



## **Rail Telecommunications (RT); Future Rail Mobile Communication System (FRMCS); Study on system architecture**

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# Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Railway Telecommunications (RT).

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# Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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# Executive summary

Since the first studies on the successor to GSM-R have been launched by UIC in 2012, the railway community has been considering how to meet railway requirements with a future proof and flexible radio communication system.

The rail needs are defined in the User Requirements Specification (URS) delivered by the UIC Project Future Rail Mobile Communications System (FRMCS) [i.1]. Those requirements are the basis for the development of the GSM-R successor, in the form of individual and technology independent applications.

The present document is a study on system architecture which describes a potential high-level functional architecture, investigating how the rail requirements can be met. The need for interworking with the legacy GSM-R system during the transition period to its successor is also considered. The document presents a high level grouping of FRMCS features for each major system function. In addition, it investigates different technical options and solutions to address those requirements.

A comparison of technical solutions (including 4G versus 5G) in the context of typical rail applications is presented. While no conclusion can be drawn, it is understood that several building blocks defined in 3GPP can be used to address most of the requirements. However, it is acknowledged that a gap analysis should be undertaken to identify which rail features require a potential standardization effort in ETSI. In addition, a mapping of applications to system functions, and a mapping of system functions to subsystems and network elements would be needed to refine the FRMCS architecture.

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## Introduction

GSM-R has been a great success not only in Europe where more than 100 000 Km of railway tracks are daily operated through GSM-R but also worldwide, and this number will double within the next years due to the on-going installations of this technology all over the world.

As the needs of the railways are constantly evolving, and that the telecom standards evolution remains dependent of the telecom industry evolution cycles, with an end of support for GSM-R planned by 2030 onwards, UIC launched in 2012 the first studies for a successor to GSM-R, pertinently named Future Rail Mobile Communications System (FRMCS). The UIC Project then concretely delivered the new User Requirements Specifications (URS) [i.1] focusing mainly on rail communication needs as a basis for the development of the GSM-R successor.

The present document is a study on system architecture, investigating how the requirements from the URS can be met; keeping in mind that interworking with the legacy GSM-R system is necessary during the transition period from GSM-R to its successor.

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# 1 Scope

The present document:

- 1) Provides a reference model of FRMCS system architecture from a functional point of view.
- 2) Provides a high-level description of the functions that address FRMCS requirements (as specified by FRMCS URS and Use Cases).
- 3) Defines internal and external boundaries of the FRMCS system (e.g. transport versus applications, external systems, external networks, etc.).
- 4) Defines further potential steps.

The present document describes a potential high-level functional architecture, as well as a high level grouping of FRMCS system functions and mapping towards requirements.

In addition, the present document investigates different technical possibilities, e.g. 3GPP building blocks, to address the requirements of the FRMCS system. Some of the currently developed techniques, e.g. Service Based Architecture (SBA) or Software Defined Networks (SDN), have not been considered in the present document and might be included in a future release.

Finally, the present document identifies the next steps to ensure the complete definition of the FRMCS system.

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## 2 References

### 2.1 Normative references

Normative references are not applicable in the present document.

### 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- |       |   |
|-------|---|
| [i.1] | UIC FRMCS URS v3.0: "User Requirements Specification".  |
| [i.2] | Recommendation ITU-T I.112: "Vocabulary of terms for ISDNs".  |
| [i.3] | ETSI TS 124 010: "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Mobile radio interface layer 3; Supplementary services specification; General aspects (3GPP TS 24.010)". |
| [i.4] | 3GPP TR 22.889: "Study on Future Railway Mobile Communication System".  |
| [i.5] | IEC 61375-1:2012: "Electronic railway equipment - Train communication network (TCN) - Part 1: General architecture".  |
| [i.6] | ETSI TS 136 300: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300)".  |
| [i.7] | ETSI TS 123 501: "5G; System Architecture for the 5G System (3GPP TS 23.501)".  |

