



INTERNATIONAL UNION  
OF RAILWAYS

# **On-Board FRMCS Functional Requirements Specification**

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|---------------------|--|
| <b>Source:</b>      | <b>UIC FMS Telecom On-Board<br/>Architecture Workgroup</b> |
| <b>Date:</b>        | <b>14 of February 2023</b>                                 |
| <b>Reference:</b>   | <b>TOBA-7510</b>   |
| <b>Version:</b>     | <b>1.0.0</b>   |
| <b>No of pages:</b> | <b>40</b>  |

ISBN 978-2-7461-2896-5

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## Document history

| Version | Date     | Details  |
|---------|----------|--|
| 0.0.1   | 22.01.19 | Creation of the document   |
| 0.0.2   | 27.02.19 | Result of TOBA Meeting#2   |
| 0.0.3   | 06.03.19 | Added conclusions from TOBA Meeting #2 to the chapters Fundamental Principles, Scope (System Definition), Functional Architecture and Architecture Migration |
| 0.0.4   | 22.03.19 | Result of TOBA Meeting #3  |
| 0.0.5   | 22.05.19 | Result of TOBA Meeting #4  |
| 0.0.6   | 19.06.19 | Result of TOBA Meeting #5  |
| 0.0.7   | 11.09.19 | Result of TOBA Meeting #6  |
| 0.0.8   | 23.10.19 | Result of TOBA Meeting #7  |
| 0.0.9   | 14.11.19 | Result of TOBA Meeting #8  |
| 0.0.10  | 07.01.20 | Result of TOBA Meeting #9  |
| 0.1.0   | 07.01.20 | Version for review within the FRMCS project  |
| 0.2.0   | 14.04.20 | Version after processing the review comments from the FRMCS project.<br>Version for UIC external review  |
| 0.2.1   | 14.04.20 | TOBA WG working version  |
| 0.2.2   | 19.05.20 | Result of TOBA Meeting #12, processing ext. review comments  |
| 0.2.3   | 10.06.20 | Result of TOBA Meeting #12-2 processing ext. review comments   |
| 0.2.4   | 17.06.20 | Result of TOBA Meeting #13 processing ext. review comments   |
| 1.0.0   | 18.06.20 | Published Version by UIC   |
| 1.0.1   | 17.02.21 | Result of TOBA FRS 7510/MG-7904 alignment ad-hoc meetings #1, #2 & #3  |
| 1.0.2   | 05.03.21 | Result of TOBA FRS 7510/MG-7904 alignment ad-hoc meetings #4 & #5  |
| 1.0.3   | 23.03.21 | Result of TOBA FRS 7510/MG-7904 alignment ad-hoc meetings #6 to #9   |
| 1.0.4   | 30.03.21 | Editorial review changes   |
| 1.0.5   | 21.04.21 | Review changes   |
| 1.0.6   | 27.04.21 | Review changes   |
| 1.0.7   | 28.04.21 | Review changes   |
| 1.0.8   | 29.04.21 | Review changes after discussion in AT WG plenary Meeting #49 Day 1   |
| 1.0.9   | 30.04.21 | Review changes after discussion with IWE   |
| 1.0.10  | 30.04.21 | Review changes   |

| Version  | Date       | Details   |
|----------|------------|---|
| 1.0.11   | 30.04.21   | Sent for information to S2R Consortium                                    |
| 1.0.12   | 21.05.21   | UIC internal review phase closed  |
| 1.0.14r5 | 04.11.21   | Document updated following the S2R Consortium review                      |
| 1.0.14r6 | 05.11.21   | Document categorized  |
| 1.0.15   | 08.11.21   | UIC final draft for S2R Consortium review approval as stable draft        |
| 1.0.16   | 09.12.2021 | Review changes  |
| 1.0.17   | 21.01.2022 | Changes after Consortium Workshop   |
| 1.0.18   | 19.05.2022 | Changes after EECT review   |
| 1.0.19   | 29.06.2022 | Changes after EECT review #2  |
| 1.0.20   | 29.07.2022 | Changes after EECT review #3  |
| 1.0.21   | 29.07.2022 | R==> M; M==> M and O UIC categorization                                   |
| 1.0.22   | 16.09.2022 | Changes after EECT review #4  |
| 1.0.23   | 30.09.2022 | Changes after EECT review #5 (Final EECT-endorsed version)                |
| 1.0.0    | 14.02.2023 | Restarted version numbering from 1.0.0 for TSI inclusion<br>Added Annex A |

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## 1 List of abbreviations

|                   |   |
|-------------------|---|
| 3GPP              | 3rd Generation Partnership Project                                    |
| 4G                | Fourth Generation technology standard for broadband cellular networks |
| 5G                | Fifth Generation technology standard for broadband cellular networks  |
| API               | Application Programming Interface                                     |
| ATO               | Automatic Train Operation (i.e. [Semi]-driverless operation)          |
| CCTV              | Closed Circuit Television   |
| CS / PS           | Circuit Switch / Packet Switch  |
| CP                | Control Plane   |
| DSD               | Driver Safety Device  |
| ED                | End Device  |
| ERTMS             | European Rail Traffic Management System                               |
| ETCS              | European Train Control System   |
| EUG               | ERTMS Users Group   |
| FCAPS             | Fault, Configuration, Accounting, Performance and Security            |
| FFS               | For Further Study   |
| FRMCS             | Future Railway Mobile Communication System                            |
| FW                | Firmware  |
| GSM               | Global System for Mobile Communications                               |
| GSM-R             | Global System for Mobile Communications – Railway                     |
| GW                | Gateway   |
| HMI               | Human-Machine Interface   |
| HW                | Hardware  |
| IAM               | Identity and Access Management  |
| IEC               | International Electrotechnical Commission                             |
| IEEE              | Institute of Electrical and Electronics Engineers                     |
| IM                | Infrastructure Manager  |
| IP                | Internet Protocol   |
| KPI               | Key Performance Indicator   |
| MCG               | Mobile Communication Gateway  |
| MCX               | 3GPP Mission Critical Services  |
| MNO               | Mobile Network Operator   |
| MOTS              | Modified Off The Shelf  |
| OB <sub>ANT</sub> | On-Board Antenna system reference point/interface                     |
| OB <sub>APP</sub> | On-Board Application reference point/interface                        |

|                   |  |
|-------------------|--|
| OB <sub>OM</sub>  | On-Board Operation & Maintenance reference point/interface |
| OB <sub>RAD</sub> | On-Board Radio Module reference point/interface            |
| O&M               | Operations & Maintenance                                   |
| OTA               | Over-The-Air   |
| PA                | Public Announcement  |
| PLMN              | Public Land Mobile Network                                 |
| QoS               | Quality of Service   |
| RAN               | Radio Access Network                                       |
| RBC               | Radio Block Centre   |
| RF                | Radio Frequency  |
| RU                | Railway Undertaking  |
| SRS               | System Requirement Specification                           |
| SW                | Software   |
| TCMS              | Train Control and Management System                        |
| TCN               | Train Communication Network                                |
| TOBA              | Telecom On-Board Architecture                              |
| TSI               | Technical Specification for Interoperability               |
| TSI CCS           | Control Command and Signalling TSI                         |
| UIC               | Union Internationale des Chemins de Fer                    |
| UE                | User Equipment   |
| UP                | User Plane   |
| URS               | User Requirements Specification                            |
| WG                | (UIC) Work Group   |



## 2 List of definitions

### Administrative Domain

A collection of resources and/or services owned and operated by a single administrative organization (e.g. a PLMN).

### Application

Provides a solution for a specific communication need that is necessary for railway operations. In the context of this document, an application is interfacing with the On-Board FRMCS through the OB<sub>APP</sub> reference point, to receive and transmit information to ground systems, (for example, ETCS, train voice radio, DSD, CCTV, passenger announcements, etc.). List of defined applications is available at [FRMCS URS].

### Auxiliary Function

This function is the instantaneous collector of certain status information to be provided as feedback to the Application on the status of the Onboard System (e.g. Transport status).

### Communication services

Communication services enable two-way communication between two or more authorised service users (i.e. applications) from applications towards other applications/entities reachable through various networks. Communication services encompass both Service and Transport strata.

### Control plane

The control plane carries signalling traffic between the network entities. Control plane and user plane are to be considered independently of one another and can accordingly be managed separately between entities.

