OCORA

Open CCS On-board Reference Architecture

Functional Vehicle Adapter

Introduction

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Revision history

Version	Change Description	Name (Initials)	Date of change
1.00	Review input from SNCF and DB incorporated. Official version for the Beta release.	CG	30.06.2020
2.00	Updated for the Gamma release: ▪ Some adaptations required for Gamma Release. ▪ Updated Figure 1 and Figure 8. ▪ Small text corrections in chapter 7. Official version for OCORA Gamma Release.	CG	04.12.2020
2.61	Updated for the Delta release: ▪ New document number. ▪ Updated references. ▪ Modifications in order be consistent with the modified content of the CCS-TCMS interface documents for ETCS and ATO functionality that have been migrated into new documents. ▪ Modifications in order to be consistent with the naming of RCA. New chapter 4 describing the architectural context of the FVA. Official version for OCORA Delta Release.	CG	30.06.2021
4.00	Updated for the Release R1: ▪ Updated references. ▪ Updated figures 2, 3, 4 and 7. ▪ Modifications to be consistent with the OCORA system architecture. Official version for OCORA Release R1.	CG	26.11.2021

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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. to external documents:

[1] OCORA-BWS01-010 – Release Notes

[2] OCORA-BWS01-020 – Glossary

[3] OCORA-BWS01-030 – Question and Answers

[4] OCORA-BWS01-040 – Feedback Form

[5] OCORA-BWS02-030 – Technical Slide Deck

[6] OCORA-BWS03-010 – Introduction to OCORA

[7] OCORA-BWS04-010 – Problem Statements

[8] OCORA-BWS08-010 – Methodology

[9] OCORA-TWS01-030 – System Architecture

[10] OCORA-TWS01-040 – Capella Modelling

[11] OCORA-TWS02-010 – CCS Communication Network – Evaluation

[12] OCORA-TWS04-011 – Functional Vehicle Adapter - Requirements

[13] OCORA-TWS04-012 – Functional Vehicle Adapter – Standard Communication Interface Specification

[14] OCORA-TWS04-013 – Functional Vehicle Adapter – Design Guideline

[15] 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

[16] SUBSET-139, ATO over ETCS - ATO-OB / TCMS Interface Specification

[17] SUBSET-143, ATO over ETCS - Interface Specification Communication Layers for Onboard Communication

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

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

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

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

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

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

[24] IEC61375-2-3 TCN – Train Communication Network – Communication Profile

Wherever a reference to a TSI-CCS [15] SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). We always reference to the latest available official version of the SUBSET. OCORA always references to the latest available official version of the SUBSET, unless indicated differently.

1 Introduction

1.1 Purpose of the document

The purpose of the document is to introduce the Function Vehicle Adapter component with the aim to provide to the reader:

- The OCORA approach for integrating the on-board CCS with the TCMS in a vehicle.
- The high-level concept and architecture of the technical implementation.
- An introduction that is the basis to read and understand the requirement document [12], the interface specification [13] and the design guideline [14] describing the CCS on-board to vehicle interfaces, and the integration for the ETCS on-board and the 'ATO Vehicle' applications.

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 [4].

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

If you are an organization interested in developing on-board 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.

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 [1]. 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 OCORA we recommend reading the Introduction to OCORA [6], and the Problem Statements [7]. The reader should also be aware of the Glossary [2] and the Question and Answers [3].

This specific document focusses on specific technical aspects of the architecture.

The system architecture document [9] describes a 'Train Adapter' that is used to integrate the CCS on-board system into a vehicle. Within the 'Train Adapter' four different components are foreseen:

- Wired I/O Control (WIOC): provides connectivity for the CCS on-board to wired sensors and actors of the vehicle through the FVA. The data exchanged through this component is for functions with SIL < 4.
- Wired I/O Control - SIL4 (WIOC-S4): provides connectivity for the CCS on-board to wired sensors and actors of the vehicle. The data exchanged through this component is for functions with SIL4 where the FVA is not involved.
- Functional Vehicle Adapter (FVA): adaptation of the vehicle with its Train Control and Management System (TCMS, if available) to the CCS on-board applications, interfaces to CCS on-board are SCI-FVA[1], and SCI-VL. The FVA provides the main conversion logic between vehicle (TCMS) and CCS on-board.

[1] An overview of the different interfaces is provided in the system architecture document [9].

- Passenger Information System Adapter (PISA): adaptation of the Passenger Information System (PIS) to the CCS on-board applications, interfaces to CCS on-board are SCI-PISA and SCI-VL.

Only the functional vehicle adapter (FVA) is considered in this document. The interfaces of the functional vehicle adapter are CI-TCMS, CI-WIOC, SCI-FVA and SCI-VL.

While the described technical aspects in this document are valid in the context of the current development state but also provide a future view, the interface specification [13] and the design guideline [14] describe rather the future view.

1.4 Definition

TCMS — The Train Control and Management System (TCMS) is an on-board system built with the purpose to control and monitor a list of train equipment. At interface level it refers to all aspects of the integration into the “Train”: conceptually it groups together the two types of interfaces “serial interface” and “hard-wired interface” indicated in SUBSET -119.

TIU — The Train Interface Unit (TIU) specifically defines the interface between the ERTMS / ETCS on-board equipment and the train. To avoid confusion, the term TIU is no longer used in context of OCORA as it would also be used in another context than only ERTMS / ETCS. The newly introduced Functional Vehicle Adapter (FVA) incorporates the full TIU functionality and ensures standardized communication with the TCMS on OSI layer 7. It is accessible to all OCORA applications like VS, ATO and any possible future extension.

2 OCORA approach for the CCS to vehicle (TCMS) interface

The interface from CCS on-board to vehicle (TCMS) is subject to a standardization process that resulted in the definition of the interface within different SUBSETs: 034, 119, 139 and 143.

The experience however shows that the currently released specifications are not sufficient for a smooth and uniform integration on all types of vehicles.