- [i.8] NGMN Alliance 5G White Paper v1.0.
- [i.9] ETSI TS 123 401: "LTE; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (3GPP TS 23.401)".
- [i.10] IETF RFC 7866: "Session Recording Protocol".
- [i.11] ETSI TS 103 389: "Railway Telecommunications (RT); Global System for Mobile communications (GSM); Usage of Session Initiation Protocol (SIP) on the Network Switching Subsystem (NSS) to Fixed Terminal Subsystem (FTS) interface for GSM Operation on Railways".
- [i.12] ETSI TS 133 180: "LTE; Security of the mission critical service (3GPP TS 33.180)".
- [i.13] ETSI TS 122 278: "LTE; Service requirements for the Evolved Packet System (EPS) (3GPP TS 22.278)".
- [i.14] 3GPP TR 28.801: "Telecommunication management; Study on management and orchestration of network slicing for next generation network".
- [i.15] ETSI TS 122 261: "5G; Service requirements for next generation new services and markets (3GPP TS 22.261)".
- [i.16] ETSI TS 138 211: "5G; NR; Physical channels and modulation (3GPP TS 38.211)".
- [i.17] P. Marsch et. al (editors): "5G System Design - Architectural and Functional Considerations and Long Term Research", Wiley, May 2018.
- [i.18] IEEE 802.11™: "IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

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## 3 Definition of terms, symbols and abbreviations

### 3.1 Terms

For the purposes of the present document, the following terms apply:

**FRMCS client:** client enabling the use of the FRMCS communication services and railway services for the railway applications including railway services

**FRMCS communication services:** services enabling the exchange of information (control plane) between FRMCS Users and/or external systems to manage communication between two or multiple FRMCS Users by using the capabilities of the FRMCS transport system

**FRMCS gateway:** gateway coordinating and managing FRMCS Users access to the FRMCS Transport Services offered by the FRMCS System

NOTE: The FRMCS Gateway may support the FRMCS Proxy and the Legacy Conversion functions.

**FRMCS proxy:** function interacting with the FRMCS communication services and acting in the place of railway applications for user plane purposes

**FRMCS supporting and enabling services:** services providing functions to enable communication services for FRMCS users based on the 3GPP defined mission critical services and other enabling functions such as location and recording

**FRMCS system:** telecommunication system conforming to FRMCS specifications, consisting of FRMCS transport system and FRMCS communication services

**FRMCS transport system:** system encompassing the amount of terrestrial and/or non-terrestrial radio access sub-systems consisting of 3GPP access and/or non-3GPP access, wireline access, the core sub-system having multi-access capabilities and the User Equipment



**FRMCS user:** human or machine making use of FRMCS communication services

**FRMCS user identity:** unique identity associated with a single or multiple FRMCS user and can be complemented by alternative addressing schemes

**legacy conversion:** function that provides conversion towards legacy interfaces (e.g. V.24 serial interface)

NOTE: The Legacy Conversion provides encapsulation/de-capsulation for control and user plane data as well as the necessary conversion of the physical interfaces between legacy GSM-R UE and FRMCS. The Legacy Conversion is based on FRMCS Proxy functions to use the FRMCS Communication Services.

**non-MCX enabled:** subset of the FRMCS System that provides simple connectivity by using the FRMCS Transport System and does not interact with the FRMCS communication services and railway services

**on-board transport system:** system providing on-train only transport services and enables the interaction with the FRMCS Gateway and the FRMCS communication services where applicable

**proxy:** person or entity acting or being used in the place of someone or something else

**railway applications:** applications that provides critical, performance and business related railway functionality using communication services offered by the FRMCS System

**railway services:** railway specific services, using enabler services including 3GPP building blocks necessary for railway applications

**reference point:** conceptual point at the conjunction of two non-overlapping functional groups

NOTE: See Recommendation ITU-T I.112 [i.2].

**train communication network:** sub-system of on-board transport system that aggregates various train backbones

**user equipment:** equipment that allows a user access to transport services via 3GPP and/or non-3GPP accesses

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	3 <sup>rd</sup> Generation Partnership Project
4G	Fourth Generation Mobile Networks
5G	Fifth Generation Mobile Networks
AKA	Authentication and Key Agreement
AMF	Access and Mobility Management Function
APN	Access Point Name
ARP	Allocation and Retention Priority
AS	Access Stratum
ASCI	Advanced Speech Call items
ATO	Automatic Train Operation
AUSF	Authentication Server Function
BGCF	Breakout Gateway Control Function
BICN	Bearer Independent Core Network
CN	Core Network
COTS	Commercial off-the-shelf
CUPS	Control and User Plane Separation
DCN	Dedicated Core Network
DCN-ID	Dedicated Core Network Identity
DECOR	Dedicated Core Networks
DN	Data Network
DRB	Data Radio Bearer
EAP	Extensible Authentication Protocol