### Corrective Maintenance

Corrective maintenance is a maintenance task performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the tolerances or limits established for in-service operations.

### Data communication

Exchange of information in the form of data.

Note: Specific communication types that in other contexts are defined as data communications such as Video and Voice are considered as separate communication types in the context of FRMCS.

### Domain

The highest-level group of functional entities (e.g., FRMCS is a domain, whereas PLMNs operated by different operators are administrative domains).

#### Driver

A person capable and authorised to drive trains, including locomotives, shunting locomotives, work trains, maintenance railway vehicles or trains for the carriage of passengers or goods by rail in an autonomous, responsible and safe manner

#### Driver safety device

An on-train system that monitors the alertness of the driver and provides warnings, alarms and action to other systems as appropriate.

#### Emergency operation

The operational state of the railway when a current unforeseen or unplanned event has occurred which has life threatening or extreme loss implication and which requires immediate attention

#### European Railway Agency

The agency for railway safety and interoperability established by Regulation (EC) No 881/2004 of the European Parliament and the Council of 29th April 2004 establishing a European Railway Agency.

#### External system

A back-office type of system connected to the FRMCS system, such as traffic management systems, tracking systems, planning systems, weather report system, etc.

#### FRMCS gateway functions

FRMCS Gateway Functions encompasses Orchestration Function, Transport Gateway Function, Auxiliary Function, Local Binding

#### FRMCS Radio Module

An FRMCS Radio Module ensures wireless transport between train and ground with one or more 3GPP or/and non-3GPP radio access technologies supported by the FRMCS system.

#### FRMCS Service Session Function

Processes the communication parameters (e.g. Identity, CODEC parameters) received from the Application stratum via corresponding reference point OB<sub>APP</sub>.

#### Functional identity

A description of the function performed by a called or calling party. The functional identity can include characters and numbers. This is used within the functional addressing scheme to identify an end user/system by function or identity rather than by a specific item of radio equipment or user subscription.

#### Integrated Communication Service AP

Integrated Communication Service AP provides pre-set communication parameters as integral part of the FRMCS Service Session Function.

#### Normal Operation

The state of the railway when it is fully functional and operating as planned. Normal operation also includes any maintenance activities that do not affect the ability to provide a fully functional operational railway.

#### OB<sub>APP</sub>-Aware Application

An application that is capable of using the OB<sub>APP</sub> reference point as specified

#### On-Board FRMCS

System enabling FRMCS communication to on-board applications.

#### On-net and Off-net communications

Off-network communications in the context of this document refers to the direct communications between devices (UE) without the use of the network infrastructure such as base stations, access points etc.;

On the contrary, in "on-network" the communications between devices are always established through the network.

#### Operation and Maintenance (O&M) function

Provides functions for Operation and Maintenance purposes including SW Management and Configuration Management. O&M Function may also provide Performance Metrics and Events to applications.

#### Orchestration function

The Orchestration function is generic and may encompass several sub-functions. Generally, Orchestration Functions control and monitor the communication (and in some distinct cases signalling) flows for unicast and multicast mode between the communication onboard entities and the Service Session Function(s) on the ground. Note: the communication flow refers to both unicast and multicast transmission modes

#### System Boundary

The system boundary separates on-board FRMCS system from its environment, i.e. it defines the interfaces / reference points.

#### System Context

The system context defines the part of the environment of a system, which is relevant for the definition of requirements for this system.

#### Train Consist

Single vehicle or a group of vehicles that are not separated during normal operation

#### Train Staff

Railway staff that are on-board a train but are not drivers, for example conductors, catering staff, security staff etc.

#### Transport Gateway Function

The Transport Gateway Function forms the bridge (up to OSI layer 3) between OB<sub>RAD</sub> and OB<sub>APP</sub> and ensures that CP and UP resources are allocated between the mentioned interfaces to the communication entities and bundled wireless access.

#### Transport domain

It is a set of Transport Services allocated to the same administrative domain (including for example the case of an IM's dedicated mobile network or an MNO's network).

A transport domain is uniquely identifiable, consists of access domain(s) (wireline and/or wireless) with the necessary central control (core domain), and authorizes its use (e.g., via SIM card).

#### Transport service

It is a service that provides transport of user information and control signals between corresponding reference points considering the required QoS for the individual communication. From a global perspective, the Transport Stratum provides services for both unicast and multicast transmissions for users within a transport domain and for users between different transport domains.

#### Transport stratum

It is the FRMCS stratum that provides Transport Services.

#### User

The users in the context of this document are the railway undertakings / infrastructure managers.

#### User plane

The user plane (sometimes called data plane or bearer plane), carries the user/application traffic. For the exchange of information between the communication partners (payload), the user plane provides the necessary formats in order to provide the desired quality. Voice, video and data require different formats e.g. Codec to enable communication between partners. This will be determined by the corresponding user plane instance on the application side and controlled accordingly.

## Voice communication

Exchange of information in the form of voice requiring corresponding QoS treatment, regardless of the transmission method.

## 3 Introduction

### 3.1 Background

- 3.1.1 Globally, many railway infrastructure managers and railway undertakings currently use an interoperable radio communications network, GSM-R (Global System for Mobile Communications – Rail), for operational voice communications and to provide the data bearer for ETCS (European Train Control System). In the European Union this is legally mandated in the Technical Specifications for Interoperability that are applicable in the European Member States. Voice and data communications are also used for various other applications. (I)
- 3.1.2 GSM-R is a MOTS (modified off the shelf technology) system based around manufacturers' commercial GSM (Global System for Mobile Communications) offerings, enhanced to deliver specific "R" (railway) functionality. Due to the product modifications required to provide "R" functionality, and the need to utilise dedicated non-commercial radio spectrum, much of the equipment utilised for GSM-R comprises manufacturers' special-build equipment and/or software variants. (I)
- 3.1.3 The predicted obsolescence of GSM-R, combined with the long-term life expectancy of ETCS and the Railway business needs, have led to the European Railway community initiating work to identify a successor for GSM-R, which is the FRMCS (Future Railway Mobile Communication System). The successor has to be future proof, learn from past experiences / lessons and comply with Railway requirements. (I)

### 3.2 Categorization of requirements

- 3.2.1 The requirements are categorised in (I):
- **Mandatory for the System** (indicated by '(M)' at the end of the clause). These requirements mean a condition set out in this specification that must be met without exception in order to deliver a system ensuring the fulfilment of essential functional and system needs, compliance to relevant standards and technical integration. The mandatory requirements are identified as sentences using the keyword "shall".
  - **Optional for the system** (indicated by '(O)' at the end of the clause). These requirements may be used based on the implementers' choice. When an option is selected, the related requirement(s) of this specification becomes mandatory for the system. The optional requirements are identified as sentences using the keyword "should".
  - **Information** (indicated by "(I)" at the end of the clause). These statements provide additional information to help the reader understanding a requirement.

Note: In a further step, appropriate identification of requirements as Mandatory for Interoperability will be carried out, and recorded in Annex A of this document.

### 3.3 Purpose of this document

- 3.3.1 The purpose of this document is to define functional requirements for the On-Board FRMCS in complement to the [FRMCS FRS]. (I)
- 3.3.2 This specification version focuses on the necessary requirements of the On-Board FRMCS enabling critical applications for the purpose of TSI 2022 (i.e., ETCS, ATO and critical voice). (I)
- 3.3.3 The requirements for the On-Board FRMCS are split into functional requirements and non-functional requirements (Chapter 8). The requirements are justified by giving a rationale. (I)
- 3.3.4 The FRMCS SRS is part of the FRMCS specifications as depicted in Figure 1.

