# OCORA

## Open CCS On-board Reference Architecture

# Stakeholder Requirements



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# Management Summary

OCORA requirements are engineered in a top-down manner. The following levels are defined:

- **"Stakeholder Requirements" (A-Level requirements)**
- **"Program- & Design Requirements" (B-Level requirements)**
- **"System Requirements" (C-Level requirements)**
- **"Building Block Requirements" (D-Level requirements)**

This document intend to hold all **"Stakeholder Requirements" (A-Level requirements).** It will be updated and enriched with return on experience.

OCORA requirements are engineered in Polarion with full traceability.

# Revision History

| Version | Change Description | Initials | Date of change |
|---|---|---|---|
| 1.01 | Official version for OCORA Delta Release | RM | 30.06.2021 |
| 2.0 | Official version for OCORA Release R1 | RM | 26.11.2021 |

# Table of Contents

# References

Reader's note: please be aware that the document ids in square brackets, e.g. [OCORA-BWS01-010], as per the list of referenced documents below, are used throughout this document to indicate the references to external documents. Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). OCORA always reference to the latest available official version of the SUBSET, unless indicated differently.

- [OCORA-BWS01-010] – Release Notes
- [OCORA-BWS01-020] – Glossary
- [OCORA-BWS01-030] – Question and Answers
- [OCORA-BWS01-040] – Feedback Form
- [OCORA-BWS03-010] - Introduction to OCORA
- [OCORA-BWS03-020] - Guiding Principles
- [OCORA-BWS04-010] - Problem Statements
- [OCORA-BWS07-010] - Alliances

# 1 Introduction

## 1.1 Purpose of the document

The purpose of this document is to provide the collection of all Stakeholder Requirements in a structured manner.

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA concepts for on-board CCS. The reader 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 documentation can be given by using the feedback form [OCORA-BWS01-040] .

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

If you are an organisation interested in developing CCS building blocks according to the OCORA standard, information provided in this document can be used as input for your development.

## 1.2 Applicability of the document

The document is currently considered informative but may become a standard at a later stage for OCORA compliant on-board CCS solutions. Subsequent releases of this document will be developed based on a modular and iterative approach, evolving within the progress of the OCORA collaboration.

OCORA requirements can be divided into two application groups.

1. OCORA Initiative Requirements applied for any OCORA internal activities (e.g. modelling)
2. OCORA CCS On-Board System Requirements, applied for any development and tendering (e.g. prototyping, MVP developments, projects)

## 1.3 Context of the document

This document is published as part of the OCORA Release R1, together with the documents listed in the release notes [OCORA-BWS01-010] . Before reading this document, it is recommended to read the Release Notes [OCORA-BWS01-010]. If you are interested in the context and the motivation that drives OCORA we recommend to read the Introduction to OCORA [OCORA-BWS03-010], and the Problem Statements [OCORA-BWS04-010]. The reader should also be aware of the Glossary [OCORA-BWS01-020] and the Question and Answers [OCORA-BWS01-030].

### 1.4 Requirements Engineering Process

This OCORA requirement document is developed, using the Requirements Management Guideline [OCORA-TWS05-010]. The requirements are engineered in a top-down manner:

- As a starting point all **"Stakeholder Requirements"** towards the OCORA initiative **(A-Level requirements)** are captured and formalised.

- In a second step, the **"Program- and Design Requirements" (B-Level requirements)** are developed. These requirements define tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.

- As a next step, the A- and B-Level requirements are further developed in the MBSE analysis to become **"System Requirements" (C-Level requirements).**

- As part of the MBSE architecture work, building blocks are identified taking into account the MBSE analysis (C-Level requirements). All applicable requirements (A-Level, B-Level, and C-Level) are apportioned to the identified building blocks, resulting in **"Building Block Requirements" (D-Level requirements)**, forming the OCORA tender templates, together with the applicable program & design requirements.

