INTERNATIONAL UNION
OF RAILWAYS

Future Railway Mobile Communication System

FRMCS - Transition

Technical Guideline for the Application of FRMCS to 4G Networks

Source:	**UIC**
Date:	**19 of July 2024**
Reference:	**FRMCS-T**
Version:	**1.0**

ISBN 978-2-7461-3415-7

Table of Content

1 List of Abbreviations

3GPP	3rd Generation Partnership Project
4G	4th Generation of cellular telecommunications technologies standardized by 3GPP
5G	5th Generation of cellular telecommunications technologies standardized by 3GPP
ARP	Allocation and Retention Priority
ATSSS	Access Traffic Steering, Switching and Splitting
CCTV	Closed Circuit Television
EAP-AKA	Extensible Authentication Protocol – Authentication and Key Management
eNodeB	LTE Base Station
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute
EU	European Union
FFFIS	Form Fit Functional Interface Specification
FFS	For Further Study
FIS	Functional Interface Specification
FRMCS	Future Railway Mobile Communications System
FRMCS-T	Future Railway Mobile Communications System-Transition
FRS	Functional Requirements Specification
FTR	FRMCS-T Recommended
GSM	Global System for Mobile Communications
GSM-R	Global System for Mobile Communications – Railway
ID	IDentity
IM	Infrastructure Manager
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IPUPS	Inter-PLMN User Plane Security
ISDN	Integrated Services Digital Network
MC	Mission Critical
MCX	Mission Critical Services
NEF	Network Exposure Function
MNO	Mobile Network Operator
NA	Not Applicable
NR	New Radio
OB	On-Board
PCF	Policy Control Function
PLMN	Public Land Mobile Network
PMNO	Public Mobile Network Operator
QoS	Quality of Service
QCI	QoS Class Identifier
RAN	Radio Access Network
RAT	Radio Access Technology
RF	Radio Frequency
RMR	Railway Mobile Radio
RRC	Radio Resource Control
SIP	Session Initiation Protocol
SMF	Session Management Function
SRS	System Requirements Specification
SUCI	Subscription Concealed Identifier
SUPI	Subscription Permanent Identifier
TBD	To Be Defined

TOBA	Telecom On-Board Architecture
TR	Technical Report
TS	Technical Specification
UE	User Equipment
UIC	Union Internationale des Chemins de Fer
UPF	User Plane Function
URS	User Requirements Specification

2 List of Definitions

Terms	Definitions
Administrative Domain	Domain managed by a single administrative authority (e.g., FRMCS Operator). The Administrative Domain is characterized by organizational/operator boundaries.
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 FRMCS Access Point, to receive and transmit information to ground systems, (for example, ETCS, DSD, CCTV, passenger announcements, etc.).
Communication Services	Communication services enable two-way communication between two or more authorized service users (i.e. applications) from applications towards other applications/entities reachable through various networks.
Complementary Services	Ancillary services, e.g., providing and/or utilizing the location of the service user, supporting Communication Services and the Railway Application Stratum.
Control Plane	The control plane carries signalling traffic between the network entities.
Data Communication	Exchange of information in the form of data, including video (excluding voice communication), requiring corresponding QoS treatment.
Data Network Name	According to 3GPP terminology ([TS 23.003]).
Domain	According to 3GPP terminology ([TR 21.905]).
FRMCS Domain	A FRMCS Domain is an administrative domain which comprises a Service Domain and a Transport Domain under the control of an FRMCS Operator.
On-Board FRMCS	According to [TOBA-FRS] terminology.
FRMCS Operator	An FRMCS Operator is a railway Infrastructure Manager, or an operator delegated by a railway Infrastructure Manager who manages the Transport Domain and/or Service Domain for which FRMCS policies and FRMCS user subscriptions are applicable.
FRMCS Radio Module	Modem with one or more 3GPP or/and non-3GPP radio access technologies supported by the FRMCS system.
FRMCS System	

	Telecommunication system conforming to FRMCS specifications, consisting of Transport Stratum and Service Stratum.
FRMCS Transport Domain	Implementation of (part of) the Transport Stratum which belongs to and/or is operated by a unique organization.
FRMCS User	Human or machine making use of Communication Services and/or Complementary Services.
Interface	An interface represents identifiable implementation of a reference point. An interface exposes functionalities associated to Functions. An interface can be specified or unspecified in this specification.
Media	The exchange of information among Railway Applications endpoints passing through the FRMCS System.
OB_{APP} Control Plane	Flow of information between applications and the On-Board FRMCS (e.g., through an API) pertaining to registration to the On-Board FRMCS and to request for services (communication-related or others) enabled by the On-Board FRMCS.
OB_{APP} User Plane	Flow of information to and from applications going through the On-Board FRMCS.
Policy and Charging Control	According to 3GPP terminology ([TS 23.503]).
Railway Application Stratum	Railway-specific functionalities using services offered by the FRMCS Service Stratum.
Reference Point	According to ITU-T terminology ([ITU-T-M.60]).
Reliability	The probability that an item can perform a required function under stated conditions for a given time interval.
Security	According to 3GPP terminology ([TR 21.905]).
Service Stratum	Communication Services and Complementary Services.
Signalling	The exchange of information specifically concerned with the establishment and control of communications, and with management, in the FRMCS System.
SIP Core	According to 3GPP ([TS 23.280 clause 7.4.3.1.3.1]).
Subsystem	A Subsystem is a System included in higher order system.

System	A System is an autonomous functional entity. A System is composed of Function(s).
Transport Stratum	Set of access functions and corresponding core functions applicable for the FRMCS system.
User Equipment	According to 3GPP terminology ([TR 21.905]). In this context, the Mobile Termination (MT) corresponds to the FRMCS Radio Module that enables radio capabilities within the FRMCS Transport Stratum.
User Plane	The User Plane (sometimes called data plane or bearer plane) carries the user/application traffic.

