



INTERNATIONAL UNION  
OF RAILWAYS

# FRMCS

## Telecom On-Board System – Architecture Migration Scenarios

**Source:** FMS Telecom On-Board Architecture Workgroup  
**Date:** 15<sup>th</sup> of April 2020  
**Reference:** TOBA-7540  
**Version:** 1.0.0  
**No of pages:** 54

ISBN 978-2-7461-2922-1

**Warning**

No part of this publication may be copied, reproduced or distributed by any means whatsoever, including electronic, except for private and individual use, without the express permission of the International Union of Railways (UIC). The same applies for translation, adaptation or transformation, arrangement or reproduction by any method or procedure whatsoever. The sole exceptions – noting the author’s name and the source –are “analyses and brief quotations justified by the critical, argumentative, educational, scientific or informative nature of the publication into which they are incorporated” (Articles L 122-4 and L122-5 of the French Intellectual Property Code).

© International Union of Railways (UIC) – Paris, 2020



**Key to contributors:**

Name	Company
Christian Nänni	SBB Infrastructure Division (Netmodule) (UIC)
Chiel Spaans	European Union Agency for Railways
Henk Barten	NS
Torben Hallberg	Banedanmark
Piero Petruccioli	CER
Tore Øwre	Bane Nor
Simon Gouyou Beauchamps	SNCF Voyageurs
Peter Kotti	Trafikverket
Patrick Marsch	DB Netz AG
Pierre Juventy	SNCF Voyageurs
Joachim Eriksson	Trafikverket
José Carreira Miguel	Infraestruturas de Portugal (IP)
Maarten Bughout	NS (Ricardo)
Günter Koch	DB AG
Fang-Chun Kuo	DB Netz AG
Claude Saas	SBB Passenger Division
Michael Hopf	SBB Passenger Division
Emil Hammarström	Trafikverket
Dan Mandoc	UIC

## Table of Contents

1	List of abbreviations .....	6
2	List of definitions .....	7
3	Introduction .....	10
4	Scope of the document .....	11
5	FRMCS Only vs. FRMCS/GSM-R Dual Mode On-Board .....	12
6	Migration of ETCS .....	13
6.1	Migration variants .....	13
6.2	ETCS Variant 1b – Existing ETCS OBU with PS (or CS) Conversion/Bypass .....	14
6.3	ETCS Variant 3 – Modified Euroradio involving CS and PS bypass .....	15
7	Migration of GSM-R Cab Radio .....	16
7.1	Migration variants .....	16
7.2	Cab Radio Variant 4a – Upgrade of an existing GSM-R Cab Radio to support FRMCS .....	16
7.3	Cab Radio Variant 4b – New Cab Radio supporting FRMCS and GSM-R .....	17
8	Combined migration of ETCS and Cab Radio .....	18
8.1	Current situation .....	18
8.2	Target configuration .....	18
8.3	Migration .....	19
9	Migration of other Users and Systems .....	20
9.1	Migration of other Applications using GSM-R today .....	20
9.2	Migration of Applications using Public Mobile Networks today .....	20
9.3	Migration of Handheld Devices .....	20
10	References .....	21
	Annex A – TOBA-7515 Version 1.2 .....	22
	• <b>Introduction and Aim</b> .....	22
	• <b>Functional Architecture of the FRMCS on-board system</b> .....	23
	• <b>ETCS Migration Variants</b> .....	26
	○ <b>Architecture of existing ETCS OBU</b> .....	26
	○ <b>Description of Variants</b> .....	27
	○ <b>Comparison</b> .....	41
	○ <b>Migration paths</b> .....	42
	• <b>ETCS interworking between on-board and trackside</b> .....	44
	• <b>Cab Radio Migration</b> .....	46
	○ <b>Description of Variants</b> .....	46
	○ <b>Comparison</b> .....	51
	• <b>ANNEX 1 – Euroradio protocol stack</b> .....	52
	• <b>ANNEX 2 – List of Acronym</b> .....	53

## 1 List of abbreviations

3GPP	3rd Generation Partnership Project
CCTV	Closed Circuit Television
CS / PS	Circuit Switch / Packet Switch
DSD	Driver Safety Device
EDOR	ETCS Data Only Radio
ERA	European Railway Agency
ETCS	European Train Control System
EUG	ERTMS Users Group
FCAPS	Fault, Configuration, Accounting, Performance and Security
GSM-R	Global System for Mobile Communications – Railway
HMI	Human-Machine Interface
IM	Infrastructure Manager
JRU	Juridical Recorder Unit
KPI	Key Performance Indicator
M2M	Machine to machine communication
MCG	Mobile Communication Gateway
MNO	Mobile Network Operator
OB <sub>ANT</sub>	On-board Antenna system reference point/interface
OB <sub>APP</sub>	On-board Application reference point/interface
OB <sub>OM</sub>	On-board Operation & Maintenance reference point/interface
OB <sub>RAD</sub>	On-board Radio Module reference point/interface
OTA	Over-The-Air
PA	Public Announcement
QoS	Quality of service
RAM	Reliability, Availability and Maintainability
RAN	Radio Access Network
RF	Radio Frequency
TCMS	Train Control and Management System
TCN	Train communication network
TIU	Train Interface Unit
TOBA	Telecom On-Board Architecture
TSI	Technical Specification for Interoperability
TSI CCS	Control Command and Signalling TSI
UIC	Union Internationale des Chemins de Fer

## 2 List of definitions

### 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 on-board system, to receive and transmit information to ground systems, (for example, ETCS, DSD, CCTV, passenger announcements, etc.).

### Communication services

Services enabling the exchange of information between two or more applications

### 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).

### Driver

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

### Driver safety device

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

### European Union Agency for Railways (EUAR or ERA)

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

### FRMCS gateway function

It is an on-board gateway responsible for the coordination and managing of access to the FRMCS transport services offered by the FRMCS system.

### FRMCS On-Board Application Client

Enables authorization of an application to the FRMCS Gateway.

## FRMCS Radio Module

Modem with one or more 3GPP or/and non-3GPP radio access technologies supported by the FRMCS system.

## FRMCS Service Client

Enables the use of the Communication Services and/or Complementary Services for the railway applications.

## Proxy function

In the context of this document, the term "proxy function" refers to a function that enables the connection between the "FRMCS Gateway Function" with the other on-board systems/applications that do not have native support for the common control application protocol (OB<sub>APP</sub>).

## System Context

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

## Train Interface Unit

The TIU can be considered as a translation function between different train types input and output signals on the one side and OB<sub>APP</sub> interface on the other side. TIU is specific for each rolling stock type since the train signals are rolling stock specific.

## Train Staff

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

## Transport service

It is a service that provides transport of user information and control signals between corresponding reference points considering the required QoS for the individual communication.

## User

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

## User plane

The user plane (sometimes called data plane or bearer plane), carries the user/application traffic.

## Voice communication

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

### 3 Introduction

This document describes how from a technical point of view existing applications which are using GSM-R today can be migrated to the new architecture with the FRMCS on-board system.

The content of this document was extracted from TOBA-7510 (main chapters) and TOBA-7515 (Annex A). The TOBA WG will maintain this document and update it when necessary. The Annex A will remain frozen, as preservation of all the migration variants discussed, before the variants deemed most favourable were further detailed upon. These variants are now the content of this document.

## 4 Scope of the document

This document proposes and analyses relevant scenarios for migration of ETCS, Cab Radio and both ETCS and Cab Radio in dual mode operation (FRMCS/GSM-R). The FRMCS only scenario is not considered.

Different variants how to migrate current GSM-R ETCS and Cab Radio installation towards dual-mode FRMCS/GSM-R implementations have been discussed among different stakeholders like the UIC FRMCS project, EUG, UNITEL and UNISIG. The results have been documented in [TOBA-7515], which can be found in Annex A – TOBA-7515 Version 1.2 of this document.

In addition, UNITEL and UNISIG have provided their assessment of the different variants in [UNITEL TOBA-7515] and [UNISIG TOBA-7515].

The migration variants discussed in this document are a subset from the variants described and analysed in [TOBA-7515].

## 5 FRMCS Only vs. FRMCS/GSM-R Dual Mode On-Board

- 5.1.1 The current understanding is that EU does not intend to make it mandatory to install FRMCS onboard/trackside for new trains and new lines after the publication in the TSI CCS update planned for 2022. Migration will thus be a nationally coordinated matter, where all involved RU's/IM's have to agree upon the time schedule.
- 5.1.2 Considering that not one single FRMCS migration plan (incl. timelines) for Europe exists, the on-board architecture shall support FRMCS/GSM-R dual mode as well as FRMCS only.
- 5.1.3 This does not necessarily mean that GSM-R and FRMCS are operated in parallel, but also that some lines may utilise GSM-R only and other lines FRMCS only. Some national migration scenarios may even allow single mode FRMCS on-board equipment.

## 6 Migration of ETCS

### 6.1 Migration variants

6.1.1 Migration variants for existing ETCS on-board installations are discussed and evaluated by TOBA WG in [TOBA-7515], by UNITEL in [UNITEL TOBA-7515] and by UNISIG in [UNISIG TOBA-7515]. The following two variants are considered being the most favourable ones by TOBA workgroup:

- ETCS Variant 1b – Existing ETCS OBU with PS (or CS) Conversion/Bypass
- ETCS Variant 3 – Modified Euroradio involving CS and PS bypass

## 6.2 ETCS Variant 1b – Existing ETCS OBU with PS (or CS) Conversion/Bypass

6.2.1 In this variant, as shown in Figure 1, an existing ETCS BL3 MR1 OBU is connected to the FRMCS gateway function through appropriate CS protocol conversion, for GSM-R the ETCS OBU is directly connected to the EDOR.

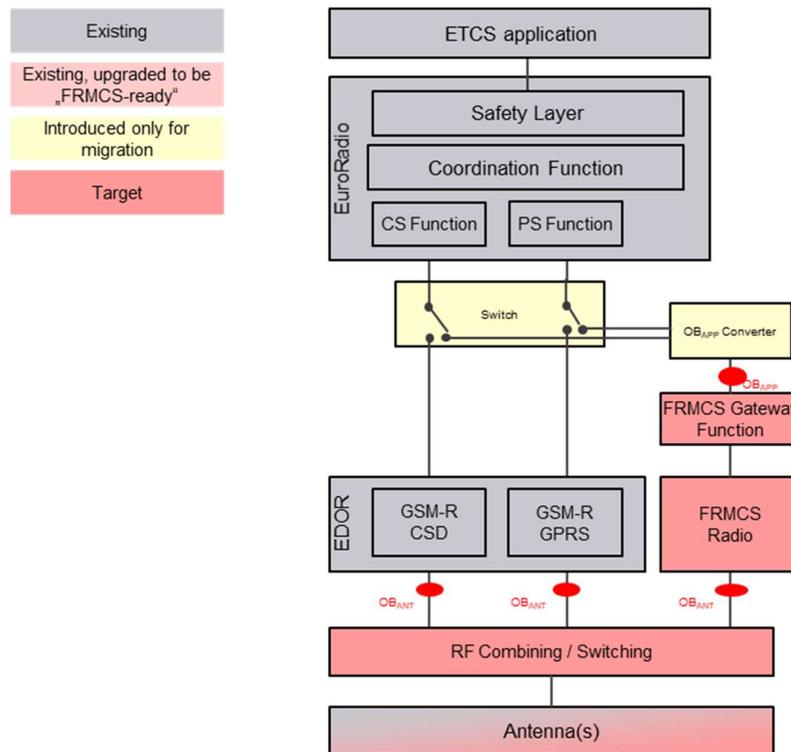


Figure 1: Existing ETCS OBU with PS/CS Conversion/Bypass

- 6.2.2 An ETCS BL3 R2 OBU, which includes PS, is connected to the FRMCS gateway through appropriate PS protocol conversion, for GSM-R the ETCS OBU is directly connected to the EDOR for both CS and PS.
- 6.2.3 This variant may be a viable option for existing ETCS OBU where an upgrade of the OBU to support OB<sub>APP</sub> interface (as in variant 3) is not feasible / economical.
- 6.2.4 This variant is not recommended for new ETCS OBUs.