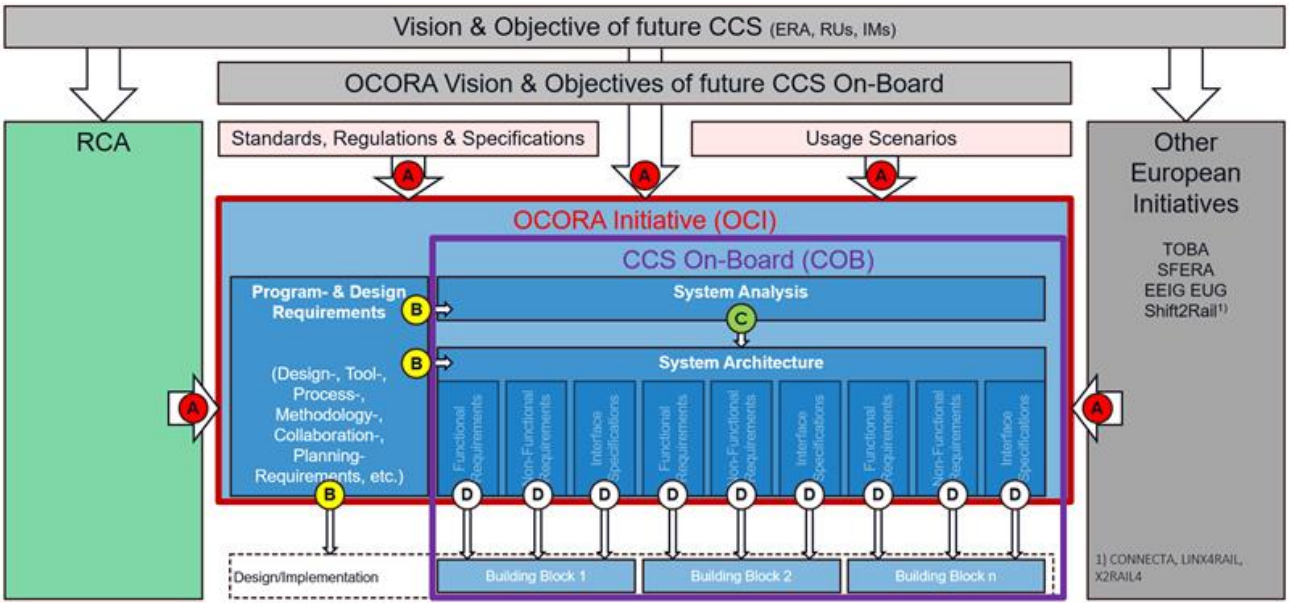


*Figure 1 OCORA Requirements Engineering Process*

Please note, that the A-Level requirements are applicable to the OCORA Initiative (OCI) while the B- and C-Level requirements are targeted towards the CCS On-Board System (COB) and its architecture. D-Level requirements are applicable to the respective building blocks.

# 2 Requirements

## 2.1 Vision & Objectives of future CCS (ERA, RUs, IMs)

This chapter is based on the Introduction to OCORA [OCORA-BWS03-010] and the Problem Statements [OCORA-BWS04-010] .

**OCORA-617, A-Level - Improve Technical Specifications for Interoperability, TSI**

Improve the current Technical Specifications for Interoperability, TSI

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To close gaps in TSI subset specifications<br>• To eliminate inconsistencies in TSI subset specifications<br>• TSI CCS is a complex, historically grown landscape. To manage this complexity (e.g. impact analysing of changes). |
| Verification Method | Design Review |

**OCORA-328, A-Level - Serving the development Technical Specifications for Interoperability, TSI improvements**

Take an active role (beyond specification/proposal review) serving sector discussions by bringing in the User / Railway Undertaking perspective.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To support a solid foundation of TSI, especially TSI-CCS<br>• To promote OCORA as de facto standard based on the normative/ de jure TSI<br>• To request unified changes among railways to the TSI, but only if current TSI does prevent a modular, open architecture framework<br>• To ensure simplification of the TSI framework wherever possible<br>• To ensure user friendly, lean and cost efficient integration of new functions into the of TSI framework |
| Verification Method | Process Review |