In addition, OCORA aims at having standardized CCS on-board applications that can be installed without modification or adaptation (except for configuration) on any type of vehicle. In order to achieve this the use of the same and standardized interface is proposed.

While interface standardization ensures portability, typically it does not provide the flexibility for the adaptation to different vehicle types. This is solved by introducing a configurable Functional Vehicle Adapter (FVA) that provides the needed mapping logic.

OCORA also supports the idea of a standardized interface on the vehicle (TCMS) side what is currently implemented with the different SUBSET-034, -119, -139 and -143. Within OCORA the current objective is to use these SUBSETs in the form they are released and propose possible improvements.

A considerable part of the CCS on-board deployments will affect existing vehicles with various TCMS architectures and implementations. The different SUBSET-034, -119, -139 and -143 however do not cover all aspects of CCS on-board integration for the different TCMS architecture and implementations. The SUBSETs are mainly applicable to new vehicles. In addition, the SUBSETs leave some room to the designer of the CCS on-board to vehicle (TCMS) interface to make his own interpretations. With this introductory document and the specifications [13] and [14], the intention is to provide precise guidance for the integration of the CCS on-board into the vehicle (TCMS), considering the various TCMS settings in existing and future fleets.

This introductory document and the specifications [13] and [14] are to be seen in the context of the SUBSET-034, -119, -139 and -143: they describe a concept and the interface at application layer (OSI layer 7[1]) for the communication between CCS on-board and vehicle (TCMS). This approach is fully compliant with the existing SUBSETs however describing a larger scope that can also be used on non-standard and legacy vehicles (which are not compliant to SUBSET-034, -119, -139 and -143) while defining, as far as possible, a standardized interface for the CCS on-board applications. The latter furthermore enables the use of standardized test specifications.

This introductory document and the specifications [13] and [14] shall be used in conjunction with SUBSET-034, -119, -139 and -143. The latter are focussing on the vehicle side while this document and the specifications [13] and [14] are focussing on the CCS on-board side and the vehicle specific adaptations.

Basically, the Functional Vehicle Adapter provides functionality and uses data that are vehicle specific, while the interfaces to CCS on-board applications (e.g. ETCS on-board, ATO Vehicle, etc.) are fully and to some vehicle types (TCMS) partially standardized. This ensures a certain degree of plug and play replaceability, from evolution and upgradeability perspective, delivering more freedom at lifecycle level.

To be noted that the implementation of the Functional Vehicle Adapter has to be in line with RAM, safety, performance and other non-functional requirements as defined by the processes in the CENELEC standards [20] to [23], this includes the consideration of SUBSET-088, -091 and -120.

Furthermore, it has to be emphasized that this introductory document and the specifications [13] and [14] address the data exchange at application layer (OSI layer 7) while the lower layers (OSI layers 1-6) and the safety layer are described in the document [11].

3 Description of the Functional Vehicle Adapter

The Functional Vehicle Adapter (FVA) is a computation function (software) deployed on the OCORA computing platform, on a separate computing unit 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 CCS on-board applications and services. Although the TSI-CCS SUBSET-034, -119, -139 and -143 are defining the interface to the vehicle (TCMS system), vehicle from different suppliers and especially from different generations have still different interfaces implemented. This adapter allows to map, on a

[1] The OSI layers are defined as indicated in figure 2 of document [8].

functional level, the commands sent, and the information received from a specific TCMS into the OCORA standard. This includes that the FVA can likewise be used to integrate vehicles through wired connections (by means of the 'Wired I/O Control' component). Also, the standardized interface to the CCS on-board applications evolves in multiple iterations. The intention is to implement the FVA as a configurable software function that can be adapted through parametrization, in order to be easily customized to the vehicle.

The FVA was already introduced in the Alpha release of the OCORA system architecture as the 'TIU Services' component. For the Beta release version of the OCORA system architecture [9] the component has been renamed to "Functional Vehicle Adapter". The term TIU is no longer used as it was specifically mentioned in the ERTMS / ETCS context, while in OCORA the functional component is also used in the ATO context and for possible future applications.

OCORA uses a phased approach for developing its architecture as described in the document [6]. For that reason, multiple stages are foreseen. In the initial stage, for preparing retrofit projects, the "ETCS on-board" is regarded as a monolithic application providing the core function of ETCS in a vehicle.

This document and the connected Interface Specification [13] and Design Guideline [14] documents are to be seen as deliverables of the initial stage of the OCORA architecture. The following Figure 1 provides the context diagram of the Functional Vehicle Adapter for the initial stage of the OCORA architecture:

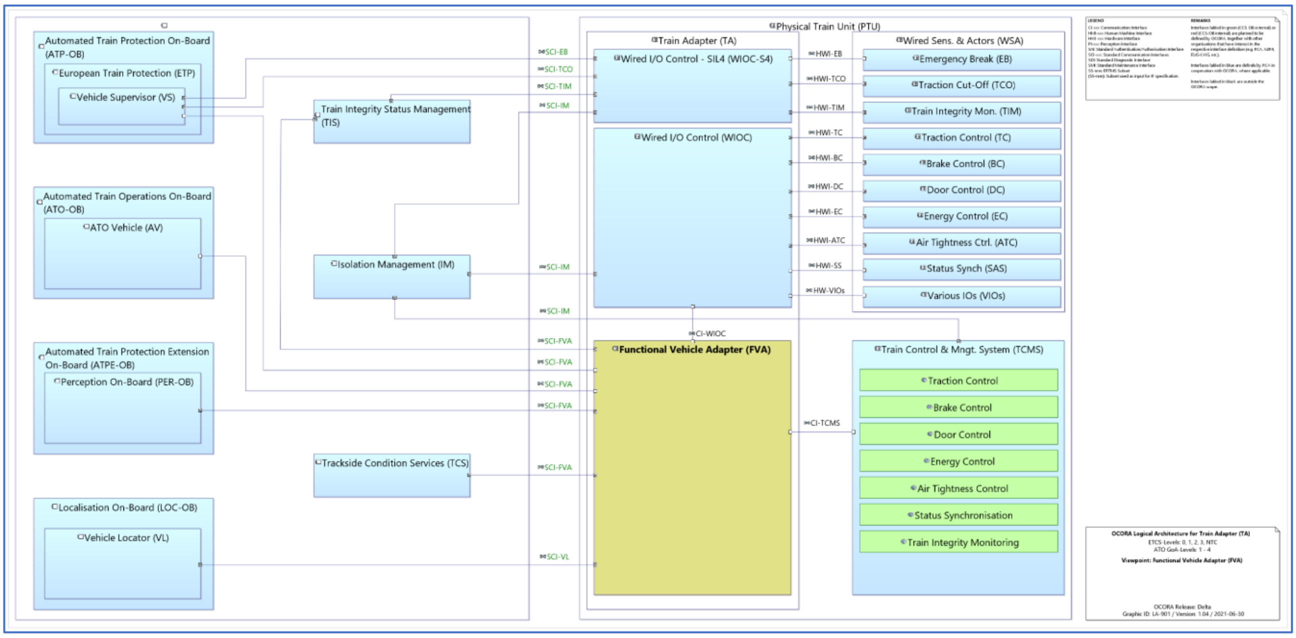

Figure 1 Functional Vehicle Adapter (FVA) context diagram – Initial Stage

Based on this, the Functional Vehicle Adapter as described in this version of the document, provides one interface "SCI-FVA" and integrates one interface "SCI-VL" to the "ETCS on-board" application that in the context diagram is displayed with the four components "Vehicle Supervisor (VS)", "Train Integrity Status Management (TIS)", "Trackside Condition Services (TCS)" and "Vehicle Locator (VL)". The concept for this integration is described in chapter 5.

The Functional Vehicle Adapter also provides the "SCI-FVA" interface to the 'ATO Vehicle' (AV) application, this integration concept is described in chapter 6. Note that regarding the ATO Vehicle application only the grades of automation up to 2 are considered.

In the OCORA architecture the "ETCS on-board" system is modularised and decomposed into multiple components. These components are applications that are either integrating the SCI-FVA interface to the Functional Vehicle Adapter, or providing the interface SCI-VL from the "Vehicle Locator (VL)" as demonstrated in the Figure 1. Having standardized these two interfaces ensures portability of the CCS on-board applications between different vehicle types and TCMS architectures.

4 Architectural concept with the FVA

The architectural concept of the CCS on-board application integration by means of the Functional Vehicle Adapter into the vehicle shall ensure a smooth integration and the portability / exchangeability of the CCS on-board system or some of its constituent / building blocks (e.g. CCS on-board application). Exchangeability means that an obsolete CCS on-board application shall easily be replaceable with the same CCS on-board application of another supplier. Portability means that the same CCS on-board application from a specific supplier can be deployed on different vehicle types with just some changes in the configuration. To achieve this, the FVA provides a standardized interface and integrates a standardized interface to the CCS on-board applications that remain always the same, while the specificities of the vehicle are abstracted within the Functional Vehicle Adapter.

It is the intention of OCORA to specify the interfaces between the CCS on-board applications and the Functional Vehicle Adapter in line with the evolving specification of SUBSET-119 and -139. This with the goal that the Functional Vehicle Adapter is not needed, once SUBSET-119 and -139 are specified without vehicle specific dependencies and for trains running a TCMS that follow these specifications.

It must also be noted that the Functional Vehicle Adapter does only address vehicle specific aspects (e.g. it decides what brake shall be applied, if this is not a capability of a specific TCMS) but it does not cover railway undertaker or mission related business logic (e.g. how much to brake, how much traction to apply, etc.). The latter remains a topic that needs to be addressed in the 'ATO Vehicle' application.

Furthermore, the architectural concept shall support the integration into older vehicles that are not yet equipped with a modern TCMS. Under these circumstances the Functional Vehicle Adapter, by involving the 'Wired I/O Control (WIOC)" component, provides the possibility to exchange data with the vehicle by means of hardwired signals.

Finally, the architectural concept must also consider the handling of data that is used in safety relevant functions. In this regard it must be achieved that the handling of data not involved in safety relevant functions can easily be adapted / changed / enhanced (independently from the safe data processing) to improve the performance of the vehicle and to be open for innovation.

According to the defined requirements the Functional Vehicle Adapter is composed of a non-safe part and a safe part (in projects where the safe part is needed). The latter not to be involved in functions higher than SIL2. This means that the few data for functions higher than SIL2 is directly exchanged between the CCS on-board applications and the vehicle, typically by means of hardwired signals.

Regarding data involved in safety relevant functions up to SIL2 the project specific implementation depends on the capability of the available TCMS. The following options are possible:

1. TCMS provides all the safety relevant functions with the required SIL:
    a. The data exchanged between TCMS and CCS on-board application is enriched by a safety layer as defined in the Train Communication Network specification [24] and is just channelled through the Functional Vehicle Adapter.
    b. The Functional Vehicle Adapter is uniquely a non-safe component providing a communication channel where possibly a protocol conversion is needed.
2. No TCMS is available or the TCMS does not provide the SIL required by the safety relevant functions:
    a. The Functional Vehicle Adapter is composed of a safe part that handles the safety relevant data only. Typically, this has by means of the 'Wired I/O Control (WIOC)' component the needed hardwired connections to the vehicle.
    b. The data exchanged between safe part of the Functional Vehicle Adapter and CCS on-board application is enriched by a safety layer as defined in the Train Communication Network specification [24].
    c. If no TCMS is available, the non-safe part of the Functional Vehicle Adapter handles the not safety relevant data. The Functional Vehicle Adapter has by means of the 'Wired I/O Control (WIOC)' component hardwired connections to the vehicle.
3. TCMS only provides a subset of the safety relevant functions, but this to the required SIL:
    a. The data that TCMS can handle is enriched by a safety layer as defined in the Train Communication Network specification [24] when it is exchanged between TCMS and CCS on-board application. This data is just channelled through the Functional Vehicle Adapter.

b. The Functional Vehicle Adapter is composed of a safe part that handles the remaining of the safety relevant data only. Typically, this has by means of the 'Wired I/O Control (WIOC)' component the needed hardwired connections to the vehicle.

c. The data exchanged between safe part of the Functional Vehicle Adapter and CCS on-board application is enriched by a safety layer as defined in the Train Communication Network specification [24].