### 6.3 ETCS Variant 3 – Modified Euroradio involving CS and PS bypass

6.3.1 In this variant, depicted in Figure 2 an existing Euroradio (e.g. ETCS OBU version BL3 MR1 or BL3 R2) is updated such as to support the  $OB_{APP}$  interface to the FRMCS Gateway Function. Existing CS and PS paths are connected directly to the GSM-R EDOR, i.e. bypassing the FRMCS Gateway Function.

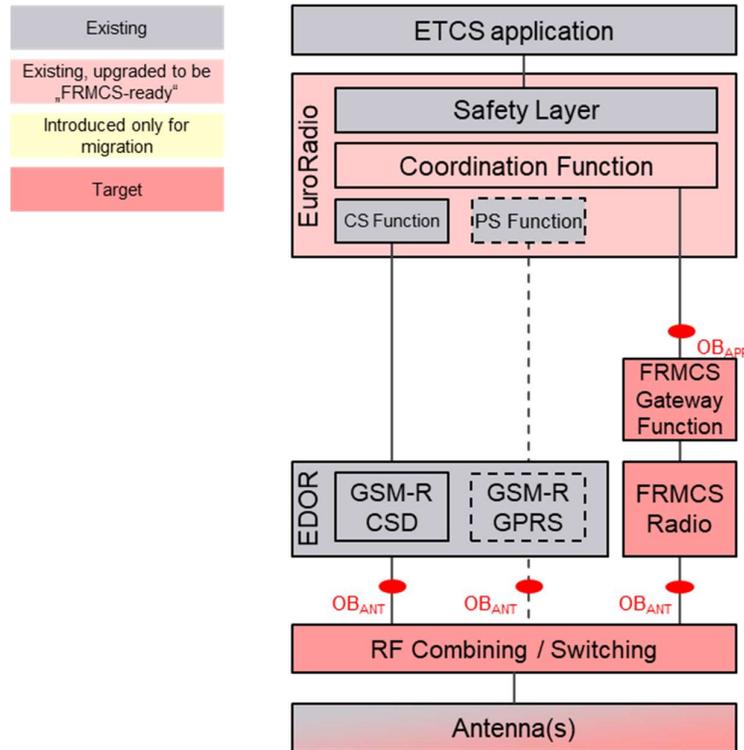


Figure 2: Modified Euroradio with CS and PS bypass

6.3.2 This variant is recommended to be used for existing ETCS OBUs where an upgrade of the OBU to support  $OB_{APP}$  interface) is feasible / economical.

6.3.3 This variant is recommended for new ETCS OBUs.

## 7 Migration of GSM-R Cab Radio

### 7.1 Migration variants

7.1.1 Migration variants for existing GSM-R Cab Radio installations were discussed and evaluated in [TOBA-7515]; its content is now part of this document in Annex A. The following two variants are considered being to most favourable one:

- Cab Radio Variant 4a – Upgrade of an existing GSM-R Cab Radio to support FRMCS
- Cab Radio Variant 4b – New Cab Radio supporting FRMCS and GSM-R

### 7.2 Cab Radio Variant 4a – Upgrade of an existing GSM-R Cab Radio to support FRMCS

7.2.1 An existing GSM-R cab radio installation is upgraded with an FRMCS Voice Function to interface via  $OB_{APP}$  with the FRMCS On-Board System. The GSM-R path is kept unchanged as shown in Figure 3.

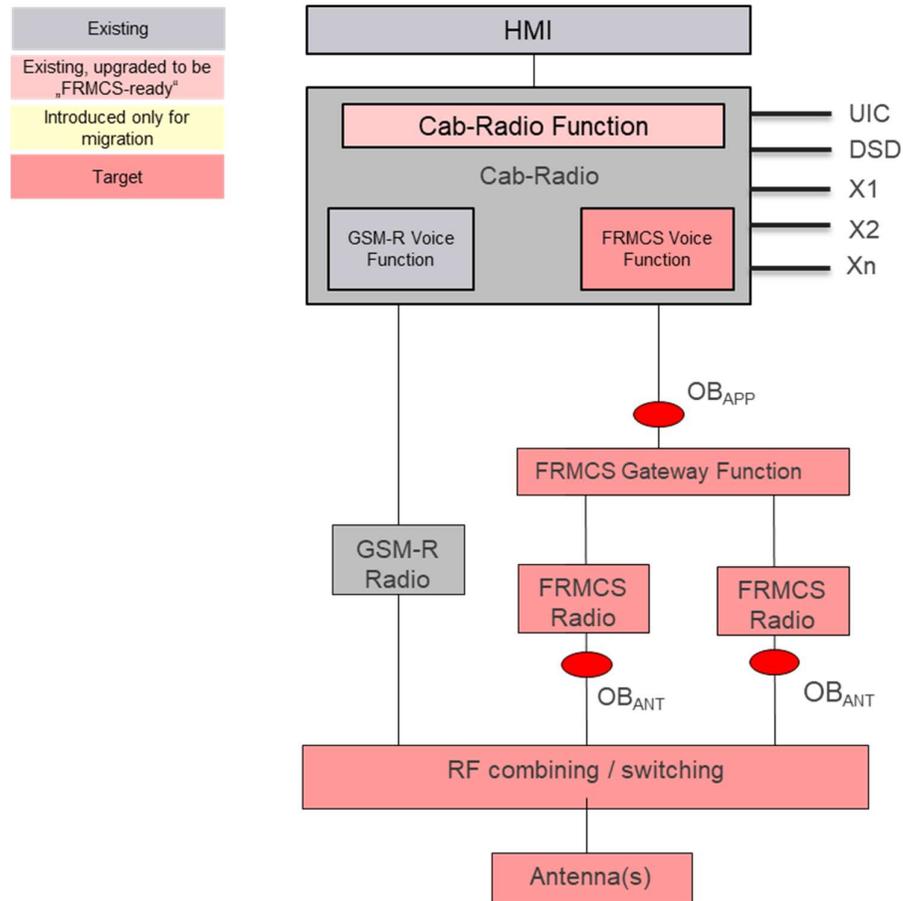


Figure 3: Cab Radio Variant 4a – Upgrade of an existing GSM-R Cab Radio to support FRMCS

### 7.3 Cab Radio Variant 4b – New Cab Radio supporting FRMCS and GSM-R

7.3.1 Similar architecture as variant 4a but reflecting a new Cab Radio supporting FRMCS out of the box and offering an interface to an existing GSM-R Radio as shown in Figure 4.

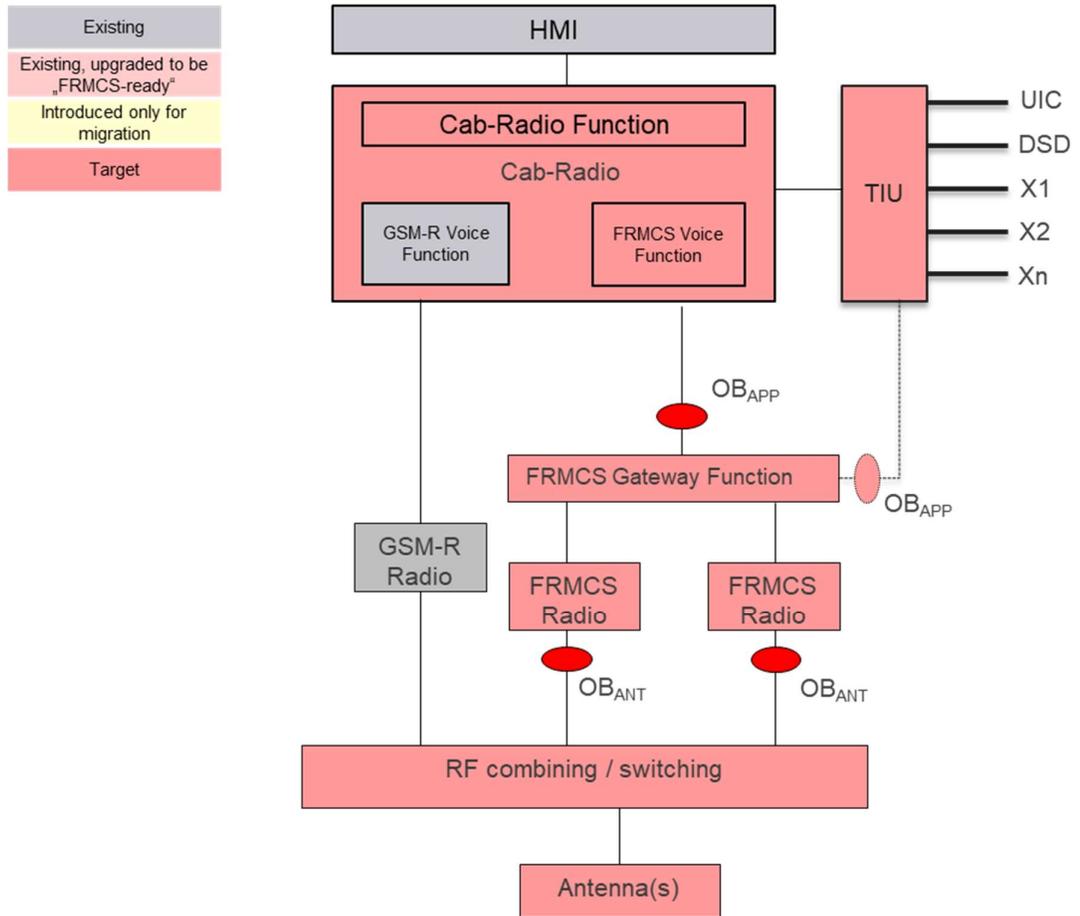


Figure 4: Cab Radio Variant 4b – New Cab Radio supporting FRMCS and GSM-R

7.3.2 The TIU could either be connected to the Cab Radio or it could use the OB<sub>APP</sub> interface to the FRMCS Gateway Function (dotted line in figure 4) (for further study).

## 8 Combined migration of ETCS and Cab Radio

### 8.1 Current situation

8.1.1 In the current GSM-R only situation, different types of typical implementations are applicable:

- Type 1
  - Voice: Each cabin has its own GSM-R radio (with integrated DMI)
  - ETCS: Central OBU with GSM-R EDOR(s)
- Type 2
  - Voice: Each cabin has its own GSM-R radio (with integrated DMI)
  - ETCS: Multiple OBUs with GSM-R EDOR(s)
- Type 3
  - Voice: Each cabin has a DMI connected to central GSM-R radio(s)
  - ETCS: Central OBU with GSM-R EDOR(s)
- Type 4
  - Voice: Each cabin has a DMI connected to central GSM-R radio(s)
  - ETCS: Multiple OBUs with GSM-R EDOR(s)

Note: For type 3 and 4, the GSM-R radio's for voice and ETCS may be installed in the same physical place in the vehicle, e.g. fitted into a single rack.

Note: Although Cab Radios can also support data applications, this document considers the Cab Radio as voice only.

Note: For redundancy purposes, multiple radio modules can be installed. However, there is always a strict separation between ETCS and voice radios (except for non-operational spare radios)

### 8.2 Target configuration

8.2.1 Based upon Variant 3 for ETCS and Variant 4a/b for Voice are considered as the relevant variants for migration, and considering the current situation, the following configurations can be identified:

- Voice and ETCS applications keep their own, separate GSM-R radios, and have common FRMCS onboard systems
- For certain implementations (e.g. refit) Voice and ETCS applications (if any) keeping their own, separate GSM-R radios, and having separate (as per today) FRMCS onboard systems is still possible.

