Deliverable D1.1

Test Plan

Grant agreement
No 951725

5GRAIL

5G for future RAILway mobile communication system

Deliverable reference number and title

Due date of deliverable: 31/10/2021

Actual submission date: 21/03/2023

Leader/Responsible of this Deliverable: UIC

Reviewed: Y

Document status		
Revision	**Date**	**Description**
0.1	01/10/2021	Draft version
0.2	08/10/2021	Review Kontron, DB, updates of Alstom, test cases of PIS - Thales
0.3	22/10/2021	Updates Nokia, DB, Alstom, CAF, UIC, Thales
0.4	29/10/2021	Voice test case from Siemens, Review Kontron, Thales
1	22/11/2021	Consolidation from Coordinator of the first deliverable version
2	19/04/2022	Update of test cases with applications KPIs, List of field test cases. Some open points are closed. Consortium's review comments included.
3	01/08/2022	Addition of lab test cases, updates in the description of some lab test cases, introduction of MCX building blocks, QoS configuration in WP3/WP4, counters and measurement KPIs
4	20/03/2023	Addition of Generic e2e Test Architecture, Enhancement of cross-border scenario, Cybersecurity test cases, Field test cases

Project funded from the European Union's Horizon 2020 research and innovation programme		
Dissemination Level		
PU	Public	✓
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

Start date of project: 01/11/2020 Duration: 36 months

Executive Summary

The Test Plan is the first deliverable of work package 1 (WP1) within 5G RAIL Project. The main content of this document is the elaboration of functional test case scenarios validating selected features and functions of FRMCS V1 specifications, using the on-board and network prototypes but also applications which are achieved mostly by the work package (WP2) within the 5G RAIL.

The test activities will be performed in two lab environments in Budapest/Hungary (led by Nokia) and Paris/France (led by Kontron), in the scope of work package 3 (WP3) and work package 4 (WP4) respectively. The field test activities will be performed in Germany and France, in the scope of work package 5 (WP5). The 5G reference lab in Hungary will validate the main FRMCS functionalities related to specific applications prototypes, such as ETCS, Voice, TCMS and CCTV/Video pre-integrated within the FRMCS-On Board Gateway (a.k.a TOBA) during WP2. The 5G reference lab in France will validate the main FRMCS functionalities related to specific application prototypes focused on data, ETCS, ATO, PIS application and a minimum set for Voice pre-integrated within the On-Board Gateway. Finally, during the field tests, the prototypes already tested in lab will be evaluated in real conditions i.e., rolling stock moving, on rail tracks with a dedicated 5G radio coverage.

Since the relevant specifications are in progress and not in the final state, the prototypes are partly based on some assumptions, that were consolidated within the 5GRAIL consortium. Besides that, additional assumptions were necessary for the description of some test cases. Also, preparation phase of WP5, treating field activities, starts in January'22. Due to all above considerations, open points have been created that need to be resolved in the next editions of this document, based on the progress of specifications' work, on the releases of the delivered prototypes and preparations of field activities.

The test case scenarios aim at demonstrating the end-to-end integration of existing or newly developed critical and performance communications railway applications and main FRMCS functionalities and features over the 5G FRMCS architecture.

As previously explained, based on the progress of specifications' activities, delivered features of the prototypes and preparations of field activities in the scope of WP5, the phased approach of D1.1 Test plan is mandatory. D1.1 Test plan v2.0 has addressed the open points presented in Table 1 which have been raised in D1.1 v1 and improve the description of some test cases by adding the monitoring of representative KPIs and QoS implementation. Moreover, some newly created open points are also added to the below table that will be addressed in further releases of this document.

The reason of submitting D1.1v3, although it is not the final one, is to inform about the ongoing activities of WP1 and supporting partners WP3, WP4 and WP5, in line with what is available as features and labs configuration during that period. Moreover, few new open points are added, as additional testing scenario.

D1.1v4 will be our final version of test plan including a complete list of test cases that are on-going in labs and a subset of them will be performed in field testbeds. Detailed description that cannot be provided by this document, mainly because the field tests have not started yet, will be covered in the next deliverables of WP1, D1.2 and D1.4 which are the reports for lab and field activities, respectively.

A generic end-to-end 5GSA architecture is proposed in this version, to demonstrate the testing ecosystem, as part of the 5G and MCX framework, both considered as the main FRMCS constituents.

Moreover, two separate figures will emphasize the two cross-border approaches of WP3 and WP4 labs, to be also tested in field testbeds in Germany and France.

ID	Chapter	Description	Raised in	Addressed in	To be addressed in	Status
OP1	§1.5	Assumptions related to the field test conditions in Germany and France	D1.1 REV1	D1.1 REV2	D1.1 REV4	**CLOSED.**
OP2	§5	A list of network configurations for tests of both labs will be provided in V2 of this deliverable	D1.1 REV1	D1.1 REV2	D1.1 REV4	**CLOSED**
OP3	§7.2.4	Authorisation of application	D1.1 REV1	D1.1 REV2		**CLOSED.**
OP4	§7.2.7	QoS negotiation	D1.1 REV1	D1.1 REV2		**CLOSED.** Alternatively, the QoS requirements will be treated inside the description of each test case. The common test case is deleted.
OP5	§7.7	5G to 5G voice cross-border	D1.1 REV1	D1.1 REV2		**CLOSED.**
OP6	§7.9	Combined voice in parallel with MCData application in degraded conditions	D1.1 REV3		D1.1 REV4	**CLOSED.**
OP7	§9.2.3	Cross-border scenario with TCMS – Telemetry or other MCData application	D1.1 REV1	D1.1 REV2 (Preliminary description)	D1.1 REV4	**CLOSED.** More details will be provided in D1.2
OP8	§11.2	Remote control of engines in parallel with ETCS application in lab nominal conditions (derisking test case)	D1.1 REV4		D1.1 REV4	**CLOSED.**

OP9	§11.3	Remote Vision of engines in parallel with ETCS application using Vertex in degraded conditions (derisking test case)	D1.1 REV4		D1.1 REV4	**CLOSED.**
OP10	§12	Cybersecurity **(NEW)**		D1.1 REV2	D1.1 REV4	**CLOSED**
OP11	§13	Field test cases	D1.1 REV4		D1.1 REV4	**CLOSED**
OP12	§13.3.3	Remote Control of engines nominal description for field	D1.1 REV1	D1.1 REV2		**CLOSED.**

Table 1: Follow-up of the status of the open points in D1.1

For the reader's convenience, the below table summarizes only the updates between D1.1 v3 and v4, not referring to open points:

List of updates performed between D1.1v3 andD1.1 v4		
1	Executive Summary	Explanations about the content of D1.1 v4.
2	§1	Table 3: Update of WP1 delivery plan including request for 8 months extension of 5GRail project
3	§1.3	Addition of a generic 5GRail e2e architecture, including cross-border setting and GSM-R interworking
4	§1.4	Addition of Cross-border implementation chapter in 5GRAIL
5	§6	Update of the list of test cases to clarify which ones are performed in lab, or field, TOBA to be used, in which frequency
6	§8.2.2.3.7.5 and §8.2.2.3.7.6	Addition of test case ETCS in parallel with iPerf8.2.2.3.7.6 for bearers aggregation in bearer flex
7	§11	Remote vision test cases for derisking in WP4
8	§12	Cybersecurity
9	§13	Field Test cases

10	§2.1.3 and §16.3	Updates of QoS management in WP3. Priority QoS in WP3
11	§2.2.3 and §16.4	Updates of QoS management in WP4. Priority QoS in WP4
12	§11.4	Remote Vision in cross-border scenario using 1UE

Table 2: Updates between D1.1v3 and D1.1v4 not related to open points.