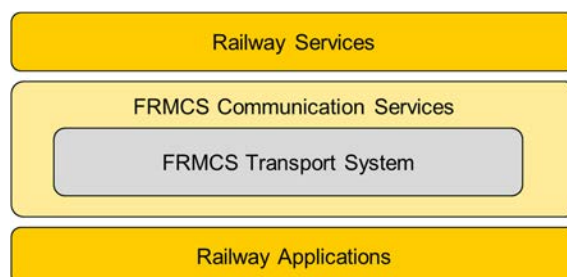
eDECOR	enhancements of Dedicated Core Networks
EIRENE	European Integrated Railway Radio Enhanced Network
eNB	evolved NodeB
EPS	Enhanced Packet System
ETCS	European Train Control System
E-UTRAN	Enhanced UMTS Terrestrial Radio Access Network
EVC	European Vital Computer
FA	Functional Addressing
FEEI	Fachverband der Elektro- und Elektronikindustrie Bereich Technik
FFS	for further study
FQDN	Fully Qualified Domain Name
FRMCS	Future Rail Mobile Communications System
FRMCS	Future Railway Mobile Communication System
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication
GSM-R	Global System for Mobile communication for Railways applications
GUMMEI	Globally Unique MME Identifier
HPLMN	Home Public Land Mobile Network
HSS	Home Subscriber server
IEEE	Institute of Electrical and Electronics Engineers
IMS	Internet Multimedia Subsystem
IN	Intelligent Network
IoT	Internet of Things
IP	Internet Protocol
KASME	Key transferred from the HSS to the Access Security Management Entity
KMS	Key Management Server
LAA	Licensed-Assisted Access
LDA	Location Dependent Addressing
LTE	Long Term Evolution
LTE-U	Long Term Evolution-Unlicensed
LWA	LTE-WLAN Aggregation
MAC	Media Access Control
MC	Mission Critical
MCDData	Mission Critical Data
MCPTT	Mission Critical Push To Talk
MCVideo	Mission Critical Video
MCX	Mission Critical services
MGCF	Media Gateway Control Function
MGW	Media GateWay
MME	Mobile Management Entity
MNO	Mobile Network Operator
MOCN	Multi Operator Core Network
MORANE	MOBILE radio for RAILway Networks in Europe
NAS	Non-Access Stratum
NEF	Network Exposure Function
NGMN	Next Generation Mobile Network
NR	New Radio
NRF	Network Repository Function
NSSAI	Network Slice Selection Assistance Information
NSSF	Network Slice Selection Function
OTT	Over The Top
PCF	Policy Control Function
PCRF	Policy and Charging Rule Function
PDCP	Packet Data Convergence Protocol
PDU	Packet Data Unit
PLMN	Public Land Mobile Network
PLMN-ID	Public Land Mobile Network Identification
PSTN	Public Switch Telephone Network
QCI	QoS Class Identifier
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technology

RBC	Radio Block Centre
REC	Railway Emergency Call
RLC	Radio Link Control
RRC	Radio Resource Control
S/P-GW	Serving Packet GateWay
SBA	Service Based Architecture
SBC	Session Border Controller
SDAP	Service Data Adaptation Protocol
SDF	Service Data Flow
SDN	Software Defined Networks
SGSN	Serving GPRS Support Node
SIEM	Security Information and Event Management
SIL	Safety Integrity Level
SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SMF	Session Management Function
SS7	Signalling System No 7
SST	Slice/Service Type
TAU	Tracking Area Update
TC	Technical Committee
TCN	Train Communication Network
TCP	Transmission Control Protocol
UDM	Unified Data Management
UE	User Equipment
UIC	Union Internationale des Chemins de Fer
UPF	User Plane Function
URS	User Requirements Specification
USDM	User & Service Data Management
UTRAN	UMTS Terrestrial Radio Access Network
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network

## 4 High level approach description

### 4.1 Introduction

The FRMCS functional architecture objective is a clear separation between FRMCS Communication Services and FRMCS Transport System to enable bearer flexibility/multi-access support. The FRMCS Transport System is embedded within the FRMCS Communication Services, which provide a generic interface for Railway Applications to support the communication between FRMCS Users. Railway Services address specific railway operational requirements, which are not covered by FRMCS Communication Services.



**Figure 1: High Level functional layers**

The FRMCS architecture can be vertically split into Railway Applications using FRMCS Communication Services and other, which are Non-MCX enabled.