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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Railway Telecommunications (RT) and is now submitted for the combined Public Enquiry and Vote phase of the ETSI Standardisation Request deliverable Approval Procedure (SRdAP).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**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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1 Scope

The present document describes the high-level System Architecture for the Future Railway Mobile Communications System (FRMCS). The interaction between FRMCS domains, high-level procedures, deployment scenarios and IP addressing/routing are also outlined.

2 References

2.1 Normative 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.

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The following referenced documents are necessary for the application of the present document.

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

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

[3] ETSI TS 103 765-3: "Rail Telecommunications (RT); Future Railway Mobile Communication System (FRMCS); Building Blocks and Functions; Part 3: Train On-Board functions and interfaces".

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

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

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.

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The following referenced documents may be useful in implementing an ETSI deliverable or add to the reader's understanding, but are not required for conformance to the present document.

[i.1] UIC FRMCS FFFIS-7950: "FRMCS FFFIS Form Fit Functional Interface Specification".

[i.2] UIC FRMCS FIS-7970: "FRMCS FIS Functional Interface Specification".

[i.3] UIC FRMCS SRS: FRMCS System Requirements Specification".

[i.4] ETSI TR 103 791: "Rail Telecommunications (RT); Future Railway Mobile Communication System (FRMCS); Terminology for FRMCS specifications".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TR 103 791 [i.4] and the following apply:

open session: session which has not been terminated via MCData procedures

session: tunnel established between two MCData clients on behalf of an application

3.2 Symbols

Void.

3.3 Abbreviations

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

5G	5th Generation
5GC	5G Core
API	Application Programming Interface
APP	APPlication
ATO	Automatic Train Operation
ATP	Automatic Train Protection
EIRENE	European Integrated Railway radio Enhanced NEtwork
ETCS	European Train Control System
FCOP	FRMCS Close of OPeration
FFFIS	Form Fit Functional Interface Specification
FIS	Functional Interface Specification
FRMCS	Future Railway Mobile Communication System
FS	FRMCS System
FSD	FRMCS Service Domain
FSMPU	FRMCS MultiPath User plane
FSOP	FRMCS Start of OPeration
FTD	FRMCS Transport Domain
GSM	Global System for Mobile
GSM-R	Global System for Mobile communications - Railway
H2N	Host-To-Network
IM	Infrastructure Manager
IP	Internet Protocol
IWF	InterWorking Function
LB	Local Binding
MC	Mission Critical
MCPTT	Mission Critical Push To Talk
MCS	Mission Critical Service
MCX	Mission Critical Communications
MPM	MultiPath Management
NAT	Network Address Translation
NNI	Network-to-Network Interface
NR	New Radio
NTT	Network Transition Trigger
OB	On-Board
OM	Operation and Maintenance
OMR	OM Remote Interface
ONI	Other Network-to-Network Interface
PDU	Packet Data Unit
QoS	Quality of Service
REC	Railway Emergency Communication

RM	Radio Module
RMR	Railway Mobile Radio
RU	Railway Undertaking
SIP	Session Initiation Protocol
SRS	System Requirements Specification
SSE	Server Sent Events
TCMS	Train Control Management System
TLS	Transport Layer Security
UE	User Equipment
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
VAS	Voice Application Subsystem

4 Architecture principles and model

4.1 Introduction

The present document defines the architecture for the Future Railway Mobile Communications System (FRMCS) in on-network mode. FRMCS architecture is described and specified based on a transport stratum and a service stratum. FRMCS transport stratum provides connectivity for data transport and FRMCS service stratum enables communication as services between two or multiple FRMCS Users for voice, video and data applications.

The following is described:

- overall architecture of FRMCS within one FRMCS Domain with principles and components;
- procedures applicable for an FRMCS Domain and interactions between FRMCS Domains.

FRMCS System Architecture is designed based on the high-level principles outlined in clause 4.2. In addition, the architecture reference model is described.

4.2 General principles

4.2.0 Overview

The FRMCS System Architecture is defined to support communications between various types of FRMCS Users such as train and trackside end-users/applications, and railway personnel.

The FRMCS System Architecture satisfies the following key principles:

- Maximizing the decoupling between the strata to facilitate an independent evolution of the Transport Stratum and/or of the Service Stratum without mandating an evolution of the Application Stratum.
- Supporting QoS and priority policies that allows differentiating the communications of different types of railway applications.
- Supporting multiple Radio Access Technologies.
- Supporting Service Stratum security and Transport Stratum security.
- Supporting Operation and Maintenance for on-board FRMCS.

4.2.1 Strata

The FRMCS System Architecture is structured in two strata called Service Stratum and Transport Stratum as illustrated in Figure 4.2.1-1. External to the FRMCS System, railway applications using the FRMCS System are grouped in a third stratum named Railway Application Stratum (see Figure 4.2.1-1).

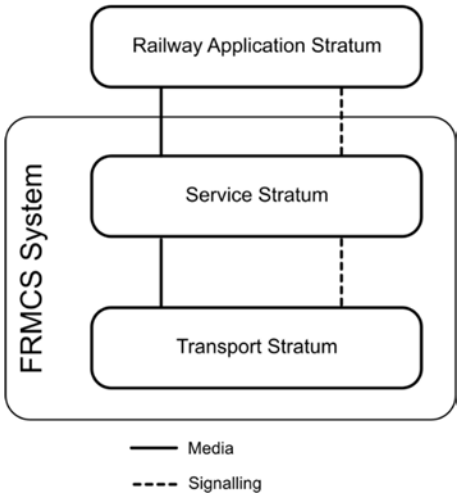


Figure 4.2.1-1: Strata in FRMCS System Architecture

The Transport Stratum provides data connectivity and corresponding services (e.g. mobility, QoS, policy control, authentication, etc.). The Service Stratum is centered around the 3GPP Mission Critical Communications (MCX) Framework and decouples the application from the underlying transport networks.

The FRMCS Transport Stratum is described in more detail in ETSI TS 103 765-1 [1].

The FRMCS Service Stratum is described in more detail in ETSI TS 103 765-2 [2].

The Application Stratum is not considered to be part of the FRMCS architecture and therefore it will not be described in the present document.

4.2.2 Modularity of deployment

The FRMCS System Architecture is intended to be deployed in different ways:

- Stand-alone deployment, i.e. deployment of an FRMCS Domain with no external connection to other FRMCS Domains.
- Deployment as part of an international network of networks, i.e. deployment of an FRMCS Domain connected to other FRMCS Domains.
- Deployment encompassing interworking with GSM-R, deployment of an FRMCS Domain with users interacting with or moving to, or from a GSM-R system, under the control of the same operator or not.
- Deployment encompassing interconnection with non-EIRENE non-FRMCS networks.

The minimal deployment of the FRMCS System Architecture is that of a stand-alone FRMCS Domain.

For a description of the deployment scenarios of FRMCS, see clause 7 of the present document.

4.2.3 Modes of operation

The FRMCS System Architecture enables:

- The communication of an FRMCS User served by its Home FRMCS Domain or served by a foreign FRMCS Domain.
- The mobility of an FRMCS User within an FRMCS Domain as well as across FRMCS Domains.

In general, mobility procedures defined at the FRMCS Transport Stratum and migration procedures defined in the FRMCS Service Stratum apply. The specific modes of operation of an On-Board FRMCS need to be taken into account:

1) In some deployment scenarios, the On-Board FRMCS is equipped with more than one On-Board Radio Module, potentially operating under the FRMCS Multipath Framework.

2) The On-Board FRMCS has to facilitate the continuity of communication under mobility conditions for the applications it enables through the OB_{APP} reference point.

For a description of high-level procedures applicable in FRMCS, see clause 6 of the present document.

