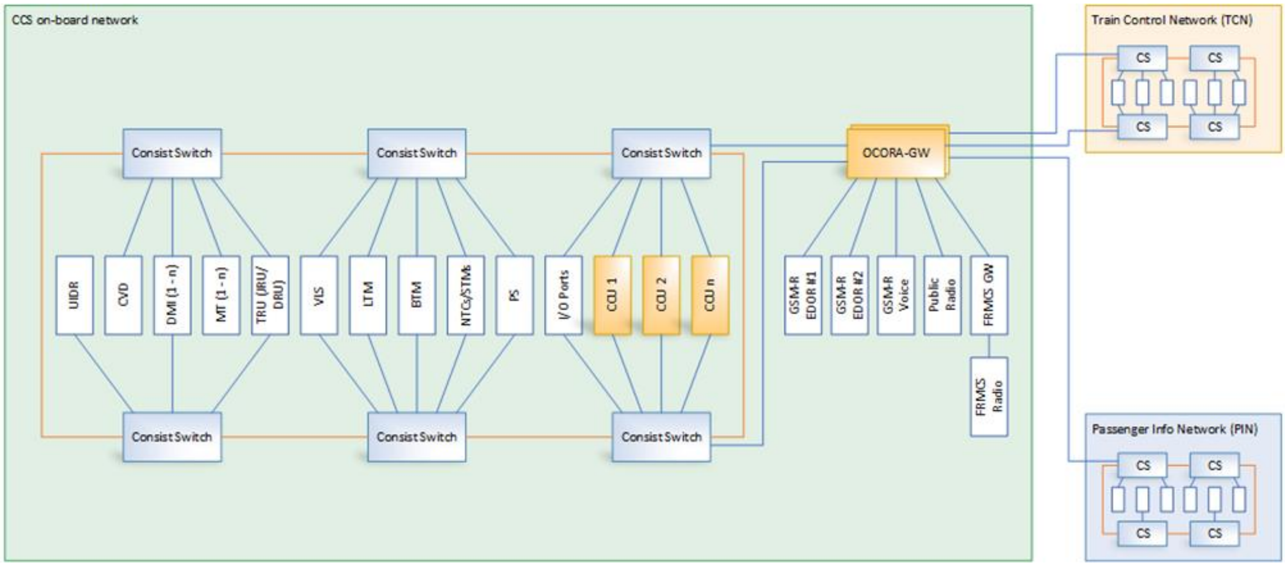

Figure 25 CCS on-board network topology – scenario 1: OCORA-GW

Advantages	Disadvantages
▪ Central firewall functionality can be realized on one device / system ▪ The FRMCS-GW functionality could be implemented on the OCORA-GW making a separate hardware for the FRMCS-GW obsolete. ▪ Different type of networks can be connected (e.g. MVB). ▪ Single device for all connections between on-board and trackside networks which can handle the bearer selection.	▪ The OCORA-GW is a critical element between the onboard networks and for the connectivity. Thus, a redundant design may be needed for RAM reasons.

B2 Scenario 2 – OCORA-GW as firewall only

In this scenario, the OCORA-GW connects all onboard networks and acts as a firewall between them. The connectivity devices are directly attached to the UVCCB (CCS Ethernet Consist Network (CCS ECN)).

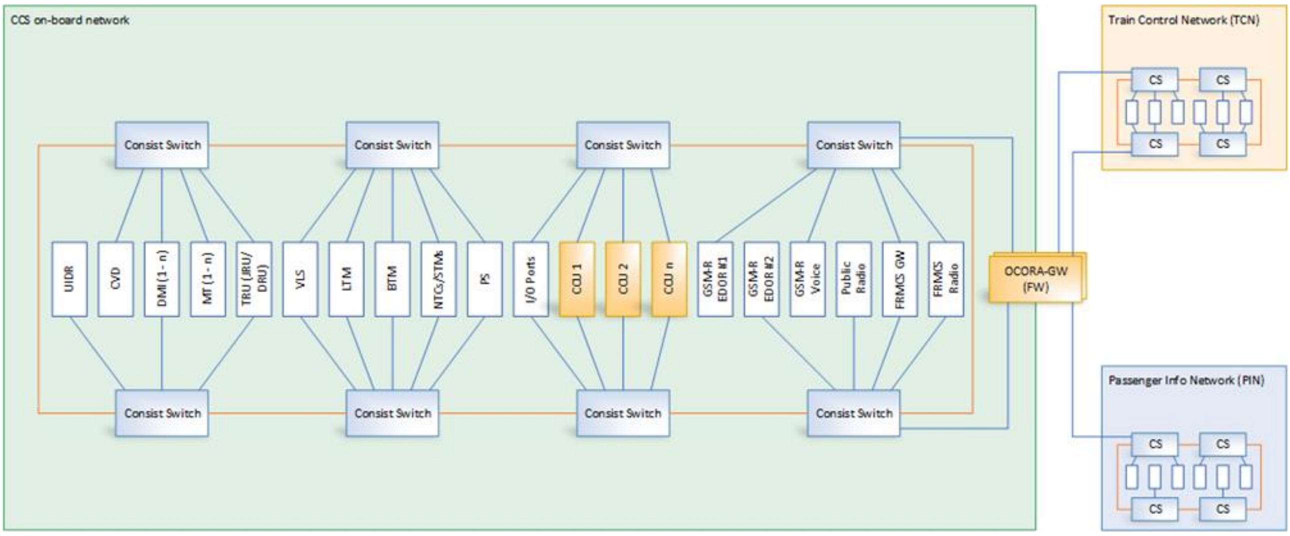

Figure 26 CCS on-board network topology – scenario 2: OCORA-GW as Firewall only

Advantages	Disadvantages
▪ Central firewall functionality can be realized on one device / system to protect the on-board networks from each other.	▪ The OCORA-GW is a critical element between the onboard networks. Thus, a redundant design may be needed for RAM reasons. ▪ Security (firewall) needs to be implemented in the Radio components. ▪ Bearer selection for the connections between on-board and trackside services must be handled by each application individually. ▪ Sharing the connectivity services with other on-board networks is more difficult than in variation 1.

B3 Scenario 3 – without OCORA-GW

This scenario omits the OCORA-GW. The on-board networks and connectivity devices are connected directly to the UVCCB (CCS Ethernet Consist Network (CCS ECN)).

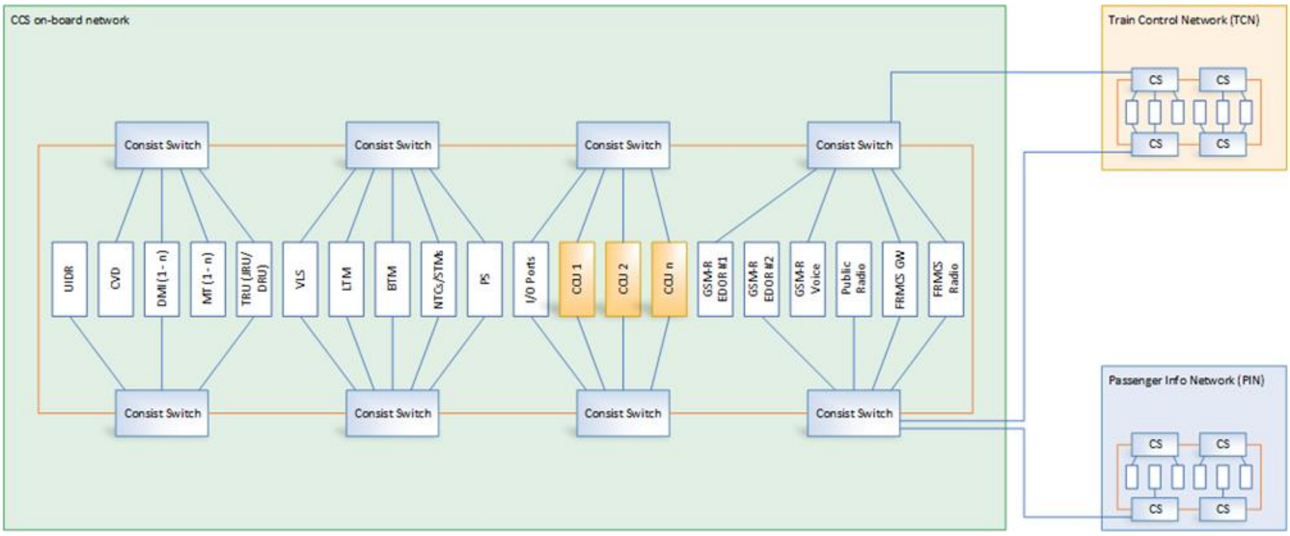

Figure 27 CCS on-board network topology – scenario 3: without OCORA-GW

Advantages	Disadvantages
▪ No OCORA-GW is required.	▪ No protection between the onboard networks. ▪ May lead to performance issues due to too many participants on the network. ▪ Security (firewall) needs to be implemented in the Radio components. ▪ Bearer selection for the connections between on-board and trackside services must be handled by each application individually. ▪ Only possible, if there is a unified train network.

Appendix C Discussion on gateway scenarios

This appendix provides various scenarios for the OCORA Gateway (OCORA-GW), focussing on cyber-security aspects. These scenarios shall serve as basis for further discussions around the OCORA-GW and its functionality and will be adapted as the architecture evolves. Refer also to Appendix B for possible UVCCB network topologies.