3 References

[FRMCS-URS] FU-7100 v5.0.0 February 2020: “FRMCS User Requirements Specification”

[FRMCS-FRS] FU-7120: “FRMCS Functional Requirements Specification”

[TOBA-FRS] TOBA-7510: “FRMCS Telecom On-Board System – Functional Requirements Specification”.

[FIS] FRMCS Functional Interface Specification

[FFFIS] FRMCS FFFIS Form Fit Functional Interface Specification

[TR 21.905] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[TS 22.146] 3GPP TS 22.146: "Multimedia Broadcast/Multicast Service (MBMS); Stage 1".

[TS 22.179] 3GPP TS 22.179: "Mission Critical Push to Talk (MCPTT); Stage 1".

[TS 22.246] 3GPP TS 22.246: "Multimedia Broadcast/Multicast Service (MBMS) user services; Stage 1".

[TS 22.261] 3GPP TS 22.261: "Technical Specification, Service requirements for the 5G system; Stage 1".

[TS 22.280] 3GPP TS 22.280: "Mission Critical Services Common Requirements (MCCoRe); Stage 1".

[TS 22.281] 3GPP TS 22.281: "Mission Critical Video services".

[TS 22.282] 3GPP TS 22.282: "Mission Critical Data services".

[TS 22.289] 3GPP TS 22.289: "Mobile communication system for railways"

[TS 23.003] 3GPP TS 23.003: "Numbering, Addressing and Identification".

[TS 23.203] 3GPP TS 23.203: "Policies and Charging control architecture; Stage 2".

[TS 23.228] 3GPP TS 23.228: "IP Multimedia Subsystem (IMS); Stage 2".

[TS 23.246] 3GPP TS 23.246: "Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description

[TS 23.280] 3GPP TS 23.280: "Common functional architecture to support mission critical services".

[TS 23.281] 3GPP TS 23.281: "Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2".

[TS 23.282] 3GPP TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCData); Stage 2".

[TS 23.303] 3GPP TS 23.303: "Proximity-based services (ProSe); Stage 2".

[TS 23.379] 3GPP TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2".

[TS 23.401] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[TS 23.468] 3GPP TS 23.468: "Group Communication System Enablers for LTE (GCSE_LTE); Stage 2".

[TS 23.501] 3GPP TS 23.501: “Technical Specification, System Architecture for the 5G System; Stage 2”.

[TS 23.502] 3GPP TS 23.502: “Procedures for the 5G System (Stage 2) v17.0.0, 03-2021”.

[TS 23.503] 3GPP TS 23.503: “Policy and charging control framework for the 5G System”

[TS 24.301] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS): Stage 3".

[TS 24.281] 3GPP TS 24.281: "Mission Critical Video (MCVideo) signalling control; Protocol specification".

[TS 24.282] 3GPP TS 24.282: "Mission Critical Data (MCData) signalling control; Protocol specification".

[TS 24.379] 3GPP TS 24.379: "Mission Critical Push To Talk (MCPTT) call control; Protocol specification".

[TS 24.380] 3GPP TS 24.380: "Mission Critical Push To Talk (MCPTT) media plane control; Protocol specification".

[TS 24.381] 3GPP TS 24.381: "Mission Critical Push To Talk (MCPTT) group management; Protocol specification".

[TS 24.382] 3GPP TS 24.382: "Mission Critical Push To Talk (MCPTT) identity management; Protocol specification".

[TS 24.383] 3GPP TS 24.383: "Mission Critical Push To Talk (MCPTT) Management Object (MO) ".

[TS 24.384] 3GPP TS 24.384: "Mission Critical Push To Talk (MCPTT) configuration management; Protocol specification".

[TS 24.481] 3GPP TS 24.481: "Mission Critical Services (MCS) group management; Protocol specification".

[TS 24.482] 3GPP TS 24.482: "Mission Critical Services (MCS) identity management; Protocol specification".

[TS 24.483] 3GPP TS 24.483: "Mission Critical Services (MCS) Management Object (MO) ".

[TS 24.484] 3GPP TS 24.484: "Mission Critical Services (MCS) configuration management; Protocol specification".

[TS 24.581] 3GPP TS 24.581: "Mission Critical Video (MCVideo) media plane control; Protocol specification".

[TS 26.179] 3GPP TS 26.179: “MCPTT: Codecs and media handling”.

[TS 29.214] 3GPP TS 29.214: “Policy and Charging Control over Rx reference point”.

[TS 29.468] 3GPP TS 29.468: "Group Communication System Enablers for LTE (GCSE_LTE); MB2 Reference Point; Stage3".

[TS 33.180] 3GPP TS 33.180: "Security of the mission critical service".

[TS 33.203] 3GPP TS 33.203: "3G security; Access security for IP-based services”.

[TS 33.303] 3GPP TS 33.303: "Proximity-based Services (ProSe); Security aspects."

[TS 33.401] 3GPP TS 33.401: “Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution (SAE); Security architecture”.

[TS 33.501] 3GPP TS 33.501: “Technical Specification Group Services and System Aspects; Security architecture and procedures for 5G system”.

[TS 36.300] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[TS 36.331] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control(RRC);Protocol specification".

[TS 36.413] 3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

[TS 36.101] 3GPP TS 36.101: " Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception"

[TS 38.101] 3GPP TS 38.101: " NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone"

[TS 103 764] ETSI TS 103 764: "Rail Telecommunications (RT); Future Rail Mobile Communication System (FRMCS); FRMCS System Architecture".

[TS 103 765-1] ETSI TS 103 765-1: "Future Rail Mobile Communication System (FRMCS); Building Blocks and Functions; Part 1: Transport Stratum".

[TS 103 765-2] ETSI TS 103 765-2: "Future Rail Mobile Communication System (FRMCS); Building Blocks and Functions; Part 2: Service Stratum".

[TS 103 765-4] ETSI TS 103 765-4: "Future Rail Mobile Communication System (FRMCS); Building Blocks and Functions; Part 4: FRMCS Trackside".

[TS 103 765-5] ETSI TS 103 765-5: "Future Rail Mobile Communication System (FRMCS); Building Blocks and Functions; Part 5: UE Capability".