4.2.4 Applications enablement

Within trains, FRMCS applications interact with the FRMCS System via the OB_{APP} reference point exposed by the On-Board FRMCS. All applications directly interfacing with the On-Board FRMCS are expected to call a Local Binding procedure to authenticate themselves with the On-Board FRMCS. Subsequently, two modes of interactions are then defined, either using the standard reference points of the 3GPP MCX Framework ("tight-coupled mode") or through additional API features of the OB_{APP} reference point ("loose-coupled mode").

On the trackside, the FRMCS Trackside Gateway exposes the TS_{APP} reference point with features similar to the OB_{APP} reference point.

When operating in "loose-coupled mode", applications are represented in the 3GPP MCX Framework by one or more MC Service User identities associated to one of the standardized mission critical services of the 3GPP MCX Framework (i.e. MCPTT, MCData and MCVideo).

Four Application Types are identified in the UIC FRMCS SRS [i.3]:

- Type I: Interoperable IM applications (e.g. ATP, ATO, REC, driver-controller voice communication).
- Type II: Non-interoperable IM applications.
- Type III: Interoperable RU applications.
- Type IV: Non-Interoperable RU applications in the scope of FRMCS (e.g. TCMS).

For more details on the interrelation between the API end points and the FRMCS Service Domain procedures, see ETSI TS 103 765-3 [3] for the OB_{APP} reference point and to ETSI TS 103 765-4 [4] for the TS_{APP} reference point.

In addition to the above, the TS_{CTRL} reference point (see UIC FRMCS SRS [i.3]) is exposed for the use of controller devices and applications.

4.2.5 Cybersecurity

For an FRMCS Domain, the approach to cybersecurity in FRMCS is multi-layered by leveraging cybersecurity measures at the FRMCS Transport Stratum and FRMCS Service Stratum levels. Applications can also implement their own additional security measures at the Application Stratum level.

At the periphery of an FRMCS Domain, additional cybersecurity measures are leveraged:

- Between On-Board applications and the On-Board FRMCS, the OB_{APP} reference point specified in UIC FRMCS FFFIS-7950 [i.1] requires the usage of the Local Binding procedure which establishes a secured TLS-backed mutually-authenticated control plane link complemented by lower layers' security measures in train network deployments.
- Similarly, between trackside applications and the FRMCS Trackside Gateway, the TS_{APP} reference point specified in UIC FRMCS FFFIS-7950 [i.1] requires the usage of the Local Binding procedure.
- For a deployment as part of an international network of FRMCS Domains, requirements related to cybersecurity are identified in clause 7.3 of the present document.
- For a deployment in interaction with an EIRENE GSM-R system, requirements related to cybersecurity are identified in clause 7.4 of the present document.

4.2.6 GSM-R interworking

Requirements induced by interworking with GSM-R are specified in ETSI TS 103 792 [5].

In particular, interworking scenarios for various services (group calls, point-to-point calls, text messaging) are specified. An overview of the mobility procedure applied in GSM-R/FRMCS Domain transition is documented in clause 6.4 of the present document.

4.2.7 FRMCS Multipath

FRMCS Multipath introduces a capability to establish communication between the On-Board FRMCS Multipath Function (called Multipath Client in ETSI TS 103 765-1 [1]) and an FRMCS Infrastructure Multipath Function (called Multipath Gateway in ETSI TS 103 765-1 [1]) over one or more data paths (called Multipath Datapaths in ETSI TS 103 765-1 [1]) for a given application, subject to FRMCS Multipath policies set in the FRMCS Domain and to parameters within the FRMCS On-Board Application. The data paths are established over one or multiple of the following Transport Domains:

1) FRMCS Transport Domain.

2) Non-FRMCS Transport Domains.

The FRMCS Multipath Function is specified in ETSI TS 103 765-1 [1], clause 5.3.

4.3 Architecture reference model

4.3.1 General

The interaction between functional blocks is represented with point-to-point reference points, showing how various network functions interact with each other.

4.3.2 FRMCS System Architecture components

The FRMCS system consists of:

1) FRMCS Domain (see clause 5.1):
   - Transport Domain (see clause 5.1.1):
     - FRMCS Infrastructure Multipath Function (see clause 5.7).
   - FRMCS Service Domain (see clause 5.1.2).
2) On-board FRMCS (see clause 5.2):
   - On-Board FRMCS Multipath Function (see clause 5.6).
3) FRMCS-capable Handheld (see clause 5.3).
4) FRMCS-capable Object (see clause 5.4).
5) FRMCS Trackside Gateway (see clause 5.5).

The FRMCS System Architecture also allows interactions with external systems such as:

1) EIRENE System (GSM-R based System) (see clause 5.8).
2) Non-EIRENE non-FRMCS System (see clause 5.9).

4.3.3 Stand-alone reference architecture

Figure 4.3.3-1 depicts the stand-alone reference architecture of FRMCS System showing how various components relate to each other.

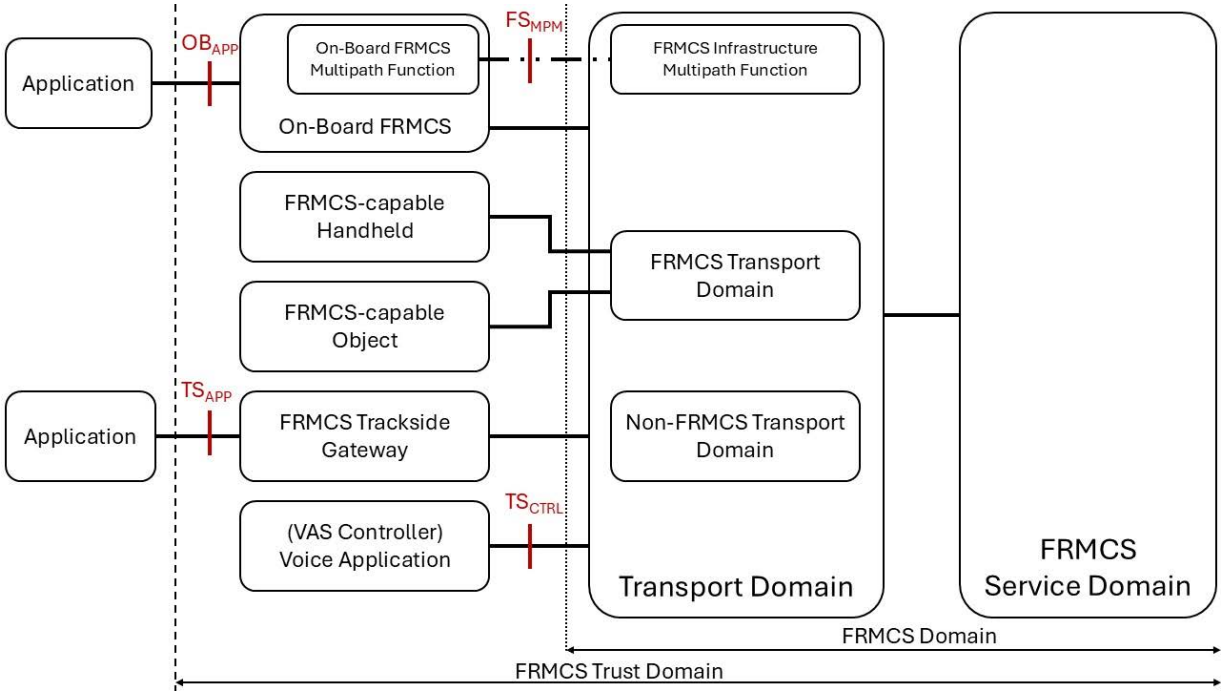


Figure 4.3.3-1: Stand-alone reference architecture of the FRMCS System

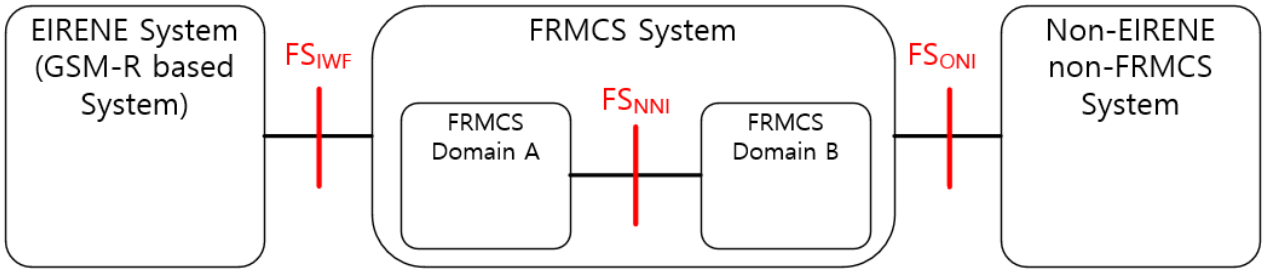
The FRMCS trust domain (see Figure 4.3.3-1) covers FRMCS communicating entities that are protected by adequate FRMCS Domain security. The FRMCS communicating entities and FRMCS reference points within the FRMCS trust domain may all be within the control of an FRMCS Operator, or some may be controlled by a trusted business partner which has a trust relationship with the FRMCS Operator e.g. another FRMCS Operator or a 3rd party.