Abbreviations

Abbreviation	Description
3GPP	3rd Generation Partnership Project
5G NSA	5G Non-Stand Alone
5G SA	5G StandAlone
a.k.a	Also Known As
AMF	Access and Mobility Management Function
API	Application Programmable Interface
APN	Access Point Name
ATO	Automatic Train Operation
CCTV	Closed Circuit TeleVision
COTS	Commercial Off The Shelf
CP	Control Plane
CSCF	Call/Session Control Functions
CU	Centralized Unit
DMI	Driver Machine Interface
DN	Domain Name
DSD	Driver Safety Device
DU	Distributed Unit
eMLPP	Enhanced Multi-Level Precedence and Pre-emption service
ES3	Engineering Sample 3 (reference to the Thales n39 band chipset)
ETCS	European Train Control System
EU	European Union
FDD	Frequency Division Duplexing
FFFIS	Form Fit Functional Interface Specification
FIS	Functional Interface Specification
FRMCS	Future Railway Mobile Communication System

FRS	Functional Requirements Specification
GA	Grant Agreement
GBR	Garanteed Bit Rate
GCG	Ground Communication Gateway
GDCP	Graphical Driver's Control Panel
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
GRE	Generic Routing Encapsulation (RFC8086) -> Tunnel GRE
GTW or GW	GaTeWay or GateWay
H2020	Horizon 2020 framework program
HMI	Human Machine Interface
HSS	Home Subscriber System
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IWF	Inter Working Function
JSON	JavaScript Object Notation
KPI	Key Performance Indicators
MCG	Mobile Communication Gateway
MCX	Mission Critical, with X=PTT (Push-To-Talk forVoice) or X=Video or X=Data
MQTT	Message Queuing Telemetry Transport
N3IWF	Non-3GPP Inter Working Function
NR	New Radio
NSA	Non-Stand Alone (5G Core architecture)
NTG	Network Transmission Gateway
NTP	Network Time Protocol
OB	On Board
OB_GTW	On-Board Gateway
OBA	On-Board Application (e.g. ETCS on-board, ATO on-board)

OBU	On-Board Unit
O&M	Operation & Maintenance
OTA	Over The Air
OTT	Over The Top
PCC	Policy and Charging Control
PCRF	Policy and Charging Rules Function
PDB	Packet Delay Budget
PDN	Packet Data Network
PER	Packet Error Rate
PIS	Passenger Information System
PSS	Process Safety System
QCI	QoS Class Identifier
5QI	5G QoS Identifier
QoS	Quality Of Service
RAN	Radio Access Network
RAT	Radio Access Technology
RBC	Remote Block Centre
REC	Railway Emergency Communication
REST	REpresentational State Transfer
RF	Radio Frequency
RTP	Real Time Transport Protocol
RTCP	Real-Time Transport Control Protocol
S-CSCF	Servicing-CSCF (Correspondence IMPU - @ IP)
SIP	Session Initiation Protocol
SMF	Session Management Function
SSH	Secure Shell
SRS	System Requirements Specification
TDD	Time Division Duplex

TE	Test Environment
TFT	Traffic Flow Template
TLS	Transport Layer Security
TC	Test case
TCMS	Train Control Management System
TCP	Transmission Control Protocol
TOBA	Telecom On-Board Architecture
TRDP	Train Realtime Data Protocol (see IEC 61375)
TS	Track Side
TS_GTW	TrackSide Gateway
TSE	Track Side Entity (e.g. RBC, KMC, ATO trackside)
TSI	Technical Specification for Interoperability
UE	User Equipment
UIC	Union Internationale des Chemins de fer
UP	User Plane
URLLC	Ultra-Reliable Low-Latency Communications (5G)
URS	User Requirements Specification
VMS	Video Management System
VoNR	Voice over New Radio
VoLTE	Voice over LTE
VPN	Virtual Private Network
WP	Work Package (e.g. WP1, WP2, WP3, WP4, WP5)

Definitions

Term	Definition
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, through the OB_{APP} reference point, to receive and transmit information to ground systems, (for example, ETCS, DSD, CCTV, passenger announcements, etc.).
Application Coupled mode	It defines if an application is aware of the services used in the FRMCS service layer.
Application Service	Application part responsible of the UP management
Communication Services	Services enabling the exchange of information between two or more applications
Communication service availability	Percentage value of the amount of time the end-to-end communication service is delivered according to an agreed QoS, divided by the amount of time the system is expected to deliver the end-to-end service according to the specification in a specific area.
Communication service reliability	Ability of the communication service to perform as required for a given time interval, under given conditions.
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).
End-to-End	Including all FRMCS ecosystem elements
End-to-end latency	The time that takes to transfer a given piece of information unidirectional from a source to a destination, measured at the communication interface, from the moment it is transmitted by the source to the moment it is successfully received at the destination.
"Flat-IP" Coupling Mode	This is a sub-mode of Loose-coupling type with static configuration of the requested session. Hence, flat-IP applications can only use the static session configured in FRMCS OB_GTW and TS_GTW.
GoA2	**Grade of Automation 2**: Starting and stopping are automated, but a driver operates the doors, drives the train if needed and handles emergencies.
Interworking	Interworking is the function that enables two different networks to communicate with each other, enabling services to be delivered across them
iPerf	Open source tool used to evaluate network performances in a client-server architecture, available in different operating systems.

NG interface	The NG interface is a logical interface between an NG-RAN and 5GC. There are two interfaces under NG interface: NG-C for control plane and NG-U for user plane.
Priority service	A service that requires priority treatment based on operator policies.
PIS controller	She/he is the individual responsible for managing passenger information.
QCI (or 5QI)	A scalar that is used as a reference to a specific packet forwarding behaviour (e.g. packet loss rate, packet delay budget) to be provided to a SDF. This may be implemented in the access network by the QCI referencing node specific parameters that control packet forwarding treatment (e.g. scheduling weights, admission thresholds, queue management thresholds, link layer protocol configuration, etc.), that have been pre-configured by the operator at a specific node(s) (e.g. eNodeB)
Reliability	In the context of network layer packet transmissions, percentage value of the amount of sent network layer packets successfully delivered to a given system entity within the time constraint required by the targeted service, divided by the total number of sent network layer packets.
Service continuity	The uninterrupted user experience of a service that is using an active communication when a UE undergoes an access change without, as far as possible, the user noticing the change.
Super-loose mode	As considered by the application, can be characterized as a “flat IP”. An ‘agent’ is located between the application and the On-board Gateway, to make this mode OBapp compatible.
Transport Domain	A Transport Domain is the administrative realm of the Transport Stratum. The Transport Stratum comprises one or more access technologies controlled by a core network. A Transport Domain is uniquely identified by the PLMN-ID.
User Equipment	An equipment that allows a user access to network services via 3GPP and/or non-3GPP accesses.
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.

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1 INTRODUCTION

This deliverable defines the test cases to validate, the functional content of the FRMCS prototypes, in lab and in field, having deployed 5G infrastructure. The goal is to perform tests in the context of the user, functional and system requirements in relation with FRMCS specifications and standards delivered by the ad-hoc work groups such as the FRMCS Functional Work Group (FWG), the FRMCS Architecture and Technology Work group (ATWG), the FRMCS Telecom On-Board Architecture group (TOBA), and the FRMCS 3GPP Task Force (3GPP TF), all supported by the ETSI Technical Committee for Railway Telecommunication (ETSI TC-RT).

The main goal of 5GRAIL, particularly driven in this WP1, is to ensure a validation, confirmation, or propose amendment/modification of FRMCS Specifications (version 1) based on prototypes of system elements. Following the conclusion of the tests and measures, with the target to provide a validated version of FRMCS to be formally introduced in the European CCS TSI (Control-Command System Technical Specifications for Interoperability) for railway regulation.