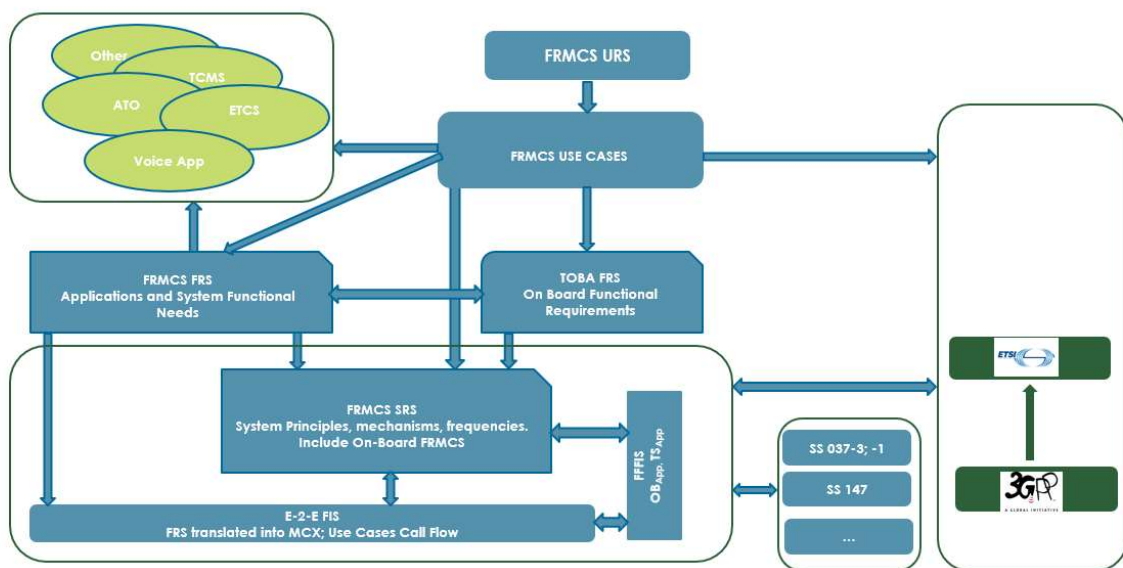


Figure 1 FRMCS Specifications

### 3.4 Fundamental Principles

- 3.4.1 The fundamental principles and associated guidance notes are defined in the FRMCS Functional Requirements Specification [FRMCS FRS] which are applicable to the telecom on-board system. (I)
- 3.4.2 FRMCS Architecture Principles are captured in [FRMCS SRS] which are applicable to the On-board FRMCS. (I)

## 4 Scope

In this chapter the system context and the system boundaries of the On-Board-FRMCS are defined. (I)

### 4.1 Definition of the On-Board FRMCS system context

- 4.1.1 Figure 2 below is derived from the FRMCS User Requirements Specification [FRMCS URS], chapter 3.3.7, the green area depicts the On-Board FRMCS context, the boundary of the train is also the boundary of the system context. (I)

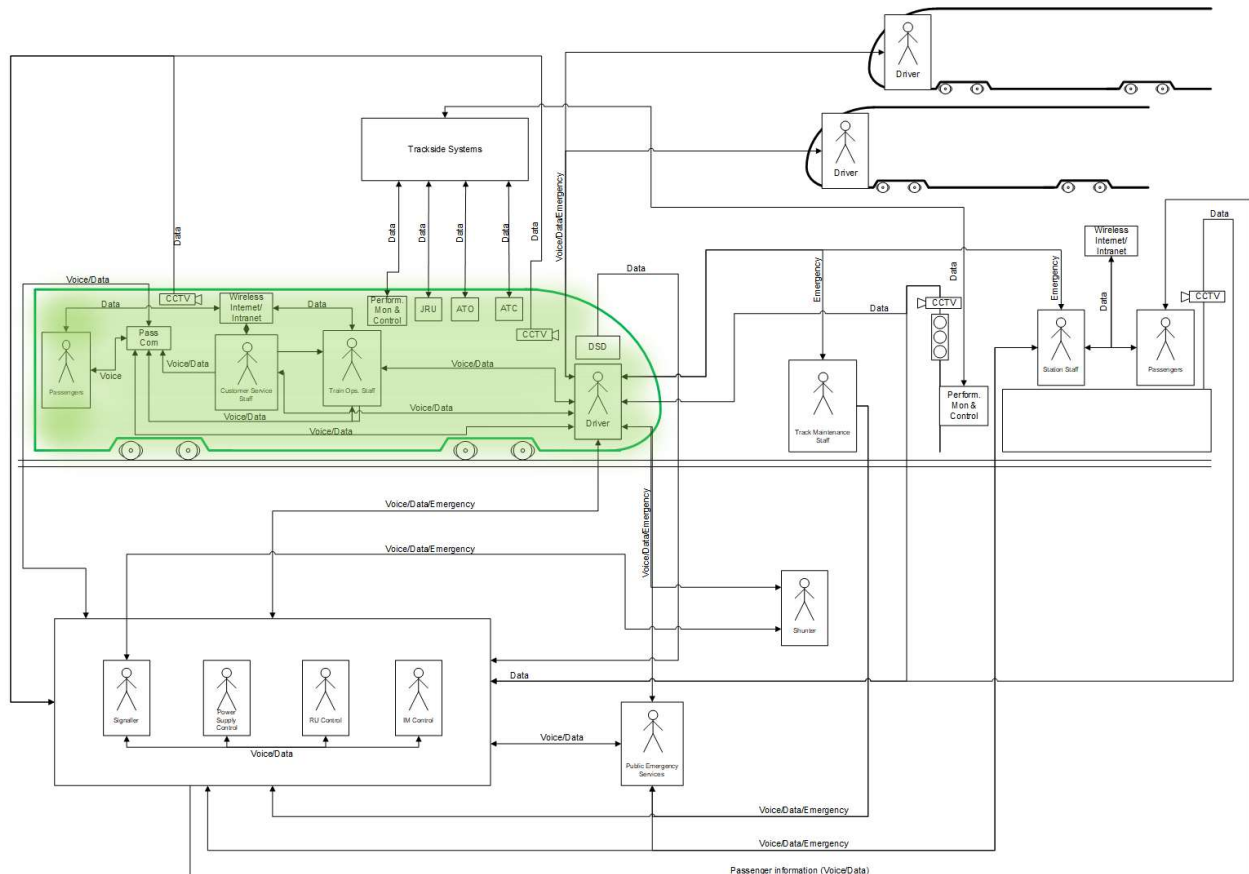


Figure 2: System Context of the FRMCS On-Board System (with examples of applications)

- 4.1.2 Any application residing stationary on-board of the train that exchanges information with the On-Board FRMCS is in the system context of the On-Board FRMCS. (I)
- 4.1.3 Applications (respectively users) moving inside or near the train (e.g. train staff with mobile devices) may connect to the FRMCS network via the On-Board FRMCS using a suitable local wireless access on-board (e.g. Wi-Fi). Using the On-Board FRMCS would overcome the penetration loss from outside to inside the train for users with mobile devices. (I)
- 4.1.4 The On-Board FRMCS provides communication transport services for any application on-board a train, regardless of the application category (critical, performance, business). (I)

NOTE: The decision as how many and which applications share one specific On-Board FRMCS is solely an implementation decision.



4.1.5 This Telecom On-Board Architecture represents the On-Board FRMCS first iteration, focused on a suitable replacement of GSM-R, which is a European need. It will be further developed in next document editions. The aim is to enable the on-board equipment flexibility and scalability as per RU's specific needs of communication and evolution. (I)

## 4.2 Definition of the On-Board FRMCS boundaries

- 4.2.1 This document covers requirements for the On-Board FRMCS itself and requirements for the identified reference points. (I)