[TS 103 792] ETSI TS 103 792: "Rail Telecommunications (RT); Future Rail Mobile Communication System (FRMCS); GSM-R/FRMCS Interworking".

4 Scope and Rationale of FRMCS-Transition

4.1 FRMCS Background

The predicted obsolescence of GSM-R, combined with the long-term life expectancy of ETCS and of the increasing needs of railway operations, has led UIC to set up a specific program to identify a successor for GSM-R, namely the UIC FRMCS (Future Railway Mobile Communication System) Program.

The UIC FRMCS Program was initially developed in the European context, due to the strong level of interconnection between the various countries of the European Community and then an even stronger necessity to anticipate the migration of GSM-R trackside and on-board systems. This Program is based on the usage of 5G Stand-Alone and MCX (Mission-Critical) 3GPP architectures, to make the system perennial over time.

In this context, a first set of UIC FRMCS Specifications (UIC FRMCS V1) was produced and published at the end of 2023. The evolution of this set of specifications, UIC FRMCS V2, is currently under finalization for a publication expected at the end of 2024.

The UIC FRMCS V1 set of specifications is depicted here after.

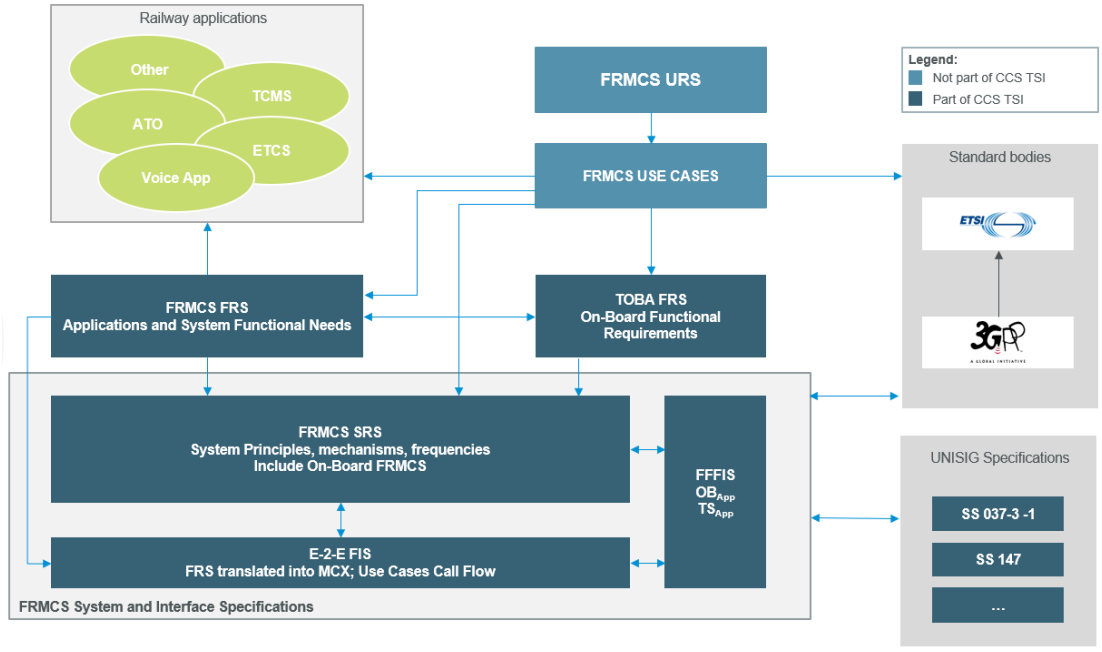

Figure 4-1: UIC FRMCS Specifications

The UIC FRMCS V1 was tested and checked in the frame of a specific European project led by UIC, 5G-Rail, financed by the European Commission Horizon Program, with the development of prototypes for the whole FRMCS ecosystem by industry-

leading companies. With the same logic, a specific European project is currently under definition, with the codename of Morane 2, as a reminder to the Morane project that created GSM-R in the early 2000s. This project will permit to test and check the UIC FRMCS V2 and then to finalize an UIC FRMCS V3 set of specifications at the end of 2026. This objective is called “FRMCS 1st Edition” and is reputed to permit the start of deployments in Europe by 2027.

The UIC FRMCS Specifications have the vocation to be used at worldwide level, as it is the case today for the UIC GSM-R Specifications.

4.2 FRMCS-Transition

With this background, UIC has been nevertheless considering in parallel the application of FRMCS in the whole world for certain countries that will not have an easy access to 5G framework and/or technologies for various reasons such as 5G spectrum unavailability or high cost, national time schedule for 5G development, cost of ownership of 5G technologies, early constraints for migration and/or time-to-market, etc.

This is the reason why a specific Technical Guideline was developed under the name of **FRMCS-Transition (“FRMCS-T”)**, with the objective to facilitate the application of FRMCS to 4G networks.

4G (Evolved Packet System), which is the predecessor of 5G system and is today globally deployed all over the world, has an all-IP based architecture quite similar to 5G architecture. In commercial use, many 4G network devices have the potential to upgrade to 5G only by software change.

UIC FRMCS specifications largely use the 3GPP MCX services, that have been standardised since 3GPP release 13, then manageable by 4G mobile communication systems. FRMCS typical mission critical services (MCPTT, MCData and soon MCVideo) are then formally applicable in 4G, simultaneously with the extensibility to 5G, as showed in Figure 4-2.