### OCORA-53, A-Level - Reduce Total Cost of Ownership

The amount of capital- and operational expenditure for a CCS On-Board must be reduced. The full life cycle is in focus. Targets for each cost category must be elaborated and set after the development of the OCORA Business Model.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Rail transport must remain competitive with other modes of transport<br>• CCS On-board solutions are costly in general<br>• CCS On-board needs to develop from project based approach to a product base<br>• CCS On-board batch sizes need to be increased<br>• CCS On-board standardisation needs to increase |
| Verification Method | Design Review |

### OCORA-54, A-Level - Shorter Time2Market

Reduce the amount of time to introduce CCS On-board in general, as well as, new or adapted CCS functionalities into a new or existing vehicle. This applies on the full cycle:

- Unifying User Requirements
- TSI improvement
- Specification
- Design
- Development
- Integration
- Testing
- Verification
- Validation
- Certification
- Rollout
- Service / Operation

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Existing and upcoming challenges require shorter Time2Market. This applies for (Cyber-) Security patching as well as error correction and functional adjustment / enhancements<br>• to adapt and foster innovation |
| Verification Method | Design Review |

**OCORA-61, A-Level - Support different vehicle types**

The OCORA reference architecture supports the following vehicle types:

- Passenger Trains: Locomotive(s), Locomotive(s)+Driver cab push-pulled and Multiple Units (EMU, DMU)
- Cargo Trains: Locomotive(s)
- On Track Machines: As long as they are types of the above

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • A wide range of vehicle types have to be supported to achieve economy of scale with a generic design based on a single open OCORA architecture. |
| Verification Method | Design Review |

**OCORA-1203, A-Level - Reduction of one-off product efforts**

Minimize the effort spend for requirement engineering, specification and development of CCS On-board as a product.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • One-off efforts are a driver for implementation costs, durations and risks. |
| Verification Method | Design Review |

**OCORA-326, A-Level - Reduction of one-off integration efforts**

Minimize engineering and certification adjusting CCS On-board to specific vehicle types / fleets.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • One-off efforts are a driver for implementation costs, durations and risks. |
| Verification Method | Design Review |

**OCORA-327, A-Level - Respect non-overlapping life cycles**

Non-overlapping technology life cycle profiles must be respected by the system design. Plug and play like exchangeability between building blocks needs to be present wherever non-overlapping technology life cycle profiles are obvious (e.g. connectivity technologies vs CCS On-Board equipment vs vehicle)

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Long lasting life cycle of rolling stock assets are in conflict with shorter, more consumer oriented technology developments. |
| Verification Method | Process Review |

**OCORA-55, A-Level - Increase performance**

Increase reliability, availability, maintainability and security of the CCS on-board solution whilst maintaining the current level of safety. Targets for each performance category must be elaborated and set after the development of the OCORA RAM Model.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • With increasing dependency on CCS On-board the general level of performance need to increase. |
| Verification Method | Design Review |

### 2.2 OCORA Vision and Objectives of future CCS On-Board

This chapter is based on the Introduction to OCORA [OCORA-BWS03-010] and on the Guiding Principles [OCORA-BWS03-020].

#### 2.2.1 Openness

In context of OCORA openness means information can be found, used, shared, easily understood, analysed, validated and verified and applied without the user being hampered by financial, legal, technical or ethical barriers or constraints.