C1 Scenario 1 – Radio is connected to the TCN / security in radio

In this scenario the Radio is connected to the Train Control System Network (TCN) and all communication to the trackside systems is handled by the vehicle radio connected to the TCN. Security to protect the on-board networks from the mobile radio network is implemented in the radio module.

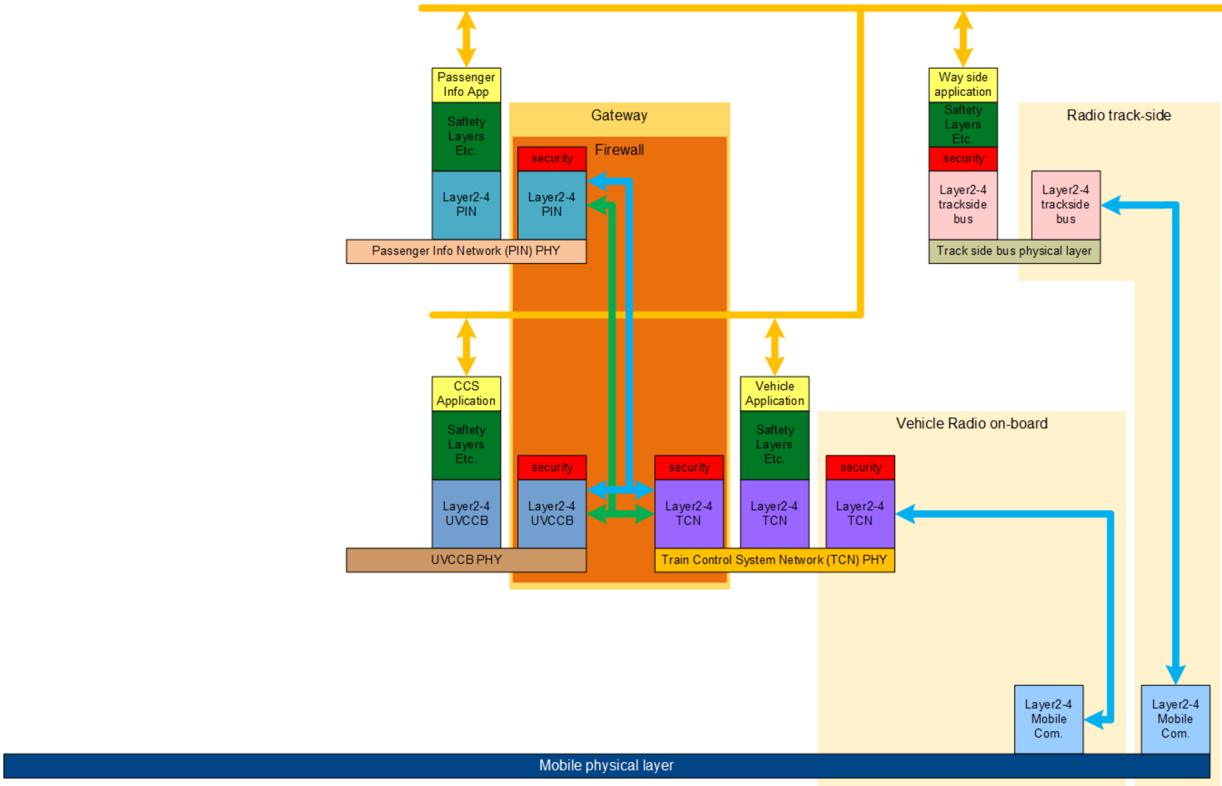

Figure 28 Radio is connected to the TCN / security in radio

Advantages	Disadvantages
▪ Radio not integrated with the gateway	▪ Security integrated with the radio may require regular upgrades. This makes it difficult to use standard radio equipment. ▪ Additional gateway required to enable radio communication for the CCS and Passenger Information System.

C2 Scenario 2 – Radio is connected to the TCN / security separate from radio

In this scenario the Radio is connected to the Train Control Network and all communications to the trackside systems is handled by the vehicle radio connected to the TCN. Security to protect the on-board networks from the mobile radio network is implemented in a separate firewall on which the radio module is connected.

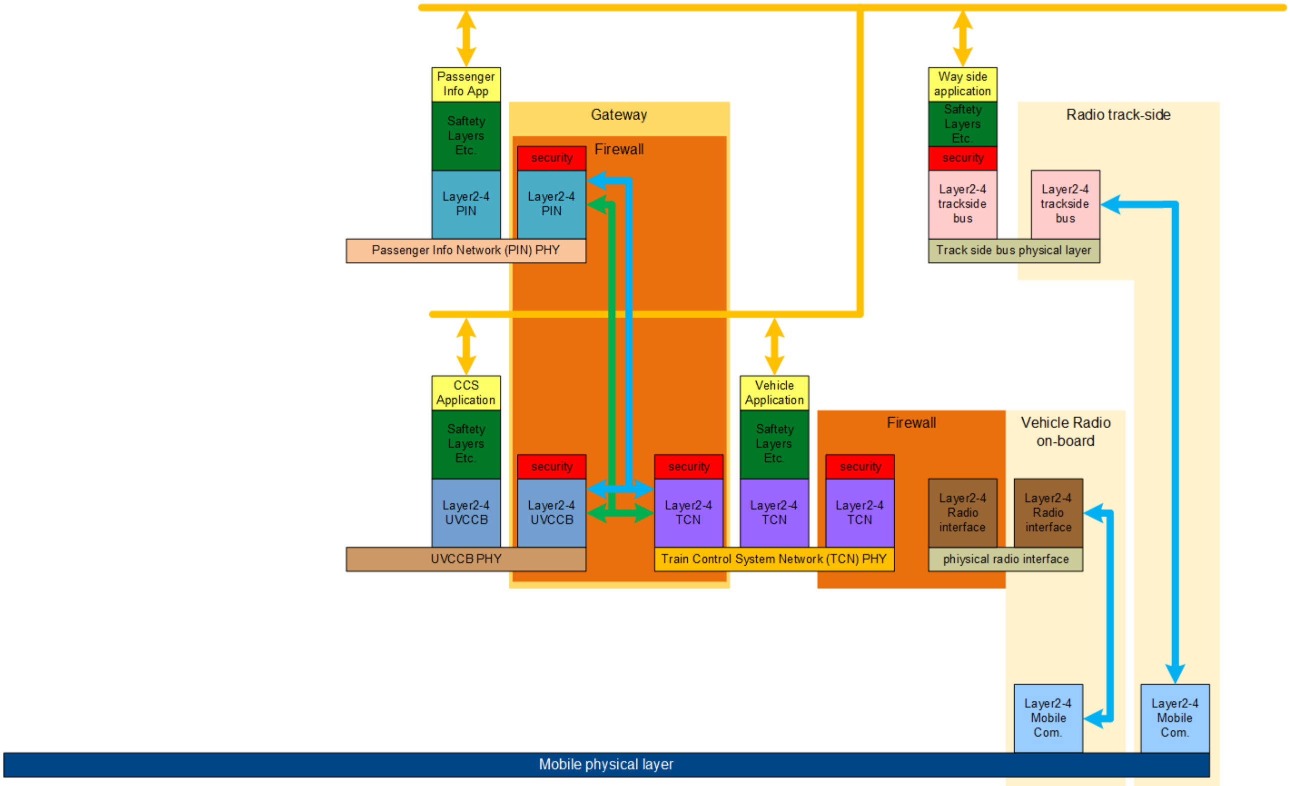

Figure 29 Radio is connected to the TCN / security is separate from radio

Advantages	Disadvantages
▪ Security (firewall) is implemented as a separate module, which could be based on standard equipment ▪ Radio not integrated with the gateway	▪ Additional hardware for the firewall towards the mobile radio network is required ▪ Additional gateway required to enable radio communication for the CCS and Passenger Information System.

C3 Scenario 3 – Radio is connected to the UVCCB / security in radio

In this scenario the Radio is connected to the UVCCB and all communication to the trackside systems is handled by the radio module connected to the UVCCB. Security to protect the on-board networks from the mobile radio network is implemented in the radio module.