Applications that have authenticated against and have been authorized by a specific FRMCS Domain on Transport and Service Stratum level are considered to be part of the trust domain of that specific FRMCS domain. Applications operating in the FRMCS trust domain shall be able to access FRMCS communicating entities on Transport and Service Stratum level as described in ETSI TS 103 765-1 [1] and ETSI TS 103 765-2 [2].

Applications and devices situated physically and logically outside of the Trust Domain shall use the Local Binding (LB) mechanism.

4.3.4 Interconnected reference architecture

Figure 4.3.4-1 depicts the FRMCS System Architecture in the roaming and interworking cases showing how various Systems and FRMCS Domains relate to each other.



NOTE: EIRENE System (GSM-R based System) and Non-EIRENE non-FRMCS System are not components of the FRMCS System Architecture but could be interacted with in some deployment scenarios.

Figure 4.3.4-1: FRMCS reference System Architecture - interconnected and interworking cases

4.3.5 FRMCS Reference points at system level

The FRMCS System Architecture contains the following FRMCS reference points:

OB_{APP}: Reference point between on-board Railway Application and on-board FRMCS. This reference point is described and specified in UIC FRMCS FFFIS-7950 [i.1] and the associated procedures are specified in ETSI TS 103 765-3 [3].

OB_{OM}: Reference point between on-board Operations and Maintenance Application and on-board FRMCS.

TS_{APP}: Reference point between trackside Railway Application and FRMCS Trackside Gateway. This reference point is described and specified in UIC FRMCS FFFIS-7950 [i.1] and the associated procedures are specified in ETSI TS 103 765-4 [4].

FS_{MPM}: Reference point between the On-Board FRMCS Multipath Function within the On-Board FRMCS and the FRMCS Infrastructure Multipath Function. This reference point is specified in ETSI TS 103 765-1 [1].

FS_{IWF}: Reference point between an FRMCS System and an EIRENE System (GSM-R based System). This reference point is comprised of the reference points IWF-g1, IWF-g2 and IWF-g5 specified in ETSI TS 103 792 [5].

FS_{NNI}: Reference point between two interconnected FRMCS Domains. The functionalities applicable to FRMCS Transport Domain are specified in ETSI TS 103 765-1 [1]. The functionalities applicable to FRMCS Service Domain are specified in ETSI TS 103 765-2 [2].

FS_{ONI}: Reference point between an FRMCS System and another non-GSM-R, non-FRMCS System. The functionalities applicable to FRMCS Transport Stratum are specified in ETSI TS 103 765-1 [1]. The functionalities applicable to FRMCS Service Stratum are specified in ETSI TS 103 765-2 [2].

FS_{OMR}: Reference point between on-board FRMCS and FRMCS trackside infrastructure for Operation and Maintenance purposes. The functionalities are specified in ETSI TS 103 765-3 [3].

TS_{CTRL}: Reference point between VAS controllers using a non-3GPP access and the FRMCS Service Domain. This reference point is solely intended for VAS controllers. TS_{CTRL} is described in ETSI TS 103 765-4 [4].

5 FRMCS System Architecture components

5.1 FRMCS Domain

5.1.0 Overview

An FRMCS Domain is an administrative domain which comprises a Transport Domain as described in clause 5.1.1, and an FRMCS Service Domain as described in clause 5.1.2 under the control of an FRMCS Operator. The interface between two FRMCS Domains, namely FS_{NNI}, is defined in clause 4.3.5.

5.1.1 Transport Domain

The Transport Domain comprises one or more FRMCS Transport Domain(s) and zero or more Non-FRMCS Transport Domain(s).

An FRMCS Transport Domain includes a 5G Core Network administrated by an FRMCS Operator, and one or more Radio Access Networks (e.g. terrestrial, satellite, Wi-Fi®) under the control of this 5G Core Network. The Access Networks include at least one 5G NR access operating on RMR harmonized spectrum.

A Non-FRMCS Transport Domain does not satisfy the mandatory requirements of an FRMCS Transport Domain (e.g. its 5GC is not administrated by an FRMCS Operator or the transport domain is not a 5G system).

The functionalities required for the FRMCS Transport Domain are specified in ETSI TS 103 765-1 [1].

5.1.2 FRMCS Service Domain

An FRMCS Service Domain is administrated by an FRMCS Operator.

The functionalities required for the FRMCS Service Domain are specified in ETSI TS 103 765-2 [2].

5.2 On-board FRMCS

The On-Board FRMCS is installed on-board the trains and enabling communication services and complementary services with the FRMCS Domain(s).

The On-Board FRMCS shall comply to ETSI TS 103 765-3 [3].

5.3 FRMCS-capable Handheld

The present document does not specify normative requirements applicable to FRMCS-capable Handhelds.

5.4 FRMCS-capable Object

The present document does not specify normative requirements applicable to FRMCS-capable Objects.

5.5 FRMCS Trackside Gateway

The FRMCS Trackside Gateway enables communication services and complementary services supported by the FRMCS System to and from authorized trackside applications.

The FRMCS Trackside Gateway shall comply to ETSI TS 103 765-4 [4], clauses 4 and 5.

5.6 On-Board FRMCS Multipath Function

The On-Board FRMCS Multipath Function enables the use of multiple transport paths over multiple On-Board FRMCS Radio Modules, through the interaction with the FRMCS Infrastructure Multipath Function of the Transport Domain.

The On-Board FRMCS Multipath Function is specified in ETSI TS 103 765-1 [1].

5.7 FRMCS Infrastructure Multipath Function

The FRMCS Infrastructure Multipath Function enables, through the interaction with the On-Board FRMCS Multipath function, the use of multiple transport paths over multiple On-Board FRMCS Radio Modules of each On-board FRMCS (over one or more Transport Domain(s)).

The FRMCS Infrastructure Multipath Function is specified in ETSI TS 103 765-1 [1].

5.8 EIRENE System (GSM-R based System)

An EIRENE System is a railway telecommunications system based on the ETSI GSM standard, which complies with all related mandatory requirements as specified in the EIRENE specifications.

NOTE: EIRENE Systems are also known as GSM-R Systems.

The functionalities required for interacting with an EIRENE System are specified in ETSI TS 103 792 [5] (see FS_{IWF}).

5.9 Non-EIRENE non-FRMCS System

The present document does not specify normative requirements applicable to interaction of FRMCS with Non-EIRENE non-FRMCS System.

6 Non-application-specific procedures

6.1 Introduction

The following clauses describe the procedures which are non-application specific from a high-level perspective. It is also identified where the detailed specification of the respective procedures in the normative manner can be found. The same procedures are defined, where relevant, in a normative format in ETSI TS 103 765-3 [3] if initiated by an On-Board FRMCS and in ETSI TS 103 765-4 [4] if initiated by an FRMCS Trackside Gateway.