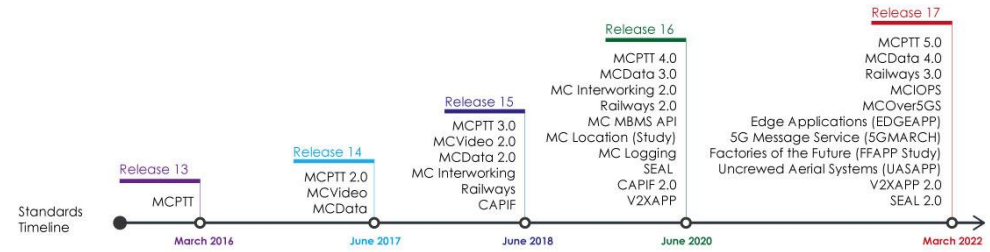

Figure 4-2: MCX specifications since 4G start (https://www.3gpp.org/technologies/sa6-app-enable

Based on this rationale, FRMCS-T has the following characteristics:

- At functional level, it must be similar to FRMCS 5G and in that sense respect the FRMCS FRS and TOBA FRS specification documents
- Due to the differences between 4G and 5G architectures, it must satisfy the design principles of the FRMCS system defined in FRMCS SRS, FRMCS FIS and FRMCS FFFIS specification documents, by adapting certain mechanisms varying from 5G to 4G
- FRMCS-T needs to be applicable to various frequency bands, as the spectrum regulations differ between countries at worldwide level
- FRMCS-T has finally to be designed so that it will facilitate the potential evolution to FRMCS 5G, to ensure the maintainability over time of the railway infrastructure.

FRMCS-T is not reputed to facilitate in a standardized manner the interconnections of networks and/or cross-boarding situations, even if such interconnections can always be envisaged in the context of ad-hoc projects. In that sense, and in addition because of the regulatory situation fixing the usage of 5G for FRMCS, it is expressly not reputed to be applicable in countries from the European Community.

4.3 Scope

The scope of the present FRMCS-T Technical Guideline is consequently:

1. To define the system functions and the mechanisms of a 4G-based FRMCS and provide the necessary parameters and configurations of those elementary functions and system blocks.

2. To define the 4G-related system architecture design principles (e.g. system characteristics).

3. To define the 4G system reference architecture, to define subsystems, constituents and the internal and external reference points or interfaces between them.

4. To reference all applicable standards and specifications upon which the FRMCS-T system is based.

The present FRMCS-T Technical Guideline does not intend to describe how to fulfill system requirements from a product perspective. This shall be developed together with the relevant suppliers and captured into adequate specifications where necessary.

4.4 Categorization of Requirements

The statements made in the present FRMCS-T Technical Guideline are assigned to the following categories:

• **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 become(s) mandatory for the system. The optional requirements are identified as sentences using the keyword "should".

• **Informative for the system** (indicated by **'(I)'** at the end of the clause). These are statements intended to provide explanatory notes.

Please note that **'NA'** is used to indicate that a particular item is not applicable and will therefore not need to be supported.

4.5 Document Life Cycle

The present FRMCS-T Technical Guideline is associated to the UIC FRMCS V1 set of specifications.

Its evolution is depending on the evolutions of UIC FRMCS Specifications that would

cause some additional elements to be considered.

5 System Architecture Design Principles for FRMCS-T

5.1 Scope of FRMCS-T System and Architecture

5.1.1 The FRMCS-T System provides communication services, applicable to the types of railways identified in [FRMCS-SRS, 5.1]. (I)

5.1.2 To enable independence between Railway Applications and the necessary physical transmission, the FRMCS-T Architecture consists of the exact same three major Strata (Railway application stratum, service stratum, transport stratum) as the FRMCS [FRMCS-SRS, 5.1], of which only two strictly belong to the FRMCS-T System: Service and Transport. (refer to Figure 5-1). (I)

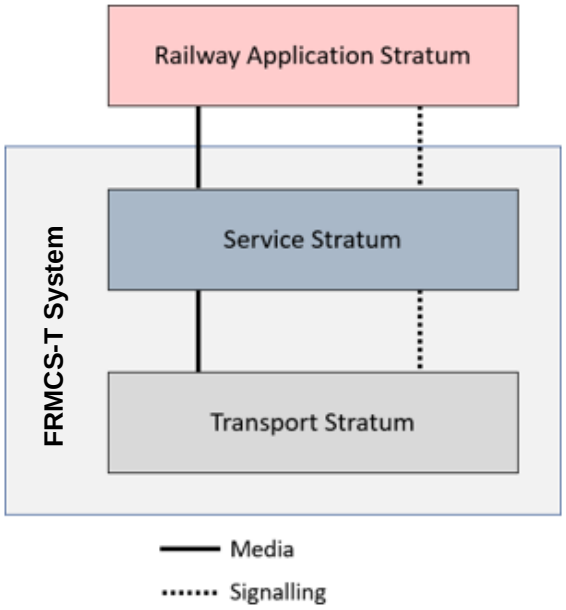

Figure 5-1: Railway Application, Service and Transport Strata

5.2 Principles for System Requirements

5.2.1 The FRMCS-T System provides the same communication services patterns as identified in [FRMCS-SRS, 5.2]. (I)

5.2.2 One aspect that FRMCS-T may differentiate from FRMCS is that the current guide has less emphasis on the interoperability of railway because of no strong single system requirement outside European area, while FRMCS needs to consider the freedom of train movement in European countries and interconnection between neighboring countries. (I)

5.2.3 The FRMCS-T System shall support 4G: Evolved Universal Terrestrial Radio Access (E-UTRA) Technologies (M).

5.3.4 The FRMCS-T System should support 5G. (O)

6 System Reference Architecture and Reference Points

6.1 Conformity to FRMCS

6.1.1 The FRMCS-T system is aligned with [FRMCS-SRS, 6]. (M)

6.1.2 An FRMCS-T Domain shall encompass the minimum necessary components: (M)

- In the Transport Domain:
  - A 4G Core Network
  - A 4G Access Network supporting a set of dedicated frequencies that may be country-specific (see section 8 for details).
- In the Service Domain:
  - A MCX infrastructure, including a SIP core.

Note: FRMCS-T could include a 5G Core and Access Network.