### OCORA-43, A-Level - European Union Public License (EUPL)

All OCORA documentation is published under the European Union Public License (EUPL) agreement.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • EUPL was selected since it is available in all EU languages and well known in die administration and government sector.<br>• To allow easy access to all interested parties sector wide.<br>• To ensure return on experience, REX from projects using OCORA artefacts |
| Verification Method | Process Review |

### OCORA-330, A-Level - Open Collaboration

OCORA is an open collaborative technical platform open to any railway company, for instance railway undertakings, fleet keepers or owners. It is based on sharing subject matter expertise and making publicly available its deliverables for the benefit of the whole railway sector. All members are bringing into the collaboration experiences, practice among CCS On-board and use OCORA Requirements for CCS purchase to establish a de facto standard.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To envisage a "de facto" unified user standard based on the "de jure" standard of TSIs. |
| Verification Method | Process Review |

### OCORA-331, A-Level - Open Standard Publishing

OCORA publishes its work as open standard.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To serve as basis for CCS On-board tenders (new build & retrofit) any OCORA publications are open to public.<br>• To avoid any conflict with competition law and IP-rights. |
| Verification Method | Process Review |

**OCORA-613, B-Level - Open Standard Usage**

OCORA bases design decision (e.g. technology choices, protocols definitions, monitoring tools, etc.) on existing open standards, if available.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To minimize specification effort.<br>• To ensure access to existing technology proven in use.<br>• To support innovation. |
| Verification Method | Design Review |

### 2.2.2 Modularity

In the context of OCORA modularity is a prerequisite for having “plug and play”-like exchangeability of an on-board CCS system or its building blocks without the need to involve either the original supplier of the vehicle, of the CCS system or one of its building blocks.

**OCORA-500, A-Level - Standardised CCS on-board system for different vehicle types**

OCORA ensures "plug-&-play" like deployment of the CCS on-board into different vehicle types with limited effort for development, certification, installation and maintenance. The simplicity and effort related to the "plug-&-play" vision is expected to develop over time depending on technical readiness level.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Reusing the same CCS on-board system for multiple vehicles reduces development, certification, installation and maintenance costs.<br>• Reusing the same CCS on-board system in different environments increases the chance of finding and eliminating issues. |
| Verification Method | Design Review |

**OCORA-501, A-Level - CCS on-board consists of separately sourceable building blocks**

OCORA decomposes the CCS on-board system into an optimal and reasonable number of standardized building blocks

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Reusing the same building blocks in different CCS on-board implementations reduces development, certification, installation and maintenance costs.<br>• Reusing the same CCS on-board building blocks in different environments increases the chance of finding and eliminating issues.<br>• Since efforts to define building blocks are quite extensive, and since OCORA wants to leave as much room as possible to the industry to provide their (already existing) solutions, OCORA defines building blocks at a reasonable granularity. |
| Verification Method | Design Review |

**OCORA-499, A-Level - Standardised Interface to the Vehicle**

Communication between the CCS on-board and the vehicle occurs through a vehicle independent, standardised interface.

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|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • A standardised interface to the vehicle ensures "plug-&-play" like exchange of a CCS on-board system of one supplier with a CCS on-board system of another supplier.<br>• To decouple TCMS and CCS migration steps<br>• To decouple the vehicle and CCS solution choice |
| Verification Method | Design Review |

### 2.2.3 Exchangeability (Interchangeability)

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

**OCORA-46, A-Level - Exchangeability (Interchangeability)**

It is possible to exchange one or multiple OCORA defined building blocks with (a) respective building block(s) of (an)other supplier(s), without affecting other building blocks or the overall CCS on-board system.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To respect the different life-cycles profiles of building blocks.<br>• To minimize the integration cost. |
| Verification Method | Process Review |

### 2.2.4 Migrateability (Upgradeability)

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

**OCORA-45, A-Level - Migrateability (Upgradeability)**

It is possible to migrate, hence introduce changes to one or multiple OCORA defined building block(s), without affecting other building blocks or the overall CCS on-board system.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Typically, the most cost of a software intensive system occurs after its initial release. Therefore, the cost for change must be low. |
| Verification Method | Process Review |

### 2.2.5 Evolvability (Flexibility)

In the context of OCORA evolvability means the ability to easily adopt to new technologies or to extend the functionality of an on-board CCS system without the involvement of the original supplier.