NOTE: UIC FRMCS FIS-7970 [i.2] defines the end-to-end application-specific procedures required to achieve the functional requirements of Railway Applications within FRMCS (such as critical voice, ETCS, etc.) and specifies which communication service procedures have to be used and how to use them by any client application using the FRMCS system.

6.2 FRMCS Start of Operation

6.2.0 Overview

The FRMCS Start of Operation (FSOP) procedure is supporting the transition of an On-Board FRMCS operational mode from the train power-up till the moment the On-Board FRMCS is ready to use an FRMCS Domain to serve communication needs (incoming or outgoing) of on-board applications. The procedure describes the expected behavior from On-Board FRMCS and FRMCS Domain upon power up of the train and the steps undertaken to establish connectivity between an On-Board FRMCS and an FRMCS Domain.

6.2.1 FRMCS Start of Operation served by the Home FRMCS Domain

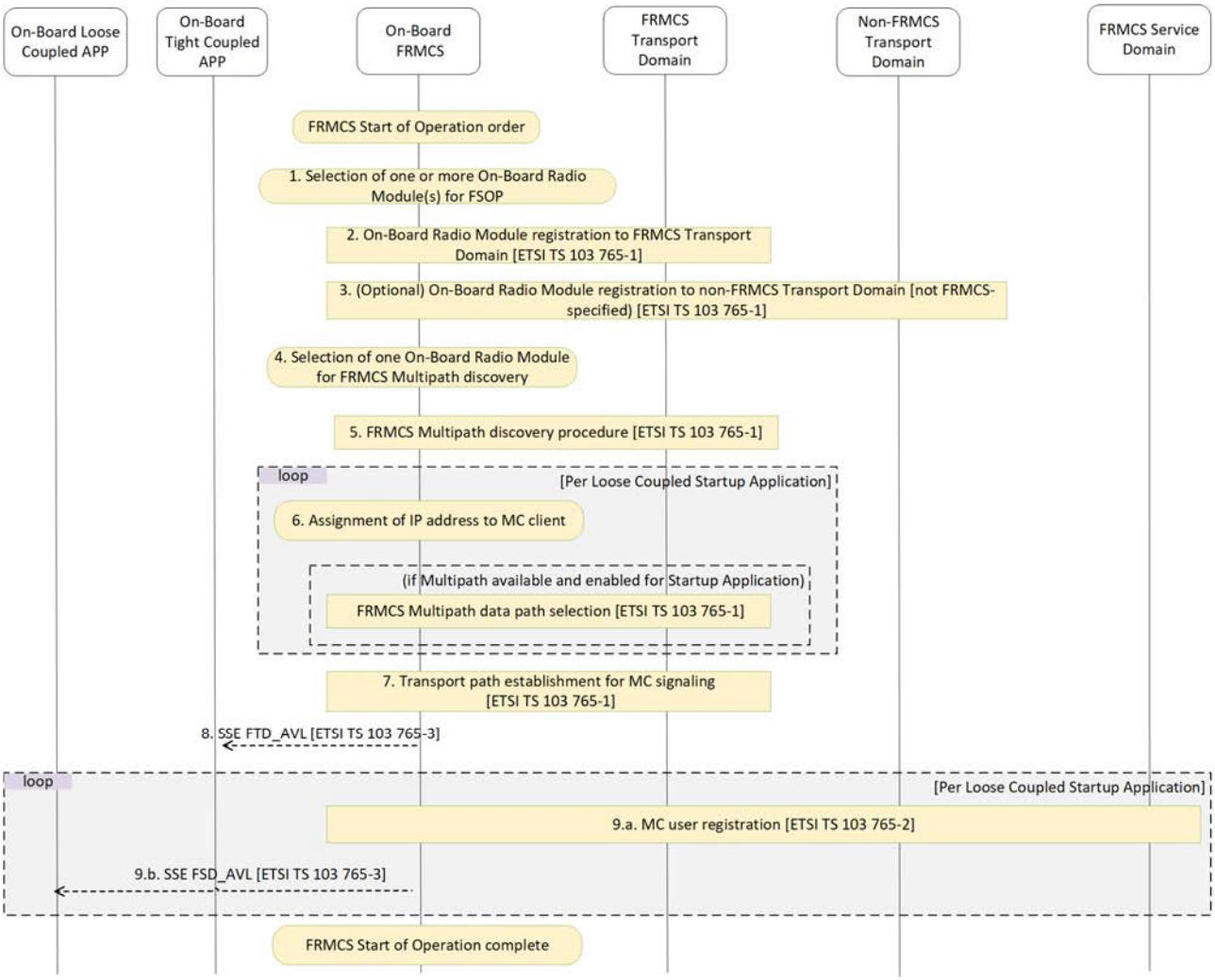


Figure 6.2.1-1: FRMCS Start of Operation served by the Home FRMCS Domain procedure

Figure 6.2.1-1 depicts the FRMCS Start of Operation for an On-Board FRMCS being served by the Home FRMCS Domain. The following steps are undertaken:

1) The On-Board FRMCS selects at least one On-Board Radio Module to be involved in the procedure (see ETSI TS 103 765-3 [3], clause 7).

2) The On-Board FRMCS executes the On-Board Radio Module registration to the FRMCS Transport Domain procedure (see ETSI TS 103 765-1 [1], clause 6) on the On-Board Radio Modules identified in the previous step.

3) (Optional) If equipped with On-Board Radio Modules associated to Non-FRMCS Transport Domains, the On-Board FRMCS can also execute the On-Board Radio Module registration to the Non-FRMCS Transport Domain (not subject to specification).

4) The On-Board FRMCS selects an On-Board Radio Module to use for FRMCS Multipath discovery.

5) The On-Board FRMCS executes the FRMCS Multipath discovery procedure (see ETSI TS 103 765-1 [1], clause 6). This step assumes that a default transport path has been established on this On-Board Radio Module towards the FRMCS Transport Domain in order to enable FRMCS Multipath control signalling.

6) For each Loose-Coupled Application identified within the list of Startup Applications in the FRMCS Railway On-Board Profile, the On-Board FRMCS executes the MC Client IP assignment procedure (see ETSI TS 103 765-3 [3], clause 7). If the FRMCS Multipath discovery (step 3) is successful, the On-Board FRMCS executes the FRMCS Multipath data path selection procedure (see ETSI TS 103 765-1 [1], clause 6).

7) If the On-Board FRMCS does not have an established PDU session for MC signaling, the On-Board FRMCS executes the Transport path establishment for MC signaling procedure (see ETSI TS 103 765-1 [1], clause 6).

8) The On-Board FRMCS notifies each Tight-Coupled Application identified as Startup Applications in the FRMCS Railway On-Board Profile and which are in the Application_Locally_Bound state of the availability of the FRMCS Transport Domain (see ETSI TS 103 765-3 [3], clause 7).

9) For each Loose-Coupled Application identified as Startup Applications in the FRMCS Railway On-Board Profile:

   a) The On-Board FRMCS executes the MC user registration procedure (see ETSI TS 103 765-2 [2], clause 6).

   b) If the application is in the Application_Locally_Bound state, the On-Board FRMCS notifies the availability of the FRMCS Service Domain (see ETSI TS 103 765-3 [3], clause 7).

6.2.2 FRMCS Start of Operation served by a Foreign FRMCS Domain

The procedure to apply for FRMCS Start of Operation when served by a Foreign FRMCS Domain is similar to the procedure in clause 6.2.1. The main difference resides in the fact that the On-Board Radio Module registration and the MC user registration need to be done with the Foreign FRMCS Domain. The detailed procedure is specified in ETSI TS 103 765-3 [3], clause 7.1.1.

6.3 FRMCS Close of Operation

The FRMCS Close of Operation (FCOP) procedure describes the expected behavior from On-Board FRMCS and FRMCS Domain upon attempt from an On-Board FRMCS to terminate connectivity to the FRMCS System.

