OCORA

Open CCS On-board Reference Architecture

Problem Statements
Beta Release

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Revision history

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0.00	Update for B-Release	BJ	2020-06-04
1.00	Final version for B-Release	BJ	2020-06-19
1.10	Final version for Beta Release	RM	2020-06-29

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References

The following references are used in this document:

[1] OCORA-10-001-Beta – Release Notes

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

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

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

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

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

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

[8] OCORA-40-005-Beta – Functional Vehicle Adapter

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

[10] OCORA-90-002-Beta – Glossary

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 and it is still in a preliminary state. It is to understand as a state of the art update of the OCORA Alpha release problem statement document.

The focus of the short-term objective is to form the reference for all FIS and FFFIS subsets linked to on-board CCS components, e.g. ATO OB - ETCS OB, ATO OB - TCMS OB (Train), ETCS OB - FRMCS OB, ATO OB - FRMCS OB, ETCS OB - TCMS OB(Train) and may be referenced in the TSI LOC&PAS and TSI CCS. The different on-board FIS and FFFIS interfaces shall comply with the reference on-board CCS architecture supported by a generic bus, in line with cybersecurity principles, in order to:

- decouple the life cycles of the main CCS on-board system components and as such allow the upgrade, integration or replacement of one of the CCS system components without affecting the other CCS on-board system components.
- Enable compliance of any future on-board CCS component with the bus definition: the parameterization and configuration for access to the bus shall allow for safe integration in order to enable modular safety.
- provide hardware/software independence through hardware and middleware on-board requirements in order to e.g. avoid future HW-changes when integrating ETCS, ATO, FRMCS, and enhanced odometry, and facilitate the use of COTS safety hardware, certified against accepted global industry standards, e.g. IEC61508.
- Facilitate the acceptance of global industry standards, e.g as defined within IEC 61375-3-4-TCN with a standardised configuration management.

This document states the problem statements and links them to the change request topics assigned to Train Architecture Topical Working Group chaired by the Agency. These topics are providing the document structure. OCORA problem statements are:

- Modular Architecture
- CCS new open Bus
- CCS – Vehicle Adapter/Gateway
- Hardware/Software independence
- Acceptance of global standards
- Non-Functional Requirements

1.2 Why should I read this document?

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 behind the headlines, overview of the listed problem statements in chapter 2, will be able to provide feedback to the authors and can, therefore, engage in shaping OCORA.

Before reading this document, it is recommended to read the Release Notes [1] and the Introduction to OCORA [2]. The reader should also be aware of the Glossary [10].

The Architecture [4], the UVCC Bus Evaluation [6], the Computing Platform [7], the Functional Vehicle Adapter [8], the Capella Model [5], the (Cyber) Security [9] and the Set of Requirements [3] provide further technical details to this document.

1.3 Overview

The OCORA expert team identified six major problems fields in the current CCS TSI. These issues and their relation to the proposed OCORA Architecture and current TSI CCS architectures are graphically represented in Figure 1 below.