**OCORA-47, A-Level - Evolvability (Flexibility)**

It is possible to adopt to new technologies or to extend the functionality of an on-board CCS system without the involvement of the original supplier.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To extend the CCS on-board system with additional components to implement new functionality not yet contained. |
| Verification Method | Design Review |

### 2.2.6 Portability (Platform Independence)

In the context of OCORA portability is achieved when a functional application, based on the generalized abstraction, runs un-changed on different (computing) platform implementations. For this, the functional application shall only use external functions through a defined application programming interface (API).

**OCORA-48, A-Level - Portability (Platform Independence)**

It is possible to effectively and efficiently transfer software building blocks from one operational or usage environment to another.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To minimize CAPEX<br>• To reduce time-to-market<br>• To reduce certification and integration efforts by appropriate test environment |
| Verification Method | Design Review |

### 2.2.7 Security (Cyber Security)

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

**OCORA-49, A-Level - Security (Cyber Security)**

Security (Cyber Security) is the protection of (especially safety related communication and data used in) CCS on-board systems against threats (in particular cyber-attacks and hacks). To achieve this, all main security functionality like identify, protect, detect, respond and recover are considered.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Limit the risk of cyber-attacks and hacks. |
| Verification Method | Design Review |

### 2.2.8 Modular Safety

In context of OCORA the safety concept applied needs to me modularised to serve the same level of modularity as the architecture defines building blocks.