From a standardization point of view, the set of functionalities to be considered will be the FRMCS specific functions defined in 3GPP Release 16, the ones pre-defined for 3GPP Release 17 (at least from 3GPP stage 1 and stage 2), which are the latest railway-relevant 5G specifications, some specific interworking elements defined at the level of ETSI TC-RT and completing 3GPP FRMCS standards and the UIC documents for functional specifications of TOBA and FRMCS principles.

The Table 3 reports the position of this deliverable in the updated execution timeframe of the WP1, which considers the 8 months extension of the whole project (cf. explanations in the below legend):

Legend		
	D1.1	Initial plan
	D1.1 v1	Submission of the 1st version Test plan without field test cases (M13). Corresponds to MS2 of WP1
	D1.1 v2	Submitted in M18. - Addressing reviewers' comments from interim period review - Introduction of applications' KPIs - Preliminary list of field test cases
	D1.1 v3	Submitted in M22. - Additional lab test cases - Updates in the description of some lab test cases - Introduction of MCX building blocks - QoS configuration in WP3/WP4 - Counters and measurement KPIs
	D1.1 v4	Proposal of final version to be delivered end of February'23, with open points resolved before starting field tests
	D1.2	Test report conclusion from simulated/lab environments
	D1.3	FRMCS Performance measurement methodology
	D1.4	Test report conclusion from real-world environment
	D1.2,3,4	Next deliverables shift including the project extension/dependancy on lab and field activities
		Extension of task activities, considering additional 8 months request

				Nov	Dec	Jan	Feb	Mars	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mars	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mars	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		Mstart	Mend	2020		2021												2022												2023				8 months extension							
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30								
WP1	**FRMCS tests definition, tests results consolidation and specification review**	1	30																																						
Task 1.1	Test plan for simulated/lab environment in Hungary	1	12																																						
Task 1.2	Test plan for simulated/lab environment in France	1	12																																						
Task 1.3	Test plan for real-world environment	11	24																																						
Task 1.4	Test report conclusion	21	30																																						
	Deliverables																																								
D1.1	Test Plan		M12												D1.1	D1.1 v1	→	→	→	→	D1.1 v2	→	→	→	D1.1 v3	→	→	→	→	→	→	D1.1 v4									
D1.2	Test report conclusion from simulated/lab environments		M24																								D1.2	→	→	→	→	→	→	→	D1.2						
D1.3	FRMCS Performance measurement methodology		M24																								D1.3	→	→	→	→	→	→	→	→	→	D1.3				
D1.4	Test report conclusion from real-world environment		M30																														D1.4	→	→	→	→	→	→	→	D1.4
	Milestones																																								
MS2	Test Plan ready (D1.1)		M12													MS2																									

Table 3: Planning of work package 1

1.1 Scope of the document

The scope of this document is:

- To define functional tests that allow the validation of specifications based on implementation of selected critical and performance applications using the on-board and trackside protypes over the FRMCS architecture.
- To consolidate the inputs of the WP1, which are the design of the on-board prototypes and trackside simulators, the definition of applications' interfaces (OBAPP/TSAPP), the applications' implementations and the essential requirements to be tested. The following figure presents the interdependencies between the work packages:

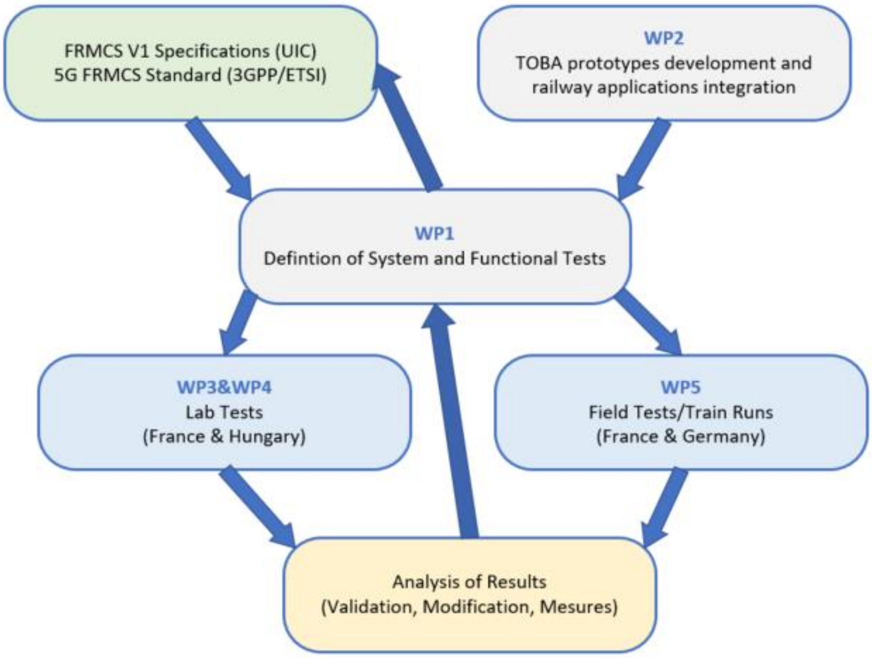


Figure 1: Interaction between WP1 and other WPs

1.2 5G, the main enabler of 5GRAIL

5G SA, encompassing 5G core only and 5G radio as well as MCX features are the two main prerequisites of protypes implementation and testing activities in lab and field, for 5GRAIL. **All the mandatory 5G FRMCS principles and MCX features applicable to the selected use cases are listed in the §16.1**

5G:

- offers many attractive features for railways: **ultra-low latency**, the delay between sending and receiving information can approximatively be 1ms, which is 200 times faster than 4G. 5G ensures a high reliability of 99.999%; and
- transports **massive amounts of data extremely quickly**. The maximum data rate is 10Gbps.5G is between ten and 100 times faster than current 4G technology. Until now, performance of this sort could only be achieved using wired networks – a big drawback if you want to

exchange data quickly with a moving object, like a train. But with 5G, you can connect anything, anywhere. And that has big implications for railways.

However not all of these features and data rates are covered in the framework of 5GRAIL but can be considered as an important enabler for improvement of existing or addition of new applications.

Railway signalling will overtake thanks to a new ability to process massive amounts of data in near real time. Accurate 5G positioning will enable closer spacing between trains, so more trains can travel over existing tracks. Even train-to-train communications will be possible. This will enable virtual coupling, so two trains can move along together as if they were physically coupled.