## 8.3 Migration

8.3.1 As described in section 5, migration of Cab Radio (voice applications) and ETCS applications from GSM-R to FRMCS will start with a dual mode phase. The following scenarios can be identified:

- First migration of Cab Radio, then ETCS at a later stage
- First migration of ETCS, then Cab Radio at a later stage
- Simultaneous migration of ETCS and Cab Radio

Note: The selection of one of these scenarios is dependent of several parameters, e.g. remaining lifetime of the vehicle, the need for first installation of ETCS, the need for updating GSM-R equipment, etc.

8.3.2 Taking into consideration that any FRMCS onboard system is designed to serve multiple applications via a standard interface ( $OB_{APP}$ ), the first installation of a FRMCS onboard system is fit for the connection of either voice applications, or ETCS, or both applications.

8.3.3 Seen from architecture point of view, there is no fundamental difference between voice first or ETCS first.

8.3.4 It is recommended to define for each vehicle the preferred target configuration and to prepare the installation of physical elements (equipment positions, racks/space, cabling, antennas and their positions). This will allow the installation of FRMCS onboard systems in a flexible way.

## 9 Migration of other Users and Systems

### 9.1 Migration of other Applications using GSM-R today

- 9.1.1 Trains currently incorporate also other applications (non-interoperable / national) using GSM-R-only data modems besides Cab Radio and ETCS.
- 9.1.2 Migration of these application may be in the form of:
  - a. connecting the application to the FRMCS on-board system which is designed to carry any application by using the standardised OB<sub>APP</sub> interface, or
  - b. replacing the modem specific to the application by an applicable standalone FRMCS device.
- 9.1.3 It is assumed, that in the case that the interface between the application and the FRMCS on-board system is not compatible, a converter is used to adapt the existing interfaces to OB<sub>APP</sub>, retaining the functionality and be capable to deliver the required QoS.

### 9.2 Migration of Applications using Public Mobile Networks today

- 9.2.1 Applications that run over public mobile networks today are not affected by the decommissioning of GSM-R and can be migrated to the FRMCS on-board system at any time. It is an implementation decision if these applications should use the FRMCS on-board system in future.
- 9.2.2 If such applications use the FRMCS on-board system, the applications need to support the necessary functionality related to the OB<sub>APP</sub> interface.

The interoperability aspects of this option is not subject of this document.

### 9.3 Migration of Handheld Devices

- 9.3.1 Train staff, customer service staff etc. using handheld devices (either GSM-R or public) can continue to use handheld devices. Therefore, they are not relevant for the migration to the FRMCS on-board system architecture. It is an implementation decision if these handhelds should use the FRMCS on-board system as “relay/repeater”. (see also [TOBA-7510] chapter 4.1.3).
- 9.3.2 Handhelds could however be used instead of current fixed train equipment (like the Cab Radio), using the FRMCS on-board system as “relay/repeater”, so they are becoming part of the on-board infrastructure.

## 10 References

- [TOBA-7515]** UIC, FRMCS Migration Scenarios, Description and Evaluation of Possible FRMCS Migration Variants for Existing ETCS and Cab Radio On-Board Unit, TOBA-7515, Version 1.2, 14.11.2019 (included in ANNEX A of this document)
- [UNITEL TOBA-7515]** UNITEL, TOBA variant assessment, Version 2.0, 26.11.2019
- [UNISIG TOBA-7515]** UNISIG, Design Rationale, TOBA 7515 Variants Comparisons by UNISIG, UNISIG-DSG-T-ALS-002, Version 1.0.0, 27.11.2019
- [TOBA-7510]** UIC, FRMCS Migration Scenarios, Telecom On-Board System – Functional Requirements Specification, TOBA-7510, Version 0.2, 14.04.2020

## Annex A – TOBA-7515 Version 1.2



UNION INTERNATIONALE DES CHEMINS DE FER  
INTERNATIONALER EISENBAHNVERBAND  
INTERNATIONAL UNION OF RAILWAYS

<b>FRMCS Migration Scenarios Telecom On-Board Architecture Workgroup</b>		<b>Document No. TOBA-7515</b>
<b>Title:</b>	<b>Description and Evaluation of Possible FRMCS Migration Variants for Existing ETCS and Cab Radio On-Board Units</b>	
<b>Date:</b>	14.11.19	
<b>Author(s):</b>	UIC TOBA WG	
<b>Version:</b>	1.2	
<b>Status:</b>	Final	

Version	Date	Changes
1.0	18.06.2019	Version prepared for review in TOBA#5
1.1	30.09.2019	Update after TOBA 6 Update according to review comments from SNCF CIM, UTG, EIM, UNISIG (SysG and ER), CER (SNCF and DB), X2R3, FWG  Inclusion of conclusions from EUG WP8 Meeting on September 26 <sup>th</sup> .
1.2	14.11.2019	Implementation Variant 4A and 4b by Cabradio Variant (5.1.4)

**Abstract:** This document contains a description and the evaluation of possible FRMCS migration variants for existing ETCS and cab radio on-board units.

### • Introduction and Aim

The aim of this document is to structure the discussion on the possible migration of existing ETCS and cab radio on-board units in the context of FRMCS introduction, with a particular focus on the FRMCS trackside migration period for which both the train and trackside are expected to support dual radio (GSM-R and FRMCS). Key questions to be clarified are here:

- Which specific FRMCS migration variants are most meaningful and should hence be supported by the FRMCS on-board system?
- Which technology constellations should be used when novel trains are ordered that appear during the FRMCS trackside migration period.

- **Functional Architecture of the FRMCS on-board system**

The UIC FMS Telecom On-Board Architecture WG (TOBA) currently follows certain key design paradigms and working assumption in their work on specifying the requirements for the FRMCS on-board system.

#### **Key Design Paradigms**

##### Decoupling of Applications and Transport

- With the FRMCS on-board system a decoupling of applications and communication services / transport services shall be achieved

##### Bearer Flexibility

- The FRMCS on-board system shall be capable of providing transport services using a variety of bearers (i.e. Radio Access Technologies)
- The FRMCS on-board system shall be capable of using a variety of bearers simultaneously

##### Resource Sharing

- The FRMCS on-board system shall be capable of providing transport services for multiple applications of any category using the same FRMCS on-board system considering the individual QoS requirements of the application and possibly priorities among applications.

#### **Working Assumptions**

Following the key design paradigms, the functional architecture depicted in [Figure 5](#), is regarded as the working assumption for the TOBA WG. This architecture shall be further refined in the course of TOBA WG's progress. Consequently, the migration variants described in this document are also following these key design paradigms and the working assumptions for the functional architecture of the FRMCS on-board system.

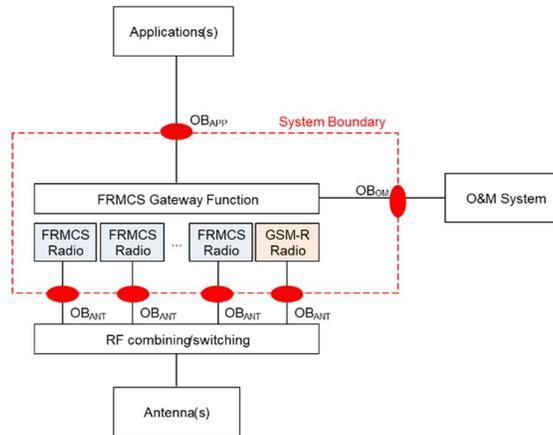


Figure 5: Functional Architecture of FRMCS On-board System

Interfaces:

- Reference point OB<sub>APP</sub>
  - Layer 3 (IP) interface between the FRMCS On-Board System and the application(s)
  - User plane data from and to the applications(s) are transparently carried over this reference point.
  - Control plane data exchange between application(s) and FRMCS On-Board System is performed over this reference point
- Reference point OB<sub>ANT</sub>
  - Between the FRMCS On-Board System and the RF combining / switching functionality or the antenna(s)
- Reference point OB<sub>OM</sub>
  - Between the FRMCS On-Board System and the O&M System responsible for the operation & management of the FRMCS On-Board System
  - Data related to O&M activities are exchanged over this reference point.

FRMCS Gateway Function:

Manages the data flows, has a control plane interface for the applications, distributes the user plane data from data applications over the various radio units depending on the application's QoS requirements and possibly priorities among applications.

FRMCS Radio:

Modem with any 3GPP or non-3GPP radio access technology supported by the FRMCS system. An FRMCS on-board system contains 1..n FRMCS radios.

Note: The FRMCS Radio does not cover GSM-R.

GSM-R Radio:

Existing GSM-R Radio for voice (e.g. Cab Radio modem) or data (e.g. EDOR modem). An FRMCS on board system contains 0..n GSM-R Radio.

Note: Management of GSM-R radio(s) will be managed by the FRMCS Gateway Function depends on the architecture migration variants discussed in this document.

RF Combining & Switching / Antennas:

For further study within TOBA WG. It is assumed that the solution(s) for the antenna sub-system will not impact the principle of the migration scenarios described in this document.

- **ETCS Migration Variants**

- **Architecture of existing ETCS OBU**

In the context of this document, an existing ETCS OBU is represented with the functional blocks depicted in [Figure 6](#). An ETCS OBU in version BL3 MR1 only includes the CS function, a version BL3 R2 unit also includes the PS function, represented by the dotted line. The CS and PS function share the same physical serial interface to the EDOR.

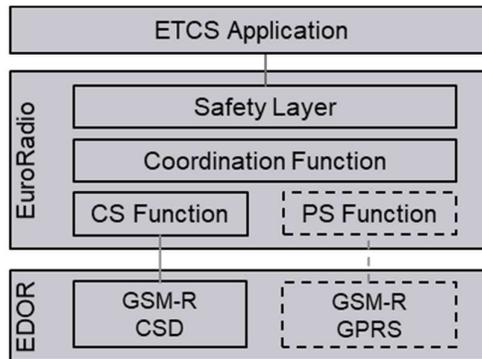


Figure 6: Functional block of existing ETCS OBU<sup>1</sup>

---

<sup>1</sup> CS and PS links are logically separated, even if they are physically one single interface.

## ○ Description of Variants

Currently, the following variants of ETCS onboard and GSM-R / FRMCS technology constellations are being considered.

### ▪ ETCS Variant 1a – Existing ETCS OBU with CS and PS Conversion

Description: In this variant, as shown in Figure 7, an existing ETCS OBU, e.g. ETCS OBU BL3 MR1 or BL3 R2 which includes PS (dotted line in the figure below) is connected to the FRMCS gateway function through appropriate protocol conversion. Underneath the FRMCS gateway function, existing GSM-R EDOR unit(s) can be used beside FRMCS radio unit(s).