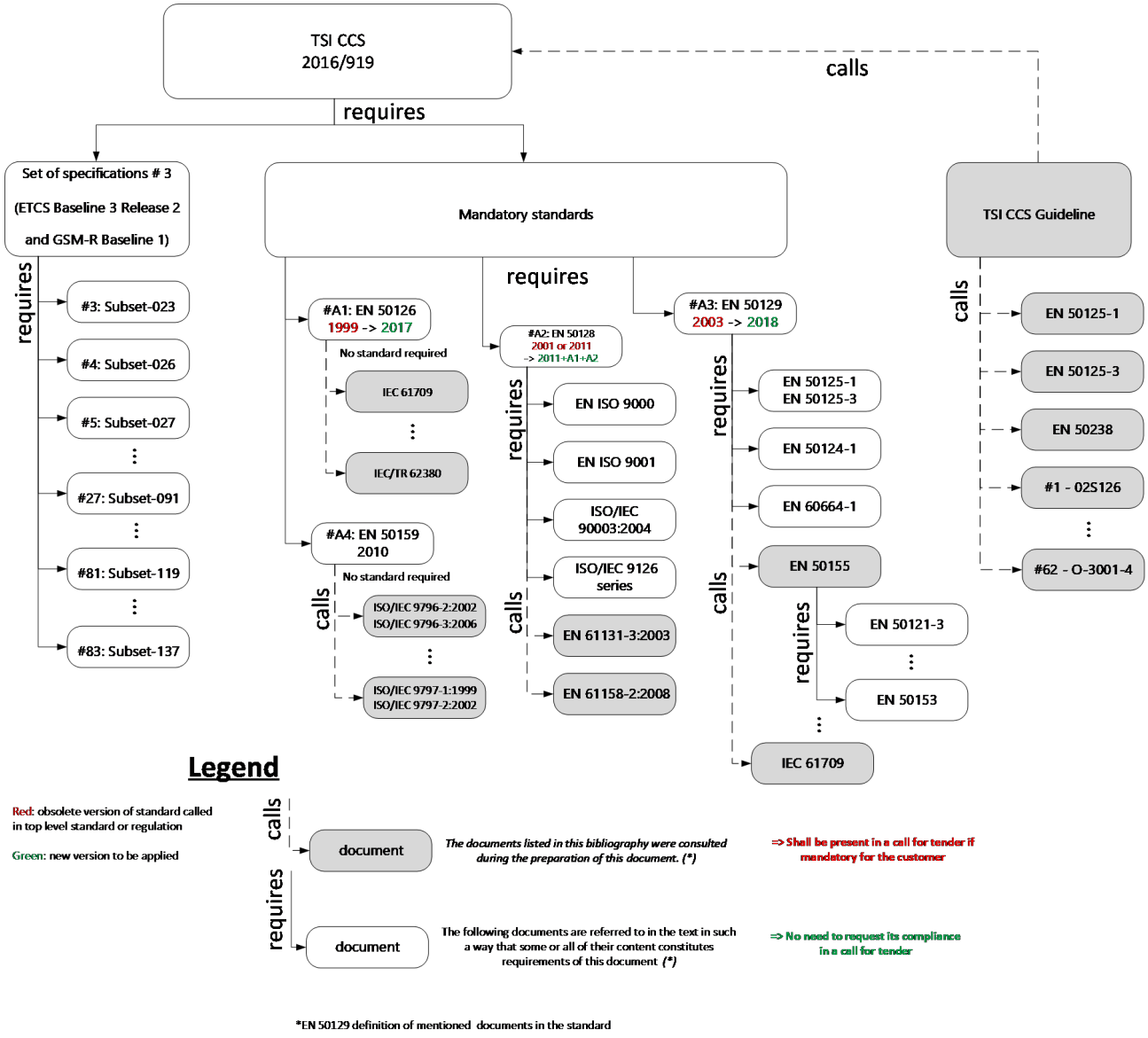
**OCORA-111, A-Level - Modular Safety**

To provide a modular safety concept on multiple layers (e.g. building blocks, CCS On-board system, CCS vehicle integration)

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To enable changes, adaptations and extensions throughout the life cycle of CCS On-board<br>• To enable a safe system and its certification based on building block<br>• To minimize effort for safety assessment |
| Verification Method | Design Review |

## 2.3 Standards, Regulations & Specifications

For illustration and better understanding, the below diagram provides an overview of applicable standards, regulations & specifications with their dependencies.



**OCORA-40, A-Level - Adhere to TSI-CCS incl. CENELEC standards EN50126, 50128, 50129**

The CCS on-board solution complies with the regulation TSI-CCS (latest version including any amendments) for the set of specifications #3 (ETCS Baseline 3 Release 2 and GSM-R Baseline 1), in particular with the following standards & regulations: SS026, SS027, SS035, SS038, SS091, SS093, SS108, SS114, SS119, SS139, SS147, EN50126, EN50128, EN50129

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To ensure interoperability according to Technical Specifications for Interoperability, TSI |
| Verification Method | Certification |

**OCORA-63, A-Level - Adhere to TSI-CSS Guidelines**

The CCS on-board solution is designed according to TSI guideline GUI/CCS TSI/2019 (latest version from ERA website) regarding the following specifications and standards for the *Set of specifications #3 (ETCS baseline 3 Release 2 and GSM-R baseline 1)*:

*Standards:*

- EN 50125-1
- EN 50125-3
- EN 50238

*Specifications:*

- #1 - 02S126
- #2 - 97S066
- #3 - SUBSET-074-1
- #4 - 97E267
- #9 - ERA/ERTMS/040092
- #16 - ERA/ERTMS/040093
- #40 - ERA/ERTMS/040063
- #47 - SUBSET-113
- #49A – EN 50592
- #54 - SUBSET-11

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To ensure interoperability according to Technical Specifications for Interoperability, TSI. |
| Verification Method | Certification |

**OCORA-1040, A-Level - Adhere to TS 50701 Railway Application Cyber Security Standard**

The CCS on-board solution complies with the railway application cyber security standard TS 50701.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To ensure state-of-the-art cyber security by design |
| Verification Method | Certification |

**OCORA-616, A-Level - Acceptance of Global Standards**

OCORA to investigate if Acceptance of Global Standards (no rail) are alternatives

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To increase possibilities for other pre-certified products<br>• To enable innovation and easier technology transfer into the rail sector |
| Verification Method | Process Review |