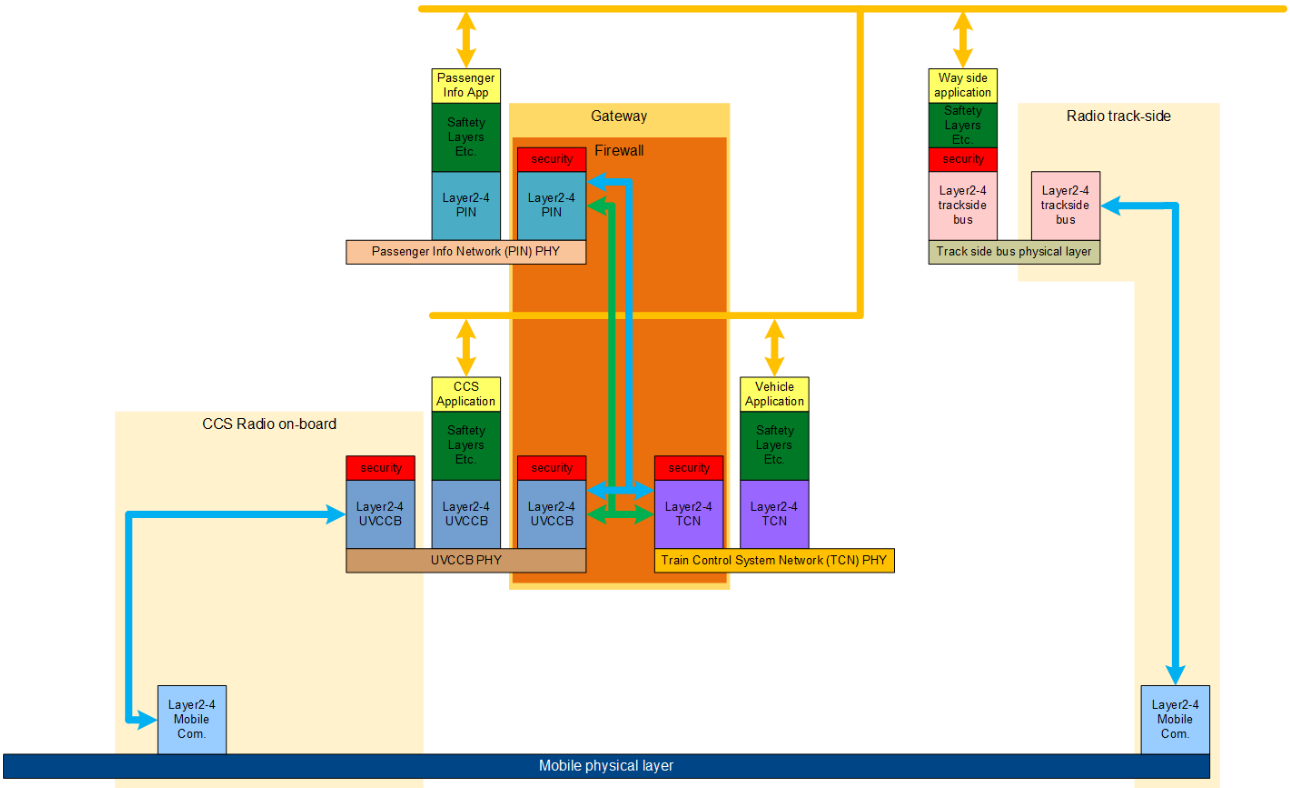

Figure 30 Radio is connected to the UVCCB / security in radio

Advantages	Disadvantages
▪ Radio not integrated with the gateway	▪ Security integrated with the radio may require regular upgrades. This makes it difficult to use standard radio equipment. ▪ Additional gateway required to enable radio communication for the Train Control Systems and Passenger Information System.

C4 Scenario 4 – Radio is connected to the UVCCB / security separate from radio

In this scenario the Radio is connected to the UVCCB and all communication to the trackside systems is handled by the vehicle radio module connected to the UVCCB. Security to protect the on-board networks from the mobile radio network is implemented in a separate firewall on which the radio module is connected.

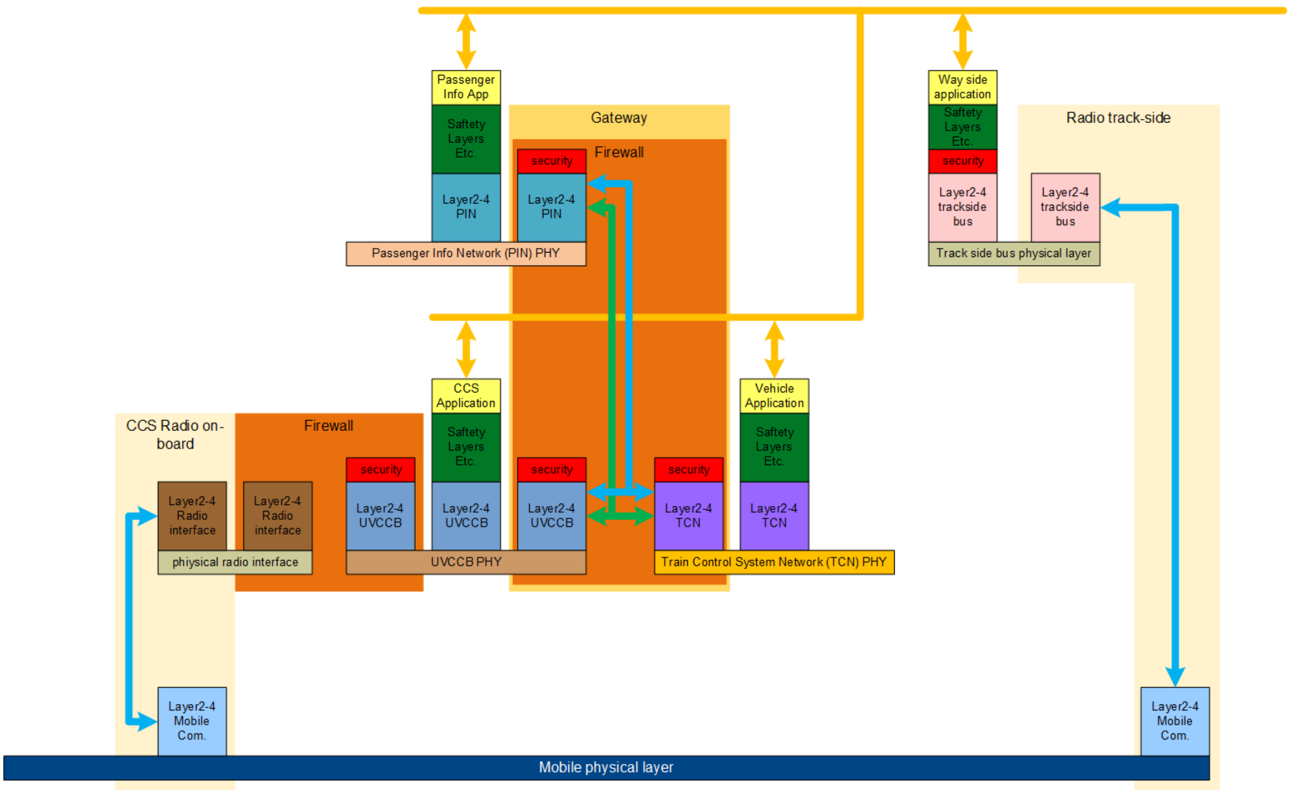

Figure 31 Radio is connected to the UVCCB / security separate from radio

Advantages	Disadvantages
▪ Security (firewall) is implemented as a separate module, which could be based on standard equipment ▪ Radio not integrated with the gateway	▪ Additional hardware for the firewall towards the mobile radio network is required ▪ Additional gateway required to enable radio communication for the Train Control Systems and Passenger Information System.

C5 Scenario 5 – Radio is connected to PIN / security in radio

In this scenario the Radio is connected to the Passenger Information Network (PIN) and all communications to the trackside systems is handled by the radio module connected to the PIN. Security to protect the on-board networks from the mobile radio network is implemented in the radio module.

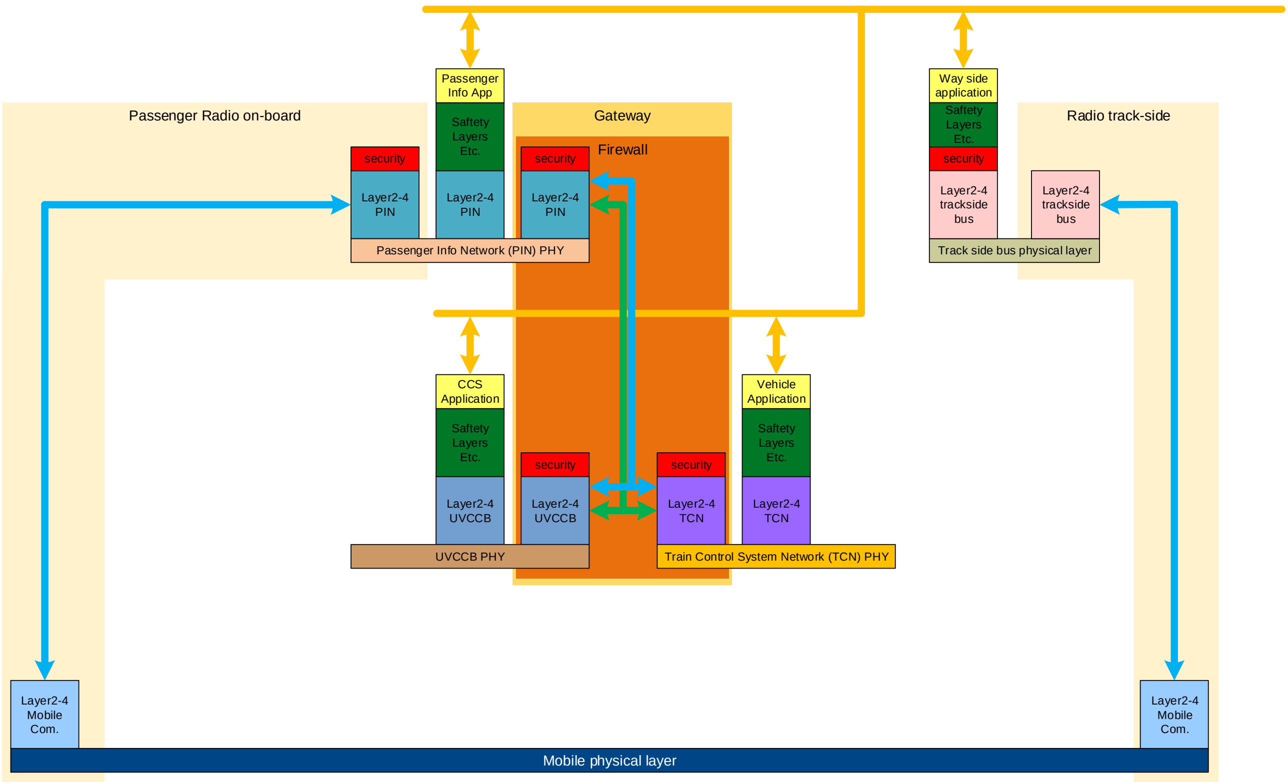

Figure 32 Radio is connected to PIN / security in radio

Advantages	Disadvantages
▪ Radio not integrated with the gateway	▪ Security integrated with the radio may require regular upgrades. This makes it difficult to use standard radio equipment. ▪ Additional gateway required to enable radio communication for the Train Control Systems and the CCS.