6.2 System Reference Architecture and Reference Points of FRMCS-T

6.2.1 FRMCS-T System Reference Architecture and Reference Points are aligned with [FRMCS-SRS, 6.2-6.3]. (M)

6.2.2 FRMCS-T Version changes to the three strata of FRMCS. (M)

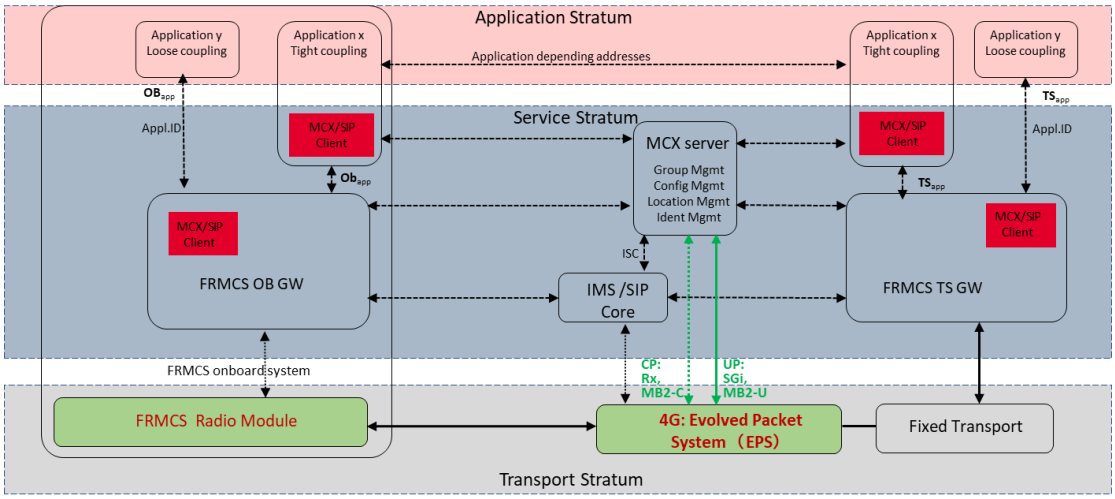

Figure 6-1: 4G-based FRMCS-T System in Application, Service and Transport Strata

In Figure 6-1, the main difference from original FRMCS is that the 4G system is used in Transport and Service strata. The green lines describe the 4G-specific modification to reference points for the FRMCS-T system:

- Control Plane (CP):
  - **Rx**: Reference point between the AF and PCRF, Rx protocol is based on diameter [3GPP TS 29.214]. (M)

    Note: FRMCS also supports Rx.
  - **MB2-C**: Reference point between the BM-SC and the AS to manage the eMBMS Bearer [3GPP TS 23.468]. (O)
- User Plane (UP):
  - **SGi**: Reference point between the Evolved Packet Core (EPC) and the Public IP network. (M)
  - **MB2-U**: Reference point between the BM-SC and the AS to deliver downlink data. (O)

6.2.3 The FRMCS-T architecture requires that all applications shall support to be implemented by through MCX services, as the same as FRMCS requires. (M)

6.3 Evolving FRMCS-T to FRMCS

6.3.1 The FRMCS-T architecture shall support the capability to be upgraded to FRMCS 5G system. (M)

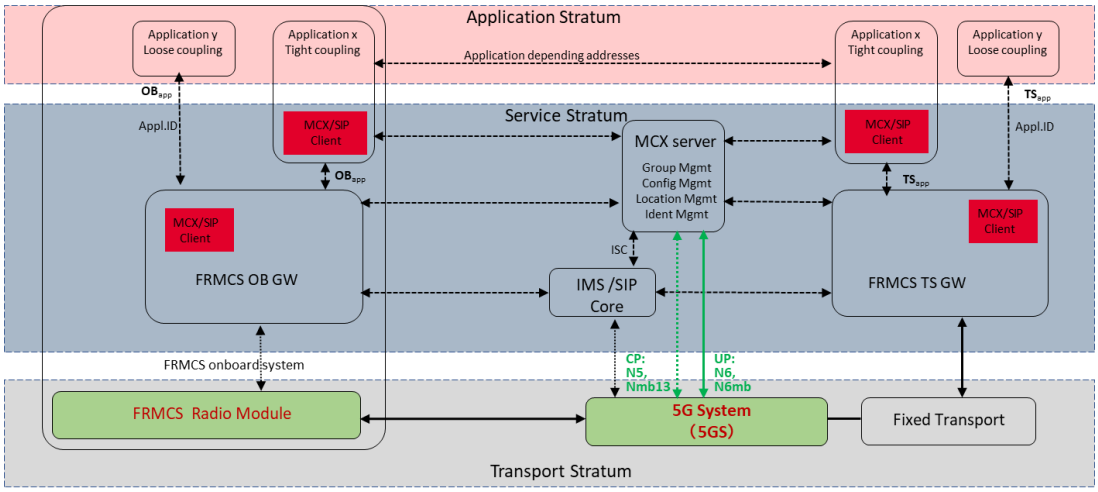

Figure 6-3: 5G-based FRMCS System in Application, Service and Transport Strata

6.3.2 By using 5GS (RAN and Core) to replace 4G EPS, the transport stratum will support 5G communication capability. In this case, radio module of terminals and chips shall be upgraded. (M)

6.3.3 Reference points between MCX server and 5GS are required to change for 5G compatibility. In Figure 6-3, FRMCS-T is shown how to upgrade to 5G-based FRMCS architecture by transforming the interfaces and reference points, as well as 5GS system in Transport and Service strata. The green lines describe the 5G-specific modification to reference points for the FRMCS-T system:

- Control Plane (CP):
  - **N5:** Reference point between the PCF (Policy Function) and an AF (Application Function), N5 protocol is based on HTTP RESTFUL. (M)

    Note: FRMCS also supports Rx as an alternative to N5.
  - **Nmb13:** Reference point between the MB-SMF and the AF, to 5MBS session. (O)
- User Plane (UP):
  - **N6:** Reference point between the UPF and the Public Data Network. (M)
  - **N6mb:** Reference point between the MB-UPF and the AS to deliver downlink data. (O)

7 Description of Subsystems and Constituents

7.1 On-Board FRMCS-T

7.1.1 On-Board FRMCS-T is aligned with the original FRMCS, as per [FRMCS-SRS, 7.1] definition. (M)

7.1.2 *On-Board FRMCS-T Architecture overview*

The figure 7-2 represents the On-Board FRMCS-T architecture, which is the same as On-Board FRMCS v1, except that the Radio Functions are 4G LTE. (M)