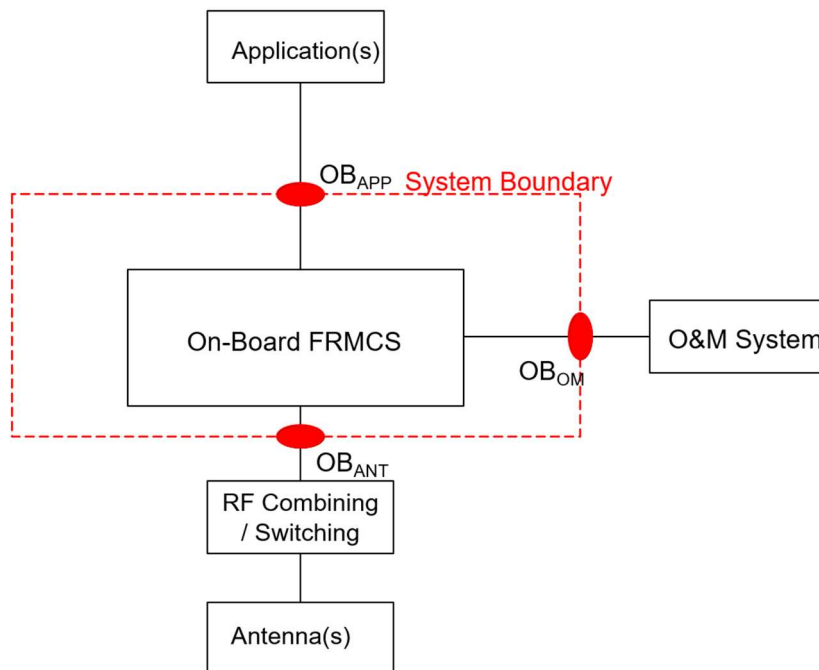


Figure 3 System Boundary of the On-Board FRMCS

- 4.2.2 The On-Board FRMCS shall implement the interfaces associated to  $OB_{APP}$ ,  $OB_{ANT}$  and  $OB_{OM}$  reference points, as per [TOBA SRS]. (M)
- 4.2.3 Reference point  $OB_{APP}$
- 4.2.3.1 Reference point  $OB_{APP}$  is between the On-Board FRMCS and the application(s). (I)
- 4.2.3.2  $OB_{APP}$  is the only reference point for the applications to access the On-Board FRMCS. (I)
- 4.2.3.3 User plane data from and to the applications(s) are carried over this reference point. (I)
- 4.2.3.4 Control plane data exchange between application(s) and On-Board FRMCS is performed over this reference point. (I)
- 4.2.4 Reference point  $OB_{ANT}$
- 4.2.4.1 Reference point  $OB_{ANT}$  is between the On-Board FRMCS and the RF combining / switching functionality or the antenna(s). (I)
- 4.2.5 Reference point  $OB_{OM}$
- 4.2.5.1 Reference point  $OB_{OM}$  is between the On-Board FRMCS and the O&M System responsible for the operation & maintenance (FCAPS) of the FRMCS On-Board System. (I)
- 4.2.5.2 Data related to O&M activities are exchanged over this reference point. (I)
- 4.2.6 Modularity and implementation choices

- 4.2.6.1 In this document, On-Board FRMCS architecture elements are identified and described, each with its functions and interfaces. (I)
- 4.2.6.2 Combination or duplication of functions, in software and/or in hardware, is an implementation choice, and depends on the user's needs, such as space restrictions, redundancy, used or foreseen applications, etc. (I)

### 4.3 Interfacing with applications not fully supporting OB<sub>APP</sub> including TCMS

- 4.3.1 For applications not fully supporting OB<sub>APP</sub>, a specific function should implement OB<sub>APP</sub> to make the application supported. (I)
- 4.3.2 In particular, train control and management system (TCMS) uses a Mobile Communication Gateway (MCG) which will have the role to implement OB<sub>APP</sub> for applications that do not have this capability. (I)
- 4.3.3 The TCMS applications send and retrieve data through the MCG. (I)
- 4.3.4 Instead of implementing Radios in the MCG, the MCG could use the transport services provided by the FRMCS On-Board System (I):
  - The train borne TCMS applications/equipment that is connected to the train control network (TCN) and needs to communicate with servers on trackside, will do it via the MCG using the transport services provided by the FRMCS system.
  - The MCG is part of the TCMS architecture and interfaces with the FRMCS On-Board System via the OB<sub>APP</sub>.
  - The MCG therefore acts as a proxy function that implements OB<sub>APP</sub> interface for the different TCMS applications which do not support OB<sub>APP</sub>.

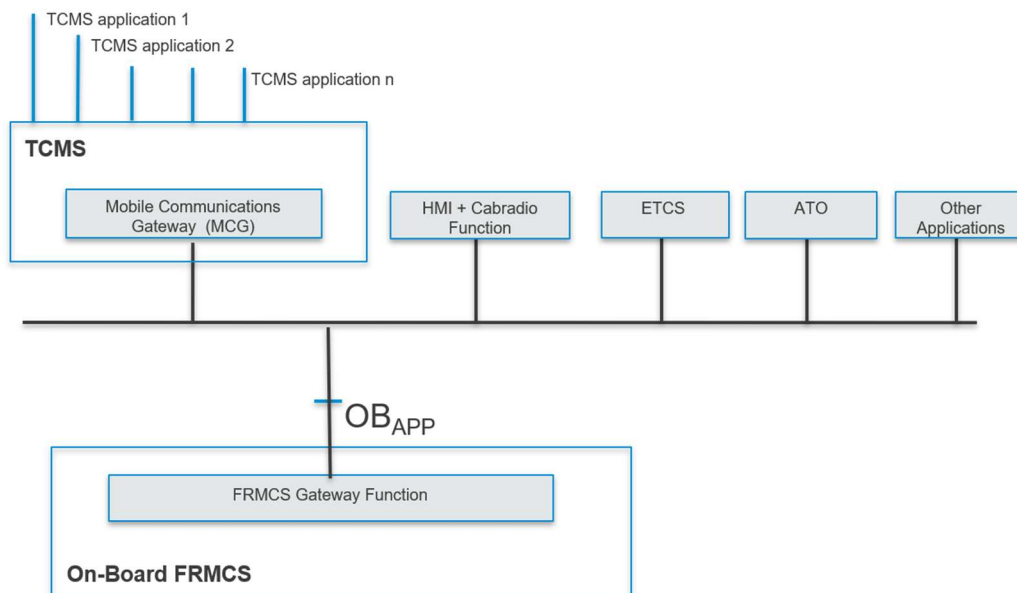


Figure 4 TCMS MCG Interfacing with On-Board FRMCS

## 5 Functional Architecture

### 5.1 Key Design Paradigms

5.1.1 Logical separation of applications from service and transport strata

5.1.1.1 The On-Board FRMCS shall achieve a logical separation between application stratum and service stratum as well as transport stratum. (M)

Note : The strata separation follows the requirements in the [FRMCS FFFIS]

5.1.2 Bearer Flexibility

5.1.2.1 The On-Board FRMCS shall be capable of supporting transport services using a defined variety of bearers (i.e. Radio Access Technologies). (M)

5.1.2.2 The On-Board FRMCS shall be capable of using a defined variety of bearers simultaneously. (M)

Note: Trackside and On-Board functionalities must be coordinated to perform this feature.

Note: The list of bearers (as per technologies and frequencies) is stated in the [FRMCS SRS].

5.1.3 Resource Sharing

5.1.3.1 The On-Board FRMCS shall be capable of providing transport services for multiple applications of any category (e.g. Tight or Loose Coupled, as described in 7.7.2.7 and 7.7.2.8 using the same On-Board FRMCS). (M)

5.1.3.2 The communication service used via the On-Board FRMCS shall be able to request the individual QoS requirements of the application and corresponding priority. (M)

Note: At the time of writing, the mechanism through which the communication service will be instructed what QoS requirement will be applied for a requesting application, is under development in different Working Groups.

5.1.4 ETCS Radio Communication Requirements

5.1.4.1 By following the key design paradigms described above in this chapter, the requirements relevant for the On-Board FRMCS specified in ETCS Radio Communication Requirements are adhered to. (I)