C6 Scenario 6 – Radio is connected to PIN / security separate from radio

In this scenario the Radio is connected to the Passenger Information Network (PIN) and all communications to the trackside systems is handled by the vehicle radio module connected to the PIN. Security to protect the on-board networks from the mobile radio network is implemented in a separate firewall on which the radio module is connected.

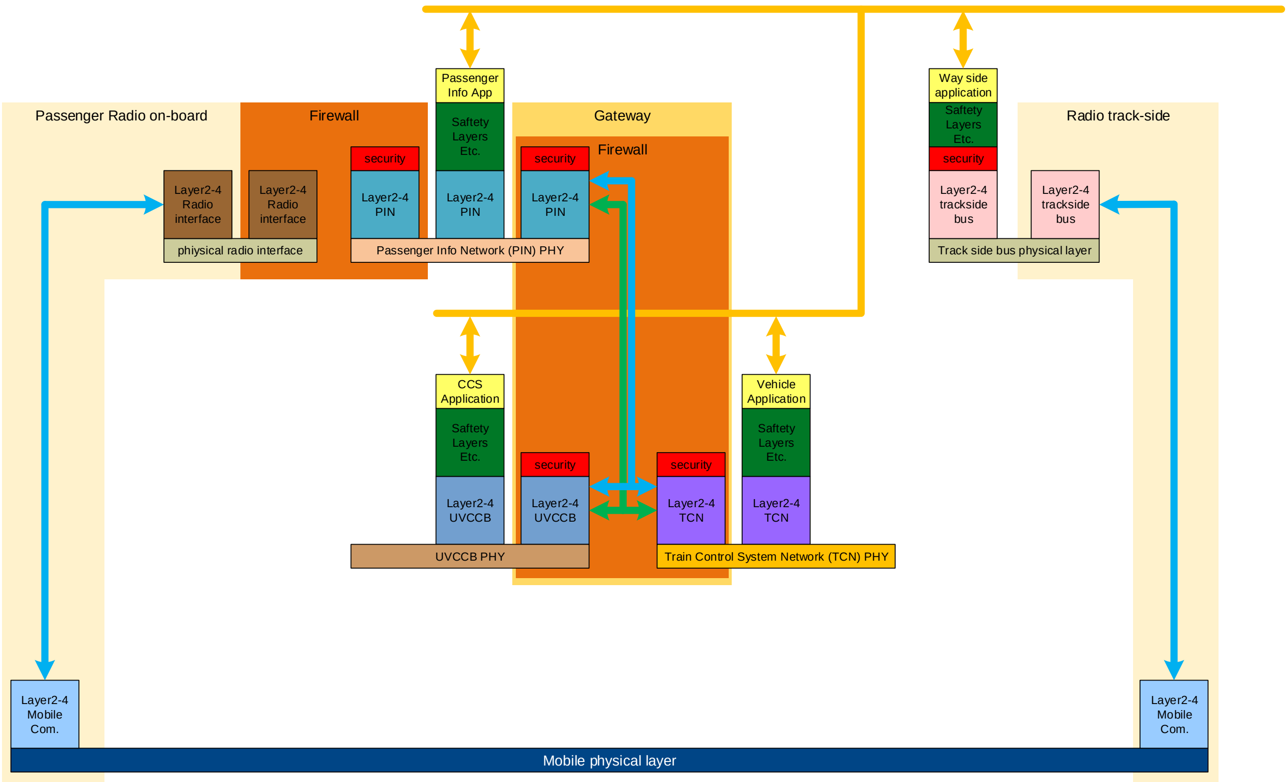

Figure 33 Radio is connected to PIN / security separate from radio

Advantages	Disadvantages
▪ Security (firewall) is implemented as a separate module, which could be based on standard equipment ▪ Radio not integrated with the gateway	▪ Additional hardware for the firewall towards the mobile radio network required ▪ Additional gateway required to enable radio communication for the Train Control Systems and the CCS

C7 Scenario 7 – Radio integrated into the OCORA Gateway

In this scenario, the radio module is integrated into the OCORA-GW and all communications to the trackside systems is handled by the radio module of the OCORA-GW. Security to protect the on-board networks from the mobile radio network is part of the integrated radio module.

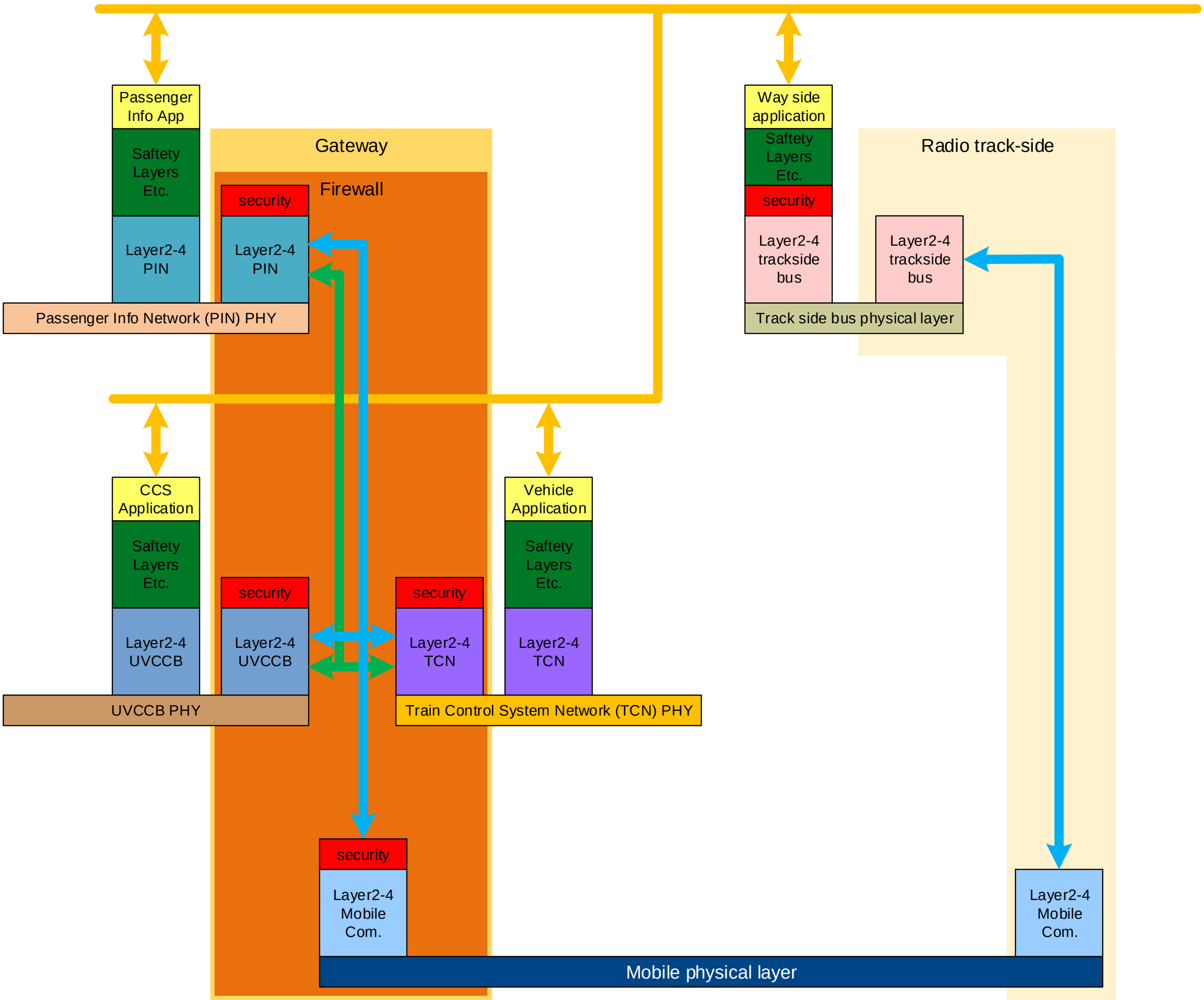

Figure 34 Radio integrated into the OCORA Gateway

Advantages	Disadvantages
▪ Security concentrated in one module, the radio module of the OCORA GW	▪ Security integrated with the radio may require regular upgrades. This makes it difficult to use standard radio equipment.