In the future if TCMS can also provide functions up to SIL4 the data is exchanged between TCMS and CCS on-board applications as described in option 1, presuming that the Train Communication Network specification [24] is amended by a safety layer valid for SIL4 data exchange. In this case the hardwired signals between the CCS on-board applications and the vehicle are no longer needed.

5 ETCS on-board application: FVA integration concept

This chapter describes the concept how the Functional Vehicle Adapter shall be integrated with the vehicle (TCMS) and the "ETCS on-board" application. In this context the latter is being regarded as a monolithic application providing the core function of the ETCS on a vehicle.

The following figure displays the general functional integration concept of the business logics "ETCS on-board" and FVA with the actor vehicle (e.g. TCMS) showing the different interfaces among them:

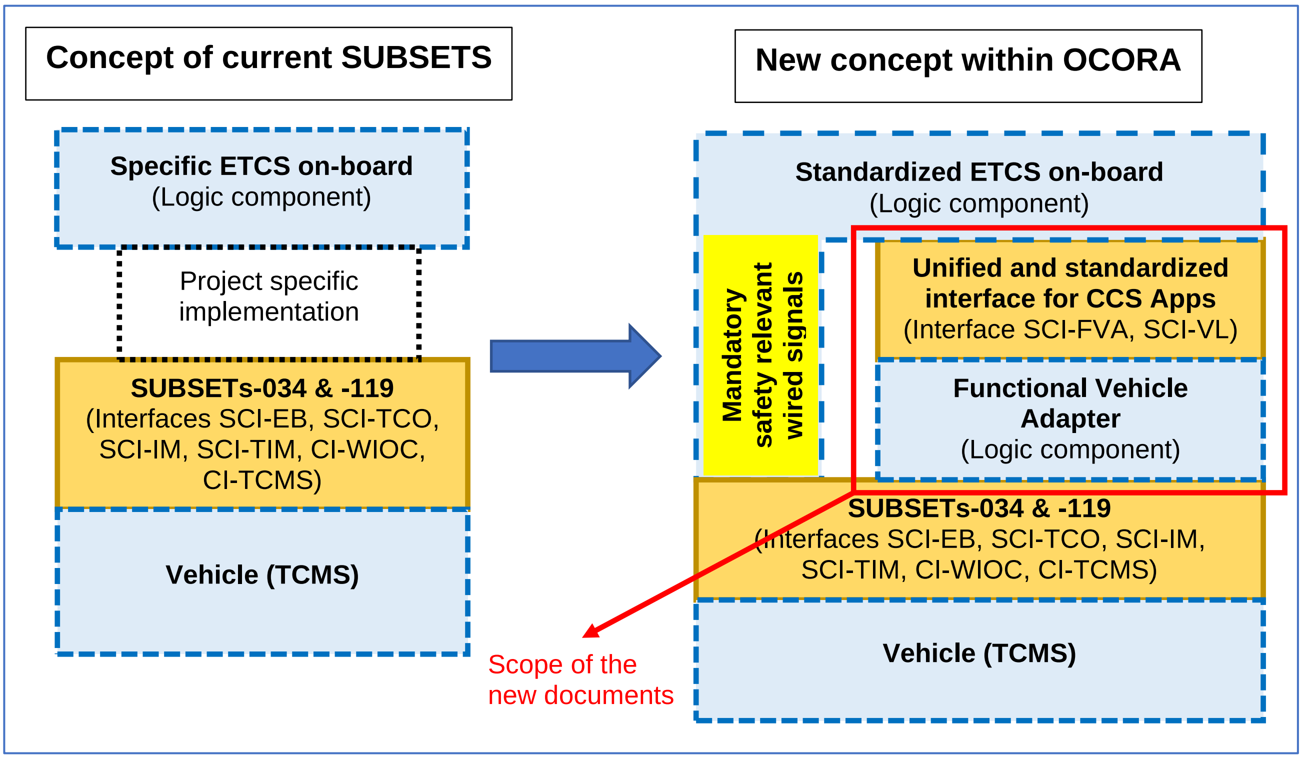

Figure 2 General integration concept of FVA with ETCS on-board

The Functional Vehicle Adapter provides the "Unified and standardized interface for CCS Apps" to the CCS application "ETCS on-board". This interface shall remain the same independently of the vehicle type allowing the portability of the "ETCS on-board" application[1]. The interface SCI-FVA is described in detail in the document [13].

The Functional Vehicle Adapter implements a logic that maps the data from the interface to the "ETCS on-board" application to the interface with the vehicle (TCMS), the latter defined in SUBSETs -034 and -119. The

[1] Currently is it assumed that the «ETCS on-board» application will cover the functionality provided by the components «Vehicle Supervisor», «STM Controller», «Vehicle Locator», «Mode and Level Manager», «Isolation Management», «Train Integrity Status Management» and «Trackside Conditions Services» that are described in the OCORA System Architecture [9].

mapping shall be handled as far as possible through parametrization and is described in detail in the document [14].

Physically the interface to the vehicle (TCMS) as defined in SUBSETs -034 and -119 is implemented by using the components “OCORA Gateway” and “I/O Ports”.

5.1 Implementation variants

The following subchapters describe possible deployment variants of the general implementation concept since the interface specifications SUBSET-034 and -119 do not cover all aspects. Moreover, different vehicles are equipped with different TCMS architectures and implementations requiring a modified implementation.

Note: the list of variants described in this document is not exclusive and shall be regarded as implementation options. It is for instance thinkable to implement a combination of the variants described in this document.