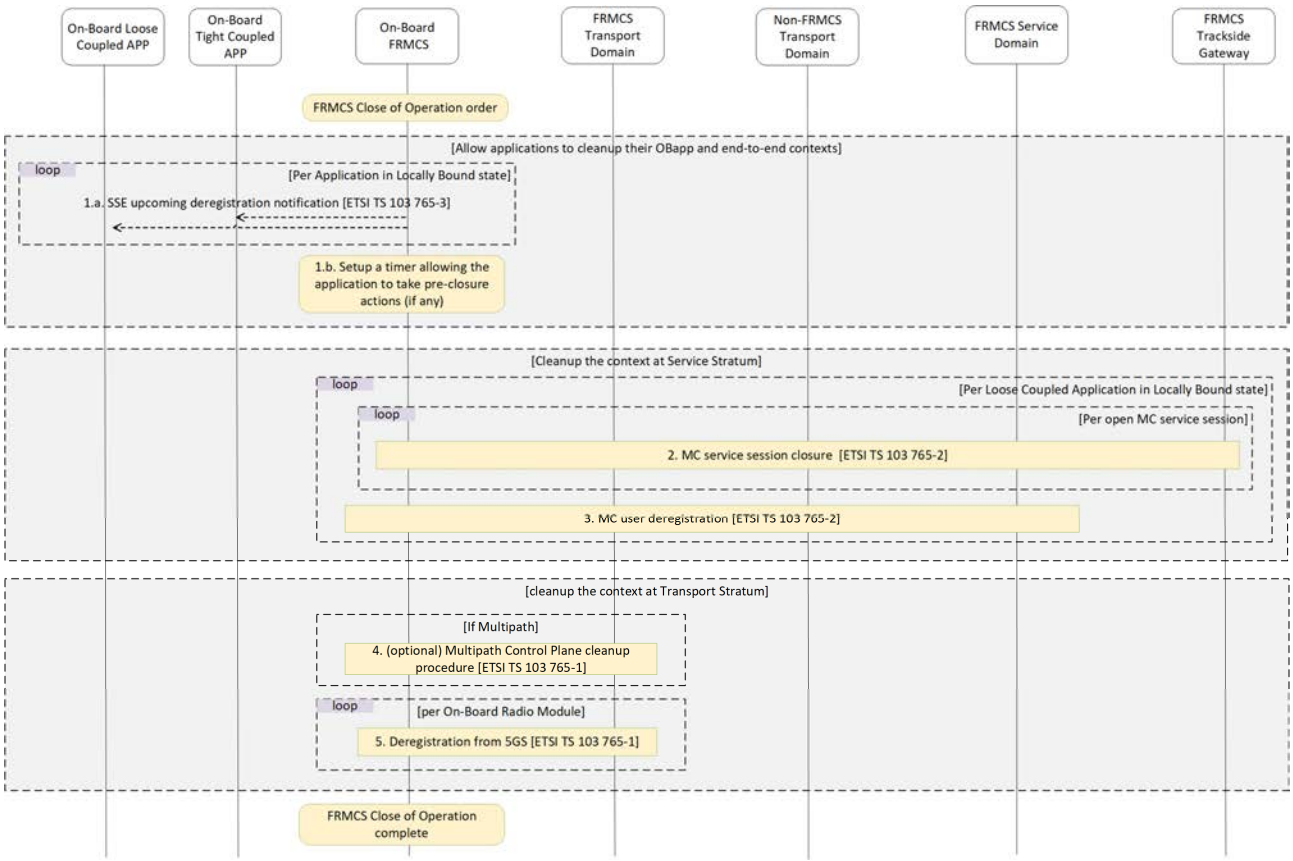


Figure 6.3-1: FRMCS Close of Operation procedure

The following steps are undertaken:

1) For each application in Locally-Bound state:

   a) the On-Board FRMCS notifies the application of the upcoming deregistration within FRMCS (with reason being set to "FCOP") (see ETSI TS 103 765-3 [3], clause 7); and

   b) the On-Board FRMCS sets up a deregistration timer (see ETSI TS 103 765-3 [3], clause 7) allowing the applications to take actions (e.g. for cleaning up their contexts). At the expiry of the timer, the next step of the procedure is executed.

2) For each Loose-Coupled Application which are in the Locally Bound state, the On-Board FRMCS executes the MCData termination procedure (see ETSI TS 103 765-2 [2], clause 6) for open MC sessions,

3) For each Loose-Coupled Application which are in the Locally Bound state, the On-Board FRMCS executes the MC deregistration procedure (see ETSI TS 103 765-2 [2], clause 6). This includes the SIP deregistration procedure.

4) If an FRMCS Multipath Control Plane connection is active, the On-Board FRMCS executes the FRMCS Multipath Control Plane cleanup procedure (see ETSI TS 103 765-1 [1], clause 6).

5) The On-Board FRMCS executes for each On-Board Radio Module the "deregistration from the FRMCS Transport Domain" procedure (see ETSI TS 103 765-1 [1], clause 6).

6.4 Domain transitions

6.4.1 Inter-FRMCS Domain transition

6.4.1.0 General

The Inter-FRMCS Domain transition procedure applies in the case of mobility of an On-Board FRMCS from an FRMCS Domain to another.

The present document details the procedure whereby the Transport Stratum transition is followed by the Service Stratum change in short succession.

NOTE 1: Other procedures are under consideration that are susceptible to be incorporated in future versions of the present document. Similarly, variants on the number of MC Clients and number of UEs are susceptible to be documented in future versions of the present document.