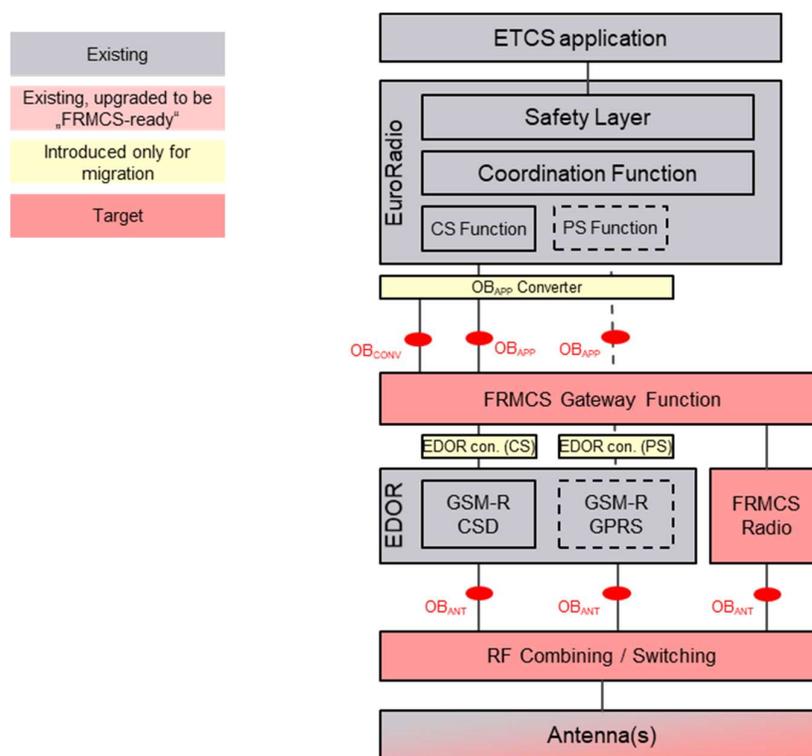


Figure 7: ETCS variant 1a - Existing ETCS OBU with CS and PS conversion.<sup>2</sup>

#### Needed protocol conversion:

- OB<sub>APP</sub> Converter: Protocol conversion from serial interface (Euroradio FIS/FFFIS) to the OB<sub>APP</sub> interface for CS User Plane, PS User Plane and CS/PS Control Plane.
- OB<sub>CONV</sub> Interface : Complementary interface to OB<sub>APP</sub> used to allow the OB<sub>APP</sub> converter to simulate a GSM-R radio for the EVC. It supports Control Plane data not included in OB<sub>APP</sub>.
- EDOR converter (CS): Protocol Conversion for CS User Plane and CS Control Plane
- EDOR converter (PS): Protocol Conversion for PS User Plane and PS Control Plane

<sup>2</sup> CS and PS links are logically separated, even if they are physically one single interface.

## Control Plane

Since in this variant, the existing PS/CS function in Euroradio are not modified, the OB<sub>APP</sub> Converter is required to emulate the behaviour of a GSM-R modem, although the underlying FRMCS on-board system is very different from being a GSM-R modem. It is important to note, that the control plane implementation is today tailored to the behaviour of specific modems (incl. SW version) and OBU SW version. Thus, this emulation would have to be implemented in many different variants.

For the implementation of the control plane, there are two different variants:

- 1) Tunneling: The AT commands sent over the serial interface are tunnelled between the OB<sub>APP</sub> Converter and the EDOR converters (using a suitable tunnelling protocol like for the CS user plane described further below). This would be rather easy to implement, but the FRMCS on-board system has to give the EDOR exclusive control of the ETCS system. Also, it would not be possible to make use of the FRMCS radio, since the existing control plane implementation can only select between GSM-R CS or GPRS but not a third path. Thus, also rendering the value of this solution limited;
- 2) Emulation of EDOR: Towards the ETCS, the OB<sub>APP</sub> converter emulates the AT-Command interface of an EDOR as defined in Euroradio FFFIS. Towards the FRMCS On-Board system, the OB<sub>APP</sub> Converter implements the OB<sub>APP</sub> control plane protocol. A translation logic is required in the OB<sub>APP</sub> Converter for translating between the two control planes. This rather complex and likely also error prone solution, would allow the FRMCS on-board system to perform the bearer management and therefore reach the goal of decoupling application and transport to some degree at least. The AT command interface will however not be able to provide all the functionality the FRMCS On-Board system could offer over OB<sub>APP</sub> to the ETCS OBU.  
The emulation of the EDOR also needs to retrieve the network and call information from the ETCS application and select the network of the physical EDOR accordingly. With the E.164 phone number retrieved from the balises via the ETCS application, the EDOR emulation can determine if the RBC support GSM-R CS/PS or FRMCS by consulting a lookup table. This look-up table needs to be kept up-to-date on all vehicles, corresponding processes have to be established;

## CS User Plane

There are three principle forms of how the CS path from Euroradio could be handled by the FRMCS gateway:

- 1) The HDLC frames could be tunnelled (e.g. L2TPv3 [IETF RFC 4349], MPLS [IETF RFC 4618]) between the Euroradio System and the GSM-R EDOR passing through FRMCS gateway, so that this would be transparent to the Euroradio protocol. The tunnelling end-points are implemented in the OB<sub>APP</sub> Converter and the EDOR converter (CS). This would be rather easy to implement, but the CS path could not utilize the FRMCS radio, hence also rendering the value of this solution limited;
- 2) Using the same method above but terminating the HDLC-tunnel on the RBC side would in principle allow to run a CS data session over the FRMCS radio. This would however require some control mechanism between the FRMCS Gateway and the OB<sub>APP</sub> Converter to decide if

a tunnel shall be established towards the GSM-R EDOR or towards the RBC via the FRMCS radio;

- 3) HDLC frames would be converted by the OB<sub>APP</sub> Converter, so that these can make use of GSM-R radio and FRMCS radio. This approach requires the implementation of the CS user plane protocol stack of Euroradio in the OB<sub>APP</sub> Converter, though resulting in significantly higher protocol conversion complexity both in terms of development and homologation. The figure below depicts exemplarily the various protocol layers that would have to be implemented in the OB<sub>APP</sub> Converter for the conversion needed for the CS functionality.

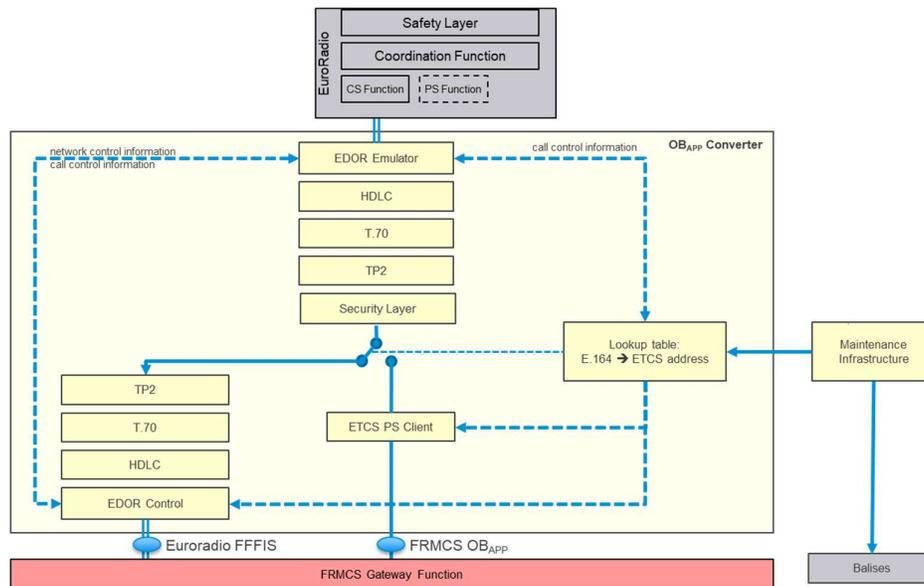


Figure 8: Detailed structure of the OB<sub>APP</sub> Converter for required for CS conversion

### PS User Plane

For PS User data, the OB<sub>APP</sub> Converter would be the PPP end point to the Euroradio system (emulation of the PPP end-point of the GSM-R EDOR). After that, the IP packets could be routed via OB<sub>APP</sub> and the FRMCS Gateway function to either the GSM-R EDOR or the FRMCS radio. Aspects of routing / addressing are FFS.

## Compatibility Matrix

Not all the combination of control plane / user plane variants described above are feasible / beneficial, the table below indicates valid combinations

Control Plane	User Plane			
	CS-UP 1)	CS-UP 2)	CS-UP 3)	PS-UP
CP-1)	GSM-R only	GSM-R only	GSM-R only	GPRS only
CP-2)	No benefit as CS-UP 1 is limited to GSM-R			

Table 1: Compatibility Matrix - Control Plane and User Plane options

**Note: Combinations with CP-1) only support GSM-R and thus, cannot be considered as migration option.**

### Benefits:

- Allows the usage of existing ETCS OBU (version BL3 MR1 or BL3 R2) as well as existing GSM-R EDOR without any HW/SW change;

### Disadvantages:

- Involves heavy protocol conversion, in particular for conversion options CS-UP 2, CS-UP 3 and CP-2 described above;
- Using FRMCS access technology and bearer management by the FRMCS on-board system is only possible with the implementation of the more complex (and likely error prone) emulation of the control plane (CP-2).
- The existing serial interfaces are carried over into an all IP system architecture. It requires another migration step to replace these serial interfaces with an IP interface (OB<sub>APP</sub>). This second migration step could of course also be achieved in later stage (after migration to FRMCS is completed) by replacing the ETCS OBU with a new system supporting OB<sub>APP</sub> out of the box.
- For each RBC, also for those that are FRMCS only, an E.164 phone number would have to be assigned and programmed into the balises. Maintenance infrastructure and processes need to be established to ensure the look-up tables required on-board always kept up-to-date (e.g. when adding a new FRMCS RBC).
- The control plane (AT-Commands) is (modem) supplier specific. Thus, many different variants of the control plane emulation have to be implemented.
- CS-UP2 and PS-UP needs to implement additional conversions on the RBC side. Both variants define additional transport channels "Tunnelling CS/PS over FRMCS". This means in worst case five interfaces for the RBC: CS, PS, FRMCS, Tunneling CS over FRMCS, Tunneling PS over FRMCS.

▪ **ETCS Variant 1b – Existing ETCS OBU with PS (or CS) Conversion/Bypass**

Description: In this variant, as shown in Figure 9, an existing ETCS OBU BL3 MR1 is connected to the FRMCS gateway function through appropriate CS protocol conversion, for GSM-R the ETCS OBU is directly connected to the EDOR. An ETCS BL3 R2, which includes PS, is connected to the FRMCS gateway through appropriate PS protocol conversion, for GSM-R the ETCS OBU is directly connected to the EDOR for both CS and PS.

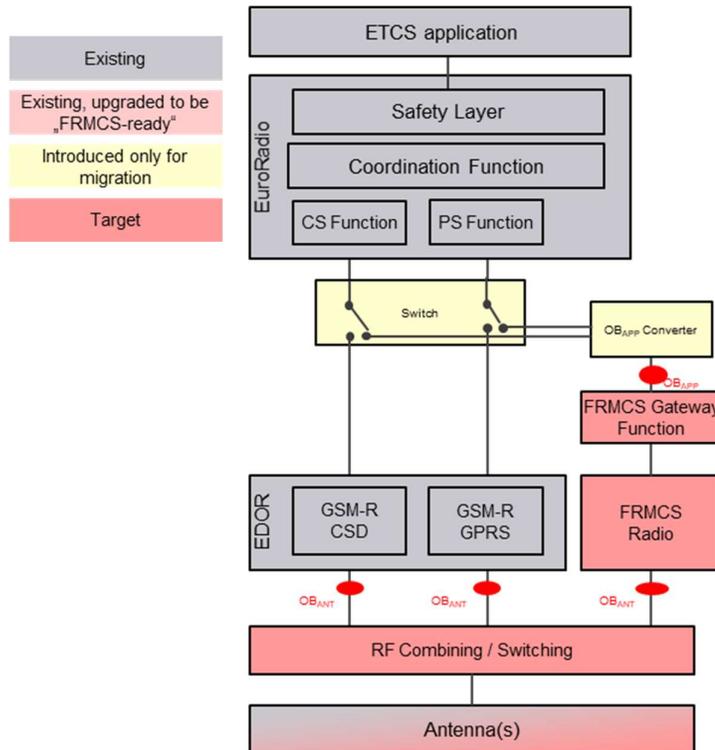


Figure 9: ETCS Variant 1b – Existing ETCS OBU with PS (or CS) Conversion/Bypass<sup>3</sup>

Needed protocol conversion:

- Switch: Switching the paths between the direct connection to the EDOR and the connection through the OB<sub>APP</sub> converter. Functionality wise it is the same switch as shown in Figure 8 under Variant 1a)
- OB<sub>APP</sub> Converter: Protocol conversion from serial interface (EuroRadio FIS/FFFIS) to the OB<sub>APP</sub> interface for PS User Plane or CS User Plane and CS/PS Control Plane.