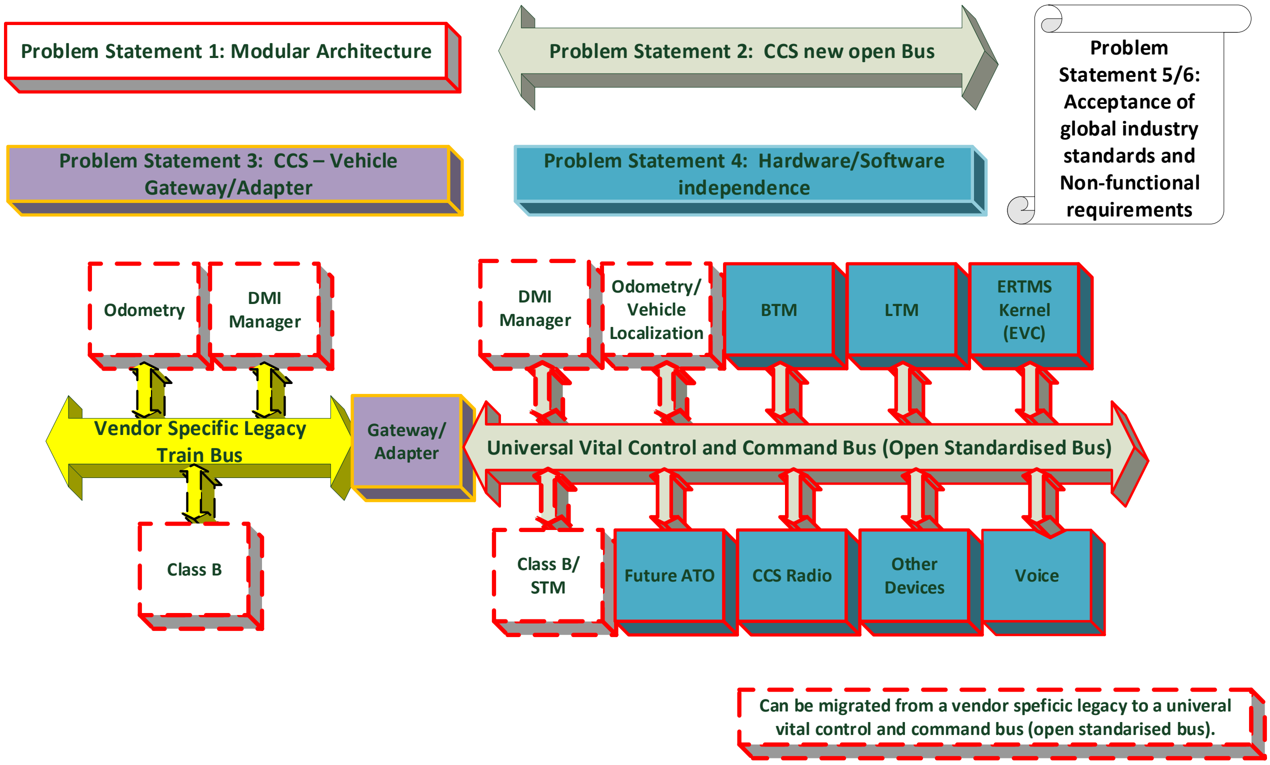

Figure 1 Overview Problem Statement

In the frame of the European Mandate toward the Agency for the revision of the CCS TSI 2022, the following Change Requests are being addressed and can be mapped as follow regarding OCORA problem statements:

CR Id	Ref Number	Headline	OCORA Problem Statement
TSI_C00000175	#21	Modular on-board architecture - standard on-board interface between on-board CCS and train [TIU] (revised subset 119)	CCS – Vehicle Adapter/Gateway
TSI_C00000193	#22	Modular on-board architecture - common standardised TCN (train communication network), based on Ethernet bus/IP and data interfaces	CCS new open Bus
TSI_C00000194	#23	Modular on-board architecture - Standard on-board interfaces between ETCS DMI and ETCS EVC (subset 121)	Modular architecture
TSI_C00000195	#24	Modular on-board architecture - Standard on-board interface between TIMS (ETCS L3) and ETCS EVC	Modular architecture
TSI_C00000196	#25	Modular on-board architecture - Standard on-board interface specification between ETCS and ATO, based on Ethernet bus/IP (revised subset 130)	CCS new open Bus
TSI_C00000197	#26	Modular on-board architecture - Standard on-board interface specification between ATO and TCMS based on Ethernet/IP	CCS – Vehicle Adapter/Gateway
TSI_C00000198	#27	Modular on-board architecture - Standard on-board interface specification between CCS-applications (ETCS/ATO) and FRMCS, based on Ethernet bus/IP	CCS new open Bus
TSI_C00000199	#28	Modular on-board architecture - Next generation communication system	*(FRMCS UIC TOBA)*
TSI_C00000272	#30	Modular safety	Non functional requirements Acceptance of Global Standard Hardware/Software independence
TSI_C00000234	E437	Trackside malfunction reporting	Modular architecture

OCORA, in close relationship and collaboration with CER, is aiming at providing technical analysis and proposals corresponding to the end users' expectations and views on each of these Change Requests.

The next chapters list the problem statements as identified by the OCORA team of experts.

2 Problem statement 1: Modular Architecture

2.1 Problem Need/Description:

The existing Onboard Architecture, as defined in SS26, did not meet the user expectations. As it turned out, it is not modular enough to adapt upcoming (and foreseeable) game changers (FRMCS, Localization,…), requests a replacement for simple baseline updates which results in very high LCC.

