OCORA

Open CCS On-board Reference Architecture

Functional Vehicle Adapter - Introduction & Overview

Gamma Release

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Revision history

Version	Change Description	Name (Initials)	Date of change
0.02	First draft.	CG	2020-06-16
0.11	Review input from SNCF and DB incorporated.	CG	2020-06-26
1.00	Review input from SNCF and DB incorporated.	CG	2020-06-30
2.00	Updated for the Gamma release: • Some adaptations required for Gamma Release. • Updated Figure 1 and Figure 8. • Small text corrections in chapter 6.	CG	2020-12-04

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Table of figures

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No tables are used within this document.

References

The following references are used in this document:

[1] OCORA-10-001-Gamma – Release Notes

[2] OCORA-10-003-Gamma – Feedback Form

[3] OCORA-20-002-Gamma – Program Slide Deck

[4] OCORA-20-003-Gamma – Technical Slide Deck

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

[6] OCORA-30-005-Gamma – Alliances

[7] OCORA-30-006-Gamma – High Level Methodology

[8] OCORA-40-001-Gamma – System Architecture

[9] OCORA-40-002-Gamma – System Architecture – Capella Model

[10] OCORA-40-003-Gamma – UVCC Bus Specification

[11] OCORA-40-006-Gamma – CCS-TCMS Interface – ETCS Functionality (SS034 & SS119)

[12] OCORA-40-007-Gamma – CCS-TCMS Interface – ATO Functionality (SS139 & SS143)

[13] OCORA-90-002-Gamma – Glossary

[14] 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

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

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

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

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

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

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

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

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

Wherever a reference to a TSI-CCS [14] SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). We always reference to the latest available official version of the SUBSET, unless indicated differently.

1 Introduction

1.1 Document context and purpose

This document is published as part of the OCORA Gamma 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.

The document focusses on technical aspects of the architecture, the content regarding the OCORA program is to be found in the documents [5] and [6]. Subsequent releases of this document (Release 1, etc.) and topic specific documentation will be developed in a modular and iterative approach, evolving within the progress of the OCORA collaboration.

This document aims to provide 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 documents describing the CCS on-board to TCMS integration for the ETCS [11] and the ATO [12] functionalities.

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 specifications [11] and [12] are focussed on the current state delivering amendments for closing gaps of the SUBSETs -034, -119, -139 [15] and -143 [16].

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

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA technical concepts for on-board CCS. The reader will gain insights regarding the topics listed in chapter 1.1, will be able to provide feedback to the authors and can, therefore, engage in shaping OCORA. For any kind of feedback, the use of the official Feedback Form [2] is appreciated.

Before reading this document, it is recommended to read the Release Notes [1], the System Architecture [8] and the Introduction to OCORA [5]. The reader should also be aware of the Glossary [13].

1.3 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 TCMS interface

The interface from CCS on-board to 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 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 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.

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 a lot of room to the designer of the CCS on-board to TCMS interface to make his own interpretations. With this introductory document and the specifications [11] and [12], the intention is to provide precise guidance for the integration of the CCS on-board into the TCMS, considering the various TCMS settings in existing and future fleets.

This introductory document and the specifications [11] and [12] 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 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 while defining, as far as possible, a standardized interface for the CCS on-board applications. The latter also enabling the use of standardized test specifications.

This introductory document and the specifications [11] and [12] 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 [11] and [12] 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.) and to TCMS are standardized. The latter ensures a certain degree of plug and play functionality, 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 [19] to [22] this includes the consideration of SUBSET-088 and 091.

3 Description of the Functional Vehicle Adapter

The Functional Vehicle Adapter (FVA) is a software function 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 OCORA on-board applications and services. Although the TSI-CCS SUBSET-034, -119, -139 and -143 are defining the interface to the TCMS system, vehicle from different suppliers and especially from different generations have still different interfaces implemented. This adapter allows to map, on a functional level, the commands sent, and the information received from a specific TCMS into the OCORA standard. This includes

[1] The OSI layers are defined as indicated in figure 2 of document [7].

that the FVA can likewise be used to integrate vehicles through wired connections. Also, the standardized interface to the CCS 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 [8] 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 5. 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 specification documents [11] and [12] 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:

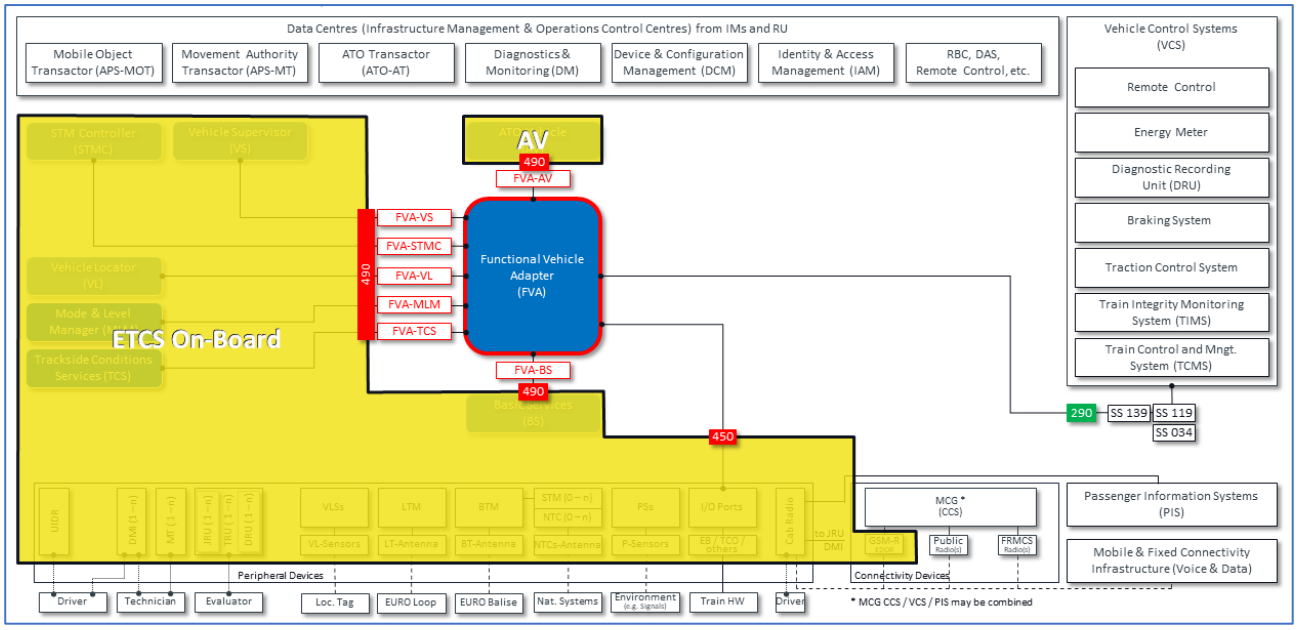

Figure 1 Functional Vehicle Adapter (FVA) context diagram – Initial Stage

Based on this, the Functional Vehicle Adapter as described in this version of the document, provides one interface to the "ETCS on-board" application that in the context diagram is displayed with the six interfaces "FVA-VS", "FVA-STMC", "FVA-VL", "FVA-MLM", "FVA-TCS" and "FVA-BS". The concept for this integration is described in chapter 4.

The Functional Vehicle Adapter also integrates the "FVA-AV" interface to the ATO Vehicle (AV) application, this integration concept is described in chapter 0.

In the OCORA architecture the "ETCS on-board" system is modularised and decomposed into multiple components. Some of these components are applications where each is having its own interface to the Functional Vehicle Adapter as demonstrated in the Figure 1. Having standardized these interfaces ensures portability of the CCS on-board applications between different vehicle types and TCMS architectures.

4 ETCS on-board application: FVA integration concept

This chapter describes the concept how the Functional Vehicle Adapter shall be integrated with the 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”, FVA and TCMS showing the different interfaces among them:

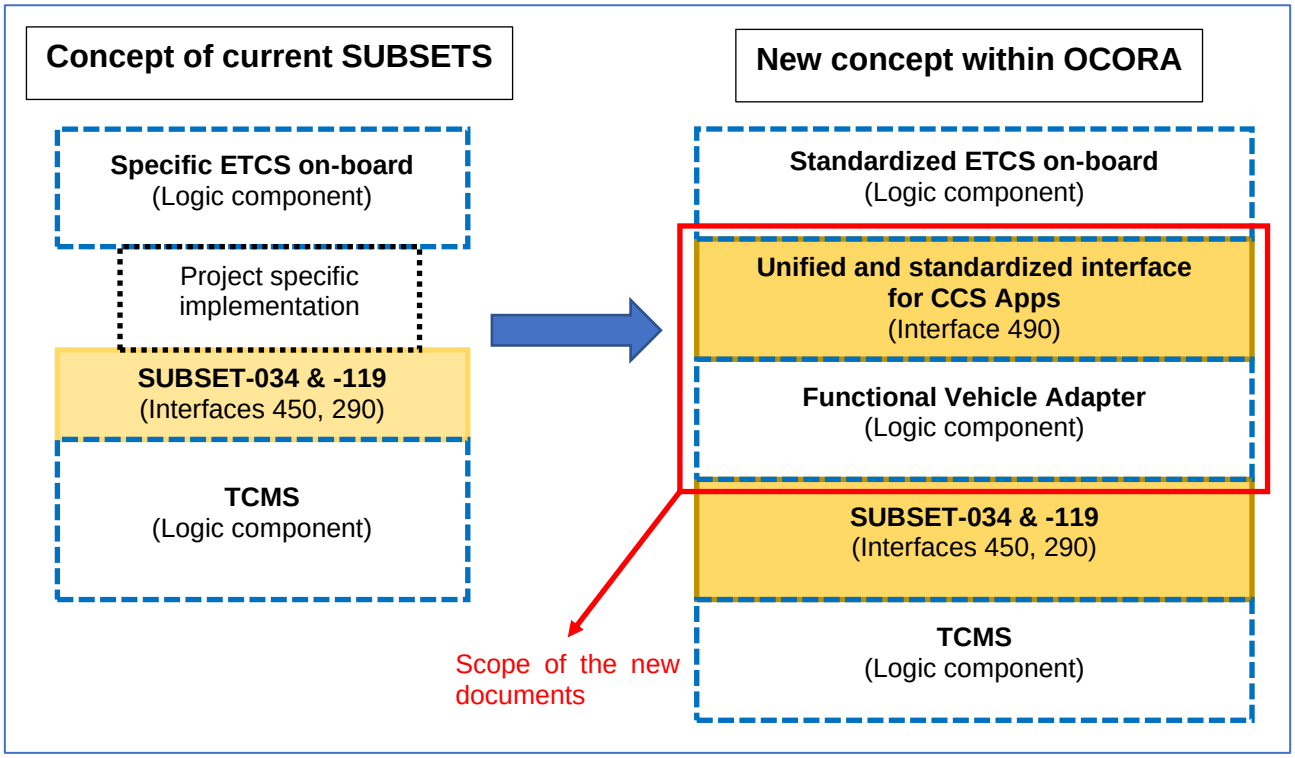

Figure 2 General integration concept of Functional Vehicle Adapter with ETCS on-board

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 is described in detail in the document [11] chapter 5.

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 TCMS (vehicle) as defined in SUBSETs -034 and -119. The mapping shall be handled as far as possible through parametrization and is described in detail in the document [11] chapter 7.

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

4.1 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.

[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» and «Trackside Conditions Service» that are described in the OCORA System Architecture [8].

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.

4.1.1 TCMS handling additional data than defined in SUBSET-034 & -119

This chapter describes the implementation concept in case the vehicle 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”, FVA and TCMS in case the TCMS is capable to handle additional data than defined in the SUBSET-034 and -119:

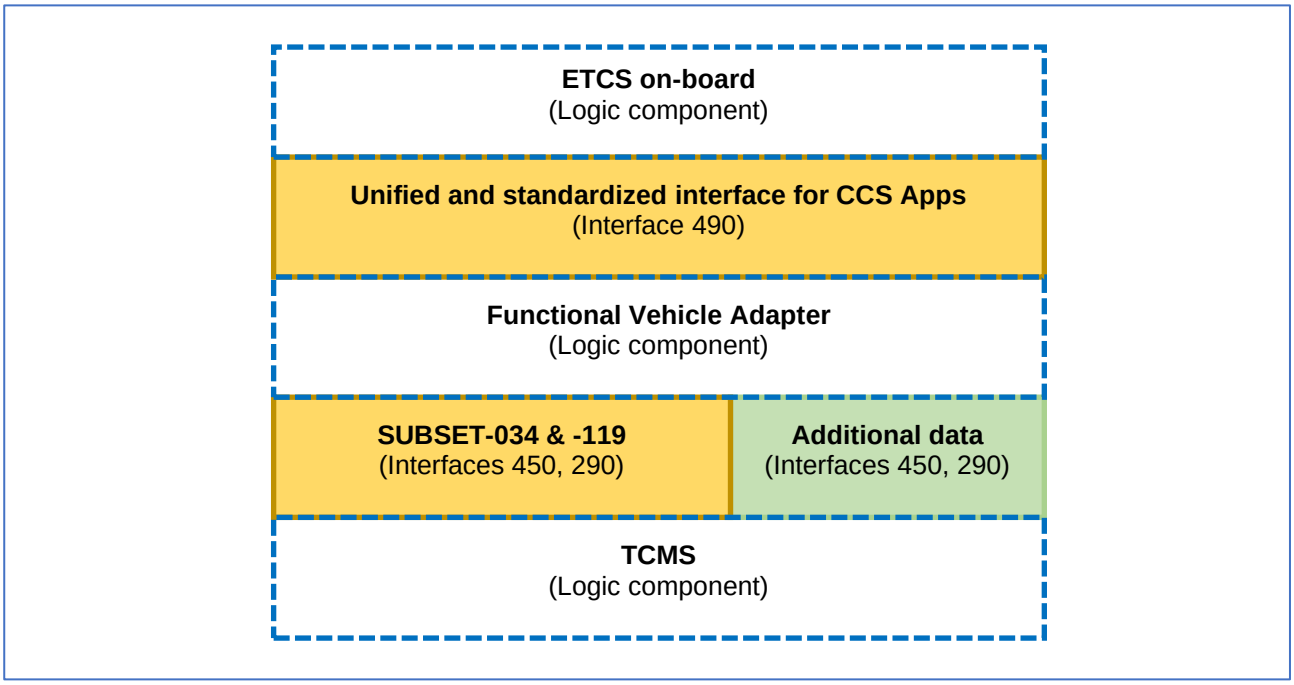

Figure 3 Integration concept of Functional Vehicle Adapter with ETCS for additional data

The Functional Vehicle Adapter presents to the TCMS an interface that covers more data than defined in the SUBSET-034 and -119.The interface is described in detail in the document [11] chapter 6.

The implementation logic for the Functional Vehicle Adapter is described in detail in the document [11] chapter 7.

It is possible to implement the TCMS with two independent systems in order to provide the full functional range, this is described in chapter 4.1.2 of this document.

4.1.2 TCMS being complemented with a TCMS extension in the vehicle

Depending on the TCMS architecture and implementation a specific vehicle is equipped with, it might be possible that the main TCMS only partially covers SUBSETs -034 and -119. Therefore, it becomes necessary or favourable introducing an independent system complementing the main TCMS at functional level within the same vehicle. These two independent systems 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 TCMS in case the TCMS consists of two independent systems in order to provide the full functional range:

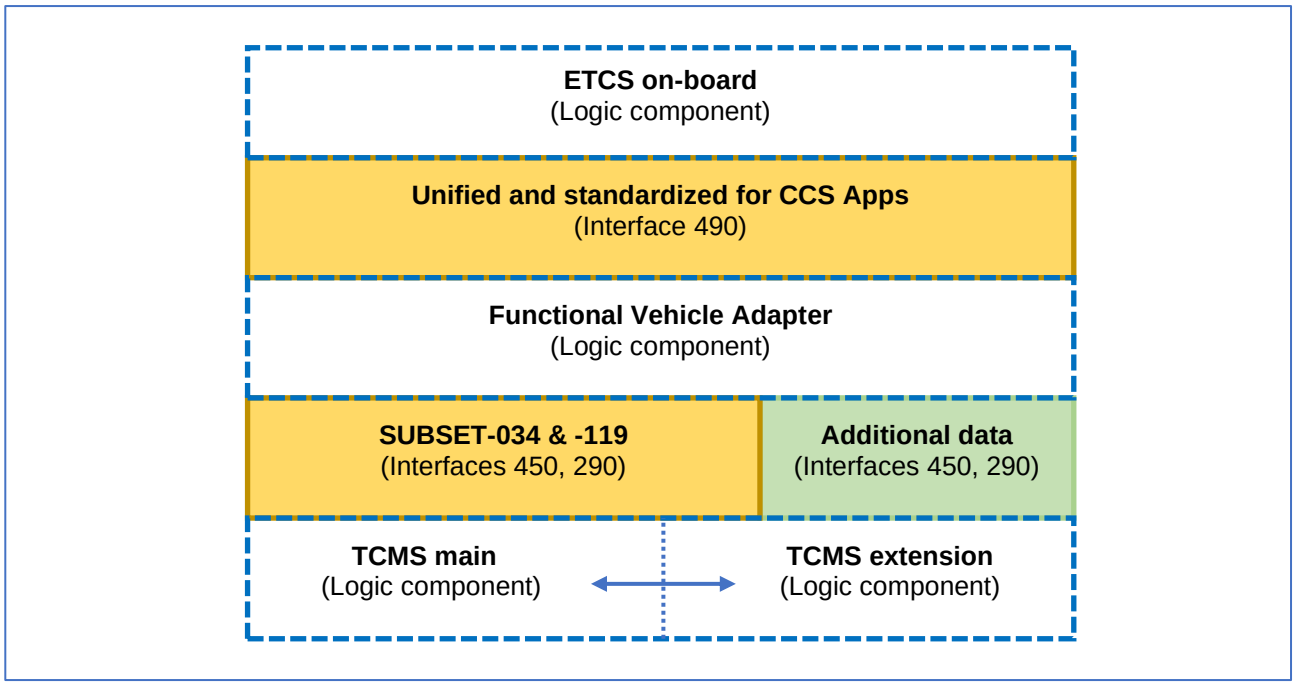

Figure 4 Integration concept of Functional Vehicle Adapter with ETCS for multiple TCMS

The system boundary between the different TCMSs has to be adjusted depending on the functional scope and the specific situation. One extreme case is shown in chapter 4.1.1 where the main TCMS provides the full functional range. Another extreme case is when the whole functional range is equally split into more than one TCMS sub-systems.

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

5 ATO Vehicle application: FVA integration concept

This chapter describes the concept how the Functional Vehicle Adapter shall be integrated with the TCMS and the “ATO Vehicle” application.

The following picture displays the general functional integration concept of the business logics ‘ATO-Vehicle’, FVA and TCMS showing the different interfaces among them:

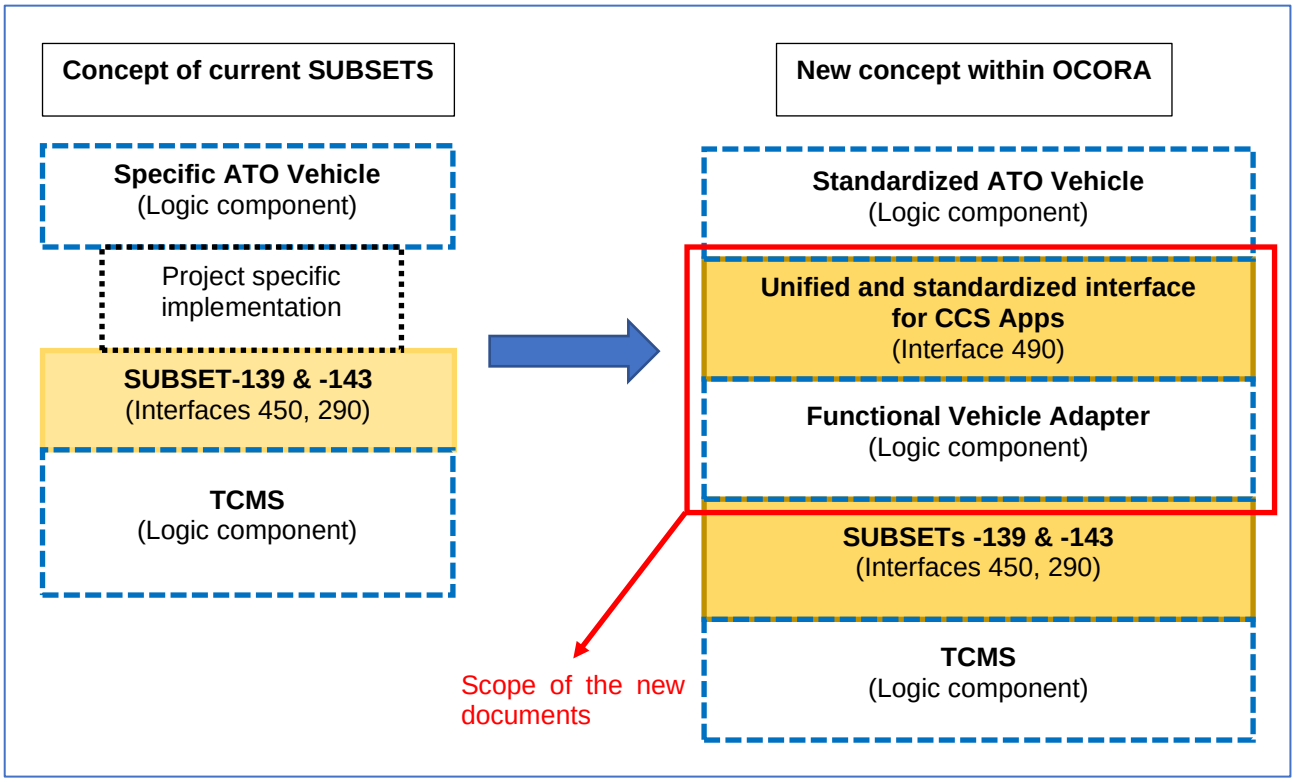

Figure 5 General integration concept of Functional Vehicle Adapter with ATO Vehicle

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 [12] chapter 5.

The Functional Vehicle Adapter implements a logic that maps the data from the interface to the “ATO Vehicle” application to the interface with the TCMS (vehicle) 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 [12] chapter 6.

Technically the interface to the TCMS as defined in SUBSETs -139 and -143 is implemented by using the components “OCORA Gateway” and “I/O Ports”.

5.1 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.

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.

[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.

5.1.1 TCMS handling additional data than defined in SUBSETs -139 and -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”, FVA and TCMS in case the TCMS is capable to handle additional data than defined in the SUBSETs -139 and -143:

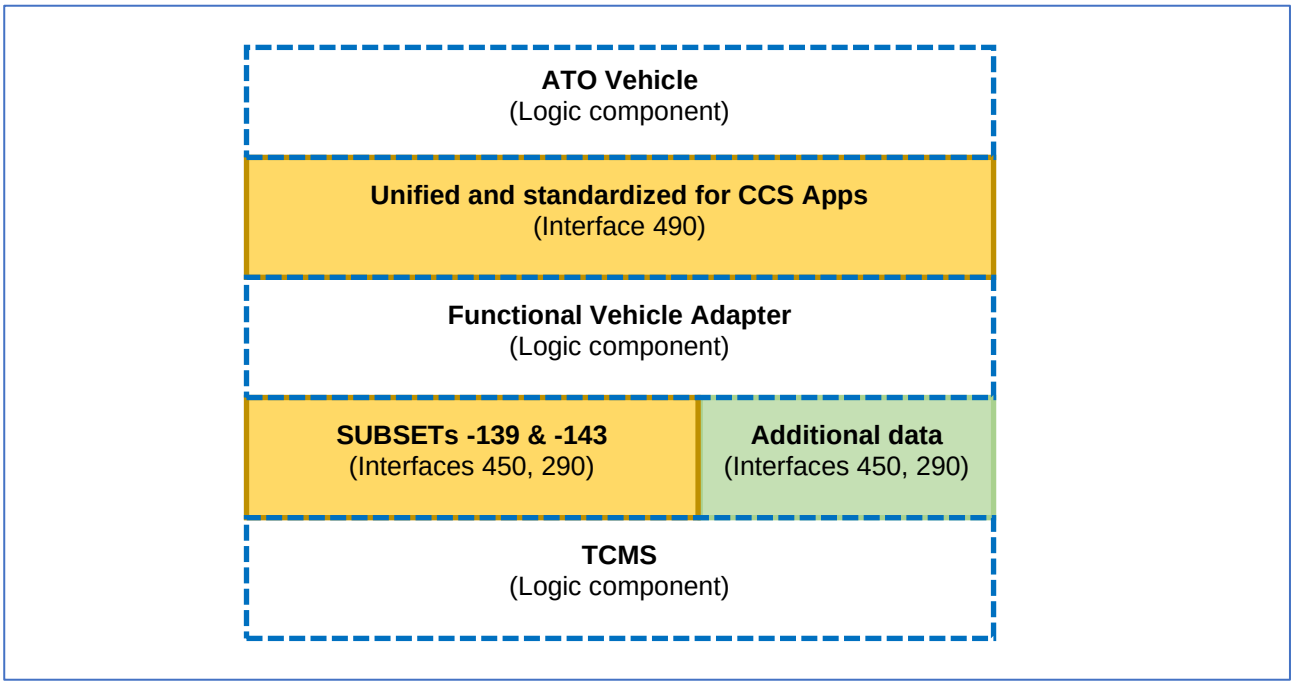

Figure 6 Integration concept of Functional Vehicle Adapter with ATO for additional data

The Functional Vehicle Adapter presents to the 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 document [12] chapter 7.

The implementation logic for the Functional Vehicle Adapter is described in detail in the document [12] chapter 6.

It is possible to implement the TCMS with two independent systems in order to provide the full functional range, this is described in chapter 5.1.2 of this document.

5.1.2 TCMS being complemented with a TCMS extension in the vehicle

Depending on the TCMS architecture and implementation a specific vehicle is equipped with, it might be possible that the main TCMS only partially covers SUBSETs -139 and -143. Therefore, it becomes necessary or favourable introducing an independent system complementing the main TCMS at functional level within the same vehicle. These two independent systems 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 TCMS in case the TCMS consists of two independent systems in order to provide the full functional range:

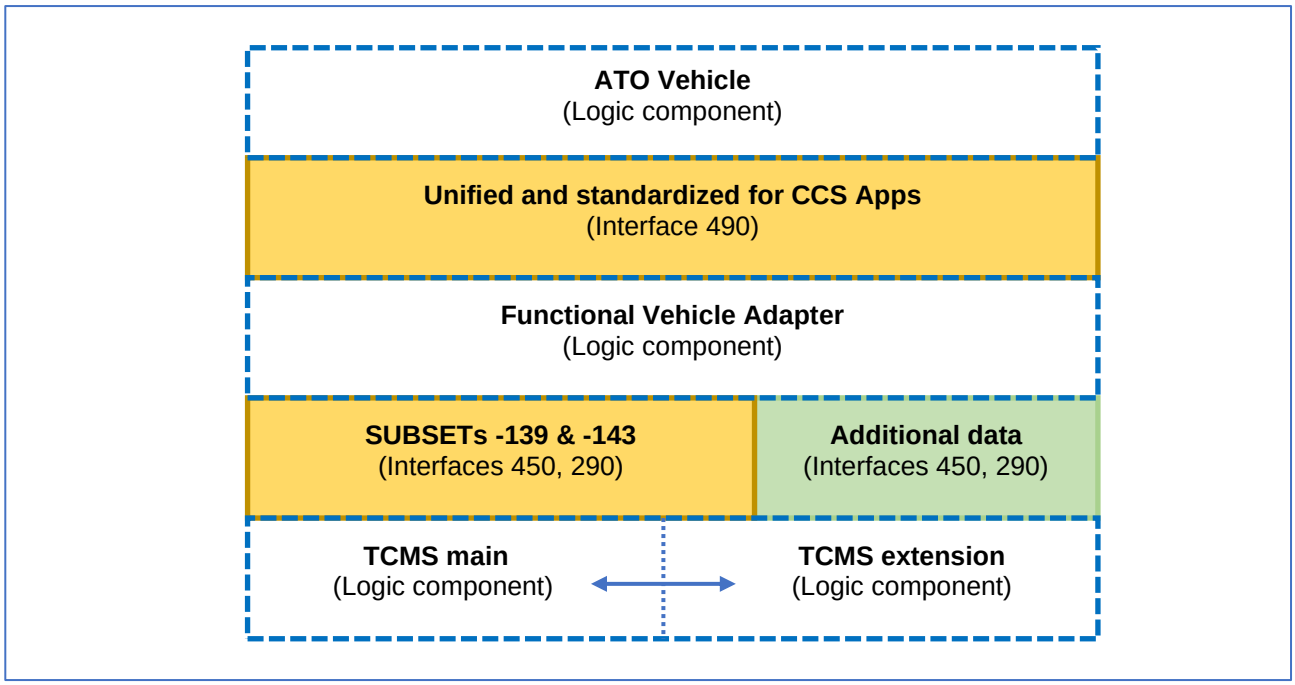

Figure 7 Integration concept of Functional Vehicle Adapter with ATO for complemented TCMS