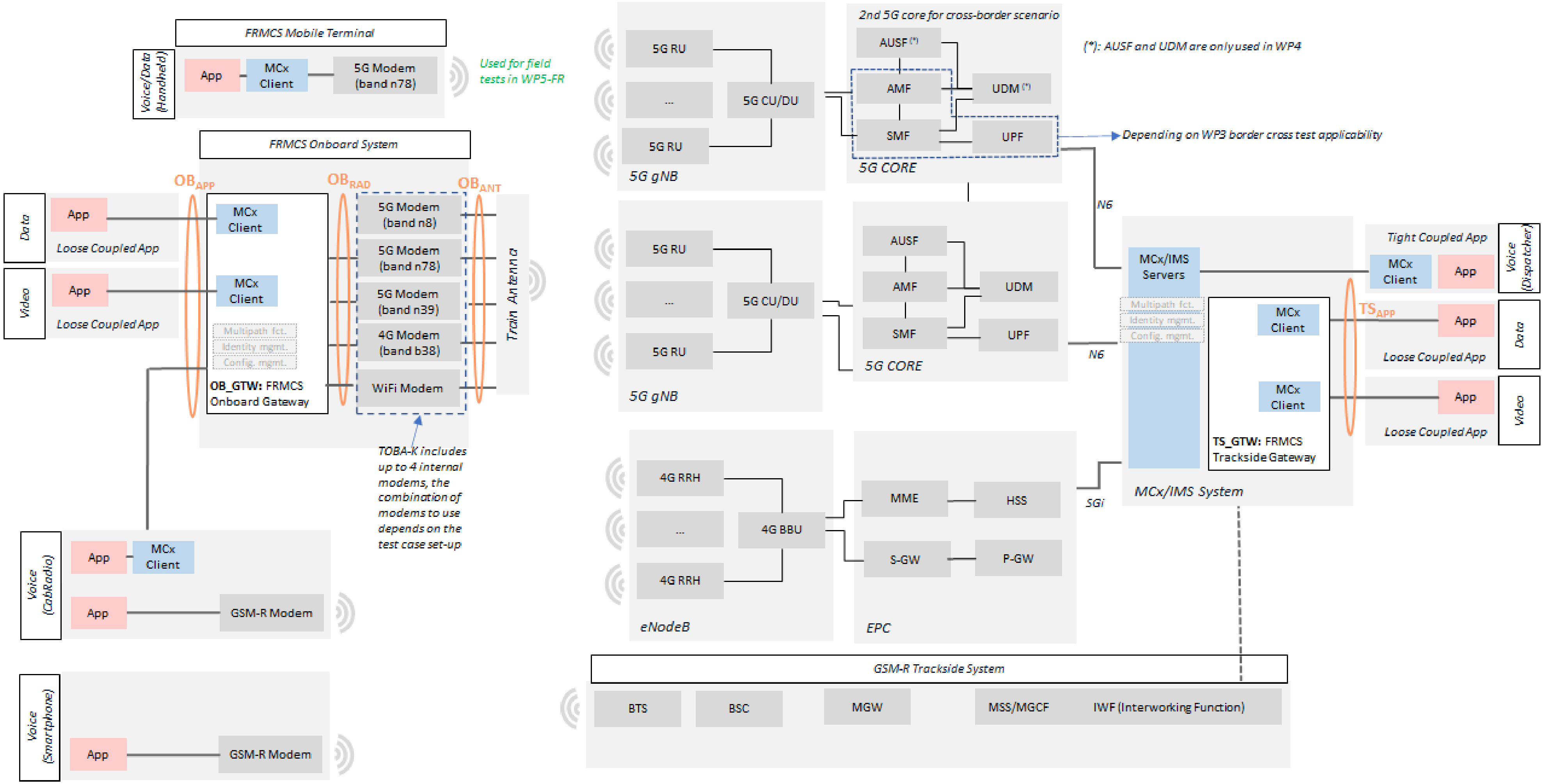
Trains communicating to the infrastructure using edge computing accelerates decision making – a vital ingredient in the evolution **of 'autonomous train operation'.**

Massive 5G-enabled Internet of Things (IoT) deployments will provide new ways to monitor trains and infrastructure. Benefits include better traffic forecasts and an ability to orchestrate train movements right across the network, eliminating bottlenecks. Operators will be able to monitor power consumption easily for greener, low-carbon journeys. Meanwhile, wear-and-tear monitoring will accelerate the shift to predictive maintenance – keeping trains on the track for longer.

5G makes trains part of the network. This makes it a catalyst for railway digitalization. The deployment of 5G FRMCS will open the possibility for railway operators to implement a variety of new applications optimizing train operations and maintenance on one side, and to improving the quality of service to passengers (security, availability, punctuality, and information) on the other side.

1.3 Overview of the FRMCS system architecture

The following figure presents the generic end-to-end architecture for 5GRAIL project:

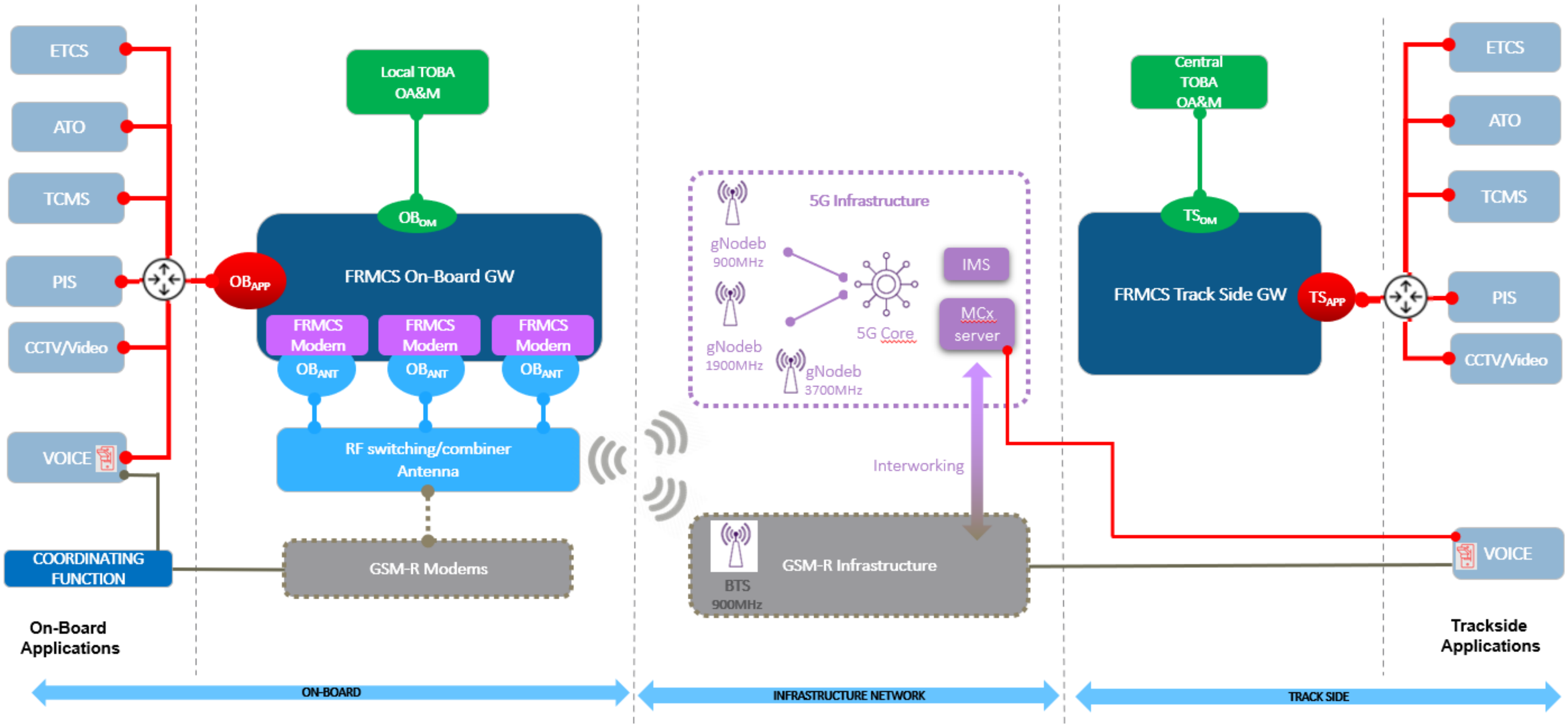


5GRail Generic e2e Test Architecture

The following figure is a complementary view to the above one, focus on the global FRMCS architecture of the project, involving the protypes (On-board, trackside gateway and applications) under testing:

Figure 2: Architecture overview (Ref. D2.1)

***Note**: The figure has been modified in D1.1v3, to represent the set-up of both labs with all frequency bands used in 5GRAIL.*



Referring to figure 2, the applications are implemented in two parts: **on-board** and **trackside**

Connections between the on-board side and the trackside side of each application are using the two gateways, located on both sides of the 5G infrastructure:

- The FRMCS on board gateway (**OB_GTW**), connected to the applications through **OBapp** interface and to the 5G radio access networks, through a set of FRMCS modems;
- The FRMCS trackside gateway (**TS_GTW**), connected to the applications through **TSapp** interface and to the 5G core infrastructure.