### 2.4 Usage Scenarios

**OCORA-56, A-Level - Support ETCS**

The architecture framework supports ETCS Levels 0-3 (including level NTC). ETCS is the primary ATP, hence always present.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To ensure CCS On-board base functionality. |
| Verification Method | Design Review |

### OCORA-58, A-Level - Support ATO

The architecture framework supports ATO GoA 1-4 over ETCS

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Operator Choice |
| Rationale | • To ensure CCS On-board base functionality. |
| Verification Method | Design Review |

### OCORA-57, A-Level - Support STM Integration of National ATP Systems

The architecture framework supports the Integration of National ATP Systems using STM

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Operator Choice |
| Rationale | • To ensure CCS On-board base functionality. |
| Verification Method | Design Review |

### OCORA-458, A-Level - Support SFERA

The architecture framework supports SFERA (SMART COMMUNICATIONS FOR EFFICIENT RAIL ACTIVITIES)

Standardisation DAS (Driving Advisory Systems) languages is required for broader implementation, reduced costs and facilitating exchange of data for Traffic Management Systems.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Operator Choice |
| Rationale | • To ensure CCS On-board base functionality. |
| Verification Method | Design Review |

# 3 Collaboration / other European Initiatives

This chapter is based on the OCORA Alliance [OCORA-BWS07-010].

## 3.1 Reference CCS Architecture (RCA)

RCA aims at defining the overall future CCS reference architecture for trackside and on-board. However, RCA is focusing on the trackside aspects and manages the overall end-to-end view. OCORA focusses on the CCS on-board aspects, which is a sub-system of the overall CCS system as defined by RCA.

**OCORA-41, A-Level - Cooperation with RCA**

OCORA works in close cooperation with RCA

| | |
|---|---|
| Status | ✔ Approved |
| Req. Class | Requirement |
| Rationale | • To ensure system consistency (architecture : actors, interfaces, capabilities...) and CCS related process consistency (requirement engineering, modular safety, integration,...).<br>• Ensure that the architectures of RCA and OCORA are aligned.<br>• Minimize efforts needed for developing the overall CCS reference architecture (e.g. common development of the system capabilities).<br>• Limit efforts when performing changes on functionality that involves the trackside and on-board sub-systems.<br>• Minimize integration and testing efforts.<br>• Minimize operational interoperability issues. |
| Verification Method | Process Review |

### 3.2 Telecom On-Board Architecture (TOBA)

The Telecom On-Board Architecture (TOBA) Working Group, part of the UIC FRMCS (Future Railway Mobile Communication System) Program structure, specifies the FRMCS On-Board Connectivity Architecture.

**OCORA-42, A-Level - Cooperation with UIC TOBA**

OCORA works in close cooperation with TOBA

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To align onboard architecture for Connectivity / FRMCS<br>• Ensure that the architectures of TOBA and OCORA are aligned.<br>• Minimize efforts needed for developing the overall CCS reference architecture (e.g. common development of the sub system connectivity).<br>• Minimize integration and testing efforts.<br>• Minimize operational interoperability issues. |
| Verification Method | Process Review |

#### 3.2.1 Localisation Working Group of EEIG ERTMS Users Group

**OCORA-519, A-Level - Cooperation with LWG**

OCORA works in close cooperation with Localisation Working Group of EEIG ERTMS Users Group

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • To ensure consistent interfaces and performances for the train localisation with the rest of CCS On-board<br>• Ensure that the architectures of EUG LWG and OCORA are aligned.<br>• Minimize efforts needed for developing the overall CCS reference architecture (e.g. common development of the sub system localisation).<br>• Minimize integration and testing efforts.<br>• Minimize operational interoperability issues. |
| Verification Method | Process Review |

### 3.2.2 Shift2Rail

#### 3.2.2.1 CONNECTA

CONNECTA aims at contributing to the Shift2Rail 's next generation of TCMS architectures and components with wireless capabilities as well as to the next generation of electronic braking systems. The project conducts research into new technological concepts, standard specifications and architectures for train control and monitoring, with specific applications in train-to-ground communications and high safety electronic control of brakes.
The project is developed in four phases of work which are reinforcing and extending the early work done in the TCMS part of Roll2Rail as well as start the specific activities of the MAAP of Shift2Rail. The major streams are described below.