5.1.1 Vehicle handling additional data than defined in SUBSET-034 & -119

This chapter describes the implementation concept in case the vehicle (TCMS) side can handle additional aspects than those defined in the SUBSET-034 and -119.

The following picture displays the functional integration concept of the business logics “ETCS on-board” and FVA and the vehicle actors (e.g. TCMS) in case the TCMS is capable to handle additional data than defined in the SUBSET-034 and -119:

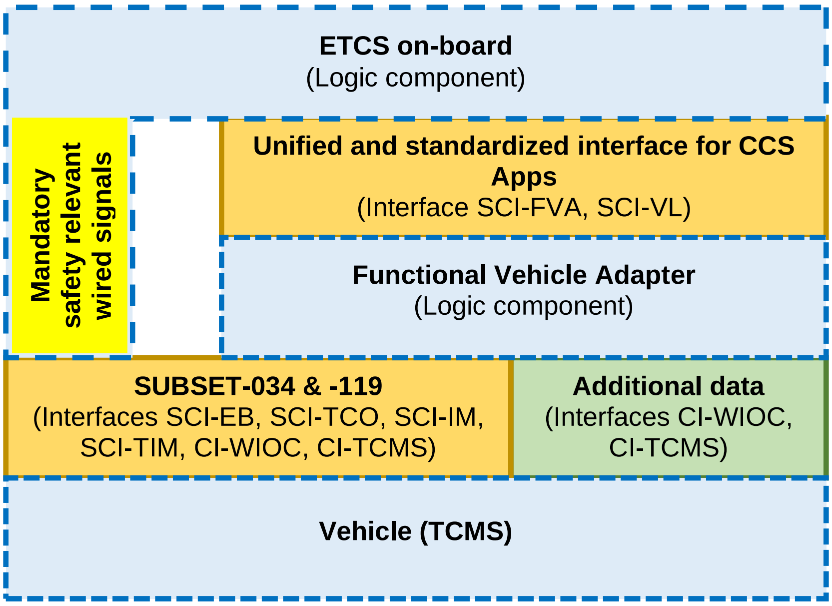

Figure 3 Integration concept of FVA with ETCS for additional data

The Functional Vehicle Adapter presents to the vehicle (TCMS) an interface that covers more data than defined in the SUBSET-034 and -119.The interface is described in detail in the document [14] that also includes the detailed implementation logic for the Functional Vehicle Adapter.

It is possible that the vehicle requires more than one interface to the Functional Vehicle Adapter from more than one independent sub-system in order to provide the full functional range, this is described in chapter 5.1.2 of this document. Typically, this is used for retrofitting purposes where TCMS only provides limited functionality or is not present at all.

5.1.2 Functional Vehicle Adapter in the context of ETCS and retrofitting purpose

Depending on the TCMS architecture and implementation a specific vehicle is equipped with, it might be possible that the interface provided by the vehicle TCMS only partially covers SUBSETs -034 and -119. Therefore, it becomes necessary or favourable introducing an independent sub-system complementing the TCMS at functional level within the same vehicle. This second sub-system (or component) has been named

"Wired I/O Control (WIOC)" in the System Architecture [9] and acts on the "Wired Sensors and Actors (WSA)". These two independent sub-systems (TCMS and WIOC) will also have to interface the Functional Vehicle Adapter in order to exchange data with the "ETCS on-board" application.

The following picture displays the functional integration concept of the business logics "ETCS on-board", FVA and vehicle in case the vehicle consists of two independent sub-systems (TCMS and WIOC) in order to provide the full functional range:

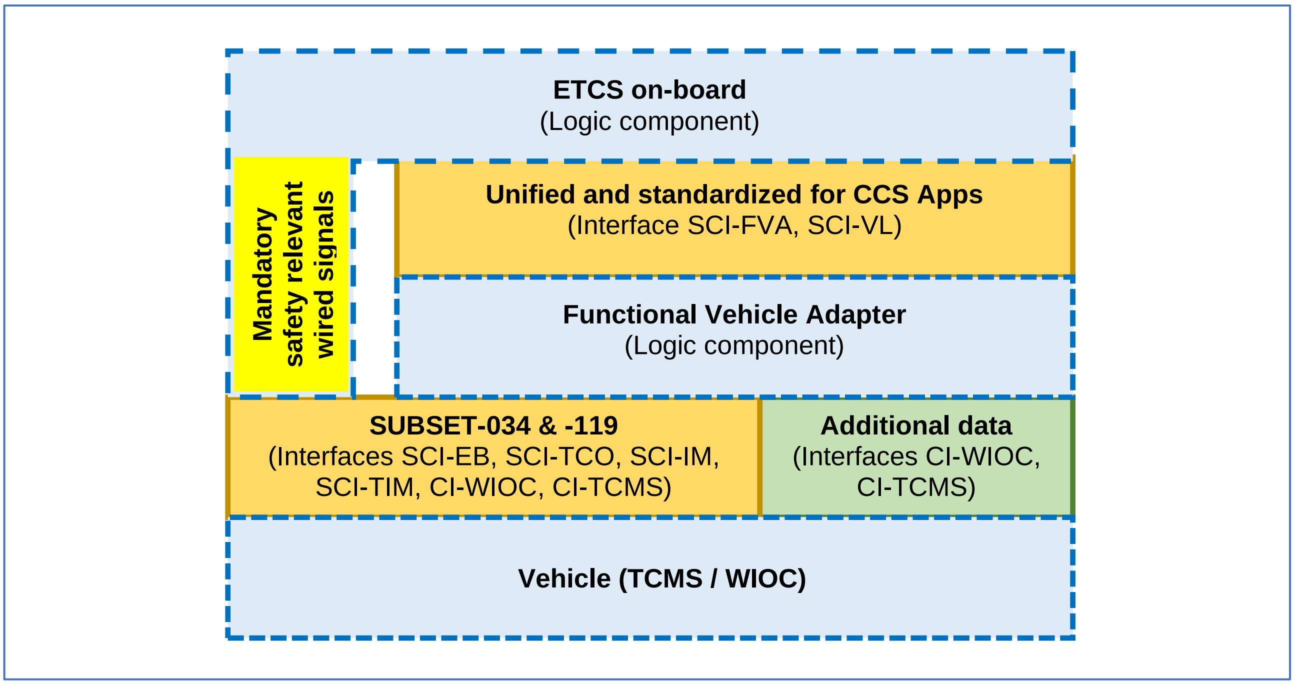

Figure 4 Integration concept of FVA with ETCS on-board for multiple vehicle sub-systems