Note: *The trackside voice application, embedded in the dispatcher, is directly connected to the MCX server, without using neither TSapp nor TS_GTW, in the 5GRAIL context.*

The main principle of the FRMCS architecture is that an evolution in the transport or service stratum does not require an evolution in the application stratum. This requirement can be fulfilled with the separation between the so-called **Railway Application Stratum**, **Service Stratum**, and **Transport Stratum**, as illustrated in the figure below:

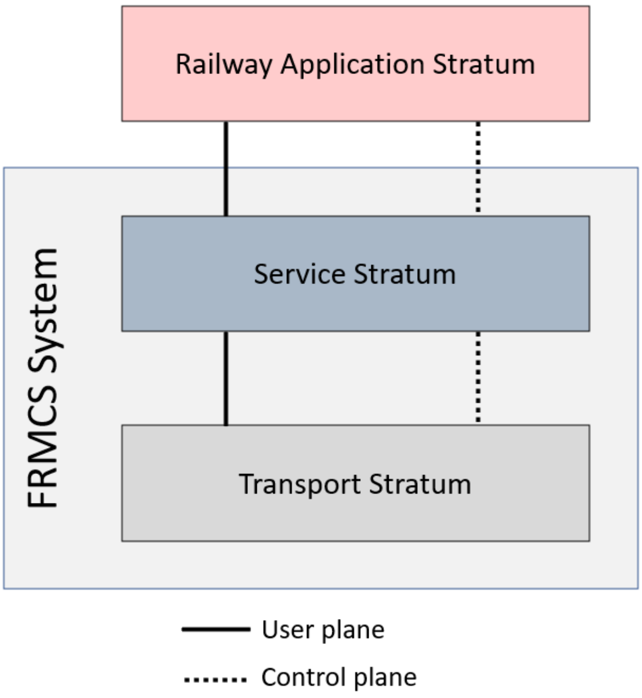


Figure 3: Railway Application, Service and Transport Strata (§15 [R4])

The following definitions are applicable to the above architecture:

- The **Railway Application Stratum** provides railway-specific functionalities using services offered by the Service Stratum.
- **Service Stratum** will be in charge of processing application requests using the facilities offered by the transport stratum.

- The **Transport Stratum** encompasses a set of access and corresponding core functions applicable for the FRMCS system.

Two modes of applications can be connected to the FRMCS On-Board System and FRMCS Trackside System:

- **Loose Coupling mode**: Coupling mode for an application which is not 3GPP Mission Critical Service aware.
- **Tight Coupling mode**: Coupling mode for an application which is 3GPP Mission Critical aware.

The figure below represents the end-to-end communication logical view for the tight and loose coupled applications:

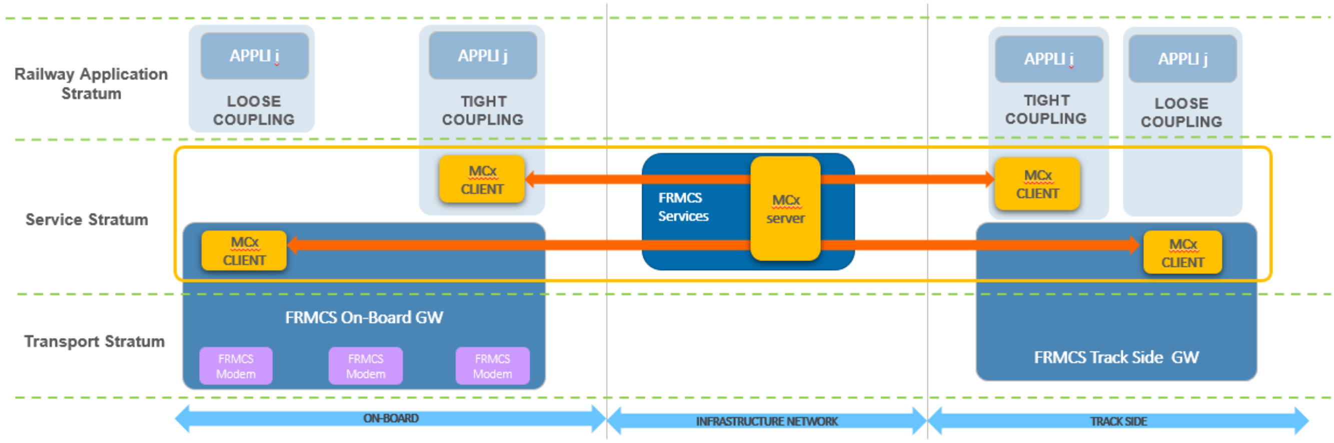


Figure 4: End-to-end view of loose and tight coupling applications (ref. D2.1)

The main difference between those two coupling modes is:

- For **tight** coupling, the MCX client is embedded in the application,
- For **loose** coupling, the MCX client is embedded in the FRMCS On-Board and Trackside Gateway.

1.4 Cross-border implementation in 5GRAIL

The cross-border topic for railways use cases is not fully specified in the 3GPP specifications framework, meaning that the necessary features to demonstrate a seamless service continuity are not available yet, in case of 5GSA network.

However, there are different options already implemented or proposed to be implemented, at that moment in time, in the two labs of 5GRAIL to handle this crucial scenario for railways. These implementations will also be used for field testing demonstration in the scope of WP5-DE with Video application and in WP5-FR with ETCS and probably also Remote Vision application.

The first approach of the cross-border tested in WP4 was a kind of *degraded radio conditions,* using coverage of gNodeBs belonging to two different 5Gcores. This experience emulates where the train simply disconnect from a 5G network and reconnect to another one, with an application still being active. In that case, the MCx client of the OB_GTW must manage the change of IP address when entering new 5G network: a new registration and communication re-establishment is needed.

The figure below is presenting the entities involved in the implementation of this cross-border variant in WP4:

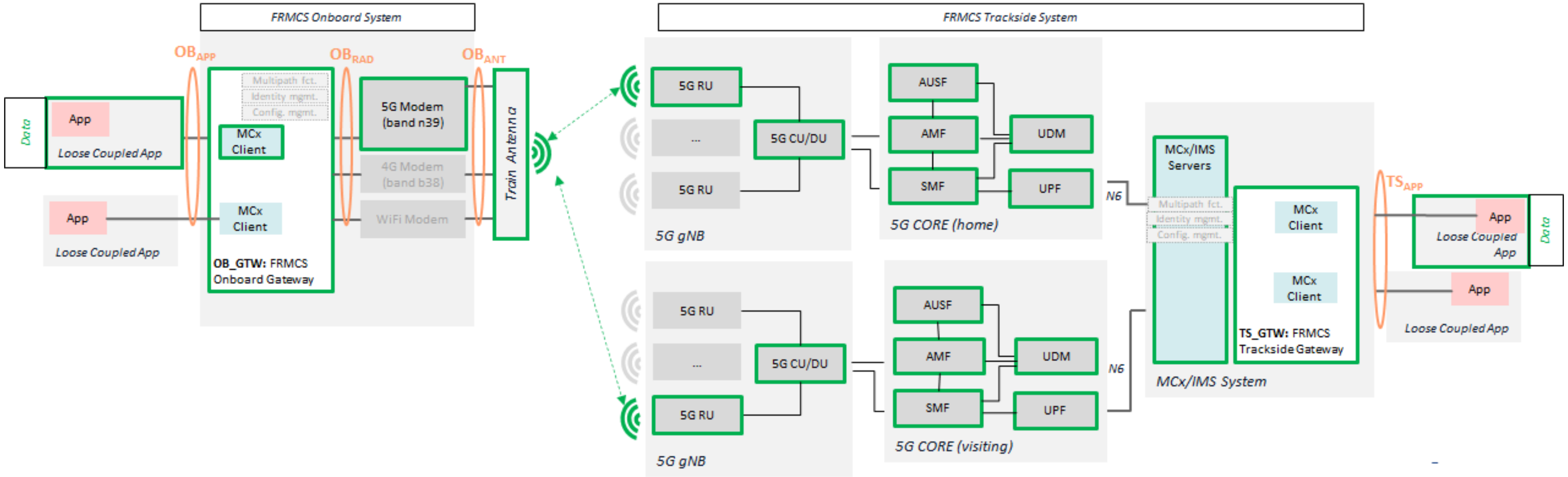
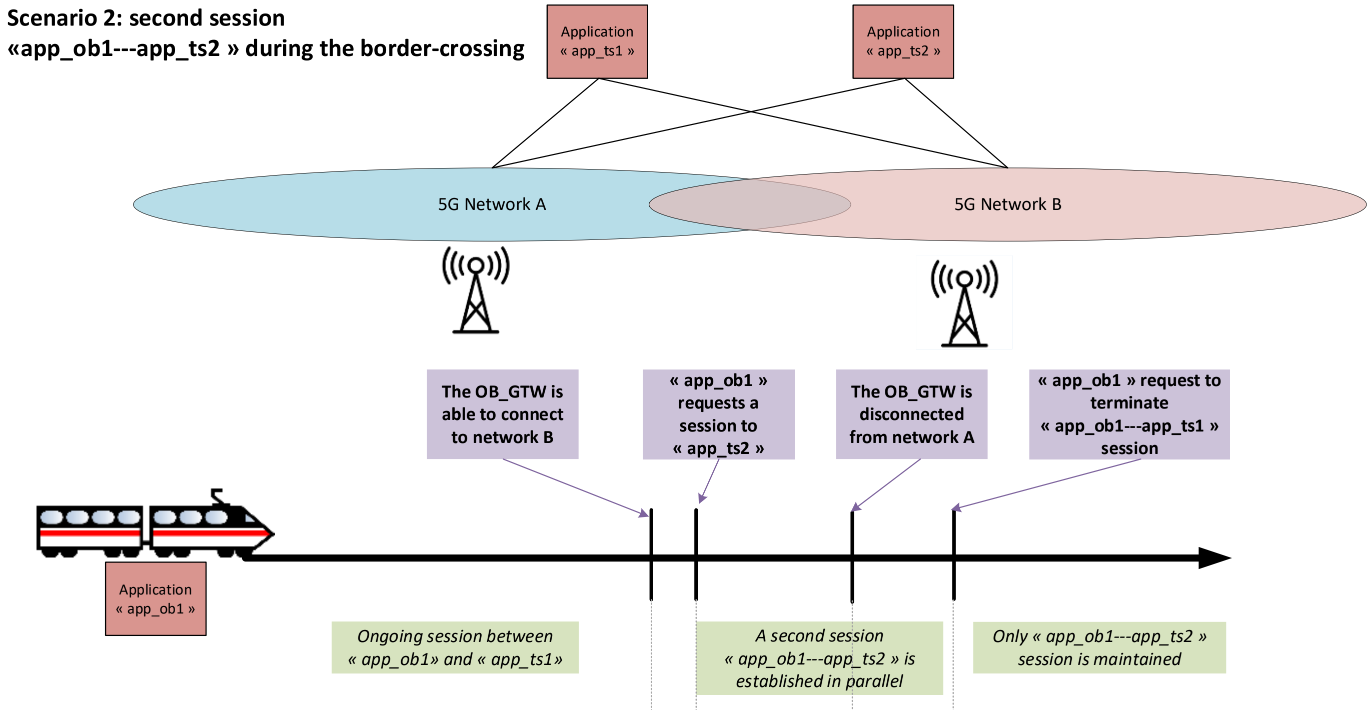


Figure 5: Cross-border implementation with 1x5GUE in WP4 lab

Another approach also tested in WP4 lab is the usage of at least two 5G modems (e.g., two 5G modems for a border-crossing between two 5G networks). In that case it is the multi-connectivity feature that is applied, triggering the switching of user plane data from the first network to the second one. This implementation is an innovation solution as it is close to the FRMCS v1 specifications recommendations.

The following figure is representing the steps of border-crossing with 2x5GUEs:



OB_GTW is attached to :	Network A (modem 1)	Network A (mod. 1) + Network B (mod. 2)	Network B (modem 2)
Active sessions	app_ob1 --- app_ts1	app_ob1 --- app_ts1 app_ob1 --- app_ts2	app_ob1 --- app_ts2

Figure 6: Cross-border implementation with 2x5GUE in WP4 lab (Ref. D2.1)

Each modem is configured with a priority of attachment to a network, depending on the coverage. In that case “app_ob1” will request a second session to “app_ts2” just before the connection to network B. “app_ob1” will keep the first session to “app-ts1” till the modem comes out of coverage from network A. Depending on the priority level configured for each modem, the session between “app_ob1” and “app_ts2” may use network A or network B.

In the scope of WP3, another implementation is suggested based on handover between gNodeBs over AMF (using NG interface). In that case only one IP address is used, as if it was one PLMN. This configuration based on the NG interface is presented in the two following figures and it will probably be tested with Video application. It is also interesting and innovative because it makes usage of 5G functions and interfaces, in the absence of 5GSA roaming features:

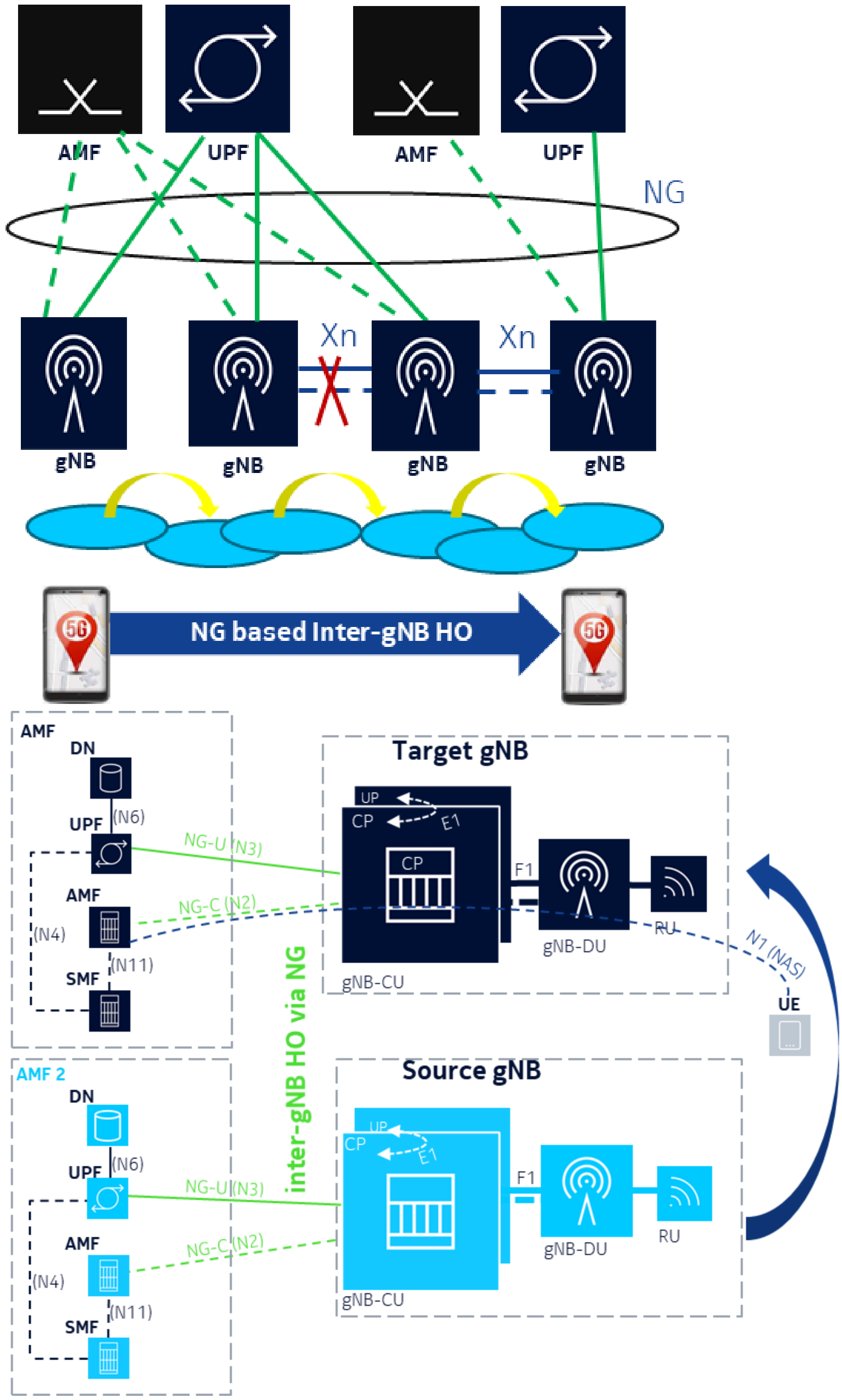


Figure 7: Cross-border implementation in WP3 lab: handover between gNodeBs over AMF (inter AMF)

QoS in cross-border conditions will also be handled via the DSCP static configuration because there is no PCF in any of the labs of 5GRAIL.

In the following table, we have extracted from chapter §6 Overview of test cases, listing all the test cases, the ones referring to the cross-border:

Application_TC_ID	Test case	Test Environment		TOBA	Frequency	Chapter
		Lab	Field			
TCMS_TC_003	Cross border scenario with TCMS – or other MCData application	WP3	WP5-DE	TOBA-K	n78	9.2.3
Video_TC_004	Cross-border with streaming of video from train to trackside, using inter-gNodeB handover over AMF	WP3	WP5-DE	TOBA-K	n78	9.4.3
Voice_015(*)	GSM-R to FRMCS system transition with service continuation	WP3	WP5-DE	TOBA-K	n78	7.6.6
ETCS_WP4-WP5_TC_003:	RBC handover on a different 5G network: cross-border use case	WP4	WP5-FR	TOBA-K(2xUEs)	n39&b38	8.2.2.3.5
		WP4		TOBA-A (2xUEs)	n8	
RV_WP4-TC_004	Remote Vision in cross-border scenario using 1 UE	WP4 (optional)	WP5-FR	TOBA-K	n39	13.3.5

Table 4: List of cross-border test cases

Note: *This is an inter-technology (FRMCS/GSM-R) test case, to replace the cross-border 5G to 5G TC for voice*

1.5 5GRAIL set-up related assumptions

Either due to the parallel availability of standards or due to the organizational constraints in labs and in field, assumptions agreed by all the contributors are necessary for the execution of the 5GRAIL project. This paragraph will list two kinds of assumptions:

- **Architecture design assumptions**

The assumptions of the FRMCS On-Board Gateway, are considered as an essential and impacting input for the proposed test cases. These are described in the deliverable, D2.1 TOBA Architecture Report §3.1 Assumption table.

- **Organizational assumptions (in lab Hungary/France, in field Germany/France)**

The following tables present the assumptions of both labs:

ID	Technical Architecture Open Items and Assumptions to support WP3 execution
1	5G public Band Modem (2.7 GHz TDD/ Band n78.) Band n8 for some dedicated use cases
2	Remote access to equipment for maintenance
3	No MCVIDEO, use MCData instead. Loose Coupling for Video as a data bearer
4	Separate dispatcher (GSM-R- FRMCS). Simple dispatcher (mobile dispatcher phone) for GSM-R
5	Numbering Plan: MC User ID : 11 digit. Functional Alias: 128 byte including domain name.
6	No MCX - MCX Interworking (3GPP Rel. 18)
7	Bearer Flex vs. Multiconnectivity use case : bearer Flex (multi access, one core) : No integration of WiFi in 5GCore (missing functionality e.g. no N3IWF in Rel. 15 Modem) -> no Multi Access/ bearer flex possible. Alternative for Multi Access: : two 3GPP bands / one modem (n78 sub bands, preferred by Field test / DB). Applications: no ETCS, no TCMS. Video offload archive. . Use Cae: CCTV offload: open how to trigger . No Multi Connectivity in WP3
8	Trackside GW provided by WP2 (OB App equivalent) -> TSApp for tight coupling/Voice not needed (direct connection to server). TS GW for Loose Coupling needed
9	Location: MCX support: Voice. GPS emulated available for LAB (eCGI emulation option not considered). No GMLC for 5G. Simulation in lab for Loose Coupled is tbd
10	GSM-R Interworking: Voice only. Group call only (REC)
11	Group Communication Interworking: FRMCS initiated group call only
12	Group Communication Interworking: no floor control / talker change (not specified yet for between system)
13	No PCF functionality, No MCX related 5GQI (66,67,..) supported. 5QI for MC Data -> non GBR (aligned with Rel. 17 MC Data 5QI 70 definition). Flexible assignment of 5QI/QFlowIdentifer in ToBa needed during test
14	Group Communication Interworking: no security/encryption for IWF (Note Two options. A) "Stop at IWF (as not in GSM-R)" B) no security for security in FRMCS)
15	Group Communication Interworking: no eMLPP mapping /interworking. Not defined in ETSI yet
16	MC Data / IP CONN : no functional alias required (3GPP Rel. 17)
17	Cross Border Use case: Re - registration needed (e.g. no inter plmn handover). Trigger by application tbd (no information on network registration info known on application layer)
18	Cross Border Use Case: Voice related: No FRMCS - FRMCS use case (WP5 open) . FRMCS - GSM-R Interworking scenario can be seen as roaming scenario
19	Cross Border Use Case: No ETCS use case. TCMS use case (home routed) Full functionality in Rel. 18 (automatic) . Proposal with one MCX Server
20	Emergency Alert: base on MCPTT , 3GPP Rel. 16 capabilities. Automatic Voice call setup.
21	Multi Talker Control use case: only for Multi Train /Group call
22	MCData IPCon : Client to Client routing of user plane, MCX Server only in Control Plane
23	Private call for Train to Controller and controller to train
24	Floor request and GDCP for multi talker control: solved
25	MCData IPCon : Open: border crossing
26	Group Communication Interworking: no Functional Alias mapping. Not defined in ETSI yet
27	Location: MCX support for Loose: GPS emulated available for LAB
28	Dynamic QoS to be realized by static configuration in network, (DSCP/TOS) (as described in 3GPP 23.501.) Modem evaluation . Alignment with modem capabilities for voice:: 5QI-1 GBR supported by Nokia only for Voice (VoNR) capable devices. Proposed alterative is non-GBR for Voice (Ongoing plan for GBR capabilities in Nokia for non voice)