Control Plane:

Same as Variant 1a), but without the need for any conversion in case of usage of GSM-R

CS User Plane:

Same as Variant 1a), but without the need for any conversion in case of usage of GSM-R

<sup>3</sup> CS and PS links are logically separated, even if they are physically one single interface.

PS User Plane:

Same as Variant 1a), but without the need for any conversion in case of usage of GSM-R

Benefits:

- Same as variant 1a), with the additional benefit that no conversion is needed in case of GSM-R usage.

Disadvantages:

- Same as variant 1a) except it only requires the protocol conversion for communication over FRMCS;
- By switching between GSM-R and FRMCS, the CS/PS Function will lose the state of the radio. Depending on the implementation, the driver would be informed about the loss of the radio.

▪ **ETCS Variant 2 – Existing ETCS OBU with CS bypass and PS Conversion**

**Further analyses have proven that the single physical serial interface is indeed making this variant not feasible. The variant is kept in the document for reference only.**

Description: Same as in ETCS variant 1a/b, this variant, as depicted in Figure 10, allows the usage of an existing ETCS OBU and existing GSM-R EDOR. The difference is, however, that in this case the CS part of the EuroRadio connects directly to the GSM-R EDOR and hence bypasses the FRMCS gateway. The PS path, however, is handled via the FRMCS gateway. **In consequence, this variant is only meaningful for an ETCS OBU and GSM-R EDOR of BL3 R2.**

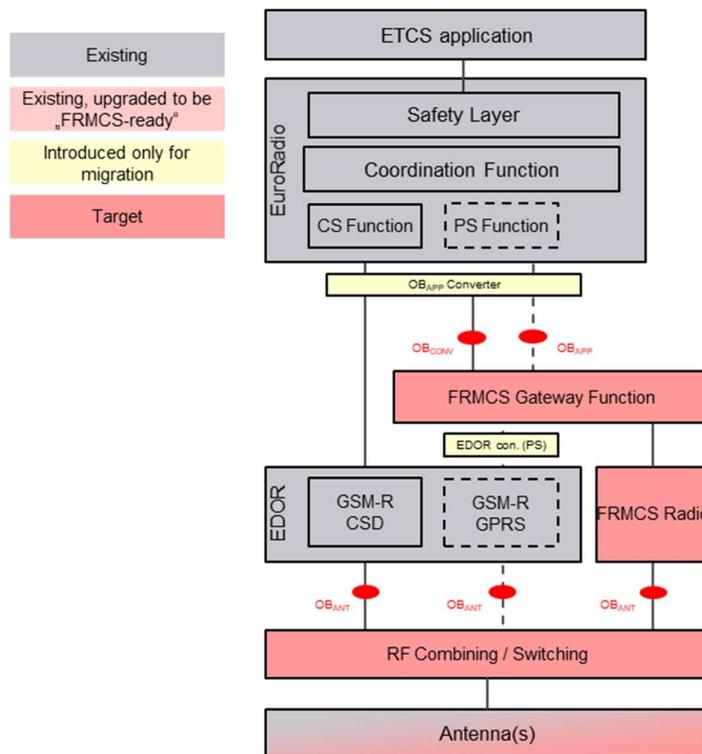


Figure 10: ETCS Variant 2 - Existing ETCS OBU with CS bypass and PS conversion.

Needed protocol conversion:

- **OB<sub>APP</sub> Converter:** Protocol conversion from serial interface (EuroRadio FIS/FFIS) to the OB<sub>APP</sub> interface for PS User Plane and PS Control Plane.
- **OB<sub>CONV</sub> Interface :** Complementary interface to OB<sub>APP</sub> used to allow the OB<sub>APP</sub> converter to simulate a GSM-R radio for the EVC. It supports Control Plane data not included in OB<sub>APP</sub>.
- **EDOR converter (PS):** Protocol Conversion for PS User Plane and PS Control Plane

Control Plane:

Same as Variant 1a)

CS User Plane:

No Conversion required.

PS User Plane:

Same as Variant 1a)

Benefits:

- Allows the usage of existing ETCS OBU (BL3 R2) as well as existing GSM-R EDOR;
- Compared to variant 1a, the protocol conversion complexity for CS user plane and CS control plane is reduced. For PS it is the same as variant 1a;

Disadvantages:

- The disadvantages of Variant 1a apply, except for the CS user/control plane conversion;
- This variant is only meaningful in the context of ETCS OBU and GSM-R EDOR of BL3 R2, as otherwise the solution would collapse into GSM-R CS only solution without any FRMCS path;
- The solution does not allow for any load balancing between GSM-R CS and FRMCS via the FRMCS gateway;
- A possible showstopper may be that the serial interface of Euroradio is one physical interface for both the CS and PS part.

▪ **ETCS Variant 3 – Modified Euroradio involving CS and PS bypass**

Description: In this variant, depicted in Figure 11, an existing Euroradio (e.g. ETCS OBU version BL3 MR1 or BL3 R2) is updated such as to support the OB<sub>APP</sub> interface to the FRMCS gateway. Existing CS and PS paths are connected directly to the GSM-R EDOR, i.e. bypassing the FRMCS on-board system. As implementation variant, the serial connection to the EDOR could be tunnelled over OB<sub>APP</sub>, in this case the EDOR would be placed under the FRMCS Gateway Function which would terminate the tunnel.

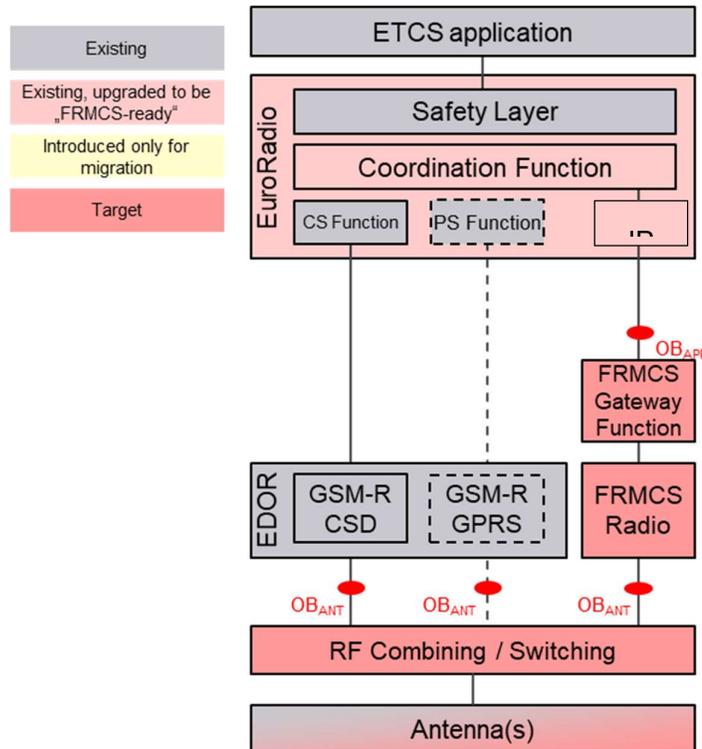


Figure 11: ETCS Variant 3 – Modified Euroradio with CS and PS bypass.<sup>4</sup>

Needed protocol conversion:

- None;

Required changes to Euroradio:

- Implementation of (yet to be standardized) OB<sub>APP</sub> user plane and control plane protocols.

Editor's Note: An in-depth analysis of the required changes and analysis of the remaining functionality of the current Euroradio stack is for further study.

<sup>4</sup> CS and PS links are logically separated, even if they are physically one single interface.

#### Benefits:

- FRMCS system itself is kept very lean, no conversion functionality required;
- Euroradio already supports the new IP interface (OB<sub>APP</sub>) natively and thus can leverage on the full feature set of the FRMCS on-board system (decoupling of application and transport, bearer flexibility, redundancy features, security, etc.)

#### Disadvantages:

- This variant would imply introducing a new version of Euroradio including an additional physical interface for already installed OBUs. Note: For new ETCS systems a new version of Euroradio will always be required in order to support the new OB<sub>APP</sub> interface.
- It has to be analysed if this variant has a significant impact on certification/authorisation– as the Euroradio stack and the ETCS application are often (depending on the vendor) implemented on the same processing platform, a modification of the “coordination” function in the Euroradio stack would require a complete re-certification of the overall setup. There may be implementation variants that could address these issues (FFS).
- 
- Future evolution in the ETCS application / security domain would require adaptation to both the FRMCS path and the GSM-R path.

▪ **ETCS Variant 4 – Modified Euroradio reduced to FRMCS support**

Description: Similar as in variant 3, the Euroradio is here updated to support a direct interface to the FRMCS gateway, but in this case the Euroradio is stripped off the existing CS and PS functionality. Underneath the FRMCS gateway function, an existing GSM-R EDOR (version BL3 MR1 or BL3 R2) can be used, as shown in Figure 12.

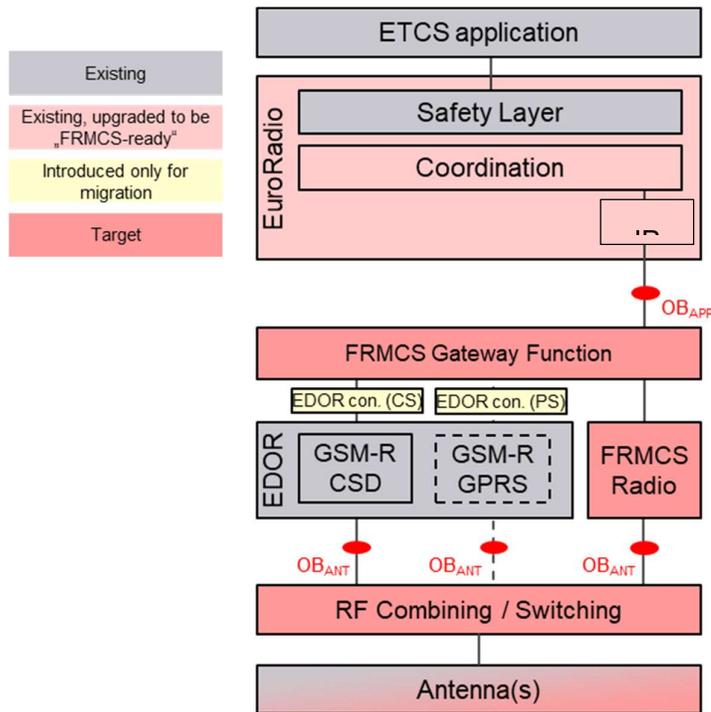


Figure 12: ETCS Variant 4 - Modified Euroradio reduced to FRMCS support.<sup>5</sup>

Needed protocol conversion:

- EDOR converter (CS): Protocol Conversion for CS User Plane and CS Control Plane
- EDOR converter (PS): Protocol Conversion for PS User Plane and PS Control Plane

Control Plane

The new (yet to be standardized)  $OB_{APP}$  control plane protocol needs to be implemented in the Euroradio system. CS/PS Modem control of the EDOR according to Euroradio FFFIS needs to be implemented in the EDOR converter. It has to be further analysed if the full scope of Euroradio FFFIS has to be implemented.

<sup>5</sup> CS and PS links are logically separated, even if they are physically one single interface.