A new architecture, following the DG Move objectives (see below) need to replace the existing SS26 architecture.

User need to reduce total cost of ownership, preservation of the investment and shorter time to market for solution as ATO.

Furthermore, the current TSI CCS Specification needs to be improved, before further systems such as game changer will be built on top of it, to avoid further increasing of total cost of ownership and higher risk of investment cost for RU´s. Therefore, the current SS 26 needs to be improved and stabilized to ensure the extension and compatibility with regards the future game changer.

The Agency and the Commission have well captured the key issues faced by Railway Undertakings:

- *« ERTMS and CCS deployment, retrofit, maintenance and upgrade are extremely challenging and costly processes involving technological change in an operational transport network. The current typical CCS on-board configuration includes multiple proprietary interfaces between the main train on-board building blocks. This induces low on-board upgradeability and dependency on one supplier where on-board upgrades are necessary*
- *Digitalisation technologies are ready for use in rail, with huge potential to improve passenger and freight services. The initial focus will be on implementation of the ERTMS Game Changers (ETCS level 3; Automated Train Operation; braking curves model, next generation communication system; satellite positioning) and cyber security. But the current structure of CCS implementation does not enable rail to take full advantage of these and future opportunities. Innovation is too slow, and time to market too long for rail technology. The current system is complex and not conducive to evolution. «*

The OCORA architecture is a proposal to address those two key issues taking the ERTMS deployment as an opportunity to fast the digitalisation and competitiveness of the railway sector.

To achieve plug and play exchangeability, the current CCS architecture needs to be unravelled through functional decomposition of the on-board CCS system.

A new alternative architecture to allow the take-off of innovation around a robust and stabilized ETCS core, need to be proposed next to the existing SS26 architecture.

To integrate future game changers, notably GoA 3 and 4, this exercise needs to be extended from the CCS architecture to the vehicle architecture since many vehicle functions are necessary to enable full automation and digitalisation of the railways:

- Functions shall be strictly isolated and connected via interfaces
- Functions shall be realised in (software) applications
- System design shall enable (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
- Core ETCS functionality (EVC cf. the supervision of location specific speed thresholds annex the ability to open the brake pipe in case of overshoot) shall be an isolated function
- No alien application artefacts or residues (e.g. GSM-r) shall be allowed to remain in future EVC application software
- Whenever no standardized TCMS/CCS bus is available, the CCS on board shall communicate with vehicle functions through a gateway that aligns CCS data

2.2 Economic Evaluation - Preliminary Assessment of Benefits:

- Reduction of total cost of ownership.
- Reduction of Investment risk and preserve investment.
- To reduce total cost of ownership.
- Support the railway signalling market and business.
- Shorter time to market for necessary solution e.g. Automation.
- Improve reliability, availability, security and safety.

By

- Simplification of the System
- Modularisation of the System Architecture
- Open and standardized interfaces
- Platform Independence (SW/HW independence)

3 Problem statement 2: CCS new open bus

3.1 Problem Need/Description:

Today we have proprietary interfaces between CCS components on the vehicle. The proprietary interfaces do not allow to exchange or update CCS components from different suppliers. The vendor locking created by proprietary interfaces leads to high costs. The existing proprietary interfaces do not allow to add new functions.

Moreover, these interfaces are implemented using heterogeneous bus technologies. This leads to increased complexity and extensive effort for the operator-maintainer to handle these heterogeneous systems.

3.2 Economic Evaluation - Preliminary Assessment of Benefits:

The bus topology allows procurement on a component-based way which leads to lower costs and optimal components.

The standardization allow as well:

- reduced efforts (time and costs) for upgrades,
- wider market size

4 Problem statement 3: CCS – Vehicle Adapter/Gateway

4.1 Problem Need/Description:

Today we have supplier-owned and implementation specific interfaces:

- For the CCS components installed in the vehicle
- For vehicle components that have to be interfaced with the CCS subsystem

The proprietary interfaces do not allow to open competition for the exchange or update of CCS components. This situation leads to prohibitive cost and high duration for retrofitting vehicles and upgrading CCS .

The “legacy” design of Vehicles export today constraints in the CCS domain, thus making CCS implementation specific for each vehicle type.

In order to improve quality and prices, it should be possible to purchase standardized CCS component. When the vehicle does not allow to connect standardized CCS component, there is a need to implement a gateway function.