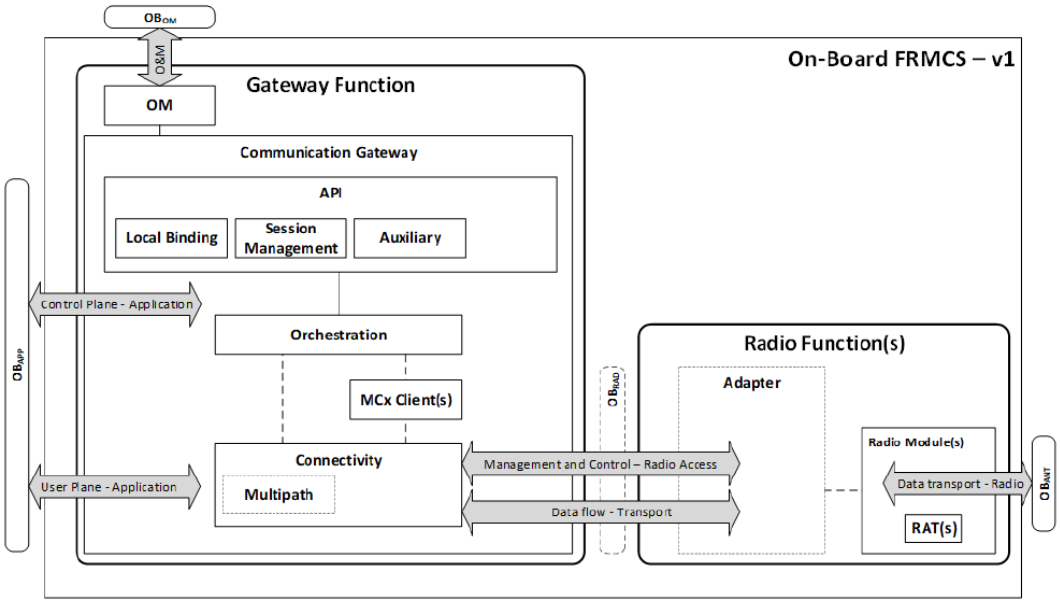

Figure 7-1: On-Board FRMCS-T architecture

7.2 Decoupling of On-Board Application and Transport

7.2.1 *Rationale*

In the GSM-R system, application and communication services, including transport, are tightly coupled which does not allow an independent evolution. Evolution of the communication and transport systems causes changes in the applications. Cf. [TOBA -SRS,7.1]. (I)

7.2.2 *Requirements*

7.2.2.1 Usage of the On-Board FRMCS-T shall be enabled for applications through the defined OB_{APP} interface. (M)

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

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

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

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

Note: FRMCS FFFIS V2 that is expected to be made available Q4 2024 will specify the FRMCS OB_{APP} API.

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

7.2.2.7 Based on the QoS Profile and associated communication attributes, the On-Board FRMCS-T 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-T Radio Modules (M)
- Which transport service to offload to in case of capacity limitations (M)

7.2.2.8 The On-Board FRMCS-T shall be addressable on the basis of a unique set of identifiers. (M)

7.3 Antenna Function

7.3.1 The Antenna Function is defined as in [FRMCS-SRS, 7.2]. (M)

8 Radio Spectrum

8.1 Introduction

8.1.1 This section describes the requirements on the use of frequency bands applicable for 4G Radio Access Technology / 3GPP E-UTRAN. (I)

8.2 Spectrum Principles

8.2.1 FRMCS-T shall support the majority of the spectrum defined in 3GPP E-UTRAN terrestrial use. (M)

8.2.2 FRMCS-T should support licensed as well as unlicensed frequency bands. (O)

Note: Spectrum licensing is a national matter.

8.2.3 FRMCS-T shall enable the use of a single frequency band as well as the simultaneous use (receive and transmit) of multiple frequency bands. (M)

8.3 Recommendation on FRMCS-T Frequency Bands

8.3.1 For **FRMCS-T Recommended (FTR)** frequency bands, it follows the general principles as provided below (I):

a. The respect of each countries' frequency regulations and policies, as well as the availability of frequency bands.

b. References such as RMR (Railway Mobile Radio) spectrum as defined in Europe, where the radio spectrum (900 MHz,1900 MHz) is identified for RMR [FRMCS SRS, 8.4], which is also known as 3GPP bands (n100, n101) [TS 38.101].

Note: RMR encompasses GSM-R and FRMCS.

8.3.2 Power class of UE for the underlying FTR bands may refer to 3GPP LTE transmission requirement [TS 36.101], as well as 3GPP NR transmission requirement [TS 38.101]. Since the category of UE Power Class 1 (maximum 31dBm) in NR and LTE is different, it is highly desired, in case of usage of these bands, to define the corresponding bands of n100 & n101 in LTE to have the capability of Power Class 1 (maximum 31dBm) for smooth upgrade to FRMCS in the future. That should rely on the work in 3GPP. (O)

8.3.3 FRMCS-T is able to flexibly use up to the maximum extent of spectrum available for rail in a given area. (I)

8.4 Public MNO Spectrum

8.4.1 FRMCS-T Radio Modules used for E-UTRAN communication purposes should support frequency bands allocated to public MNOs (PMNOs). (O)

8.4.2 FRMCS-T Radio Modules should support a subset of the major 3GPP frequency bands as listed in 3GPP TS 36.101. (I)

Frequency bands (MHz or GHz)	Band name	Uplink/Downlink (MHz)
TBD		TBD
...		