### CS-User Plane

In this variant CS support is only required in case GSM-R CS is used for connection to an RBC (e.g. operating on non-FRMCS track). Emulation of existing CS Euroradio over FRMCS is not required according chapter 7. There are two variants for implanting GSM-R CS compatibility:

- 1) The ETCS application IP data packets are converted into a HDLC session in the EDOR Converter (CS). This would require the implementation of the CS Euroradio stack (X.224/T.70/HDLC) in the EDOR Converter.
- 2) The (re-) implementation of the CS Euroradio stack in the EDOR Converter could be avoided if the existing CS-stack in Euroradio System is maintained and tunneling for transport of the HDLC frames is used. One tunneling end-point resides inside the Euroradio System, the other end-point is implemented in the EDOR converter.

### PS-User Plane

The required changes to Euroradio system are relatively simple, since in principle only the PPP part of the current PS implementation has to be omitted and instead directly interface to OB<sub>APP</sub>. For PS over GPRS, the EDOR converter (PS) needs to implement the PPP session.

The figure below depicts exemplarily the various protocol layers that would have to be implemented in the EDOR Convert for the conversion needed, some of the conversion function would be located in the FRMCS Gateway Function.

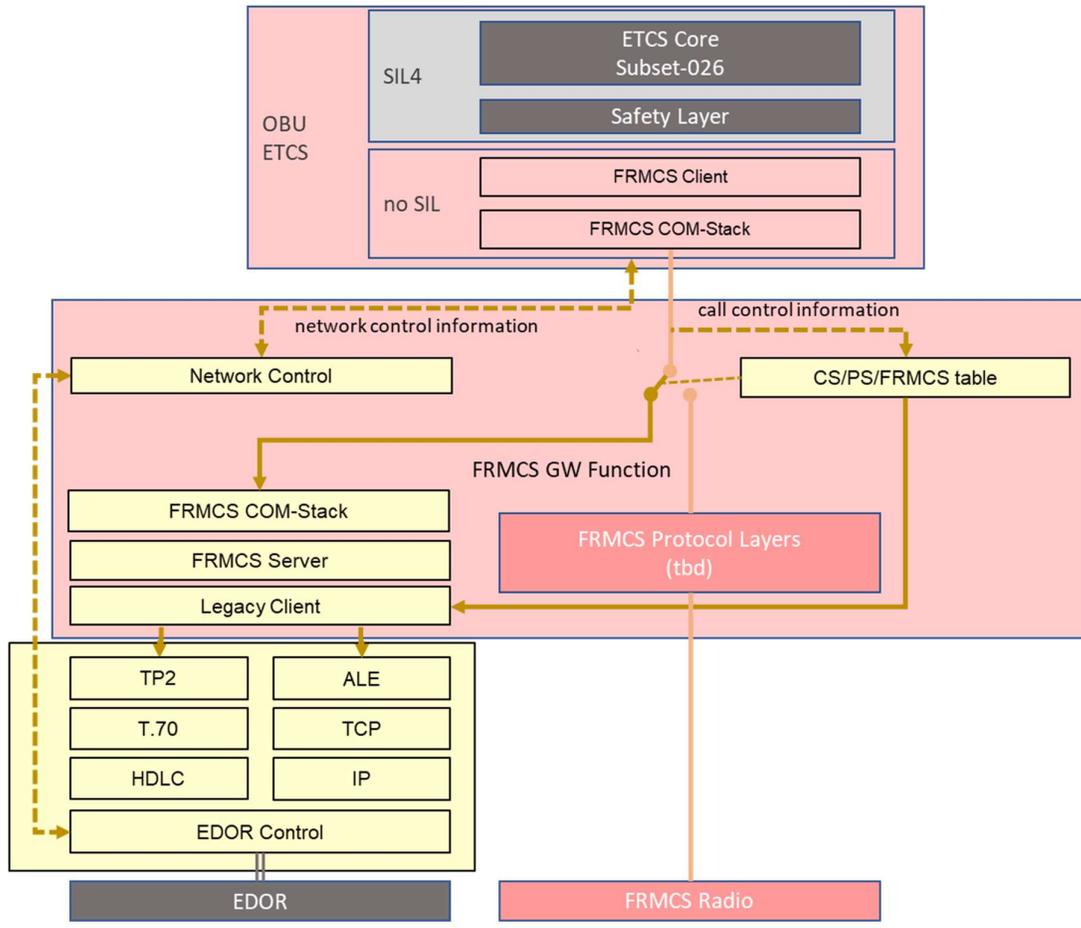


Figure 13: Detailed structure of the conversions needed for variant 4

Required changes to Euroradio:

- Implementation of (yet to be standardized) OB<sub>APP</sub> user plane and control plane protocols.  
Editor's Note: An in-depth analysis of the required changes and analysis of the remaining functionality of the current Euroradio stack is for further study.

Benefits:

- Large parts of the protocol conversion needs from variants 1a/b and 2 are avoided;
- Euroradio already supports the new IP interface (OB<sub>APP</sub>) natively and thus can leverage on the full feature set of the FRMCS on-board system (decoupling of application and transport, bearer flexibility, redundancy features, security, etc.)
- Compared to variant 3, the FRMCS on-board system will become capable of managing the GSM-R bearers, whereas the ETCS OBU is completely freed from any duty of radio connection management.
- Any future evolution in the ETCS application / security domain could also be deployed using GSM-R connectivity.

Disadvantages:

- Same as for variant 3, a modified Euroradio is introduced for already installed OBUs. ;
- Compared to variant 3, a higher protocol conversion burden applies, since the Euroradio stack has to be implemented in the EDOR converter, including supplier specific adaption to the EDOR in use.
- As a selection key for the “CS/PS/FRMCS table” depicted in Figure 9, the EVC would have to pass the RBC address information to the FRMCS gateway / converter. This results into application specific information elements in the OB<sub>APP</sub> interface. Based on this RBC address information a look-up table or an algorithm needs to decide which communication path to choose from.

○ **Comparison**

The key characteristics of the different FRMCS migration variants in the context of ETCS are summarized **Error! Reference source not found.**

	<b>Variant 1a</b> - Existing ETCS OBU with CS and PS Conversion	<b>Variant 1b</b> - Existing ETCS OBU with PS (or CS) Conversion/Bypass	<b>Variant 3</b> - Modified Euroradio involving CS and PS bypass	<b>Variant 4</b> - Modified Euroradio reduced to FRMCS support
Decoupling of Application and Transport for FRMCS	No	No	Yes	Yes
Protocol conversion burden / extent of functionality introduced only for migration	Very high, incl. supplier specific implementation of EDOR emulation	High, incl. supplier specific implementation of EDOR emulation (reduced compared to 1a)	None	Very High, incl. supplier specific implementation of EDOR interface
Required HW modification of BL3 MR1/BL3 R2 equipment	None	None	Yes (If no ethernet interface available) <sup>6</sup>	Yes (If no ethernet interface available) <sup>6</sup>
Required SW Update of BL3 MR1/B 3 R2 equipment	None	None	Yes	Yes
Requires additional, temporary interface (along OB <sub>APP</sub> ) to drive the converter(s)	Yes	Yes	No	Yes
Possibility to decommission GSM-R	Yes	Yes	Yes	Yes
Impact on trackside	Depending on chosen implementation option for CS user plane.	Depending on chosen implementation option for CS user plane.	No	No
Evolution of ETCS Cyberscurety Framework	Independent of the scenarios			

**Table 2: Comparison of key characteristics of FRMCS migration variants in context of ETCS.**

<sup>6</sup> The impact of this modification will be supplier specific.

## ○ Migration paths

Figure 14 illustrates possible evolution paths for going from an existing GSM-R ETCS on-board (BL3 MR1 or BL3 R2) installation to a FRMCS only ETCS on-board installation. The different paths are described in the following sections of this chapter.

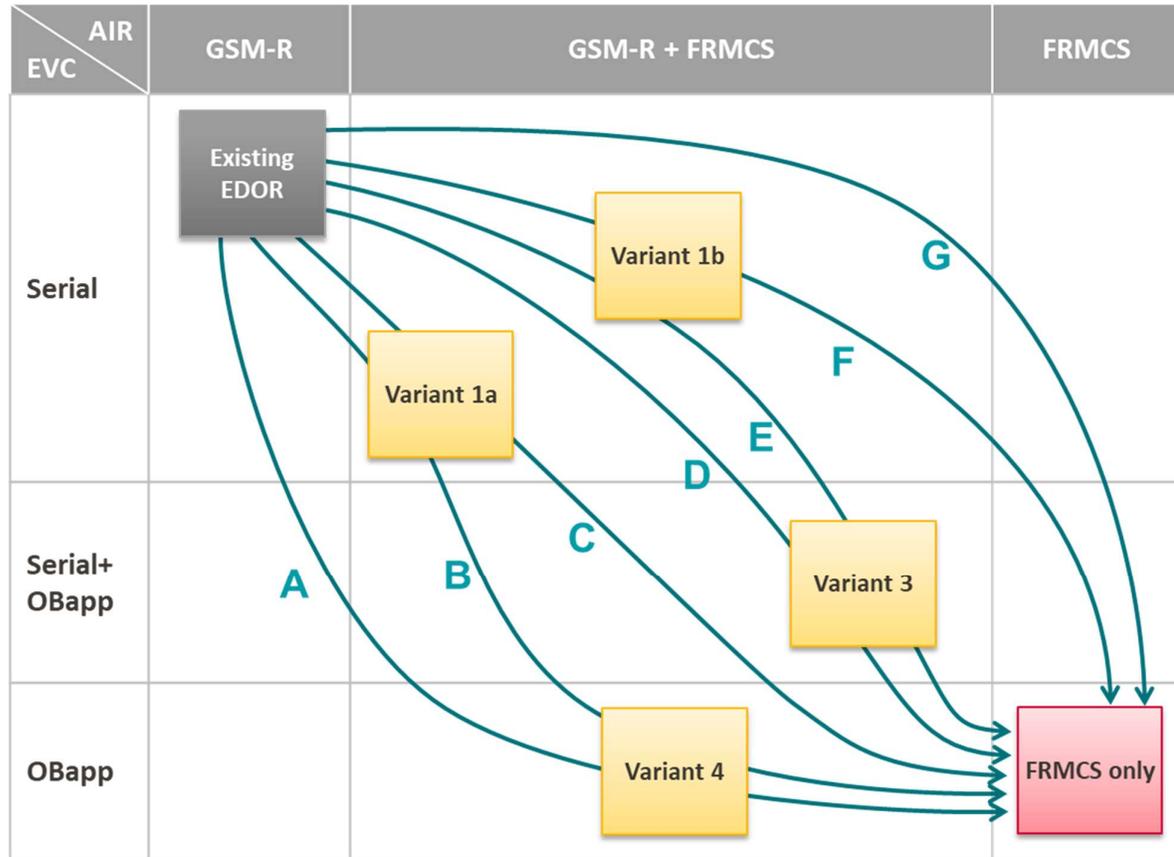


Figure 14: Possible evolution paths for ETCS migration

### 1.1.1 Scenario A (Existing EDOR → Variant 4 → FRMCS only)

Consequences:

- One intermediate migration step
- Needs to evolve EVC and FRMCS on-board system simultaneously

### 1.1.2 Scenario B (Existing EDOR → Variant 1a → Variant 4 → FRMCS only)

Consequences:

- Two intermediate migration steps
- Allows to first install the FRMCS on-board system without upgrading the EVC, and then to upgrade the EVC in later phase.
- During the upgrade of the EVC, the FRMCS on-board system is left untouched

### 1.1.3 Scenario C (Existing EDOR → Variant 1a → FRMCS only)

Consequences:

- One intermediate migration step

- Allows to first install the FRMCS on-board system without upgrading the EVC, and then to upgrade the EVC in later phase.