## 5.2 Functional Entities

5.2.1 Following the key design paradigms, the functional entities depicted below have been identified (I):

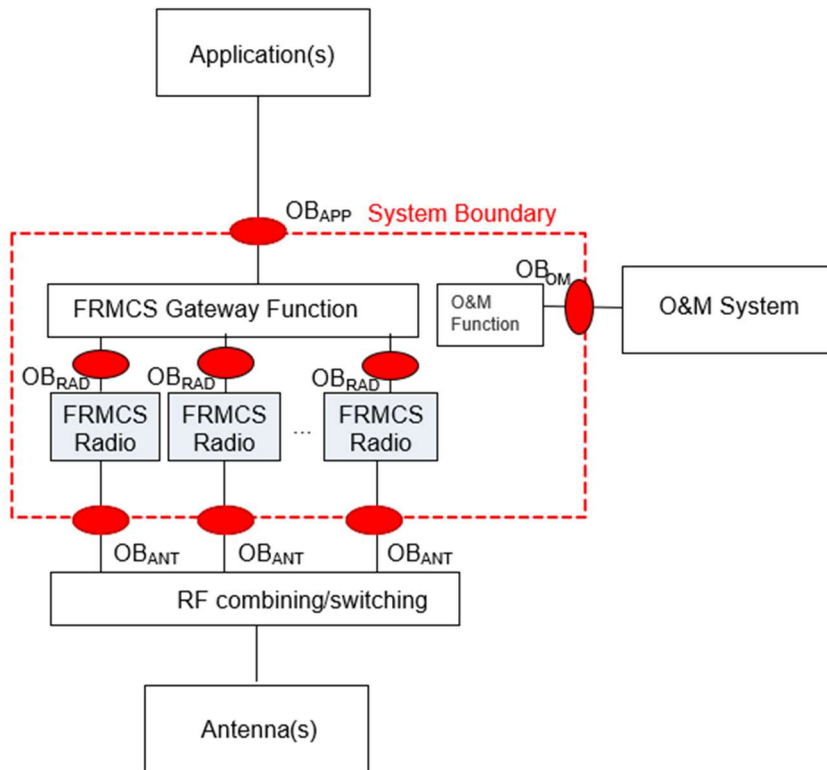


Figure 5 The Functional Entities and Reference points of the On-Board FRMCS

- 5.2.1.1 **FRMCS Gateway Function(s)**: Manage the data flows stemming **from** the applications, have a control plane ( $OB_{APP}$  control plane, as per definition in [TOBA SRS] document) for the applications, distribute the user plane data from applications over the various FRMCS radio modules depending on the application's QoS requirements and priorities between applications. (I)
- 5.2.1.2 **FRMCS Radio Module**: Modem Module with one or more 3GPP or/and non-3GPP radio access technologies supported by the FRMCS system. An On-Board FRMCS contains one or more FRMCS Radio Module(s). (I)
- Note1: The FRMCS Radio Module does not cover GSM-R technology.
- Note2: The FRMCS Radio Module may also support off-net mode of operation FFS in V2.
- 5.2.1.3 **O&M Function**: Implements the functionalities required for Fault Management, Performance Management and Configuration Management of the FRMCS Onboard System, see chapter 7.5. (I)
- 5.2.1.4 **Reference Point  $OB_{APP}$** : Reference point between the FRMCS Gateway Function(s) and On-Board Application(s). (I)
- 5.2.1.5 **Reference Point  $OB_{RAD}$** : Reference point between the FRMCS Gateway Function(s) and the FRMCS Radio Module(s). (I)
- 5.2.1.6 **Reference Point  $OB_{ANT}$** : Reference point between the FRMCS Radio Module(s) and the Antenna System (including RF Combining/Switching). (I)
- 5.2.1.7 **Reference Point  $OB_{OM}$** : FRMCS Gateway O&M Function and O&M System. (I)

## 6 Architecture Migration

Intentionally deleted. Subject addressed in [TOBA MIGRATION].

Note: Current requirements in [TOBA FRS] and [TOBA SRS] supersede the requirements provided in the Annex A (TOBA-7515) of the [TOBA MIGRATION] document.

## 7 Functional Requirements

### 7.1 Decoupling of application and transport

#### 7.1.1 Rationale

In the GSM-R system, application and communication services, including transport, are tightly coupled (7.7.2.7) which does not allow an independent evolution. Evolution of the communication and transport systems causes changes in the applications. (I)

#### 7.1.2 Requirements

7.1.2.1 Usage of the On-Board FRMCS shall be enabled for applications through the defined OB<sub>APP</sub> interface. (M)

7.1.2.2 The applications shall be unaware of the way the FRMCS system provides the communication services and the transport services between train and ground as well as between trains. (M)

7.1.2.3 The way the On-Board FRMCS provides communication services and transport services shall be transparent to applications that use those services. (M)

Note: It is considered that the MCX client embedded within the application environment in case of tight coupling (7.7.2.7) is not part of the core of the application and therefore belongs to FRMCS.

7.1.2.4 The applications shall be able to request communication services from the FRMCS system with individual QoS requirements via an API. (M)

7.1.2.5 The On-Board FRMCS shall enable applications to request communications services with individual QoS requirements via an API. (M)

7.1.2.6 The On-Board FRMCS shall allow allocation of priorities among the applications. (M)

7.1.2.7 Based on the QoS Profile and associated communication attributes, the On-Board FRMCS shall be able to determine:

- The need for using multiple transport services (increased reliability) (O)
- The need for bandwidth aggregation (M)
- The suitable transport services/FRMCS Radio Modules (M)
- The preferred transport service/FRMCS Radio Module (M)
- Which transport service to offload in case of capacity limitations (M)

7.1.2.8 The On-Board FRMCS shall be addressable on the basis of a unique set of identifiers. (M) (refer to [FRMCS FRS])

Note: This will be achieved, for example, with the Engine Number (refer to [FRMCS FRS]).



## 7.2 Bearer Flexibility

- 7.2.1 The On-Board FRMCS shall enable communication for Harmonized and Non-Harmonized Applications. (M)

Note: Harmonized and Non-Harmonized Applications are defined in [FRMCS FRS] Chapter 5.2.6.

- 7.2.2 The On-Board FRMCS should enable communication over multiple transport domains. (O)
- 7.2.3 The On-Board FRMCS shall enable communication at least over a single transport domain. (M)
- 7.2.4 The On-Board FRMCS should enable communication concurrently over multiple transport domains (Multipath, as defined in [FRMCS SRS]). (O)
- 7.2.5 The On-Board FRMCS shall enable communication over FRMCS transport domains. (M)
- 7.2.6 The On-Board FRMCS should enable communication over non-FRMCS transport domains (O)

## 7.3 Providing transport services to multiple applications

### 7.3.1 Rationale

In order to reduce the number of components (e.g. rack space, cabling, antennas, etc.) required for communication, the On-Board FRMCS system shall be able to provide connectivity to multiple applications, regardless of the category of application (critical, performance or business) by sharing the resources of the FRMCS Radio Modules. (I)

### 7.3.2 Requirements

7.3.2.1 The On-Board FRMCS shall have the capability to share FRMCS Radio Modules among different communication services (e.g. multiple applications using the same FRMCS Radio Module). (M)

7.3.2.2 The On-Board FRMCS shall provide transport services simultaneously to multiple communication services and their corresponding diversified applications, as defined in [FRMCS SRS]. (M)

7.3.2.3 Multiple applications or application instances may simultaneously share a FRMCS Service Function and its corresponding service access point. (I)

7.3.2.4 Examples of such applications (I):

- ETCS on-board equipment;
- Passenger announcement system and intercom;
- Supervision, management and remote control of on-board systems;
- Driver Safety Device;
- CCTV;
- FRMCS cab radio voice function;
- Train-Borne Recorder;
- Applications related to passenger experience (e.g. passenger information system);
- Etc.

7.3.2.5 Considering the limited number of available FRMCS Radio Modules, the limited resources available from the radio access networks and the set of concurrent applications requiring transport services, the On-Board FRMCS shall manage and contribute to the delivery of those transport services according to priorities and QoS criteria. (M)

7.3.2.6 The On-Board FRMCS shall provide transport services with QoS profiles specific to the application. (M)

## 7.4 Application-driven Domain Selection and Transition

7.4.1 Application-driven Domain Selection and Transition (transport domain transitions e.g. for border crossing), are excluded by the principle of decoupling of Strata. (I)

Note: Any exception to 7.4.1 is FFS and to be dealt with within the frame of this chapter in future versions of the document.

7.4.2 The telecommunication service continuity across FRMCS transport Domain borders (geographical border crossing) shall be guaranteed by the FRMCS system at minimum for critical applications (e.g. ETCS). (I)

Note: This section will be fully developed in V2 of this document in full alignment with the [FRMCS SRS].

## 7.5 Local Binding Function

### 7.5.1 Rationale

It is assumed that any application attempting to access the services provided by the On-Board FRMCS is considered as untrusted. (I)

Note: This could be adapted as soon as application related subsets, UIC's cyber security guidelines and ENISA implementation instructions are available.