C8 Scenario 8 – Radio connected to Gateway

In this scenario, the radio module is connected to the OCORA-GW and all communications to the trackside systems is handled by this radio module connected to the OCORA-GW. Security to protect the on-board networks from the mobile radio network is implemented in the OCORA-GW.

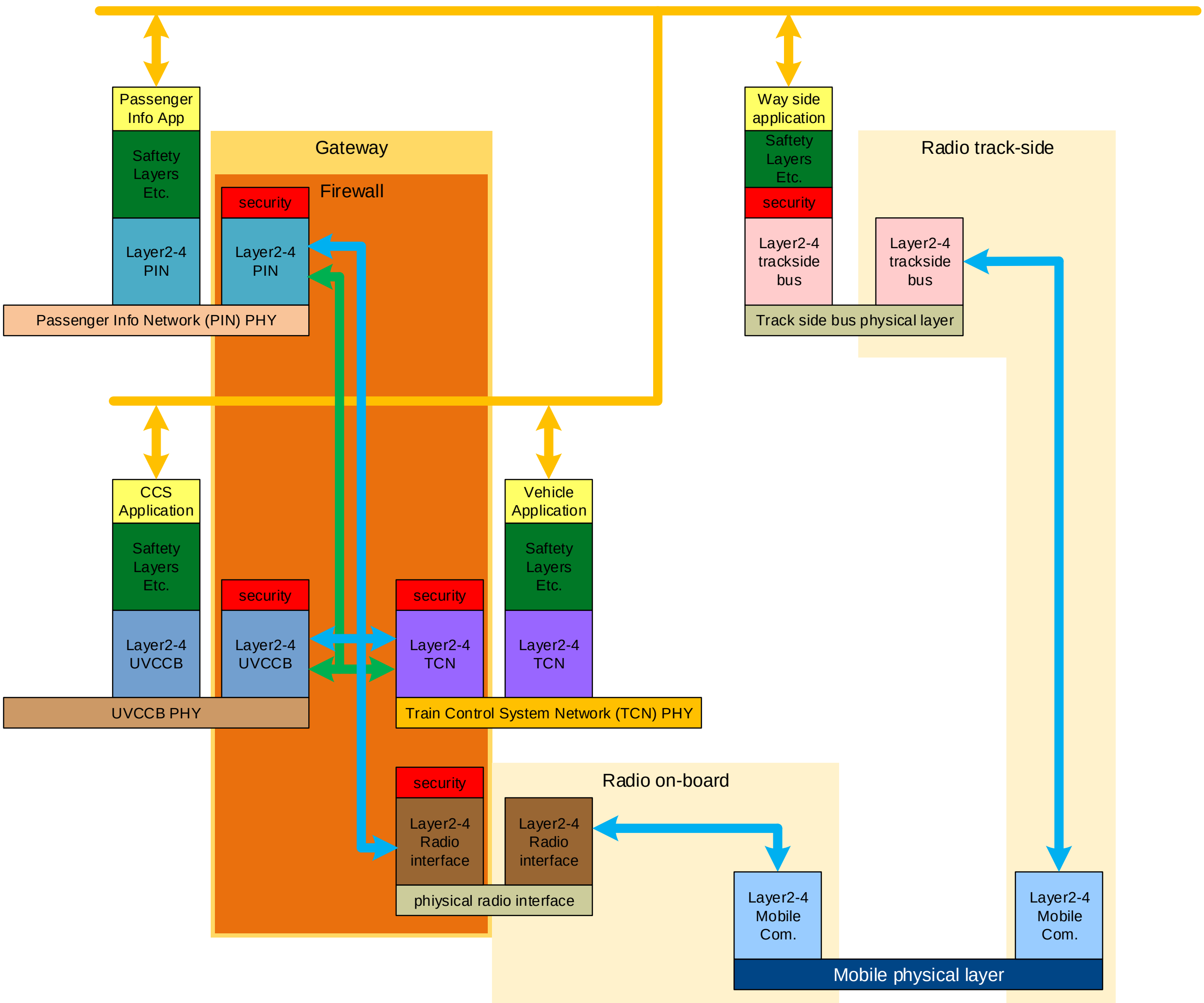

Figure 35 Radio connected to Gateway

Advantages	Disadvantages
▪ Security concentrated in one module, the OCORA GW ▪ Standard radio equipment can be used.	▪ Radio communication goes always via a gateway and could have an impact to the availability. ▪ To provide the required availability, the OCORA-GW may have to implement redundancies on the hardware and software levels.

C9 Scenario 9 – Separate Radio on all networks

In this scenario every on-board network has its own connectivity to the trackside systems including a firewall and a separate radio module. The OCORA-GW is only used to interconnect the on-board networks.

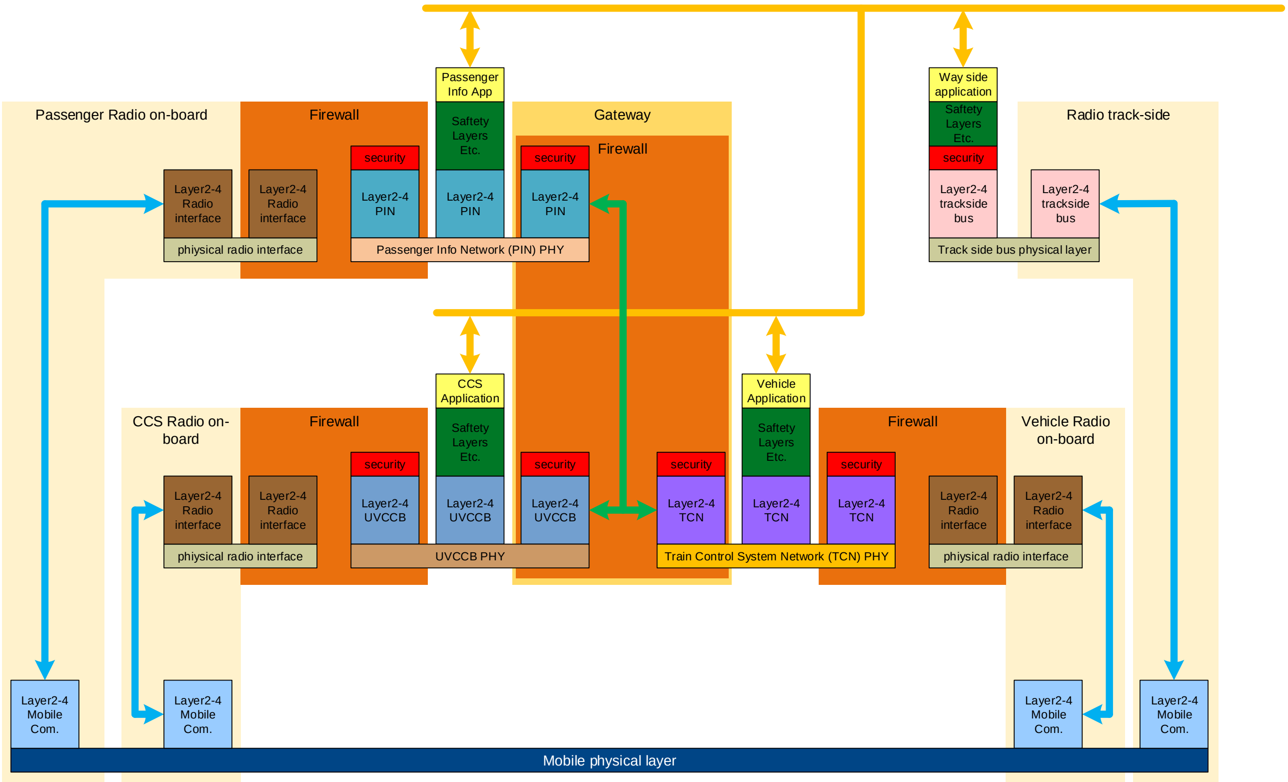

Figure 36 Separate Radio on all networks

Advantages	Disadvantages
▪ The OCORA-GW only interconnects the on-board networks. ▪ No need to handle mobile communication.	▪ High number of equipment which will be reflected in higher hardware costs and space requirements

C10 Scenario 10 – CCS communicates over OCORA GW

In this scenario the TCN and PIN have their own connectivity to the trackside systems including a firewall and a separate radio module. The OCORA-GW interconnects the on-board networks and provides the trackside connectivity to the UVCCB including security and a connected radio module.