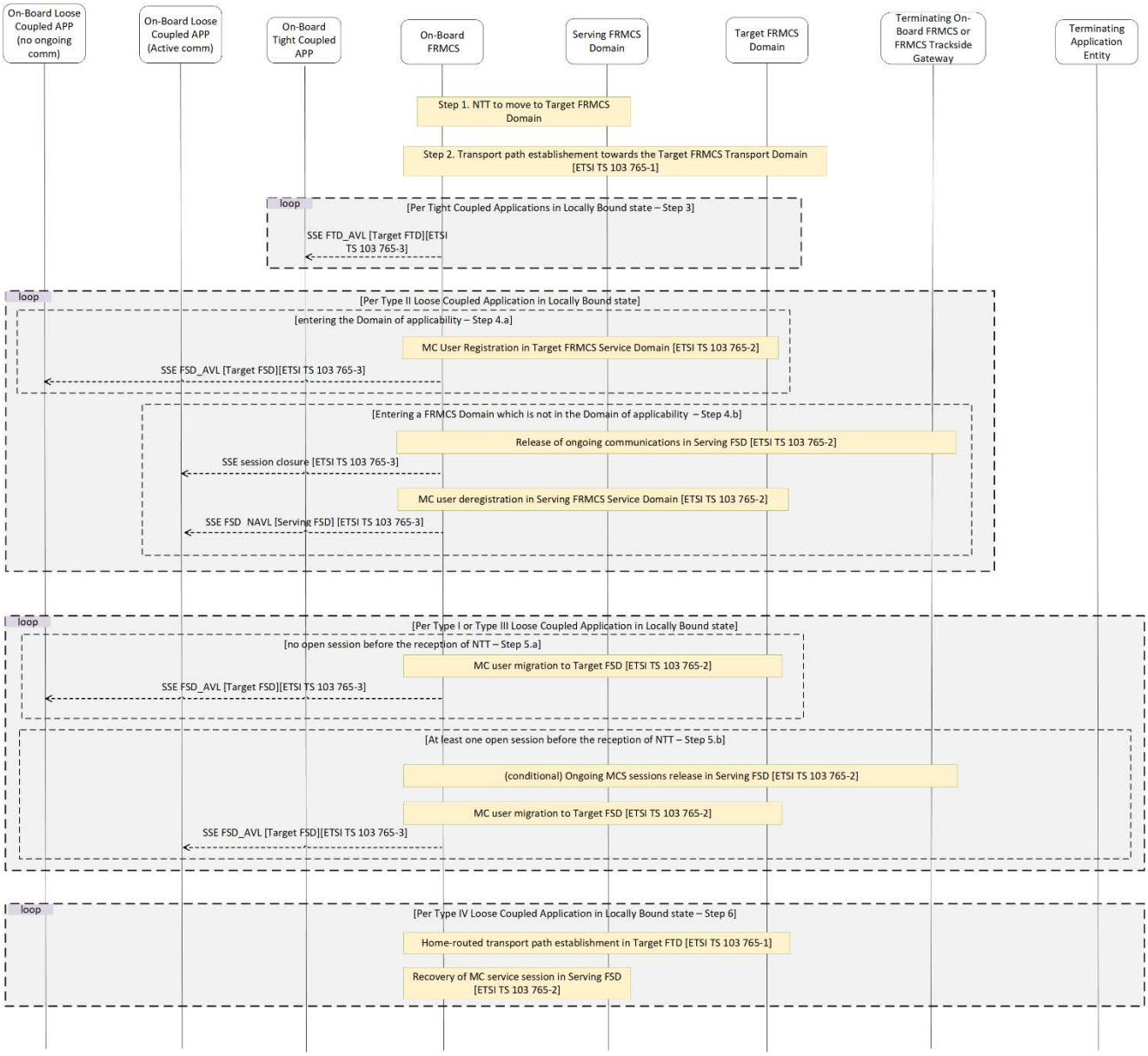


Figure 6.4.1.0-1: Inter-FRMCS Domain transition procedure

The following steps are undertaken:

1) The On-Board FRMCS receives a Network Transition Trigger (NTT) indicating a change to the Target FRMCS Domain.

NOTE 2: The nature and contents of the Network Transition Trigger is not specified in the present document.

2) The On-Board FRMCS selects at least one On-Board Radio Module to be involved in the procedure. The On-Board FRMCS performs transport path establishment towards the Target FRMCS Transport Domain using this On-Board Radio Module (see ETSI TS 103 765-1 [1], clause 6).

3) For each Tight-Coupled Application in Locally Bound state:

   a) The On-Board FRMCS notifies of availability of the FRMCS Transport Domain 2 (see ETSI TS 103 765-3 [3], clause 7).

4) For each Loose-Coupled Application in Locally Bound state and identified as Type II in the FRMCS Railway On-Board Profile:

   a) If the On-Board FRMCS is entering the FRMCS Domain corresponding to the Domain of applicability of the application, the On-Board FRMCS executes the procedure identified in clause 6.4.1.2.1.

b) If the On-Board FRMCS is exiting the FRMCS Domain corresponding to the Domain of applicability of the application, the On-Board FRMCS executes the procedure identified in clause 6.4.1.2.2.

5) For each Loose-Coupled Application in Locally Bound state and identified as Type I or III in the FRMCS Railway On-Board Profile:

a) If the application has no open session, the On-Board FRMCS executes the procedure identified in clause 6.4.1.1.1.

b) If the application has an open session, the On-Board FRMCS executes the procedure identified in clause 6.4.1.1.2.

6) For each Loose-Coupled Application in Locally Bound state and identified as Type IV in the FRMCS Railway On-Board Profile, the On-Board FRMCS executes the procedure identified in clause 6.4.1.3.

6.4.1.1 Inter-FRMCS Domain transition: Type I or Type III applications

6.4.1.1.1 Inter-FRMCS Domain transition: Type I or Type III applications with no open session

For each Loose-Coupled Application in Locally Bound state and identified as interoperable in any FRMCS Domain in the FRMCS Railway On-Board Profile, if the application has no open sessions, the following steps are undertaken:

1) the On-Board FRMCS executes the "MC user migration" procedure (see ETSI TS 103 765-2 [2], clause 6) between Serving FRMCS Domain and Target FRMCS Domain; and

2) the On-Board FRMCS notifies the application of the availability of the Target FRMCS Service Domain (see ETSI TS 103 765-3 [3], clause 7).

6.4.1.1.2 Inter-FRMCS Domain transition: Type I or Type III applications with an open session

For each Loose-Coupled Application in Locally Bound state and identified as interoperable in any FRMCS Domain in the FRMCS Railway On-Board Profile, if the application has at least one open session, the following steps are undertaken:

1) the On-Board FRMCS executes the "MC user migration" procedure (see ETSI TS 103 765-2 [2], clause 6) between Serving FRMCS Domain and Target FRMCS Domain; and

2) the On-Board FRMCS notifies the application of the availability of the Target FRMCS Service Domain (see ETSI TS 103 765-3 [3], clause 7).

NOTE: Depending on the type of application, the On-Board FRMCS can request the release of the open sessions in the Serving FRMCS Service Domain before the Step 1 (see ETSI TS 103 765-3 [3], clause 7.1.3 for the details).

6.4.1.2 Inter-FRMCS Domain transition: Type II applications

6.4.1.2.1 Inter-FRMCS Domain transition: Type II applications entering the Domain of applicability

For each Loose-Coupled Application in Locally Bound state and for which the On-Board FRMCS is entering the FRMCS Domain corresponding to the Domain of applicability of the application as identified from the FRMCS Railway On-Board Profile, the following steps are undertaken:

1) the On-Board FRMCS executes the "MC user registration" procedure (both SIP and MC layers) in Target FRMCS Service Domain (see ETSI TS 103 765-2 [2], clause 6); and

2) the On-Board FRMCS notifies the availability of the Target FRMCS Service Domain (see ETSI TS 103 765-3 [3] ETSI TS 103 765-3 [3], clause 7).

6.4.1.2.2 Inter-FRMCS Domain transition: Type II applications entering an FRMCS Domain which is not in the Domain of applicability

For each Loose-Coupled Application which is in Locally Bound state and for which the On-Board FRMCS is entering an FRMCS Domain which is not in the Domain of applicability of the application as identified from the FRMCS Railway On-Board Profile, the following steps are undertaken:

1) The On-Board FRMCS executes the "MCS session release" procedure (both SIP and MC layers) in FRMCS Service Domain 1 (see ETSI TS 103 765-2 [2], clause 6) for open sessions associated to the Loose-Coupled Application.

2) The On-Board FRMCS notifies the application of the closure of its previously opened sessions (see ETSI TS 103 765-3 [3], clause 7).

3) The On-Board FRMCS executes the "MC user deregistration" procedure in Serving FRMCS Service Domain (see ETSI TS 103 765-2 [2], clause 6).

4) The On-Board FRMCS notifies the application of the unavailability of the FRMCS Service Domain (see ETSI TS 103 765-3 [3], clause 7).

6.4.1.3 Inter-FRMCS Domain transition: Type IV applications

For each Loose-Coupled Application of Type IV according to the FRMCS Railway On-Board Profile, if the application has at least one open session:

1) the On-Board FRMCS executes "home-routed transport path establishment" procedure on the On-Board Radio Modules (see ETSI TS 103 765-1 [1], clause 6); and

2) the On-Board FRMCS executes "recovery of MCS session" in Serving FRMCS Service Domain (see ETSI TS 103 765-2 [2], clause 6).

6.4.2 Transition between GSM-R and FRMCS Domain

The present document does not specify the procedures for transitions from GSM-R to an FRMCS Domain and for transitions from FRMCS to a GSM-R System.

7 Deployment scenarios of FRMCS

7.1 Introduction

FRMCS addresses two elements of strategic importance for the future of the railways: end of life of GSM-R and rail transport digitalisation while ensuring rail system interoperability across countries.

The FRMCS System Architecture is aimed at deployment in a variety of contexts:

- Stand-alone deployment, i.e. deployment of an FRMCS Domain with no external connection to other FRMCS Domains.
- Deployment as part of an international network of networks, i.e. deployment of an FRMCS Domain connected to other FRMCS Domains.
- Deployment encompassing interworking with GSM-R, deployment of an FRMCS Domain with users interacting with or moving to or from a GSM-R system, under the control of the same operator or not.
- Deployment encompassing interconnection with non-EIRENE non-FRMCS networks.