Table 8-1: Public Frequency bands for FRMCS Radio Modules (FFS) (I)

8.5 FRMCS-T Radio Module Support of Radio Access Technologies and Frequency Bands

8.5.1 The train-borne equipment supports several types of FRMCS-T Radio Modules. (I)

8.5.2 FRMCS-T Radio Module types are for example (non-exhaustive list): (I)

a. Radio Modules which exclusively support FTR bands

b. Radio Modules which support FTR bands and a subset of other bands (e.g. PMNO and/or WLAN bands)

c. Radio modules which exclusively support a subset of PMNO bands

d. Radio modules which exclusively support WLAN (e.g. Wi-Fi) frequency bands

8.5.3 A FRMCS-T Radio Module should support a single or multiple of the following frequency bands and corresponding RATs (O):

a. FTR frequency bands using 4G E-UTRAN terrestrial

b. PMNO frequency bands using 5G NR terrestrial

c. PMNO frequency bands using 4G E-UTRAN terrestrial

d. Non-3GPP terrestrial frequency bands using WLAN (e.g., Wi-Fi)

8.5.4 FRMCS-T Radio Modules should support the frequency bands (and corresponding RATs) in accordance with par. 8.5.3 which are used for E-UTRAN by different IMs at the trackside. The responsible IM should have the choice to choose one or more frequency bands in FTR and PMNO. (I)

8.5.5 The choice of non-FTR frequency bands for the train-borne equipment shall be done to protect the performance of FTR frequency bands and minimize associated interferences. (M)

8.5.6 The train-borne equipment (i.e., one or more E-UTRAN Radio Modules) should support a subset of the PMNO frequency bands as identified in Table 8-1. (I)

8.5.7 The train-borne equipment (i.e., one or more E-UTRAN Radio Modules) should support WLAN frequency bands. (I)

8.6.8 The train-borne equipment (i.e., one or more FRMCS-T Radio Modules) should support 5G NR non-terrestrial and/or legacy non-terrestrial frequency bands. (I)

8.6 For Further Study

8.6.1 Identification and designation of public MNOs bands (including associated RATs) used for FRMCS-T (Table 8-1). (I)

8.6.2 According to the progress of FRMCS standards [FRMCS-SRS, 8.7], radio spectrum should be further studied. (I)

9 GSM-R Interworking and Migration

Interworking and Migration from GSM-R to FRMCS-T (including dispatcher systems) will be further studied, in accordance with [TS 103 792]. (I)

10 Interconnection, Roaming and Border Crossing

As explained in Chapter 4, these elements are not addressed in the present version of FRMCS-T. (I)

11 Identifiers

11.1 Introduction

11.1.1 International standardization of user identities is required to ensure interworking between E-UTRAN domains. FRMCS-T follows the description and requirements in [FRMCS-SRS, 11]. (M)

11.1.2 One significant difference of 5G ID is the SUPI/SUCI that will be used, which is for further study in [FRMCS-SRS]. In FRMCS-T, IMSI could be simply used instead. (I)

12 Bearer Flexibility

12.1 Introduction

12.1.1 Bearer flexibility enables the use of the transport/access networks which are available within the administrative domains of an FRMCS Operator and/or a PMNO. (I)

12.1.2 FRMCS-T follows the requirements described in [FRMCS-SRS, 12]. (M)

12.1.3 In addition to 12.1.2, there are some requirements specifically to 4G, in Multipath, Multi Access and Intra-RAT. (I)

12.2 Multipath for FRMCS-T

12.2.1 Multipath is the capability that enables data connectivity using multiple transport paths over separate UEs. (I)

12.2.2 Definition of FRMCS-T Multipath follows the [FRMCS-SRS, 12.4], with the exception that FRMCS transport domain are using 4G LTE, replacing 5G. (M)

12.2.3 FRMCS-T Multipath should be supported by the FRMCS On-Board System. (O)

12.2.4 FRMCS-T Multipath shall be based on an (evolved) standard (e.g., IETF). (M)

12.3 Multi Access for FRMCS-T

12.3.1 The FRMCS-T Multi Access capability enables the simultaneous use of 3GPP and non-3GPP RATs in accordance with 3GPP standards and shall encompass at least the combination of terrestrial 4G RAT or terrestrial Non-3GPP RAT. (O)

12.3.2 FRMCS Multi Access shall be based on 3GPP 4G system standard, which does not support 5G standard (e.g. ATSSS). (M)

12.4 FRMCS-T Intra-RAT

12.4.1 FRMCS-T Intra-RAT capability shall support the selection, in a single UE, of either 4G terrestrial access making use of RMR spectrum or 5G NR terrestrial access making use of spectrum allocated to PMNOs (e.g. RAN Sharing with a PMNO). (O)

12.4.2 FRMCS Intra-RAT capability shall support the inter-frequency transition for 4G terrestrial access (intra-RAT) between FTR spectrum and spectrum allocated to PMNOs for an ongoing communication. (O)

12.4.3 FRMCS Intra-RAT capability shall be provided based on 3GPP 4G system capabilities (e.g. Intra-RAT Inter-frequency cell selection/handover). (M)

13 Network Slicing

Since 4G does not support network slicing function, this element is not considered in FRMCS-T.

14 Quality of Service and Priority

14.1 Introduction

14.1.1 This section defines the requirements of FRMCS-T Quality of Service and Priority, which is aligned with [FRMCS-SRS, 14], mapping towards the 3GPP mechanisms and its utilization. (M)

14.1.2 The signalling and enforcement procedures of the 4G / E-UTRAN QoS and priority framework shall be based on 3GPP mechanisms defined for the 4G System in transport stratum and the Mission Critical services in service stratums. (M)

14.2 4G Specific QoS Requirements Mapping from 5G System

14.2.1 The FRMCS-T system shall support the set of standardized QCI which MC services need to reflect the requirements on latency and packet reliability given in [FRMCS-SRS, 14.4.7]. (M)

14.2.2 The specific 4G QCI levels that FRMCS-T needs to support are described in the following Table. 14-1. 4G QCI and 5G 5QI have almost the same definition and requirement, according to 3GPP [TS 23.203] [TS 23.501]. Since [FRMCS-SRS, 14.5.2] has defined the 5QI values that FRMCS needs, it is required for FRMCS-T system to support the following 4G QCI values mapped one-by-one, as well. These values shall be complied no matter of the network deployment model. (M)