The system boundary between the different sub-systems (TCMS and WIOC) needs to be adjusted depending on the functional scope and the specific situation. One extreme case is shown in chapter 5.1.1 where the vehicle TCMS provides the full functional range. Another extreme case is when no vehicle TCMS is available and the whole functional range is provided by the vehicle WIOC sub-system.

The development and definition of the vehicle TCMS is outside the scope of the OCORA initiative and will therefore not be further described in any document.

6 ATO Vehicle application: FVA integration concept

This chapter describes the concept how the Functional Vehicle Adapter shall be integrated with the vehicle (e.g. TCMS) and the "ATO Vehicle" application. In this context the latter is being regarded as the ATO application providing functionality for grade of automation up to 2, the grades of automation 3 and 4 are not considered yet.

The following picture displays the general functional integration concept of the business logics 'ATO-Vehicle' with the Functional Vehicle Adapter and the actor vehicle (e.g. TCMS) showing the different interfaces among them:

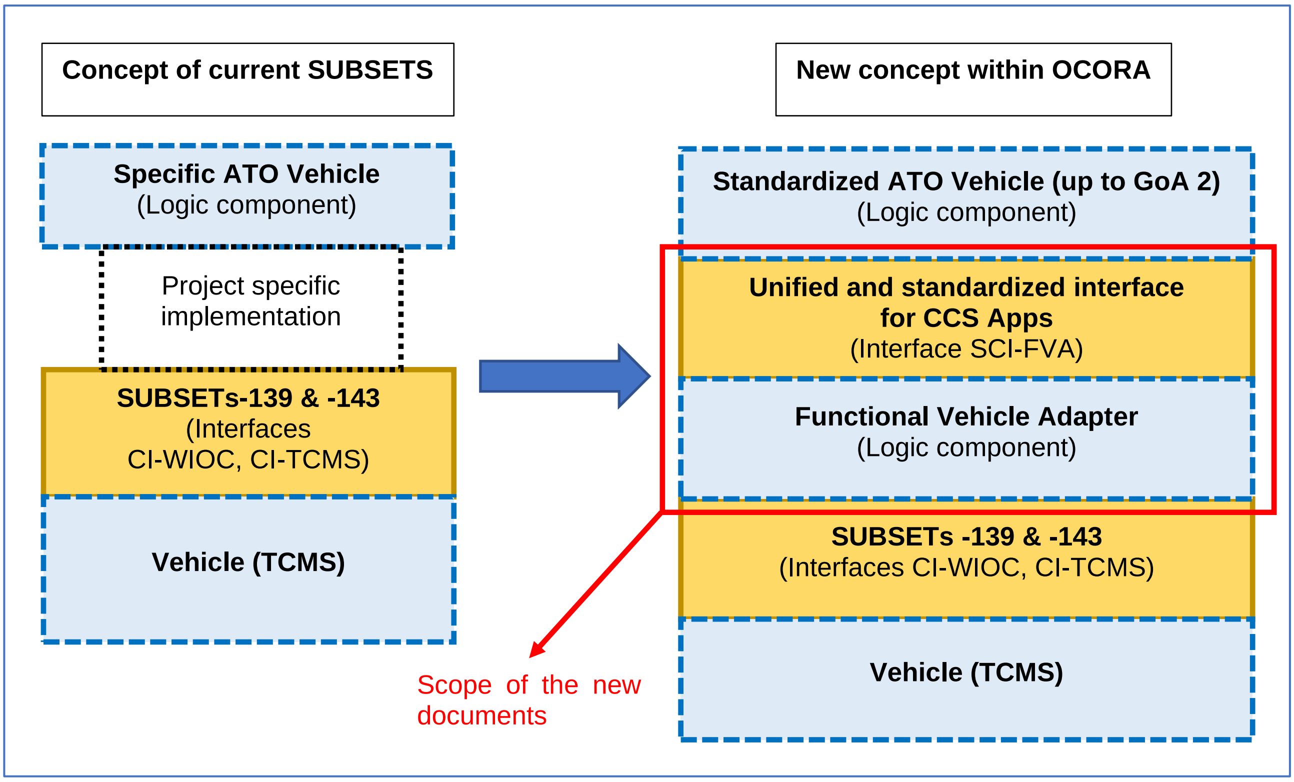

Figure 5 General integration concept of FVA with ATO Vehicle

The Functional Vehicle Adapter provides the "Unified and standardized interface for CCS Apps" to the CCS application "ATO Vehicle". This interface shall remain the same independently of the vehicle type allowing the portability of the "ATO Vehicle" application[1]. The interface is described in detail in the document [13].

The Functional Vehicle Adapter implements a logic that maps the data from the interface to the "ATO Vehicle" application to the interface with the vehicle (TCMS) as defined in SUBSETs -139 and -143. The mapping shall be handled as far as possible through parametrization and is described in detail in the document [14].

Physically the interface to the vehicle (TCMS) as defined in SUBSETs -139 and -143 is implemented by using the components "OCORA Gateway" and "I/O Ports".

6.1 Implementation variants

The following subchapters describe possible employment variants of the general implementation concept since the interface specification SUBSETs -139 and -143 do not cover all aspects. Moreover, different vehicles are equipped with different TCMS architectures and implementations requiring a modified implementation.