NOTE 1: The present document does not specify the requirements associated with non-EIRENE non-FRMCS networks.

NOTE 2: The deployment scenarios are not necessarily disjoint, i.e. an FRMCS Domain that would interact with another FRMCS Domain within the FRMCS System interacting with a GSM-R system would essentially need to meet the requirements of clauses 7.2, 7.3 and 7.4.

7.2 Stand-alone FRMCS Domain

A stand-alone FRMCS Domain shall:

- Comply with the FRMCS Transport Domain stand-alone deployment requirements as specified in ETSI TS 103 765-1 [1], clause 4.2.2.
- Comply with the FRMCS Service Domain stand-alone deployment requirements as specified in ETSI TS 103 765-2 [2], clause 5.1.

7.3 FRMCS Domain in interaction with other FRMCS Domains

An FRMCS Domain deployed to interact with another FRMCS Domain shall:

- Comply with the requirements for an FRMCS Domain stand-alone deployment as specified in clause 7.2 of the present document.
- Comply with the FRMCS Transport Domain network-to-network deployment requirements as specified in ETSI TS 103 765-1 [1], clause 4.2.3.
- Comply with the FRMCS Service Domain network-to-network deployment requirements as specified in ETSI TS 103 765-2 [2], clause 5.2.
- Implement the FS_{NNI} reference point.

7.4 FRMCS Domain in interaction with a GSM-R system

An FRMCS Domain deployed to interact with a GSM-R system shall:

- Comply with the requirements for an FRMCS Domain stand-alone deployment as specified in clause 7.2 of the present document.
- Comply with the FRMCS Service Domain network-to-network deployment requirements as specified in ETSI TS 103 765-2 [2], clause 5.3.
- Implement the FS_{IWF} reference point (clause 4.3.5) and the IWF function as specified in ETSI TS 103 792 [5].

7.5 FRMCS Domain in interaction with a non-EIRENE non-FRMCS network

The present document does not specify the interactions between an FRMCS Domain and a non-EIRENE non-FRMCS network as a deployment model.

8 IP addresses and routing

8.0 Generalities

For applications enablement, the FRMCS system provides communication services between endpoints which are connected to a diverse set of networks.

For example, an On-Board FRMCS enables the connectivity of applications residing on the train network which usually operates on the basis of a private IP range which can be the same, differ or overlap with the IP range of the train network of another train.

Likewise, when using the Host-to-Host addressing scheme, an FRMCS Trackside Gateway enables the connectivity of applications which can reside on a subnetwork under complete control of the operator of the FRMCS Trackside Gateway but it also enables the connectivity of applications which can reside on a network which operates on a private IP range and for which the routing from or towards the FRMCS Trackside Gateway subnetwork would require some form of NAT.

Finally, when using the Host-to-Network addressing scheme, an FRMCS Trackside Gateway also enables the connectivity to a set of subnetworks (one per H2N Network endpoint) for which the routing from or towards the FRMCS Trackside Gateway subnetwork would require some form of NAT.

Figure 8.0-1 depicts these variants of situations.

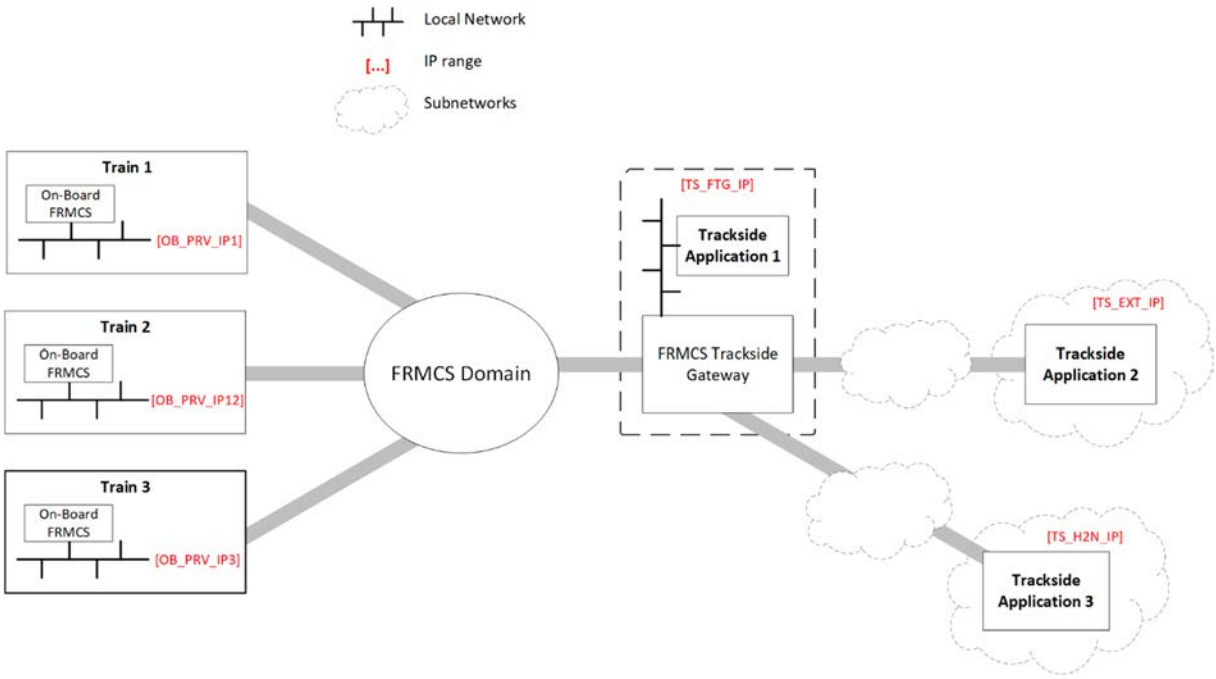


Figure 8.0-1: Variants of IP address ranges of the train networks and of the trackside networks

In Figure 8.0-1:

- OB_PRV_IP1 is a private IP range for Train 1.
- OB_PRV_IP12 is a private IP range for Train 2, overlapping with OB_PRV_IP1.
- OB_PRV_IP3 is a private IP range for Train 3, disjoint from OB_PRV_IP1.
- TS_FTG_IP is an IP range under control (from an IP routing perspective) of the operator of the FRMCS Trackside Gateway.
- TS_EXT_IP is an IP range not under complete control (from an IP routing perspective) of the operator of the FRMCS Trackside Gateway but for which IP routing from or towards the FRMCS Trackside Gateway subnetwork can be established, possibly through some interim NAT.
- TS_H2N_IP is an IP range associated to a H2N Network Endpoint.

The Trackside Network IP range (TS_NET_IP) can be any of TS_FTG_IP, TS_EXT_IP, and TS_H2N_IP defined above. This concept is used in the subsequent clauses.

NOTE: Routing is in the present document assumed to be solely based on IP.