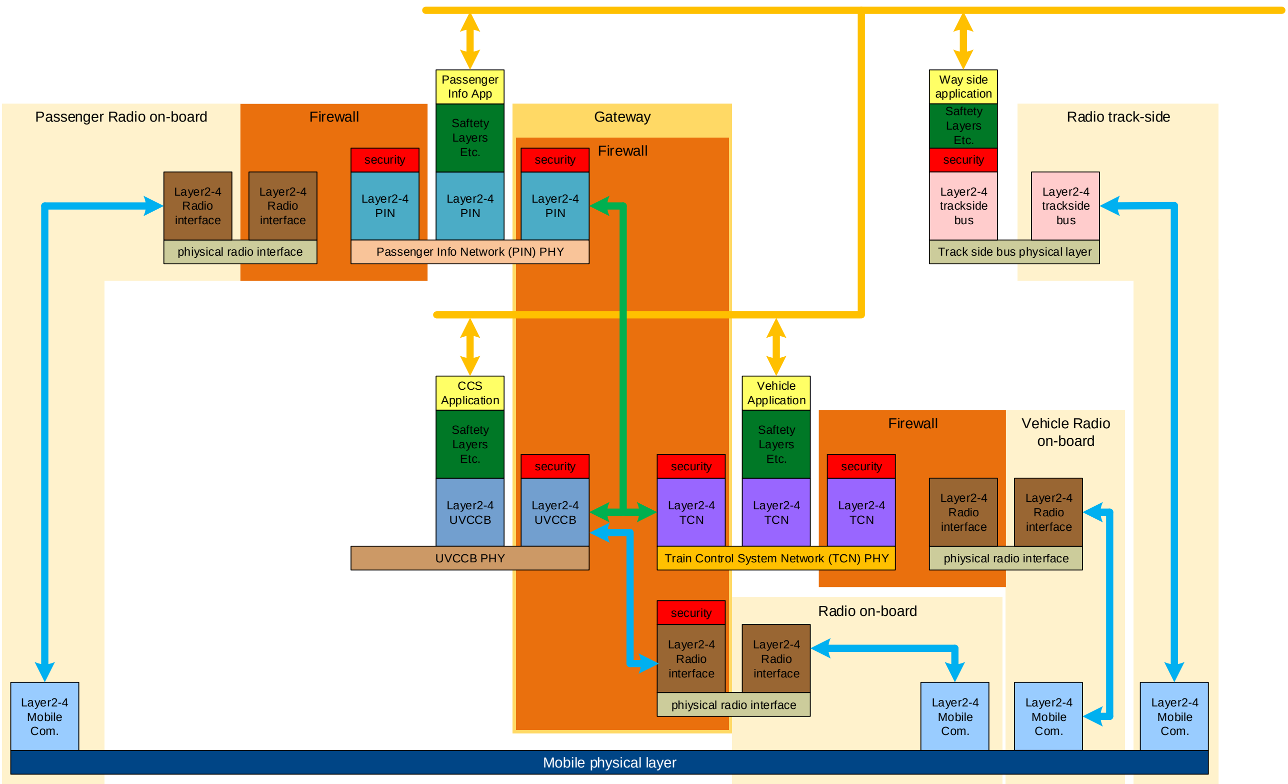

Figure 37 CCS communicates over OCORA GW

Advantages	Disadvantages
▪ Possible solution for migration scenarios on existing vehicles	▪ High number of equipment which will be reflected in high hardware costs and space requirements

Appendix D Relating Functions from SUBSET-026

To support modularity, OCORA suggests implementing the current ETCS on-board functionality in separate functional blocks. Among others, the following key functional blocks have been identified in the OCORA Alpha release already: VS = Vehicle Supervisor / VL = Vehicle Locator / ATPM[2] = Automatic Train Protection Manager.

The following table assigns current ETCS on-board functionality (as per SUBSET-026, chapter 4.5) to the respective functional block. It contains, on a very high-level, a first proposed split of functionality between the VS, VL, and the ATPM. The OCORA architecture team is aware that splitting the functionality only based on the SUBSET-026, chapter 4.5 is not sufficient, because the subset does not provide all requirements. SUBSET-026 is providing the mandatory requirement specifications only. A more detailed separation and a first version of a complete VS, VL, and ATPM model, identifying additional requirement to SUBSET-026, can be expected in subsequent OCORA documentation releases.

On-Board Functions	Reference SUBSET-026	VS	VL	ATPM	Others
Data Consistency					
Check linking consistency	3.16.2.3 3.4.4	X [3]			
Check Balise Group Message Consistency if linking consistency is checked	3.16.2.4.1 3.16.2.4.3	X [3]			
Check Balise Group Message Consistency if no linking consistency is checked (because no linking information is available and/or because the function “check linking consistency is not active)	3.16.2.4.4	X [3]			
Check Unlinked Balise Group Message Consistency	3.16.2.5	X [3]			
Check correctness of radio messages	3.16.3.1.1	X			
Check radio sequence	3.16.3.3	X			
Check safe radio connection (only level 2/3)	3.16.3.4	X			
Determine Train Speed and Position					
Determine train position referenced to LRBG	3.6.1 3.6.4		X		
Determine train speed, train acceleration, train standstill	None		X		
Determine Geographical Position	3.6.6	X	X [4]		
Report train position when train reaches standstill	3.6.5.1.4 a)	X [5]			
Report train position when mode changes to...1	3.6.5.1.4 b)	X [5]			
Report train position when train integrity confirmed by driver	3.6.5.1.4 c)	X [5]			
Report train position when loss of train integrity is detected	3.6.5.1.4 d)	X [5]			
Report train position when train front/rear passes an RBC/RBC border (only level 2/3)	3.6.5.1.4 e) 3.6.5.1.4 k)	X [5]			
Report train position when train rear passes a level transition border (from level 2/3 to 0, NTC, 1)	3.6.5.1.4f)	X [5]			
Report train position when change of level due to trackside order	3.6.5.1.4 g)	X [5]			
Report train position when change of level due to driver request	3.6.5.1.4 g)	X [5]			
Report train position when establishing a session with RBC	3.6.5.1.4 h)	X [5]			
Report train position when a data consistency error is detected (only level 2/3)	3.6.5.1.4 i)	X [5]			
Report train position as requested by RBC...	3.6.5.1.4	X [5]			
... or Report train position at every passage of an LRBG compliant balise group	3.6.5.1.4 j)	X [5]			
Determine Train Speed and Position					
Request MA Cyclically respect to approach of perturbation location (T_MAR) or MA timer elapsing (T_TIMEOUTRQST) (only level 2/3)	3.8.2.3 a) and b)	X			
Request MA Cyclically when “Start” is selected (only level 2/3)	4.4.11 5.4, 5.11	X			
Request MA on reception of "track ahead free up to the level 2/3 transition location" (only level 0,1,NTC)	3.8.2.7.1	X			
Request MA on track description deletion (only level 2/3)	3.8.2.7.3	X			
Determine EOA/LOA, SvL, Danger Point, etc...	3.8.4 3.8.5	X			
Handle Co-operative MA revocation (only level 2/3)	3.8.6	X			
Manage Unconditional Emergency Stop	3.10	X			
Manage Conditional Emergency Stop	3.10	X			
Determine Most Restrictive Speed Profile, based on:					
SSP	3.11.3	X			
ASP	3.11.4	X			
TSR	3.11.5	X			
Signalling related speed restriction when evaluated as a speed limit	3.11.6	X			
Mode related speed restriction	3.11.7	X			

[2] In the OCORA Alpha version, this was called «NTC Control»
[3] VS informs VL about valid Balise Groups
[4] In case of on-board localisation
[5] Content has to be safe in future (L3 / moving block); Trigger for Report is “ns”

On-Board Functions	Reference SUBSET-026	VS	VL	ATPM	Others
Train related speed restriction	3.11.8	X			
STM max speed	3.11.2.2 g)	X			
STM system speed	3.11.2.2 h)	X			
LX speed	3.12.5.6	X			
Speed restriction to ensure a given permitted braking distance	3.11.11	X			
Override related speed restriction	5.8.3.6	X			
Supervise Train Speed					
Speed and Distance Monitoring based on MRSP, MA, release speed, gradient, mode profile, non-protected LX start location, and route unsuitability location	3.13 5.9.3.5 57.3.4 3.12.2.8 3.12.5.4	X			
Speed and Distance Monitoring based on MRSP	4.4.10.1	X			
Speed and Distance Monitoring based on MRSP, allowed distance to run in Staff Resp. mode	4.4.11	X			
Ceiling Speed Monitoring only (no braking curve) based on MRSP	4.4.8.1.1 a) 4.4.18.1.3 a)	X			
Supervise Train Movements					
Backwards Distance Monitoring	4.4	X			
Roll Away Protection	3.14.2	X			
Reverse Movement Protection	3.14.3	X			
Standstill Supervision	3.14.4 4.4.7.1.5	X			
Supervise “danger for shunting” information and list of expected balises for shunting	4.4.8.1.1 b) and c)	X			
Supervise “Stop if in SR” information and list of expected balises for Staff Responsible	4.4.11.1.3 c) and d)	X			
Supervise signalling related speed restriction when evaluated as a trip order	3.11.6.4	X			
Command Emergency Brake	4	X		tbd	NTC-APPs APV
Determine Mode and Level					
Determine ERTMS/ETCS Mode	3.12.4 4.6	tbd		tbd	
Determine ERTMS/ETCS level	5.10	tbd		tbd	
Other functions					
System Version Management	3.17	X			
Manage Communication Session	3.5	X [6]			
Delete Revoked TSR	3.11.5.5	X			
Override (Trip inhibition)	5.8	X			
Manage Track Conditions excluding Sound Horn, Non-Stopping Areas, Tunnel Stopping Areas and Big Metal Masses	3.12.1	X			
Manage Track Conditions Sound Horn, Non-Stopping Areas, Tunnel Stopping Areas	3.12.1	X			
Manage Track Condition Big Metal Masses	3.12.1	X			
Manage Route Suitability	3.12.2	X			
Manage Text Display to the driver	3.12.3	X			
Manage LSSMA display to the driver	4.4.19.1	X			
Manage RBC/RBC Handover (only level 2/3)	3.15.1 5.15	X [7]			
Manage Track Ahead Free Request (only level 2/3)	3.15.5	X			
Provide Fixed Values, and Default/National Values	3.18.1 3.18.2	X			
Manage change of Train Data from external sources	5.17	X			
Provide Date and Time	3.18.5				TSS
Provide Juridical Data	3.20	X			
Inhibition of revocable TSRs from balises (only level 2/3)	3.11.5.12 3.11.5.13 3.11.5.14 3.11.5.15	X			
Cold Movement Detection	3.15.8		X [8]		
Continue Shunting on desk closure (Enabling transition to Passive Shunting mode)	5.12.4	X			
Manage “Stop Shunting on desk opening” information	4.4.20.1.8 4.4.20.1.9	X			
Manage Virtual Balise Covers	3.15.9	X			
Advance display of route related information	3.15.10	X			