[1] Currently the «ATO Vehicle» application is regarded as the ATO over ETCS application. However, OCORA in future wants the "ATO Vehicle" application to evolve independently from ETCS.

Note: the list of variants described in this document is not exclusive and shall be regarded as implementation options. It is for instance thinkable to implement a combination of the variants described in this document.

6.1.1 Vehicle handling additional data than defined in SUBSET-139 & -143

This chapter describes the implementation concept in case the vehicle side can handle additional aspects than those defined in the SUBSETs -139 and -143.

The following picture displays the functional integration concept of the business logics "ATO Vehicle" with the FVA and the actor vehicle in case the TCMS is capable to handle additional data than defined in the SUBSETs -139 and -143:

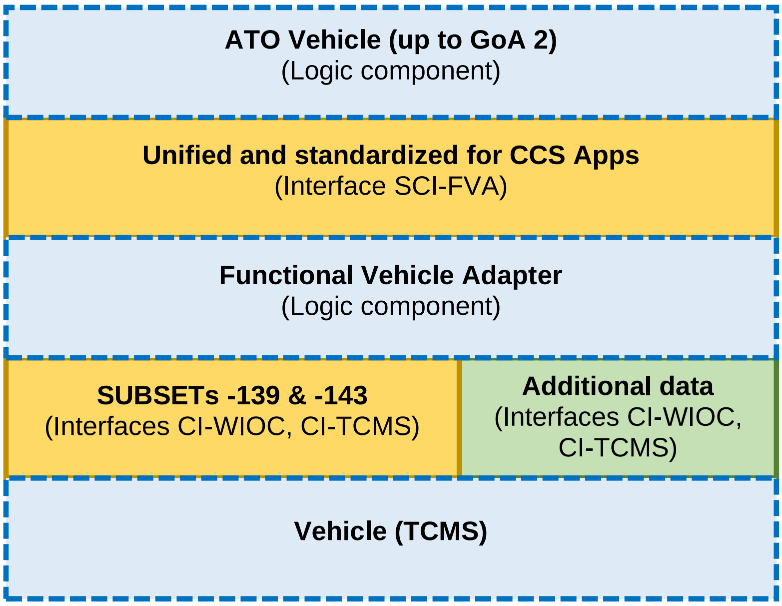

Figure 6 Integration concept of FVA with ATO for additional data

The Functional Vehicle Adapter presents to the vehicle (TCMS) the "Additional data" interface that covers more data than defined in the SUBSETs -139 and -143. The interface is described in detail in the Design Guideline document [14] that also includes the detailed implementation logic for the Functional Vehicle Adapter.

It is possible that the vehicle requires more than one interface to the Functional Vehicle Adapter from more than one independent sub-system in order to provide the full functional range, this is described in chapter 6.1.2 of this document. Typically, this is used for retrofitting purposes where TCMS only provides limited functionality or is not present at all.

6.1.2 Functional Vehicle Adapter in the context of ATO and retrofitting purpose

Depending on the TCMS architecture and implementation a specific vehicle is equipped with, it might be possible that the interface provided by the vehicle TCMS only partially covers SUBSETs -139 and -143. Therefore, it becomes necessary or favourable introducing an independent sub-system complementing the TCMS at functional level within the same vehicle. This second sub-system (or component) has been named "Wired I/O Control (WIOC)" in the System Architecture [9] and acts on the "Wired Sensors and Actors (WSA)". These two independent sub-systems (TCMS and WIOC) will also have to interface the Functional Vehicle Adapter in order to exchange data with the "ATO Vehicle" application.

The following picture displays the functional integration concept of the business logics “ATO Vehicle”, FVA and vehicle in case the vehicle consists of two independent sub-systems (TCMS and WIOC) in order to provide the full functional range:

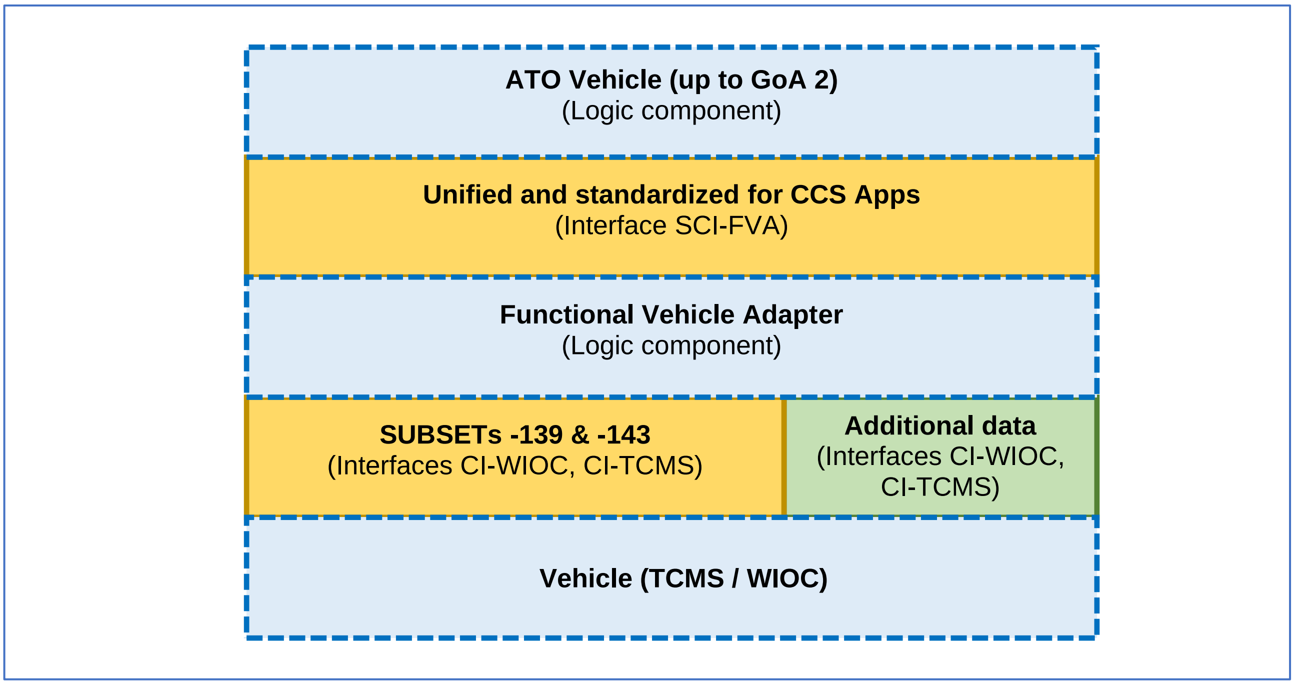

Figure 7 Integration concept of FVA with ATO Vehicle for multiple vehicle sub-systems