8.1 IP address ranges - Loose-Coupled Applications, without FRMCS Multipath

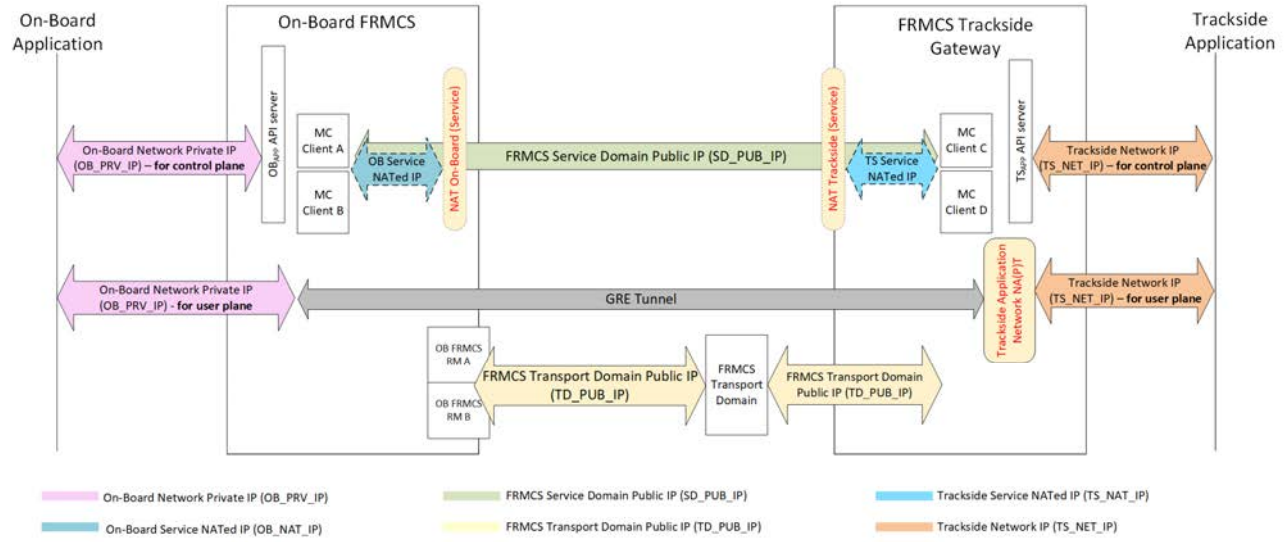


Figure 8.1-1: Overview of FRMCS IP ranges for Loose-Coupled Applications without FRMCS Multipath

The IP address ranges for Loose-Coupled Applications without FRMCS Multipath are depicted in Figure 8.1-1.

Several different IP address ranges are used as depicted in Figure 8.1-1:

- On-Board Network Private IP (OB_PRV_IP) range: the local private IP Address range within the On-Board network:
  - It is used for IP exchanges on OB_{APP} between On-Board Applications and the On-Board FRMCS.
  - It is also used for data transfer between an On-Board Application and a Trackside Application but NATing will need to occur in the FRMCS Trackside Gateway.
  - OB_PRV_IP can be the same or overlap for different On-Board FRMCS. This can have an impact on the Trackside Application Network NAT Function.
- FRMCS Service Domain Public IP (SD_PUB_IP) range: the public IP address range (within the address realm of the FRMCS Service Domain) used by the On-Board FRMCS and the FRMCS Trackside Gateway to connect to the FRMCS Service Domain.
- FRMCS Transport Domain Public IP (TD_PUB_IP) range: the public IP address range (within the address realm of the FRMCS Transport Domain) used by the On-Board FRMCS and the FRMCS Trackside Gateway to connect to the FRMCS Transport Domain.
- Trackside Application Network IP (TS_NET_IP) range: the local IP Address range within the trackside network:
  - It is used for IP exchanges on TS_{APP} between Trackside Applications and the FRMCS Trackside Gateway.
  - It is also used for the data transfer between a Trackside Application and an On-Board Application:
    - For data flowing from an On-Board Application to a Trackside Application, the source IP address in the OB_PRV_IP range is NATed into TS_NET_IP.
    - For data flowing from a Trackside Application to an On-Board Application, the destination IP address in TS_NET_IP is reverse NATed into the OB_PRV_IP range.

In addition, NAT may occur at the service layer. In this case, the following additional IP ranges may be needed:

- On-Board Service NATed IP (OB_NAT_IP) range: the IP range used by the on-board MCData Clients to connect to the FRMCS Service server and NATed by the On-Board FRMCS to the FRMCS Service Domain Public IP address range.
- Trackside Service NATed IP (TS_NAT_IP) range: the IP range used by the trackside MCData Clients to connect to the FRMCS Service server and NATed by the FRMCS Trackside Gateway to the FRMCS Service Domain Public IP address range.

8.2 IP address ranges - Tight-Coupled Applications, without FRMCS Multipath

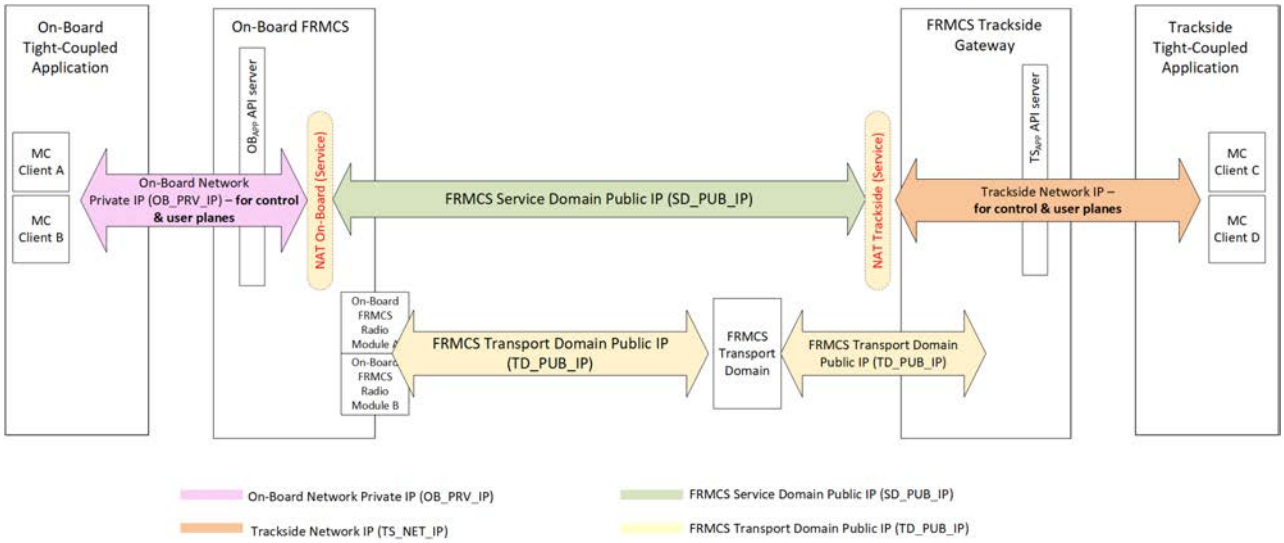


Figure 8.2-1: Overview of FRMCS IP ranges for Tight-Coupled Applications without FRMCS Multipath

The IP address ranges for Tight-Coupled Applications without FRMCS Multipath are depicted in Figure 8.2-1.

Several different IP address ranges are used as depicted in Figure 8.2-1:

- On-Board Network Private IP (OB_PRV_IP) range: the local private IP Address range within the On-Board network:
  - It is used for IP exchanges on OB_{APP} between On-Board Applications and the On-Board FRMCS.
  - It is NATed within the On-Board FRMCS into SD_PUB_IP range.
  - OB_PRV_IP can be the same or overlap for different On-Board FRMCS.
- FRMCS Service Domain Public IP (SD_PUB_IP) range: the public IP address range (within the address realm of the FRMCS Service Domain) used by the On-Board FRMCS and the FRMCS Trackside Gateway to connect to the FRMCS Service Domain.
- FRMCS Transport Domain Public IP (TD_PUB_IP) range: the public IP address range (within the address realm of the FRMCS Transport Domain) used by the On-Board FRMCS and the FRMCS Trackside Gateway to connect to the FRMCS Transport Domain.
- Trackside Application Network IP (TS_NET_IP) range: the IP Address range within the trackside network:
  - It is used for IP exchanges on TS_{APP} between Trackside Applications and the FRMCS Trackside Gateway.
  - If this IP address range is not within SD_PUB_IP, it is NATed into the SD_PUB_IP range.

NOTE: Trackside Application Network IP is not applicable to TS_{CTRL}.

History

Version	Date	Status
V1.0.0	July 2025	SRdAP process EV 20251008: 2025-07-10 to 2025-10-08