Table 24 Relating Functions from SUBSET-026

[6] OCORA aims to split safe from non-safe functionality. Hence, it might be reasonable to remove this functionality from the VS and have it implemented in a separate component. This will be elaborated in more detail in subsequent versions of this document.
[7] RBC handover might also be relevant for VL, e.g. digital map downloads
[8] Depends on technology used. In general, VL could provide input for cold movement detection

Appendix E Overview of available specifications useful for OCORA

The table in this appendix contains an overview of available specifications, useful for the OCORA architecture and design work. The table attempts to assign the different specifications to the respective OSI layer(s), but this does not imply that a listed specification is applicable (to the assigned OSI layer) in the OCORA contexts. It just indicates that there is (useful) information in the listed specification that could be helpful for the OCORA architecture and design work. The table is a working instrument and not complete at this point in time. It is updated as information becomes available. The priority column indicates the priority an interface has within OCORA (1 = high priority / 3 = low priority).

Red indicates mandatory interface specifications

[ ] indicates that the specification is not released yet

E1 Hardware interfaces - available specifications useful for OCORA

IF ID	IF Name	OSI Layer 1	OSI Layer 2	OSI Layer 3	OSI Layer 4	OSI Layer 5	OSI Layer 6	OSI Layer 7	Remark	Priority
101	UIDR-Driver	-	-	-	-	-	-	-		-
102	CVDs-Driver	-	-	-	-	-	-	-		-
103	DMI-Driver/Technician	-	-	-	-	-	-	ERA_ERTMS_015 560		3
104	MT-Technician	-	-	-	-	-	-	-		3
110	TRU-Evaluator	-	-	-	-	-	-	SS 027		3
120	VL-Sensors	-	-	-	-	-	-	-		-
130	LT-Antenna	-	-	-	-	-	-	**SS 044**		-
131	BT-Antenna	-	-	-	-	-	-	**SS 036**		-
132	NTC-Antenna	-	-	-	-	-	-	-		-
140	P-Sensors	-	-	-	-	-	-	-		-
150	EB / TCO / others	-	-	-	-	-	-	-		-
181	GSM-R EDOR Radio (Air)	-	-	-	-	-	-	**SS 037**		-
182	GSM-R Voice Radio (Air)	-	-	-	-	-	-	-		-
183	Public Radio (Air)	-	-	-	-	-	-	-		-
184	FRMCS Radio (Air)	-	-	-	-	-	-	-	TOBA responsibility	-
190	Train Control Bus	-	-	-	-	-	-	-		-
195	Passenger Info Bus	-	-	-	-	-	-	-		-
300	UVCC Bus	**EN50170** SS 035		-	-	**SS 056** **SS 057**	**SS 037**	-	OCORA Workstream #02	1
381	GSM-R EDOR Radio	-	-	-	-	-	-	-		2
382	GSM-R Voice Radio	-	-	-	-	-	-	-		2
383	Public Radio	-	-	-	-	-	-	-		2
384	FRMCS Radio	-	-	-	-	-	-	-	TOBA responsibility	1
390	Vehicle Control Systems	SS 119, [SS 143]						-	OCORA Workstream #05	1
395	Passenger Info Systems	-						-		3

Table 25 Hardware interfaces (OSI layer 1-6)

E2 Functional interfaces - available specifications useful for OCORA

IF ID	IF Name	OSI Layer 1	OSI Layer 2	OSI Layer 3	OSI Layer 4	OSI Layer 5	OSI Layer 6	OSI Layer 7	Remark	Priority
401	UIDR	-	-	-	-	-	-	-		3
402	CVDs	-	-	-	-	-	-	-		3
403	DMI	-	-	-	-	-	-	[SS 121]		1
404	MT	-	-	-	-	-	-	-		3
410	TRU	-	-	-	-	-	-	**SS 027** [SS 140]		1
420	VLS	-	-	-	-	-	-	97E2675B		1
430	LTM	-	-	-	-	-	-	SS 026-7 & 8		1
431	BTM	-	-	-	-	-	-	SS 026-7 & 8 SS 101		1
432	STM	-	-	-	-	-	-	**SS 035 / 058** **SS 101**		1
440	PS	-	-	-	-	-	-	-		3
450	I/O Ports	-	-	-	-	-	-	**SS 034** SS 119		1
481	GSM-R EDOR Appl.	-	-	-	-	-	-	-		2
482	GSM-R Voice Appl.	-	-	-	-	-	-	-		2
483	Public Radio Appl.	-	-	-	-	-	-	-		2
484	FRMCS Radio Appl.	-	-	-	-	-	-	-	TOBA responsibility	1
490	Train Control System	[SS 143]						**SS 034** SS 119, [SS 139]	OCORA Workstream #05	1
495	Passenger Info System	-	-	-	-	-	-	-		3
RCA-05	APS-MOT	-	-	-	-	-	-	-	Cooperation with RCA	3
RCA-06	APS-MT	-	-	-	-	-	-	**SS 026-7 & 8**	Cooperation with RCA	1
RCA-08	ATO-AT	-	-	-	-	[IRS 90940]		[IRS 90940] [SS 126]	Cooperation with RCA	1
RCA-41	DM (IM)	-	-	-	-	-	-	-	Cooperation with RCA	2
541	DM (RU)	-	-	-	-	-	-	-		2
RCA-42	DCM (IM)	-	-	-	-	-	-	-	Cooperation with RCA	2
542	CDM (RU	-	-	-	-	-	-	-		2
RCA-43	IAM (IM)	-	-	-	-	-	-	-	Cooperation with RCA	2
543	IAM (RU)	-	-	-	-	-	-	-		2
SFERA	SFERA	-	-	-	-	-	-		Cooperation with RCA	3

Table 26 Functional interfaces (OSI layer 7)