The system boundary between the different TCMSs has to be adjusted depending on the functional scope and the specific situation. One extreme case is shown in chapter 5.1.1 where the main TCMS provides the full functional range. Another extreme case is when the whole functional range is equally split into more than one TCMS sub-systems.

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

6 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 document 5. 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 [17] and [18]. The technical approach is described in more detail in [9]. The following figure provides the context diagram of the Functional Vehicle Adapter from the document [8] after modularisation:

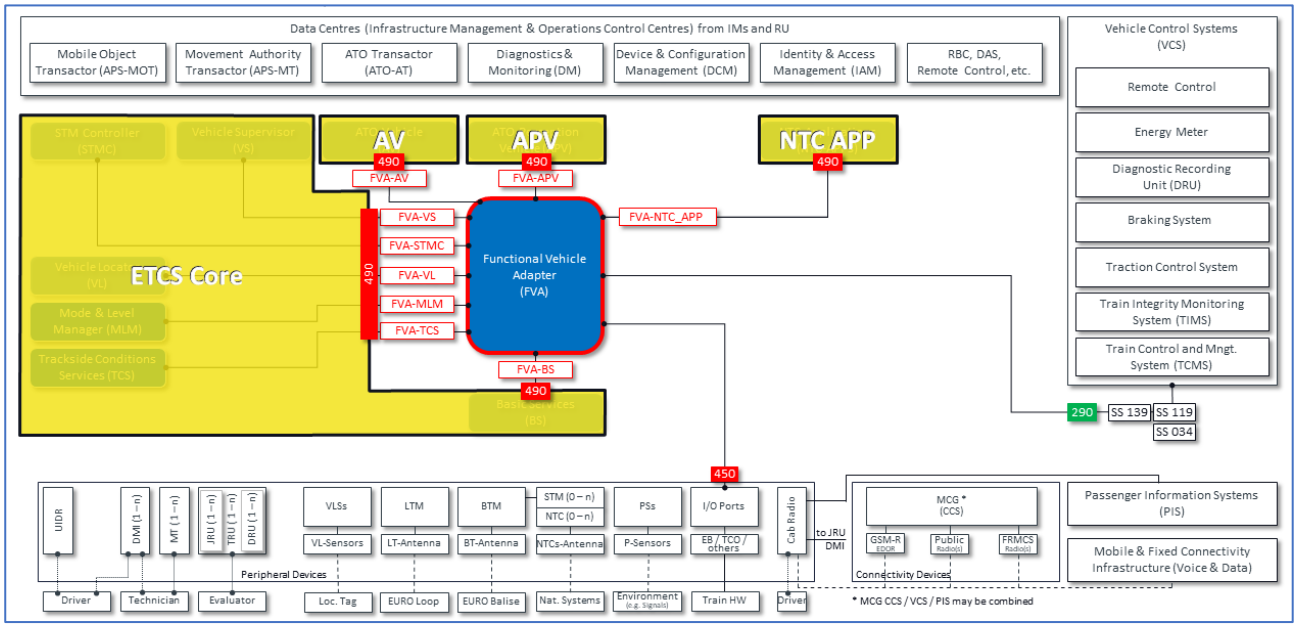

Figure 8 Functional Vehicle Adapter (FVA) context diagram – After modularisation

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 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 FVA-STMC, FVA-VS, FVA-VL, FVA-MLM, FVA-TCS, FVA-BS and FVA-AV as defined in [11] and [12] might change. These interfaces currently describe the data exchange by means of packets. Depending on the final protocol adopted in the UVCCB (for further details see [10]) 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 to be decided if the interface between STM / NTC sub-system and the TCMS will be standardized. This work may also consider track condition and emergency brake handling during transitions while driving.