4.2 Economic Evaluation - Preliminary Assessment of Benefits:

In order to gain rapid benefit from digitalization, it is necessary to uncouple CCS evolution from the long lasting rolling stock evolution cycle.

It should be possible for fleet owner to order in 2 independent tender the vehicle retrofit and CCS equipments. For this, a “universal gateway” should be specified, but the standard may be adapted depending on the vehicle type design. Standardized and or adaptive solutions for the gateway will allow to achieve higher volumes of product, thus driving price down and quality up.

The gateway could contribute to cyber security by ensuring segmentation between networks.

5 Problem statement 4: Hardware/Software independence

5.1 Problem Need/Description:

The current CCS on-board system is composed of different subsystems, interacting through interfaces. In the centre of this system is a central processing unit, commonly referred to as EVC. This comprehensive central processing unit consists of hardware and software components interacting together.

As the interface between HW and SW on the EVC is not standardized and publicly available, the various implementations of the EVC hardware and software is vendor specific. Therefore, a vendor lock-in exists, when the need for replacing the hardware arises or when a software update needs to be implemented. Eventually it is needed to change the entire system since the software is hardware dependent.

This leads to costly development, certification, homologation, and roll-out processes whenever a change is needed. The costs (and time) needed to implement changes are reaching a level that are not justifiable.

The current CCS on-board system need to be modified in the near future to support new functionality, such as FRMCS, ATO, ETCS L3, etc. Implementing these changes under the current situation (vendor locking) is not an option for most operators. In addition, the new functionality will increase the probability that changes need to be made more frequently on future EVC implementations.

To allow implementing new functionality for CCS systems in the future at reasonable costs and time, a standardized, well structured, and publicly specified implementation of the on-board computing system is needed. Separating the hardware from the software is a first step and the topic of this change request. Other topics, aiming in the same direction are covered in the following problem statements:

- Problem Statement 1- Modular Architecture
- Problem Statement 2 – CCS new open Bus

5.2 Economic Evaluation - Preliminary Assessment of Benefits:

Benefits for the operators:

- allow implementation of new functionality at lower cost

- allow faster and easier implementation of new functionality
- better management of system (the functional applications will become piece of software which can run on standard compute system)

Benefits for the suppliers:

- a wider and more focused supplier market can develop
- simplified certification and homologation
- simplified life cycle management
- better address cyber security issues
- regression free changes in individual software components
- better re-use of software code
- synergy in vendors applications: Same platform can run different functional applications from different vendors

6 Problem statement 5: Acceptance of global standards

6.1 Problem Need/Description:

The primary objective of standardisation is the definition of voluntary technical specifications with which current or future products, production processes or services may comply.

Standardisation plays an increasingly important role in international trade and the opening-up of markets.

Standardisation helps to boost the competitiveness of enterprises by facilitating in particular the free movement of goods and services, network interoperability, means of communication, technological development and innovation.

EU railway standards shall not be a hindrance to the railway sector take-off, they should help to boost the EU railway market technically and economically.

Yet, there are few particular areas in current rail standardisation framework that require improvement.

1. There have been too many standards elaborated for the rail sector that are sector-specific. This is an impediment to economies of scale and innovation take-off, which could be avoided if well-proven standards from other sectors such as aeronautics and space were used when applicable.
2. The financial impact a standard may have and even the business rationales for a standard are often underestimated. The business-added value of a standard must be assessed before elaborating a new standard.

There are several alternative standards for the EU railway regulations that provide the same level of quality and safety, are globally accepted, are regularly applied in safety critical branches of industry including the transportation industry and are tolerant to the application of state of art technologies. Therefore, there is ample technical and economic justification to use globally accepted industry standards, provided these ensure at least an equivalent RAMS level as specific referenced railway standards.

Since alternative standards that are widely used in e.g. petrochemical industry, aviation and automotive, service substantially bigger markets and are therefore put to rigorous fit for use testing, we can safely assume that they provide a viable alternative when they comply to specific railway technical needs. Components especially designed for safety applications are generally certified against standards providing access to bigger markets and not against railway standards. This is e.g. the case in markets for (safe) microprocessors and complete programmable logic controller where the railway sector is just a niche in a huge global market for industry and automotive. It is unrealistic to suppose that the global electronics business is willing to bear the cost for recertification against railway standards, let alone to comply to railway specific standards when global markets are affected.