QCI	Resource Type	Priority Level	Packet Delay Budget	Packet Error Loss	Example Services
65	GBR	0.7	75 ms	10^{-2}	Mission Critical user plane Push To Talk voice (e.g., MCPTT)
67		1.5	100 ms	10^{-3}	Mission Critical Video user plane
5	Non-GBR	1	100 ms	10^{-6}	IMS Signalling
70, 6, 8 or 9		5.5	200 ms	10^{-6}	Mission Critical Data
69		0.5	60 ms	10^{-6}	Mission Critical delay sensitive signalling (e.g., MC-PTT signalling, MC Video signalling)

Table 14-1: Standardized QCI values to be supported by FRMCS-T system and its utilization (M)

14.2.3 Guaranteed Flow Bit Rate (GFBR) is not supported by FRMCS-T, since this is a 5G specific parameter and optionally required in FRMCS. (I)

14.2.4 Allocation and Retention Priority (ARP), is defined as the same as FRMCS [FRMCS-SRS, 14.5.4]. (M)

14.3 For Further Study

14.2.1 The specification of alternative 3GPP QoS parameters (as defined by [TS 23.401]) for each application type is For Further Study (FFS). (I)

14.2.2 The interworking with core networks other than 4G Core in context of QoS is FFS. (I)

14.2.3 The dimensioning of network entities outside the scope of 4GS as introduced in 13.5.1.3 are FFS. (I)

15 FRMCS-T Cybersecurity

15.1 Introduction

15.1.1 In the following, the term cybersecurity is used only in the context of FRMCS-T security and is thus equated with that term. (I)

Note: Generally, the term security should not be confused with the term safety. Safety refers to the freedom from unacceptable risk, which is related to human health or to the environment.

15.1.2 FRMCS-T security relevant configurations, design shaping details and categorizations, for example:

- cryptographic algorithms
- key lengths
- requirement categories (mandatory vs. optional) of the protection of security attributes like data integrity, confidentiality, authenticity and privacy

are depending on risk assessments by consideration of different aspects like hazard potential (related to threats and vulnerabilities) and damage potential). (I)

Note: Risk assessments are not covered by this specification.

15.1.3 Cybersecurity elements are aligned with [FRMCS-SRS, 15], in which some are for further study and will consider primarily to be finalized ETSI Technical Specifications in the context of the FRMCS architecture, including building blocks and functions [TS 103 764], [TS 103 765-1], [TS 103 765-2], as well as secondary 3GPP specifications [TS 33.180] and [TS 33.401]. (I)

15.2 Transport Stratum for FRMCS-T

15.2.1 [TS 33.401] applies for the FRMCS-T transport stratum security in the following context:

- The FRMCS transport stratum security shall provide functions for subscription and serving network authentication. (M)
- The FRMCS transport stratum security shall provide functions for the UE and serving network authorization. (M)
- The FRMCS transport stratum security shall provide functions for the protection of the confidentiality and integrity of user data as well as of signalling data. (M)

- The FRMCS transport stratum security shall provide functions for the protection of the privacy of data, e.g. for the identifier IMSI. (M)

15.2.2 The FRMCS-T transport stratum security shall be able to protect the confidentiality and integrity as well as to authenticate subscriptions based on cryptographic algorithms and subscription authentication methods according to table 15-1:

Confidentiality of the user data between the UE and the eNB shall be protectable by 128-EEA1. (M)
Confidentiality of the user data between the UE and the eNB should be protectable by 128-EEA2. (O)
Confidentiality of the user data between the UE and the eNB should be protectable by 128-EEA3. (O)
Confidentiality of the RRC and NAS-signalling between the UE and eNB and between UE and MME, respectively shall be protectable by 128-EEA1. (M)
Confidentiality of the RRC and NAS-signalling between the UE and eNB and between UE and MME, respectively should be protectable by 128-EEA2. (O)
Confidentiality of the RRC and NAS-signalling between the UE and eNB and between UE and MME, respectively should be protectable by 128-EEA3. (O)
Integrity of the user data between the UE and the eNB shall be protectable by 128-EIA1. (M)
Integrity of the user data between the UE and the eNB should be protectable by 128-EIA2. (O)
Integrity of the user data between the UE and the eNB should be protectable by 128-EIA3. (O)
Integrity of the RRC and NAS-signalling between the UE and eNB and between UE and MME, respectively shall be protectable by 128-EIA1. (M)
Integrity of the RRC and NAS-signalling between the UE and eNB and between UE and MME, respectively should be protectable by 128-EIA2. (O)
Integrity of the RRC and NAS-signalling between the UE and eNB and between UE and MME, respectively should be protectable by 128-EIA3. (O)
UE and serving network shall support EAP-AKA' and EAP AKA subscription authentication methods. (M)
UE and serving network should support the EAP-TLS subscription authentication method. (O)
Note 1: According to [TS 33.401] the protection of the integrity of the RRC and NAS-signalling between the UE and eNB and between UE and MME, respectively is mandatory.

Table 15-1: Cryptographic 4G Security Algorithms and Subscription Authentication Methods

15.3 Minimum FRMCS-T Security Level

15.3.1 A minimum FRMCS-T security level is defined, taking into account the algorithms listed in Table 15-2. (I)

FRMCS-T Transport Stratum Security		
Scope	***Security Items***	***Cryptographic Algorithms and Subscription Authentication Methods according to [TS 33.401]***
User Data	Confidentiality of user data	128-EEA1
	Integrity of the user data	128-EIA1
Signalling Data	Confidentiality of the RRC and NAS-signalling	128-EEA1
	Integrity of the RRC and NAS-signalling	128-EIA1
Authentication	Subscription authentication	EAP-AKA' and EAP AKA

Table 15-2: Set of cryptographic algorithms, MCX user authentication and subscription authentication methods to be implemented for the minimum FRMCS-T security level

Printed by

International Union of Railways

16, rue Jean Rey 75015 Paris - France

July 2024

Legal deposit July 2024

ISBN 978-2-7461-3415-7