In relation to the security of the connectivity to the On-Board FRMCS, protective mechanisms need to be defined that guarantee a certain trust level depending on the functionality of the on-board system that is accessed by an entity outside of the on-board system boundary. (I)

This function described in the Rationale paragraph is named "Local Binding Function". (I)

Note: For local binding and OB<sub>APP</sub> please refer to chapter 0

### 7.5.2 Requirements

7.5.2.1 The On-Board FRMCS shall expose a function, called Local Binding Function, whose role is the establishment of a secure link between an Onboard Application and the FRMCS Onboard System, ensuring mutual authentication of both parties. (M)

Note: confidentiality and integrity requirements are defined in [FRMCS FFFIS]

7.5.2.2 The invocation of the Local Binding Function shall be the subject of an explicit dedicated communication mechanism between the on Onboard Application and the On-Board FRMCS (e.g., by means of an API). (M)

7.5.2.3 The successful prior invocation of the Local Binding Function shall be mandatory before further information exchange between an Onboard Application and the On-Board FRMCS. (M)

7.5.2.4 After a successful invocation of the Local Binding Function, the requesting Onboard Application is Locally Bound. (I)

7.5.2.5 The On-Board FRMCS shall maintain a set of Application Profiles. An Application Profile contains rules (Application Profile Rules) to determine whether to grant or prevent access to services provided by the FRMCS Onboard System to an Onboard Application based on information provided at invocation of the Local Binding Function. (M)

7.5.2.6 The Application Profile shall be used to determine the type of service provided to the application (e.g., in case of a Loose Coupled (7.7.2.8) application access to and usage of MCX Service will be provided, in case of a Tight Coupled (7.7.2.7) application only accesses to and usage of transport resources will be provided). (M)

7.5.2.7 Application Profiles shall be configurable. (M)

Note: This is e.g. by means of the O&M functionality, locally or remotely by the appropriate organization, the identification of which is out of scope of this document.

7.5.2.8 Application Profiles Rules may consist of sets of attributes that provide information to the On- Board FRMCS on modes of operation associated onboard applications, e.g. (I):

- Maximum number of instances of the Onboard Application currently Locally Bound
- Whether the Locally Bound Onboard Application is subject to railway interoperability (harmonized vs non-harmonized)
- Type of the Locally Bound Onboard Application (ETCS, ATO, voice, ...)

7.5.2.9 The FRMCS Onboard System shall associate a Locally Bound Onboard Application to an Application Profile. (M)

Note: The On-Board FRMCS should provide mechanisms for protection of the FRMCS On-board system itself (e.g. denial of service attacks), but this is a non-functional requirement, and it is therefore for further development.

## 7.6 Operations and Maintenance

### 7.6.1 Rationale

Reliable and efficient operation of the On-Board FRMCS is necessary. (I)

### 7.6.2 Requirements

7.6.2.1 The On-Board FRMCS shall embed an O&M function dedicated to: (M)

- providing information about events encountered by hardware and software components (supervision, monitoring, statistics, performance, security...)
- receiving instructions related to the operation of the system (configuration, software upgrade, ...)

7.6.2.2 The O&M function should act as a concentrator between all components of the On-Board FRMCS. (O)

7.6.2.3 Access to O&M function shall be secure. (M)

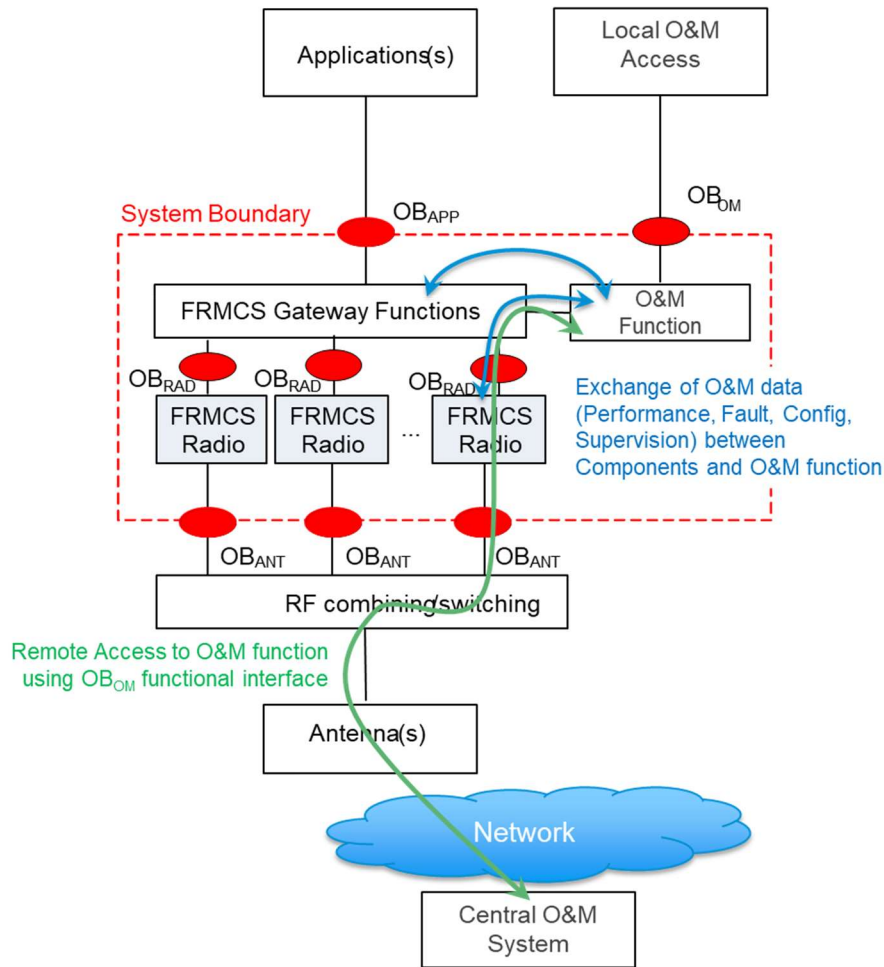


Figure 6. O&M Function and O&M Access

### 7.6.3 O&M Functionality Requirements

- 7.6.3.1 The On-Board FRMCS should be able to distinguish between performance problems that come from the FRMCS On-Board system itself. (O)
- 7.6.3.2 The O&M function should collect the O&M related data (e.g., logs, alarms, performance metrics) from the components of the FRMCS On-Board System. (O)
- 7.6.3.3 The O&M function shall distribute configuration and software updates to the components. (M)

Editor's Note: The format of the exchanged data and its encoding is for FFS.

- 7.6.3.4 O&M Data stored in the O&M Function, shall be accessible by a remote O&M system or a local O&M System through OB\_OM. (M)
- 7.6.3.5 The log data provided by the components of the On-Board FRMCS shall allow the O&M Function to provide information to enable troubleshooting. (M)
- 7.6.3.6 This should include for example the following (I):
  - Physical ID of the engine
  - Functional number of the engine on which the On-Board FRMCS is mounted (more generically, the Functional Identity, as defined in [FRMCS SRS], might be considered)

- Type of radio access and conditions (e.g., RF parameters) available
- QoS Profiles used
- Apps registered to the on-board system
- Type of radio access used by each app
- Faults detected on the radio interface of the on-board system
- Faults detected on the OB<sub>APP</sub>, OB<sub>RAD</sub>, OB<sub>OM</sub> and OB<sub>ANT</sub> interfaces
- Security logs
- ...

7.6.3.7 If required, data collected by the O&M Function should be able to be shared with other on-board systems on demand. (O)

7.6.3.8 The log data shall be classified (by the O&M Function or the O&M System) according to the criticality of the events (M):

- Information
- Warning
- Minor
- Major
- Critical

Note: Further sub-categories to support finer granularity can be defined as an option when the logging system is implemented

#### 7.6.4 Performance Management Requirements

7.6.4.1 Performance monitoring shall support collection of counters and/or KPIs. (M)

7.6.4.2 Performance monitoring functionality shall not prevent the normal operation of the On-Board FRMCS. (M)

7.6.4.3 The performance monitoring functionality shall be configurable. (M)

7.6.4.4 Performance data shall be logged by the O&M Function. (M)

7.6.4.5 The components of the On-Board FRMCS should provide raw performance data to be further processed by the O&M function. (O)