#### **1.1.4 Scenario D (Existing EDOR → Variant 3 → FRMCS only)**

##### Consequences:

- One intermediate migration step
- Needs to evolve EVC and FRMCS on-board system simultaneously

#### **1.1.5 Scenario E (Existing EDOR → Variant 1b → Variant 3 → FRMCS only)**

##### Consequences:

- Two intermediate migration steps
- Allows to first install the FRMCS on-board system without upgrading the EVC, and then to upgrade the EVC
- During the upgrade of the EVC, the FRMCS on-board system is left untouched

#### **1.1.6 Scenario F (Existing EDOR → Variant 1b → FRMCS only)**

##### Consequences:

- One intermediate migration step
- Allows to first install the FRMCS on-board system without upgrading the EVC, and then to upgrade the EVC
- The upgrade of the EVC has to wait for the complete trackside migration

#### **1.1.7 Scenario G (Existing EDOR → FRMCS only)**

##### Consequences:

- No intermediate migration steps
- Only possible if dual-mode trackside is available or if the whole migration (trackside and all rolling stock) is managed simultaneously (“Big-bang”).

- **ETCS interworking between on-board and trackside**

This chapter describes the different combinations of on-board and trackside communication technology that have to be supported during the migration phase from GSM-R to FRMCS, by any of the migration variants under evaluation. Therefore, the figure below does not reference to any particular migration variant described in this document but describes the fact that the ETCS on-board shall have the possibility to connect to the trackside (=RBC) by the means of GSM-R or FRMCS in different ways.

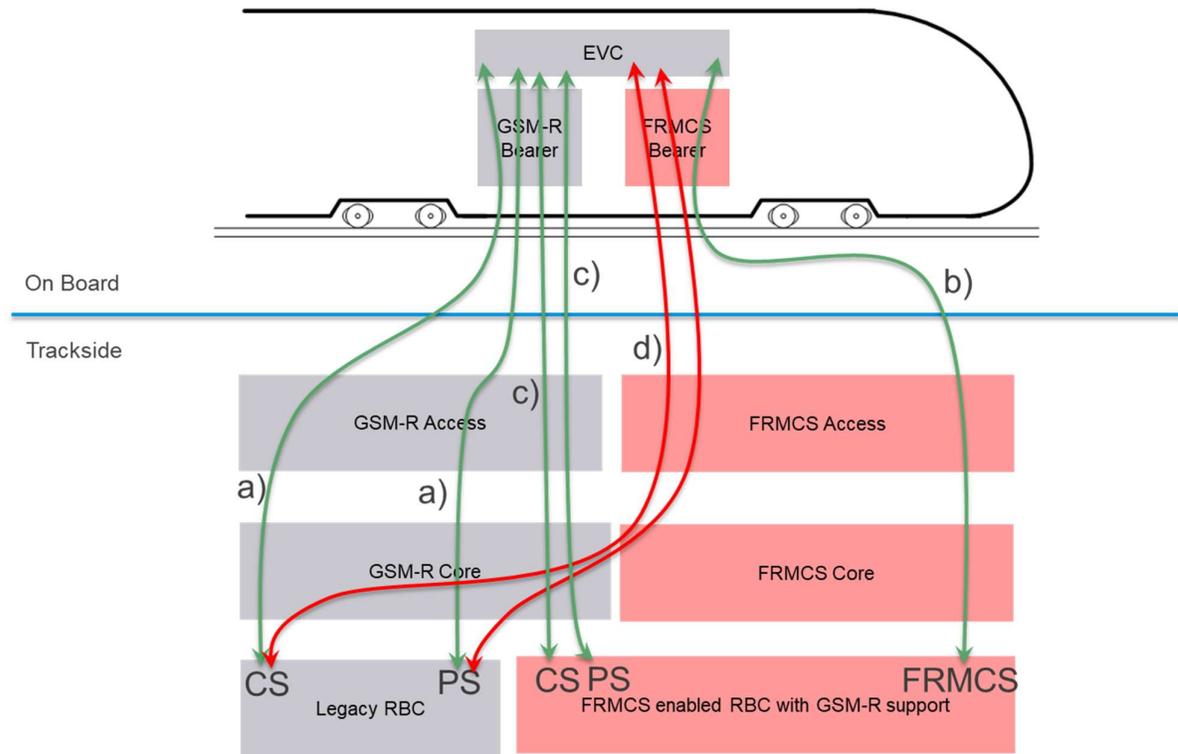


Figure 15: ETCS interworking on-board and trackside

- a) GSM-R Radio Access with Existing RBC (CS/PS) via GSM-R Core  
Use Case: ETCS operation on tracks w/o FRMCS access (not yet migrated)
- b) FRMCS Radio Access with FRMCS compatible RBC via FRMCS Core  
Use Case: ETCS operation on tracks with FRMCS Access (target)
- c) GSM-R Radio Access with FRMCS compatible RBC via GSM-R Core  
Use Case: Maintaining backwards compatibility for tracks that have been upgraded to FRMCS. A existing GSM-R ETCS on-board should therefore be able to run on this track. To avoid CS/PS Conversion the GSM-R CS/PS-Interface is maintained in the FRMCS enabled RBC.
- d) FRMCS Radio Access with Existing RBC (CS/PS) via GSM-R Core  
**Not Required:** If the trackside is being migrated to ETCS over FRMCS Radio Access, it doesn't seem logical to keep the related RBCs untouched. Either the RBC can be modified or complemented to interface with FRMCS or the RBC will be replaced.

**Note:** One RBC could be under GSM-R and FRMCS as described above. However, it is not foreseen to support changes of access technology (GSM-R to FRMCS or vice versa) for an active ETCS session.

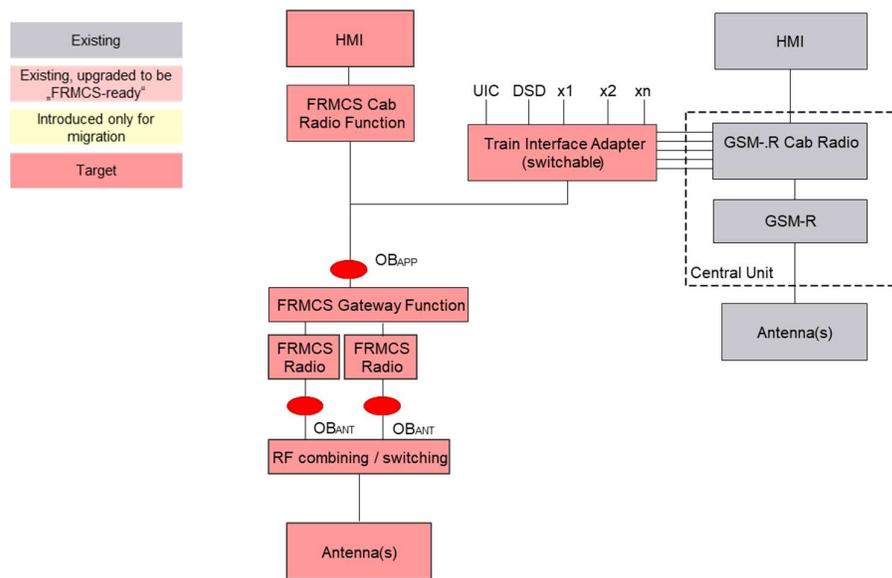
- **Cab Radio Migration**

- **Description of Variants**

In the following subchapters, the term “Train Interface Adapter” (TIA) is used. The TIA can be considered as a physical translation adapter between different train types input and output signals on the one side and OB<sub>APP</sub> interface on the other side. TIA is specific for each rolling stock type since the train signals are rolling stock specific. It also implements the Proxy Function to interface with OB<sub>APP</sub>.

- **Cab Radio Variant 1 – Existing GSM-R Cab Radio + Single Mode FRMCS Cab Radio**

Description: A complete existing cab radio setup incl. GSM-R radio is operated in parallel to an FRMCS setup with a new cab radio function and new MI, as shown in **Figure 16**, only reusing input devices such as UIC, DSD, etc.



**Figure 16: Cab Radio Variant 1 - Existing GSM-R Cab Radio + single Mode FRMCS Cab Radio**

Needed protocol conversion:

- None.

Benefits:

- Existing equipment can be reused as-is.

Disadvantages:

- In most trains, there is practically no space for a second MMI.

▪ **Cab Radio Variant 2 – New Cab Radio (Dual Mode, Option 1)**

Description: A new cab radio setup is introduced. Conversion from VoIP to PCM is introduced to allow using a GSM-R radio underneath the FRMCS gateway.

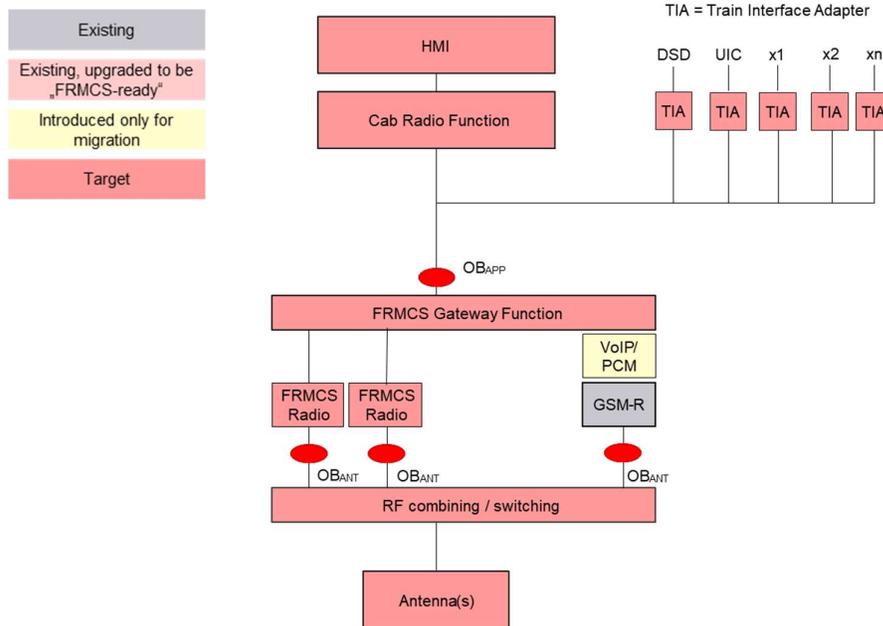


Figure 17: Cab Radio Variant 2 – New Cab Radio (Dual Mode, Option 1)

Needed protocol conversion:

- Conversion from VoIP to PCM.

Benefits:

- Existing equipment (in this case: GSM-R radio) can be reused as-is.
- Load balancing between GSM-R and FRMCS could be exploited.

Disadvantages:

- Tbd

▪ **Cab Radio Variant 3 – New Cab Radio (Dual Mode, Option 2)**

Description: A new cab radio setup is introduced. Different from variant 2, conversion from VoIP to PCM is performed separate of the FRMCS gateway and is with that outside the FRMCS onboard system boundary.