The system boundary between the different sub-systems (TCMS and WIOC) needs to be adjusted depending on the functional scope and the specific situation. One extreme case is shown in chapter 6.1.1 where the vehicle TCMS provides the full functional range. Another extreme case is when no vehicle TCMS is available and the whole functional range is provided by the vehicle WIOC sub-system.

The development and definition of the vehicle TCMS is outside the scope of the OCORA initiative and will therefore not be further described in any document.

7 Future activities

The OCORA initiative will continue developing the CCS on-board system. These activities will result in further stages of the OCORA architecture as described in the Introduction to OCORA [6]. The intention is to follow a stepwise approach that allows considering the various feedback and knowledge gained over the time.

One of the foreseen activities is to decompose by means of Model Based Systems Engineering (MBSE) the monolithic “ETCS on-board” system in multiple functional components with defined interfaces among them. The decomposition shall follow and challenge the structure that is envisaged by the RCA initiative [18] and [19]. The technical approach is described in more detail in the Capella Modelling [10]. The following figure provides the context diagram of the Functional Vehicle Adapter from the System Architecture [9] after modularisation:

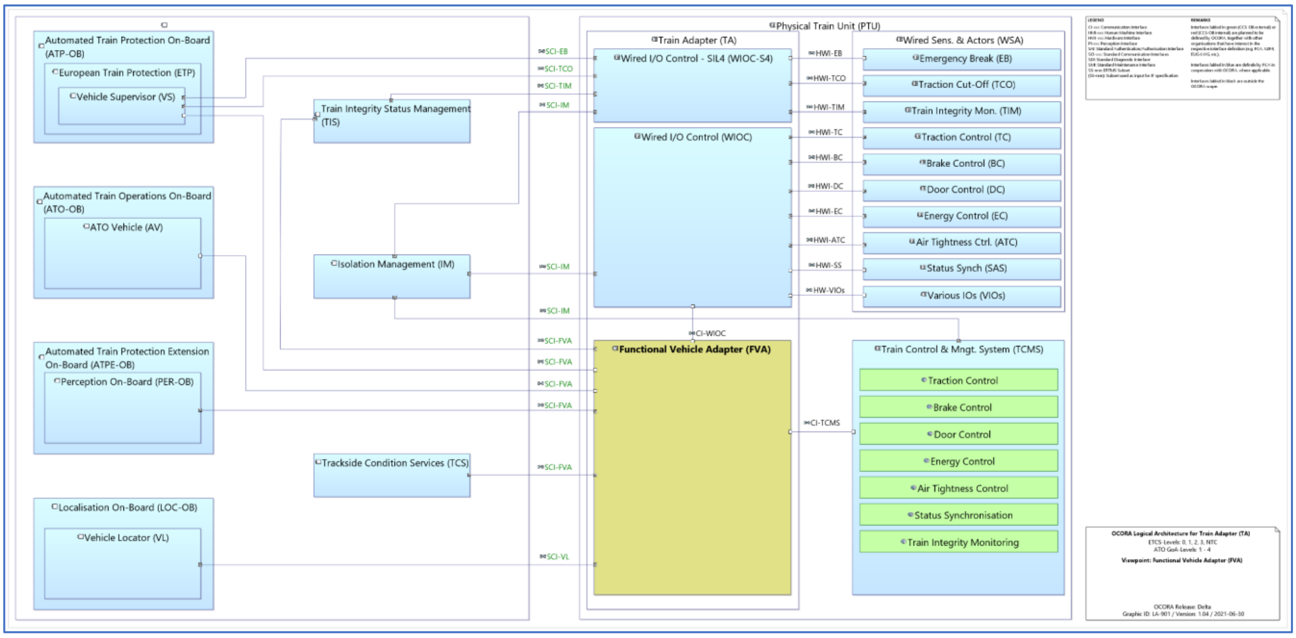

Figure 8 Functional Vehicle Adapter (FVA) context diagram – After modularisation

Another planned activity by means of Model Based Systems Engineering is to further analyse the quality of the currently available SUBSET-034, -119, -139 and -143 documents describing the interfaces between CCS on-board applications and vehicle (TCMS). Based on the outcome results it will then be decided if modification proposals for subsequent releases of the documents shall be elaborated. The MBSE model will also be used to generate test cases and specifications in order to ensure compatibility with the model. The scope is to provide a validation base for the deliverables from the different suppliers.

Finally, it has to be noted that the interfaces SCI-FVA, as defined in [13], and SCI-VL might change. These interfaces currently describe the data exchange by means of packets. Depending on the final protocol adopted in the CCN (for further details see [11]) for data exchange between the CCS on-board components it is possible that a different than the packet-based approach will be defined.

Beside the already mentioned activities for subsequent versions of the OCORA documentation it has been decided that the interface between STM / NTC sub-system and the vehicle (TCMS) will not be standardized further to what is already described in SUBSET-034 and -119. The only remaining open point is the possible need to introduce an interface between Functional Vehicle Adapter and an independent national system (not integrated to ETCS on-board through STM) with the purpose to inhibit actions from the national system when the latter is not active. This with the objective to improve the reliability of the whole system (prevent unnecessary emergency brakes).