Appendix F Large scale graphics

F1 OCORA hardware components, scope, and external interface identification

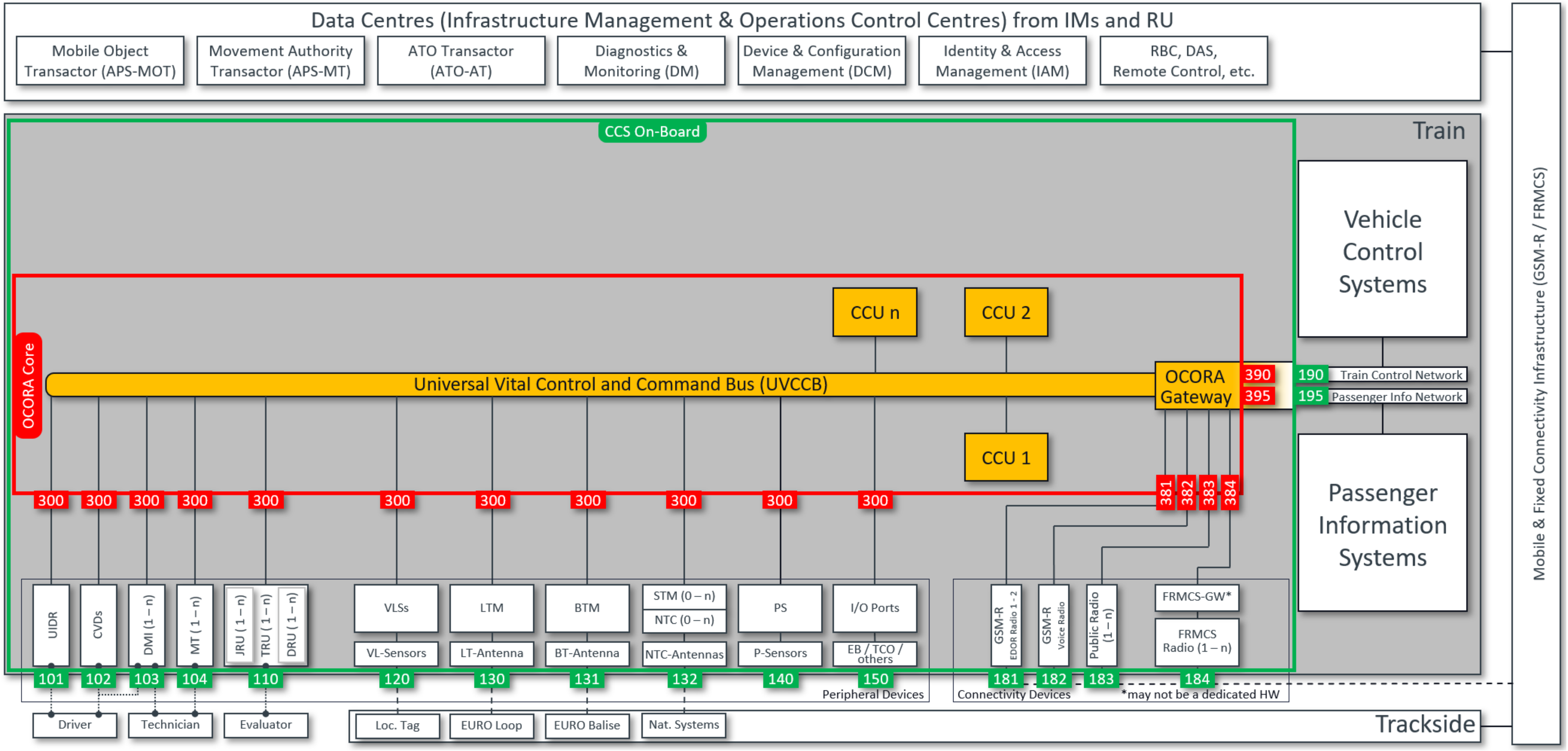

Figure 38 OCORA hardware components, scope, and interface identification

F2 OCORA functional components, scope, and external interface identification

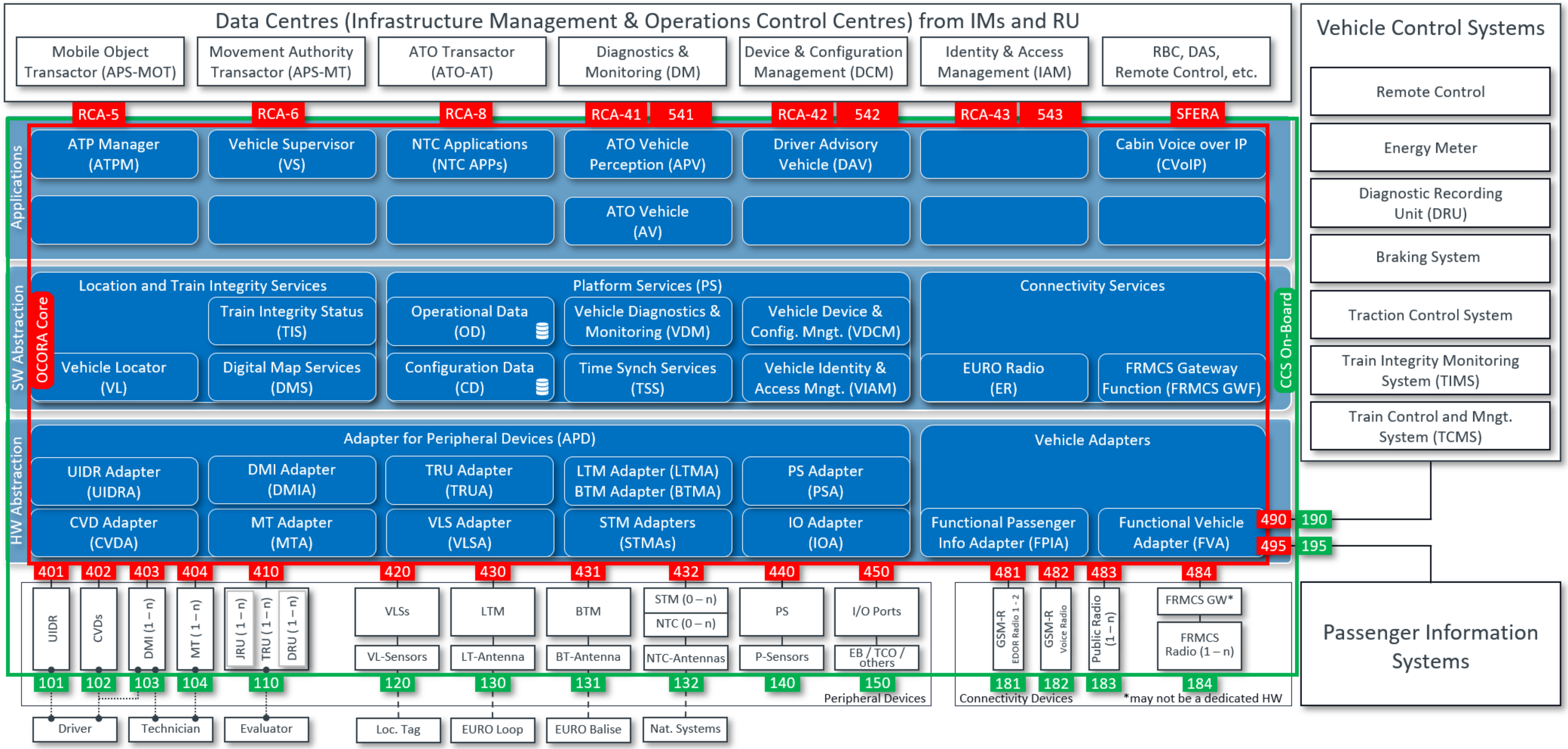

Figure 39 OCORA functional components, scope, and interface identification

F3 OCORA functional building block interfaces

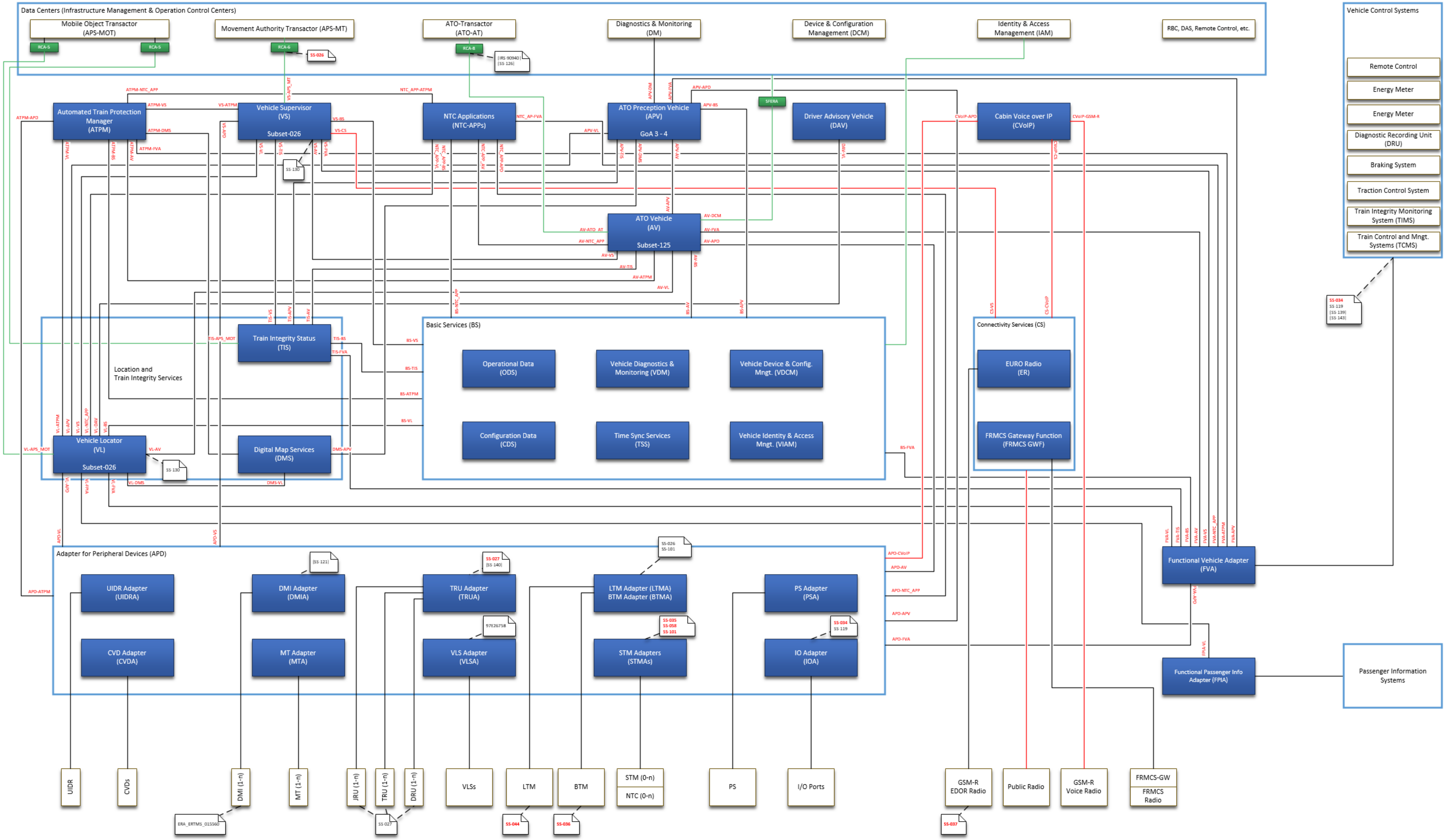

Figure 40 OCORA building block interfaces