## 7.6.5 Fault Management Requirements

- 7.6.5.1 The On-Board FRMCS system shall be able to detect and classify defects within the On-Board FRMCS boundary that affect its normal operation. (M)
- 7.6.5.2 The On-Board FRMCS system shall make information available about defects that could prevent its normal operation over the O&M interface (OB<sub>OM</sub>). (M)
- 7.6.5.3 The monitored parameter set via the O&M function shall be rich enough to allow for detecting anomalies before they develop into actual defects (M)
- 7.6.5.4 In case of a defect, the On-Board FRMCS system should be able to determine whether stopping some non-critical applications can allow the continuity of operation of critical applications. (O)
- 7.6.5.5 The On-Board FRMCS should detect malfunctioning components and disable them such that they are no longer operational, without impacting critical functionalities. (O)
- 7.6.5.6 The On-Board FRMCS should be designed in such way that a malfunctioning component after it is isolated does not disturb data transmission of the applications. (O)
- 7.6.5.7 The On-Board FRMCS should be able to perform corrective actions (e.g. rebooting, reconfiguration, health check, etc) on isolated malfunctioning component in such a way that it does not impact critical functionality. (O)
- 7.6.5.8 Only if the corrective actions result in full recovery of the malfunctioning component, it may be used again for data transmission. (I)

## 7.6.6 Configuration Management Requirements

- 7.6.6.1 It shall be possible to perform OTA firmware, software or parameters upgrade/modification of the On-Board FRMCS. (M)
- 7.6.6.2 It shall be possible to specify conditions when OTA upgrade may happen (e.g. when the cabin is not in operation, activation of maintenance mode). (M)
- 7.6.6.3 It shall be possible to switch between SW/FW versions and configuration sets locally stored on On-Board FRMCS and to choose from the remote O&M system or the local O&M access which version to operate. (M)
- 7.6.6.4 Above Software or parameters upgrade or modifications will be possible for Gateway Function and for the Radio Module. (I)
- 7.6.6.5 This mechanism will allow to decorrelate the software upload and the switch to the new version. (I)
- 7.6.6.6 System integrity: the system shall check its own integrity after a hardware or software upgrade and to inform the O&M Function. (M)
- 7.6.6.7 It shall be possible to perform hardware modification module by module. (M)
- 7.6.6.8 It shall be possible to retrieve information about the SW, HW and firmware versions and configuration on demand. (M)
- 7.6.6.9 SW/FW updates distributed to components shall be fail-safe. (M)

## 7.6.7 Supervision and Audit functions Requirements

Intentionally deleted.

## 7.7 Functional Interface between applications and On-Board FRMCS (OB<sub>APP</sub>)

### 7.7.1 Rationale

The on-board FRMCS system will interface with several on-board applications as defined in [FRMCS URS], for example, ETCS, DSD, PA, HMI, mobile handhelds of train staff etc. Consequently, this interface has to ensure management of and access to the communication services taking in consideration the priority and quality of service profile required by those applications. The interface is named OB<sub>APP</sub>, and is specified in detail in [FRMCS FFFIS]. (I)

### 7.7.2 Requirements

7.7.2.1 The interface shall provide three functions (M):

- Local Binding Function (see section 7.5 Local Binding Function)
- Service Session Management function: User plane data and related control plane data to be transmitted / received end-to-end between the applications,
- Auxiliary function: Provides information to the communication entities about the status of the communication service

7.7.2.2 The communication between the application/entity and the On-Board FRMCS will be performed via an API. This API will encompass functions for (I):

- Local Binding function
- Service Session Management function
- Auxiliary function
- (Potentially additional ones)

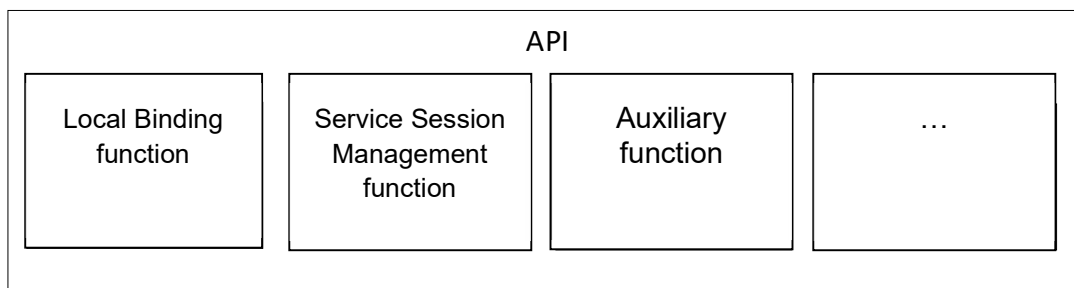


Figure 7 Example API blocks

7.7.2.3 The Local Binding function, according to section 7.5 shall provide (M):

- Support for authentication of the On-Board Application against the On-Board FRMCS.
- Support for authorisation of the On-Board Application to use transport services provided by the On-Board FRMCS.

7.7.2.4 The OB<sub>APP</sub> Service Session shall transparently carry any IP based protocol of any locally bound application requesting a transport service. (M)

7.7.2.5 The Auxiliary function is the collector of certain status information (e.g., FRMCS Service availability/link status) considered for a notification to the Application. (I)

Note: Provision of positioning and location information by the On-Board FRMCS as a service or as integration of information provided by other entities, is FFS.



7.7.2.6 The OB<sub>APP</sub> shall support two modes (M):

- Tight Coupled Mode
- Loose Coupled Mode

7.7.2.7 In Tight Coupled Mode the application or data host determines the communication parameters (e.g. Identity, CODEC parameters etc) to be provided through the OB<sub>APP</sub> to the On-Board FRMCS. The required communication parameters are further processed by the FRMCS Service Session Function (CP). Missing communication parameters are applied by defaults by the FRMCS Service Session Function. A local Orchestration Function manages the necessary interaction between CP and UP and is defined in [TOBA SRS]. (I)

Note : Tight Coupled Mode is always used when signalling information also includes user information and the application is “MC service aware”.

7.7.2.8 In Loose Coupled Mode the application or data host is unaware about the FRMCS communication service parameters and only provides UP data to be sent to corresponding host or network. In this scenario of LC mode, the parameters needed for the establishment of an appropriate MCX session need to be provided locally by the Orchestration Function that manages the necessary interaction between CP and UP. (I)

Note: Loose mode is used when the data host/application is unaware that the communication service uses MC functionality.

Note: “Non-OB<sub>APP</sub>-aware” on-board applications (e.g., IP-Camera...), that need to use FRMCS mobile access (e.g., legacy applications that cannot be updated) however are not capable to perform Local Binding and use API, and therefore need an agent for that, which is FFS in a next version of this specification.

7.7.2.9 The On-Board FRMCS shall provide communication services only to Locally Bound applications (7.5.2.4). (M)

7.7.2.10 The On-Board FRMCS shall be integrated in the FRMCS security framework specified in [FRMCS SRS] and [FRMCS FFFIS] to support secure CP communication that ensures data confidentiality, integrity, and availability of the CP. (M)

## 7.8 Functional Interface between management system(s) and O&M Function of the On-Board FRMCS (OB<sub>OM</sub>)

### 7.8.1 Rationale

An industry-specified interface between the O&M Function of the On-Board FRMCS and management system(s) will enable and promote flexible implementation and business models in terms of fleet management with respect to the management of On-Board FRMCS. (I)

## 7.8.2 Requirements

- 7.8.2.1 The OB<sub>OM</sub> shall support the O&M functionalities as specified in chapter 7.6. (M)
- 7.8.2.2 Authentication and level of authorisation to access the O&M function shall be role based (e.g. Security Administrator, System Administrator, Maintainer, etc.). (M)
- 7.8.2.3 The OB<sub>OM</sub> shall support local and remote access. (M)
- 7.8.2.4 The OB<sub>OM</sub> shall support authentication and authorisation for the use of the O&M functionalities in case of remote access. (M)
- 7.8.2.5 When using remote access, the OB<sub>OM</sub> shall support remote authentication and authorisation for the use of the O&M functionalities. (M)
- 7.8.2.6 The OB<sub>OM</sub> shall support integrity protection of any O&M communication. (M)

## 7.9 Functional Interface between FRMCS Gateway Function and FRMCS Radio Module (OB<sub>RAD</sub>)

### 7.9.1 Rationale

An industry-specified interface between the FRMCS Gateway Functions and the FRMCS Radio Modules facilitates a modular implementation of the On-Board FRMCS and increases the degrees of freedom for the fleet managers during the life cycle of the On-Board FRMCS (I):

- Facilitates the selection of different suppliers for the FRMCS Gateway Functions and the FRMCS Radio Modules
- Allows to exchange/add FRMCS Radio Modules with products from other/different suppliers
- Facilitates the implementation of the FRMCS Gateway Functions as a software component on a multi-purpose computing platform.
- Facilitates deployment option where the FRMCS Radio Modules are brought closer to the antennas and at the same time keeping the FRMCS Gateway Functions centralised within a train.
- Allows to exchange/add FRMCS Radio Modules enabling newer and/or updated radio access technologies.