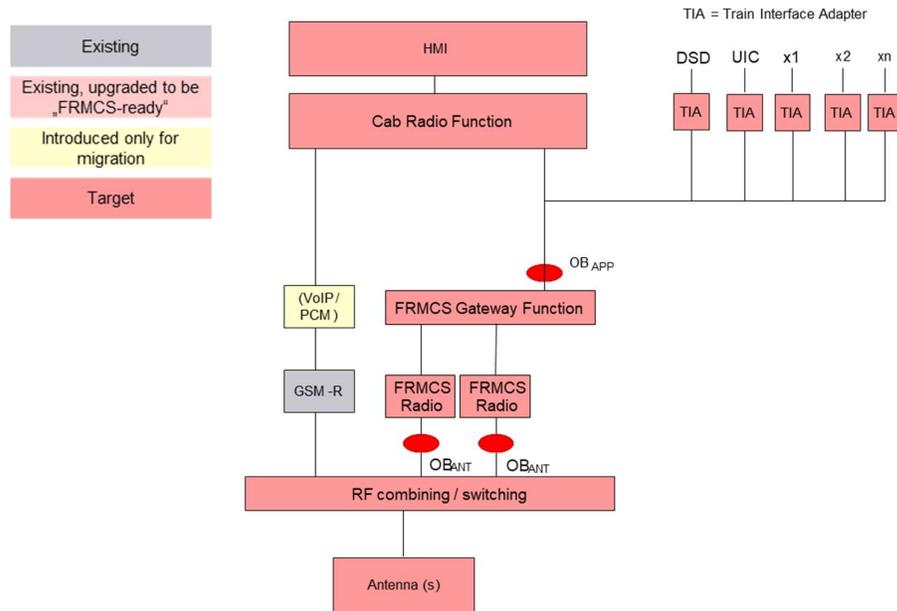


Figure 18: Cab Radio Variant 3 – New Cab Radio (Dual Mode, Option 2)

Needed protocol conversion:

- Conversion from VoIP to PCM.
- Control plane (AT-commands) from Cab Radio Function to GSM-R modem require IP to serial conversion.

Benefits:

- Existing equipment (in this case: GSM-R radio) can be reused as-is.

Disadvantages:

- Setup can likely not exploit load balancing between GSM-R and FRMCS.

▪ **Cab Radio Variant 4a – New Cab Radio (Dual Mode, Option 3)**

Description: A existing GSM-R cab radio setup is upgraded with a FRMCS Voice Function to interface via OB<sub>APP</sub> with the FRMCS On-Board System. The GSM-R path is kept unchanged.

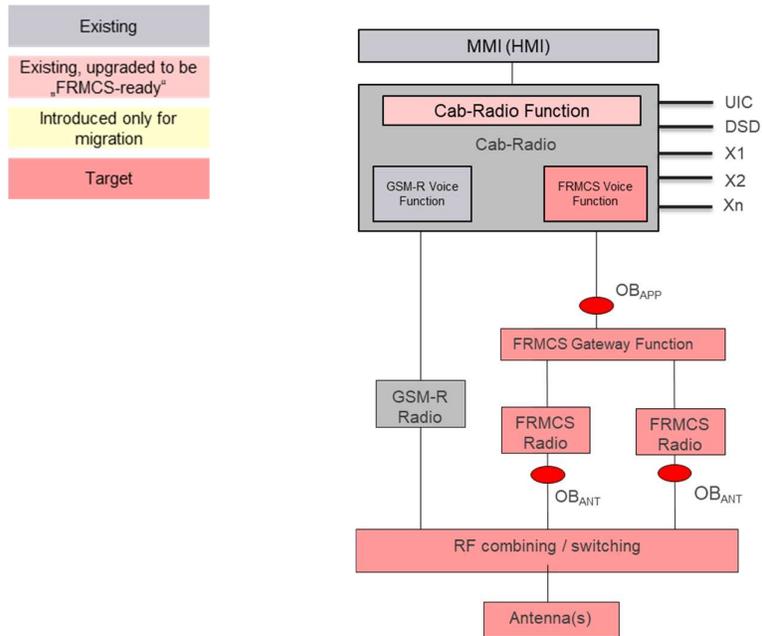


Figure 19: Cab Radio Variant 4a – New Cab Radio (Dual Mode, Option 3)

Needed protocol conversion:

- None.

Benefits:

- Existing equipment can be reused with an upgrade to support FRMCS.
- No protocol conversion required.

Disadvantages:

- The upgrade might only be possible on suitable Cab Radio platforms
- The upgrade might be limited to basic FRMCS Cab Radio features (not yet defined)

- **Cab Radio Variant 4b – New Cab Radio (Dual Mode, Option 3)**

Description: Similar architecture as variant 4a, but reflecting a new Cab Radio supporting FRMCS out of the box.

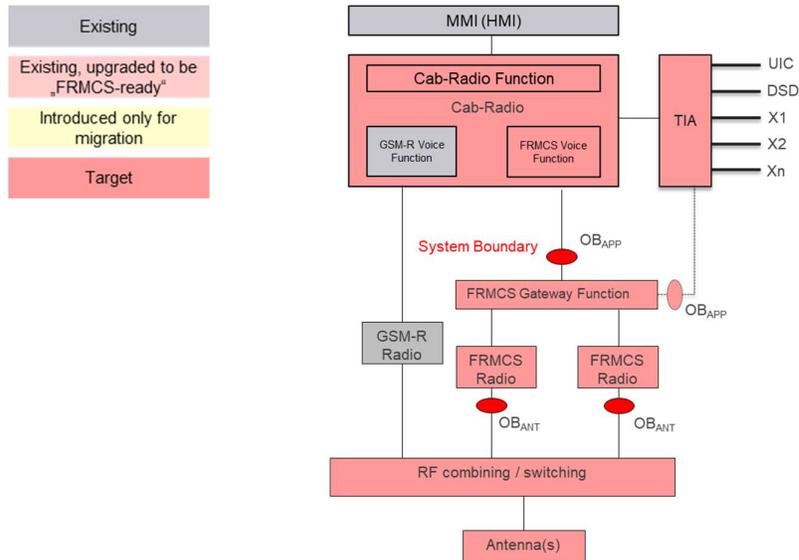


Figure 20: Cab Radio Variant 4b – New Cab Radio (Dual Mode, Option 3)

Needed protocol conversion:

- None.

Benefits:

- Dual Mode variant where a new Cab Radio platform supports GSM-R access.
- Fully supports FRMCS Cab Radio features (not yet defined)

Disadvantages:

- Additional Hardware

○ **Comparison**

The key characteristics of the different FRMCS migration variants in the context of Cab Radio are summarised in [Table 3](#). ~~Error! Reference source not found.~~

	<b>Variant 1 -</b> Existing GSM-R Cab Radio + Single Mode FRMCS Cab Radio	<b>Variant 2 -</b> New Cab Radio (Dual Mode, Option 1)	<b>Variant 3 -</b> New Cab Radio (Dual Mode, Option 2)	<b>Variant 4a -</b> Existing GSM-R Cab Radio + Single Mode FRMCS Cab Radio	<b>Variant 4b –</b> New Cab Radio (Dual Mode)
Capability to provide load balancing among GSM-R and FRMCS	Only manually	Yes	No	Only manually	Yes
Protocol conversion burden / extent of functionality introduced only for migration	None	Moderate	Moderate	None	None
Form factor	Requires two MMIs + additional rack space	Additional rack space needed	Additional rack space needed	Additional rack space needed	Additional rack space needed

Table 3: Comparison of key characteristics of FRMCS migration variants in context of cab radio.

## • ANNEX 1 – Euroradio protocol stack

This Annex provides a brief overview of the Euroradio protocol stack specified in Euroradio FIS, SUBSET-037, version 3.2.0.

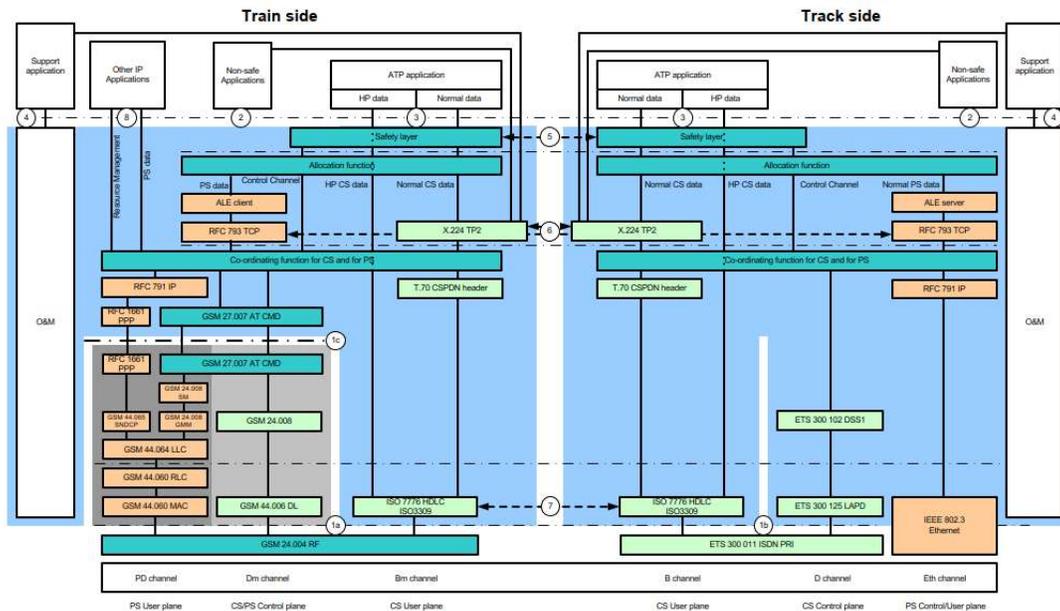


Figure 21: Euroradio Protocol Stack (Source: Euroradio FIS, SUBSET-037, version 3.2.0, Figure 2)

For the analysis of the various ETCS migration variants described in this document, the interfaces 1a and 1c depicted in the figure above are of relevance:

- **Interface 1a** is the GSM/GPRS-Interface (on-board)
- **Interface 1c** is the recommended on-board interface between the RCS (Euroradio System, in blue in the figure above) and the MT (Mobile Termination, the GSM-R/GPRS modem). For details refer to [Euroradio FFFIS].

Physically the 1a / 1c interfaces are implemented using a single serial interface (ITU-T V.24), referred to as  $I_{GSM}$  in the Euroradio FFFIS.

In addition to the interfaces, also the three data planes need to be assessed individually, since each of them uses their own protocols over the above-mentioned interfaces.

- **PS User Plane:** For the transmission of the user data IP packets over interface 1c, the Point-to-Point Protocol (PPP) as specified in IETF RFC 1661 is used.
- **CS User Plane:** The CS user plane data is transported end-to-end using HDLC.
- **CS/PS Control Plane:** Both modes use AT-commands for the signalling between the Euroradio system and the GSM-R/GPRS modem. For the evaluation of the migration variants, it is important to consider that the Co-ordinating function in the Euroradio system requires full control over the modem (i.e. Network Selection, Network Registration, Session Management). Any migration variant avoiding changes to the existing Euroradio will have to ensure that the existing control plane protocol is fully implemented also on the FRMCS on-board system side (or in a converter function).

## • ANNEX 2 – List of Acronym

3GPP	3rd Generation Partnership Project
CS / PS	Circuit Switch / Packet Switch
DSD	Driver Safety Device
EDOR	ETCS Data Only Radio
ETCS	European Train Control System
EUG	ERTMS Users Group
FIS	Functional Interface Specification
FFFIS	Form Fit Function Interface Specification
GSM-R	Global System for Mobile Communications – Railway
HDLC	High-Level Data Link Control
MMI	Man-Machine Interface (this term encompasses all Man-Machine Interfaces including the Driver-Machine Interface and the Controller-Machine Interface)
OB <sub>ANT</sub>	On-board Antenna system reference point/interface
OB <sub>APP</sub>	On-board Application reference point/interface
OB <sub>O&amp;M</sub>	On-board Operation & Maintenance reference point/interface
PCM	Pulse Coded Modulation
QoS	Quality of service
RF	Radio Frequency
TIU	Train Interface Unit
TOBA	Telecom On-Board Architecture
TSI	Technical Specification for Interoperability
TSI CCS	Control Command and Signalling TSI
UIC	Union Internationale des Chemins de Fer
VoIP	Voice over IP

Printed by

International Union of Railways

16, rue Jean Rey 75015 Paris - France

April 2020

Dépôt légal April 2020

ISBN 978-2-7461-2922-1