1. Define General Specifications for TCMS technologies and high-level architectures to shape the future system with less cabling, increased availability, enhanced performance, easier integration and commissioning of functions and, above it, reduced life cycle costs.
2. Progress and implement new architectures and technologies, tools, norms and standards for the future generation of TCMS as well as for high safety level electronic brakes.
3. Simulate and test virtually all the communication networks and functions of the new generation TCMS subsystems to help to simplify business processes and enhance the interoperability.
4. Evaluate results, disseminate, communicate and exploit as much as possible at this TRL3-4 level of achievements.

**OCORA-520, A-Level - Align with CONNECTA**

Align the long term vision and related requirements of On-board communication.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • Ensure that the architectures of CONNECTA and OCORA are aligned.<br>• Develop TCMS and CCS domain into a common compatible future<br>• Minimize integration and testing efforts.<br>• Minimize operational interoperability issues. |
| Verification Method | Design Review |

#### 3.2.2.2 LINX4RAIL

The ambition of LinX4Rail is to achieve a comprehensive approach for the Conceptual Data Model, as a models' federation, global system modelling specification and the strategy for implementation of technological breakthroughs.

**OCORA-517, A-Level - Follow the LinX4Rail**

Follow actively the Linx4Rail development of the Conceptual Data Model, its operational analysis and system architecture.

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • to ensure compatibility of the conceptual data model with OCORA<br>• to understand leveling among LinX4Rail - RCA - OCORA in terms of CCS end-2-end functionality<br>• to identify other touchpoints between LinX4Rail and OCORA outside of the CCS end-2-end functionality domain<br>• Prevent duplicated activities |
| Verification Method | Process Review |

#### 3.2.2.3 X2RAIL4

X2Rail-4 aims to bring to conclusion the research and development of some key technologies to foster innovations in the field of railway signalling, automation and supervision, as part of a longer term Shift2Rail IP2 strategy towards a flexible, real-time, intelligent traffic control management and decision support system. The actions to be undertaken in the scope of X2Rail-4 are related to the following specific objectives:

- On the basis of ERTMS/ETCS to implement (develop and test) the Automatic Driving up to the highest grade of automation GoA4 increasing line capacity, reducing operating costs, saving energy;
- To specify and prototype an innovative On-Board Train Integrity solution, capable of autonomous train tail localisation, wired or wireless communication between the tail and the front cab, safe train integrity supervision (SIL-4 at system level) of train interruption, traditional power supply or energy harvesting solutions without the deployment of any fixed trackside equipment;
- To develop a standardised communication structure linking rail different business services and new software applications for Time Table Management and Traffic Control to support the operation of the new drive modes e. g. ATO;
- To develop and test new concept Object Controllers consisting of a solution scalable and flexible enough to fulfil different configurations and scenarios, where locally derived power and wireless communications, guaranteeing safety and security justifications, together with maximum de-centralisation are applied. Additionally, the higher bandwidths will be used for transmission of status reports / maintenance information and further required data.

The actions foreseen in X2Rail-4 will bring to the highest readiness level (TRL) taking the results of previous X2Rail-1, X2Rail-2 and of the ongoing X2Rail-3 projects.

**OCORA-521, A-Level - Follow the X2Rail-4**

OCORA works in close cooperation with X2Rail-4 to implement Automatic Driving into the modular architectural framework

| | |
|---|---|
| Status | ✓ Approved |
| Req. Class | Requirement |
| Rationale | • to ensure compatibility of automatic driving with OCORA<br>• Prevent duplicated activities<br>• Use exiting or yet to be defined ATO business logic without adaptation for OCORA |
| Verification Method | Process Review |