### 7.9.2 Requirements

- 7.9.2.1 The On-Board FRMCS should support FRMCS Radio Module diversity (i.e. the Gateway and the Radio Modules could be from different vendors). (O)
- 7.9.2.2 The On-Board FRMCS should allow adding or changing FRMCS Radio Module(s) without impact on the FRMCS Gateway Function, the train applications and the train application interface, OB<sub>APP</sub>. (O)
- 7.9.2.3 Adding or replacing FRMCS Radio Module(s) should be possible on the installed On-Board FRMCS. (O)
- 7.9.2.4 It should be possible for the FRMCS Gateway Function and FRMCS Radio Module(s) to be located at different locations within the same train. (O)
- 7.9.2.5 The On-Board FRMCS may evolve to split the On-Board FRMCS into Gateway Function and FRMCS Radio Function with a specified OB<sub>RAD</sub> interface. (I)

Note: Technical solutions for requirements from 7.9.2.1 to 7.9.2.5 are FFS for FRMCS v2

7.9.2.6 The OB<sub>RAD</sub> functional interface shall support protocol(s) to retrieve FRMCS Radio Modules alarm state, log and performance data and write the data necessary for SW and configuration changes in accordance with the functional requirements specified in chapter 7.6. (M)

7.9.2.7 The OB<sub>RAD</sub> functional interface should be realised using a suitable existing industry specification. (O)

## 7.10 Physical Interface between On-Board FRMCS and the applications (OB<sub>APP</sub>)

### 7.10.1 Rationale

The on-board applications need to have connectivity in order to utilize the On-Board FRMCS. This connectivity can be of different type(s) depending on the user equipment where on-board application(s) are installed. e.g. handheld device(s) for user(s) moving within or in close proximity to a train, fixed equipment within a train or mounted on the train. (I)

### 7.10.2 Requirements

7.10.2.1 The On-Board FRMCS shall provide wired connectivity for devices using off the shelf technologies e.g. Ethernet. (M)

7.10.2.2 The On-Board FRMCS should provide wireless connectivity for devices using off the shelf technologies e.g. WiFi. (O)

7.10.2.3 The number of interfaces should be expandable. (O)

7.10.2.4 OB<sub>APP</sub> should be able to share the physical interface with OB<sub>RAD</sub>, i.e. be connected to the same local communication infrastructure. (O)

Note 1: This requirement development is for FFS in V2 of the [TOBA SRS].

Note 2: The preferred connectivity for local connectivity is the Local Bus [SS147].

## 7.11 Physical Interface between On-Board FRMCS and the FRMCS Radio Modules (OB<sub>RAD</sub>)

### 7.11.1 Requirements

7.11.1.1 The OB<sub>RAD</sub> physical interface should support distributed deployments of FRMCS Gateway Functions and FRMCS Radio Modules within a train set. (O)

Note: This requirement is currently FFS, and to be finalized in V2

7.11.1.2 The OB<sub>RAD</sub> physical interface shall enable sufficient performance (bandwidth, latency) to carry both the user plane traffic and the required control plane traffic without degrading the QoS of the Communication Services, as it is defined in [FRMCS SRS]. (M)

7.11.1.3 The OB<sub>RAD</sub> physical interface shall be realised using a suitable existing industry standard fulfilling the functional requirements stated under 7.9.2 and the non-functional requirements stated under 8 (chapter FFS). (M)

7.11.1.4 OB<sub>RAD</sub> physical interface should enable resilience measures as specified in chapter 8.1. (O)

7.11.1.5 OB<sub>RAD</sub> should be able to share the physical interface with OB<sub>APP</sub> (symmetric requirement to 7.10.2.4), i.e. be connected to the same local communication infrastructure. (O)

Note 1: This requirement development is for FFS in V2 of the [TOBA SRS].

Note 2: The preferred connectivity for local connectivity is the Local Bus [SS147].

## 7.12 Physical Interface between FRMCS Radio Modules and the antenna system (OB<sub>ANT</sub>)

### 7.12.1 Rationale

7.12.1.1 A industry-specified interface between the FRMCS Radio Modules and the antenna system, facilitates a modular implementation of the FRMCS On-Board System and increases the degrees of freedom for the fleet managers during the life cycle of the FRMCS On-Board System. (I)

### 7.12.2 Requirements

7.12.2.1 The OB<sub>ANT</sub> physical interface shall be realised using a suitable existing industry specification. (M)

## 7.13 Physical Interface between local management system(s) and O&M Function of the On-Board FRMCS (OB<sub>OM</sub>)

### 7.13.1 Rationale

7.13.1.1 An industry specified physical interface between the O&M Function of the On-Board FRMCS and local management system(s) will enable and promote flexible implementation and business models in terms of fleet management with respect to the management of On-Board FRMCS. (I)

### 7.13.2 Requirements

7.13.2.1 The On-Board FRMCS shall provide connectivity for local O&M access using off the shelf technologies e.g. Ethernet. (M)

## 8 Non-Functional Requirements

### 8.1 Resilience

#### 8.1.1 Rationale

The On-Board FRMCS provides the necessary means to eliminate single points of failure. (I)

#### 8.1.2 Requirements

8.1.2.1 The On-Board FRMCS architecture should enable availability concepts that eliminate single points of failure within the On-Board FRMCS itself (e.g., redundant gateway function, redundant OB<sub>APP</sub> interfaces, etc.). (O)

8.1.2.2 OB<sub>APP</sub> physical interface should support resilience measures. (O)

This Chapter is to be further developed.

The aim of this chapter is to encompass a number of non-functional requirements, e.g. cyber security, resilience, adaptability, accessibility, extensibility, maintainability, operability, reliability, durability, integration, upgradability, performance etc.

It is believed that these requirements will be considered as best practice.

## 9 References

|                         |   |
|-------------------------|---|
| <b>[FRMCS URS]</b>      | UIC, Future Railway Communications System, User Requirements Specification, FU-7100, Version 4.0.0, 15.01.2019      |
| <b>[TOBA MIGRATION]</b> | UIC, FRMCS, Telecom On-Board System, Architecture Migration Scenarios, TOBA-7540, Version 1.0, 16.04.2020           |
| <b>[TOBA SRS]</b>       | UIC, FRMCS, On-Board FRMCS System Requirements Specification TOBA-7530, 0.0.8, 05/11/2021                           |
| <b>[FRMCS SRS]</b>      | UIC, FRMCS, FRMCS System Requirements Specification, AT-7800, version 0.3.1.  |
| <b>[FRMCS FRS]</b>      | UIC, Future Railway Communications System, Functional Requirement Specification, FU-7120, Version 0.5.0, 15.10.2021 |
| <b>[FRMCS FFFIS]</b>    | UIC, FRMCS, FRMCS FFFIS Form Fit Functional Interface Specification, FRMCS FFFIS 7900, Version 0.2.0, 22.11.2021    |
| <b>[SS147]</b>          | UNISIG, CCS Consist Network Communication Layers, Version 0.1.8   |

## 10 Annex A: Interoperability requirements in EU

This annex is the placeholder for identifying the requirements relevant for interoperability in the European Union, i.e. the requirements, with respect to the authorisation in the EU according to the TSI, that are considered in the European Directives to be relevant for interoperability as fulfilling the essential requirements for the Control-Command and Signalling (CCS) subsystem related to safety and technical compatibility which must be met by the rail system, the subsystems, and the interoperability constituents, including interfaces according to the corresponding conditions set out in Directive (EU) 2016/797. It is mandatory that each railway subsystem in the EU meets these requirements on lines under the scope of the Directive and the CCS TSI to ensure technical compatibility between Member States and safe integration between train and track.

At this stage, the version of this specification is not considered complete for the purpose of tendering On-Board FRMCS equipment, and the identification of all requirements relevant for interoperability is for further study.

This annex is therefore only informative.

Printed by

International Union of Railways

16, rue Jean Rey 75015 Paris - France

April 2021

Dépôt légal January 2020

ISBN 978-2-7461-2896-5