Recertification of (high quality) safety components for railway applications by users is often complicated by the fact that design information needed is not publicly available.

Opening the option to apply global standards as an alternative to railway specific European standards enables the swift introduction and use in the railway domain of off the shelve products to the benefit of the European railway community.

Allowing the use of non-rail specific, largely-applied and well-proven standards helps to ensure consistency, thus enhancing the ability to manage system over the life cycle, improving user satisfaction, protecting IT investments, maximizing return on investment and reducing life cycle costs. The installed base for CCS products will be enlarged because non institutional suppliers can enter the market which enables the swift exchange of suppliers, necessary in case of e.g. bankruptcy or change of business policy. Supply chain integration will be facilitated.

6.2 Economic Evaluation - Preliminary Assessment of Benefits:

- Reduces cost and technical risks
- Reduces the burden of certification in terms of cost and duration
- Supports rapid adoption and implementation of technological innovations
- Enables the drive for digitalization and automation of operations
- Improves railway productivity
- Enlarges the railway supply market of components
- Supports bigger market volumes for railway technology applications and implementations in the CCS domain, notably ERTMS and ATO.

7 Problem statement 6: Non-Functional Requirements

7.1 Problem Need/Description:

In order to manage the innovation uptake beyond ETCS and considering recurrent updates/upgrades, the TSI CCS would require additional non-functional requirements. These non-functional requirements define a set of standardized and aligned requirements within the sector. This needs to be changed, since non-functional requirements are in the same manner important as functional requirements for continuous and safe railway operation.

Essential non-functional requirements which would help improving time to certification and time to market are in particular:

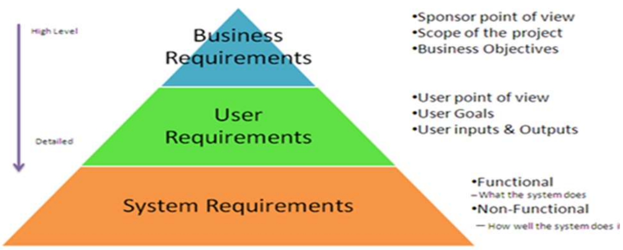

Figure 2 Requirements Pyramid

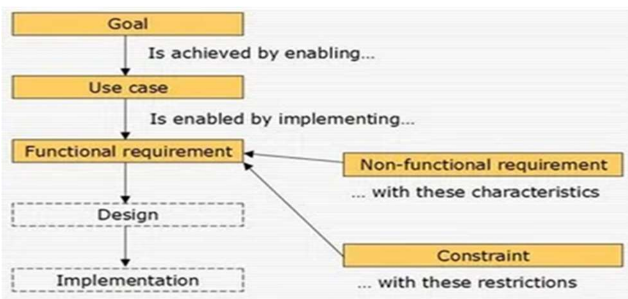

Figure 3 Requirements Process

- Modularity: “Degree to which a system or computer program is composed of discrete components such that a change to one component has minimal impact on other components.”
- Usability: “Degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.”
- Replaceability: “The degree to which a system can replace another for the same purpose in the same environment”
- Modifiability: “The degree of effectiveness and efficiency with which a product or system can be modified to improve it, correct it or adapt it to changes in environment, and in requirements.”
- Portability: “Degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another.”

Supportive elements for the validation of non-functional requirements are based on the definition of tools for testing and supervision, and processes for Integration, Verification and Validation, Certification and Authorization.

Before further systems such as game changer will be built on top of it, to avoid further increasing total cost of ownership and higher risk of investment cost for RU´s. Therefore the current set of specifications needs to be enhanced and stabilized to ensure the extension and compatibility with regards to the future game changers.

This problem statement is driven to take full advantage of digitalization, and the introduction of the gamer changers for CCS deployment and evolution.

7.2 Economic Evaluation - Preliminary Assessment of Benefits:

Such a set of non-functional requirements is necessary to reduce total cost of ownership, preservation of the investment and shorter time to market for solution as e.g. ATO:

- Reduction of total cost of ownership
- Reduction of Investment risk
- Support the railway signalling market and business
- Shorter time to market for necessary solution e.g. ATO
- Improve reliability, availability, security and safety