Table 5: WP3 Assumptions and open topic list

ID	Technical Architecture Assumptions to support WP4 execution
1	Multiconnectivity foreseen induces the need for Trackside GW to be planned in WP4 setup (WP2 deliverable)
2	TOBA prototype integrates 1900MHz FRMCS 5G modem
3	QoS managed using DSCP
4	WP4 cybersecurity assets -if any- to be provided by partner involved (potential impact on architecture and schedule)
5	For the moment WP4 plan little activity with N78 (3.7 GHz) ; main focus being N39 FRMCS band
6	Remote access to equipments for all partners
7	Some partners equipments (Alstom so far) will be installed in Montigny WP4 lab
8	No MCVIDEO, use MCData instead
9	No MCX - MCX Interworking
10	4G SIMs are suitable for 5G Rail test cases
11	ETCS on GSM-R will be based on GPRS connection
12	O&M streams should be separated for some cyber tests
13	Kontron will install a server to host DNS applications
14	Track data not linked with real one used in WP5
15	Train and Track simu separated ETCS/ATO
16	Train and Track simu and radio link simu not correlated
17	The ATO version will be the one tested in S2R and not necesseray the one currently udapted in the 2022TSI
18	RF combiner to be use in WP4 lab
19	Remote vision app will be tested in WP4 if loose coupling chosen
20	Wifi test should be run in WP4 before WP5 if agreed to be done in WP5
21	4G test should be run in WP4 before WP5 if agreed to be done in WP5
22	PIS will not use GSM-R
23	PIS application trackside must be time synchronized by NTP (master clock trackside)
24	PIS application is no longer to be considered as the demonstrator for cyber security test cases

Table 6: WP4 Assumptions list

The following list presents the field assumptions for WP5 - DB, in Germany:

- The German field site will host the 5G-based FRMCS radio access network but has no GSM-R running. Hence, the GSM-R setup for technology interworking tests is hosted in the Nokia lab in Hungary to which the German field site will be connected.

- Since the ecosystem for 900 MHz and 1900 MHz 5G equipment is not sufficiently developed yet, the field trials in Germany will make use of 5G band n78 (TDD) within 3.7-3.8 GHz. This band is used in Germany to serve industry sectors with private 5G networks (so-called Campus networks) and is used in the 5GRAIL project to demonstrate the functionality of FRMCS principles and features which shall be realized on FRMCS bands n100 (900 MHz FDD) and n101 (1900 MHz TDD) in later years.

- To demonstrate functional principles of FRMCS, the German field site will realize a 5G system with 20 MHz system bandwidth in band n78. There are currently technical product limitations which prevent from using 10 MHz system bandwidth as envisioned for FRMCS band n101.

- To demonstrate cross-border and bearer-flex principles of FRMCS, the German field site will realize two 5G systems with 20 MHz system bandwidth each in band n78. Both systems will be placed in 3.7-3.8 GHz and being separated by a guard band of at least 10 MHz.

- The 5G-based FRMCS radio access network in the German field will be realized in a manner that each radio site with its antenna mast hosts two antennas and covers two sectors, looking in opposite direction. Both sectors are part of the same radio cell and, hence, make use of the same physical cell ID. When passing the radio sites the handover procedures are between sectors within the same cell.

- The 5G-based FRMCS radio access network in the German field will use antenna heights of 10m to 15m.

- The 5G core to which the 5G radio access network in the German field is connected, will be hosted in Hungary at the Nokia lab premises. A remote connection between the 5G radio access network in the field and the 5G core in the lab will be established with sufficient capacity to realize end-to-end tests on control and user planes.
- The test track in the German field allows train speeds of up to 50 km/h.

The following table presents the field assumptions for WP5-SNCF, in France:

ID	Technical Assumptions to support WP5- FR execution	Category
1	TOBA prototype supports Flat-IP application (Case of Remote Vision) as Remote vision app is an Obapp unaware application. Moreover, It will be tested in WP4 to de-risk it in WP5.	Remote Vision
2	4G infrastructure needs to be tested in Lab in WP4, prior using it in the field in WP5. Accordingly, testing Bearer-flex multiconnectivity (Interworking of 5G with 4G) is validated in Lab prior proceeding to executing transitions in field	4G
3	RF combiner to be used in WP4 Lab to test employing unique antenna for 4G and 5G. Ideally, and if applicable, same type of RF Switch/Power combiner used in WP4 for co-existing 5G and 4G would be used in field tests. Available antenna (Infrastructure or onboard) are deemed adequate for 5GRail deployment as validated by Kontron coax cables of less than 30 m with 7/8" are used in the 3 radio sites If necessary, Kontron will provide necessary Bill of Material / Bill of Quantity (BoM/BoQ) of antenna accessories and ancillary including needed jumpers	Antenna
4	To simulate inter-PLMN transition: Two 5G Core Networks are to be deployed on two Servers (ME1210) used to implement virutalized network functions for the 5GC. These servers use Alternative Current (AC) power supply	Core
5	Only one GPS antenna is available for the 4G network on the command center site. Thorough analysis should be completed if a reuse is foreseen for the 5G network. In this case, Kontron to identify exact preparations	GPS
6	Duration of tests during a day is less than 1 hour per day (3-4 pass per day) [12 minutes per pass forth and back]	Duration
7	Test Licenses for the 1900 RMR N39 and B38 Bands depend on the grant by the Telecom Regulation Agency in France (ARCEP)	License
8	Kontron will prepare a coverage analysis and identify the anticipated intercell handover point for the 1900 spectrum. Interference from B38 used by the MNO is anticipated from the public 4G network onto SNCF private one. Kontron and SNCF will collaborate to do a frequency scan on the N39 band in the vicinity of the test sites. Nearby public roads would be used for validation of the radio coverage prior running the moving stock Proper measures should be analyzed and taken into consideration by Kontron and coordinated with SNCF-R Engineering department in order to avoid uncontrolled spectrum interference, such as but not limited to max transmitted power and other engineering parameters.	Freq Mgt
9	Kontron assures that there will be no interference on existing networks (production GSM-R and GPRS SNCF-R) networks as this is a prerequisite for testing the FRMCS prototype as well as other public MNO	Interference
10	No intervention on the masts is foreseen after installation. If an intervention on the masts is anticipated, proper security planning should be sought. Different antenna constraints (Height above average Terrain HAAT, etc) as planned by SNCF engineering team are to be considered	Masts
11	No overlap in activities of WP4 are foreseen restricting the availability of the equipments for integration for WP5	Planning
12	Kontron and its sub-contractors should abide by SNCF security measures when accessing the field. Moreover, engineers and technicians from all the suppliers that will intervene in the field should habilitated to work in field (Moving around on the railway line, and working in vicinity of electricity)	Mgt
13	Modems integrated with the Onboard GW supporting the 1900 RMR and the B38 bands are validated in lab	OBGW
14	Radio Unit are front-hauled to centralized CU/DU hotels using fiber. Architecture shall be elaborated with KT. Thorough analysis is conducted to devise the multi-RAT site taking into consideration the different implementation constraints (Fiber optic availability and optical link budget, etc)	RAN
15	Central Site is not connected to the internet. Onsite presence is required to install, and configure the equipment in SNCF premises. No remote access is possible. If not, Kontron should provide the required cybersecurity assurance if a VPN should be established.	Security
16	Same SIMs used in lab-validation will be re-used in field or equivalent SIMs when testing in WP5. Details of the universal integrated circuit card (UICC), also known as a SIM card, provisioned in the 4G HSS will be seamlessly transported into Kontron SIMs provisioned in the AUSF/UDM/UDR of Kontron 5GC during field tests|	SIM
17	3 SNCF Radio Sites are to be used for field testing with limited distance in between according to the planned shelters/towers. One of them will co-host 4G in addition to 5G/FRMCS Sites are bi-antenna per radio site with 1 cell per radio site (No intra-cell handover)	Sites
18	Some tests would be welcomed to be completed in static configuration	Tests
19	Limited distance is foreseen on the rooftop of the moving stock due to the imposed footprint for antenna installation. It was taken into consideration by the Kontron analysis in the D2.1 Kontron will help regarding the isolation between the antenna on the moving stock in case needed to ensure constrained amount of isolation is assured	Train
20	Link towards SIP, IMS Core, MCX and application servers in Kontron Lab shall be established by Kontron, ensuring required security as well as performance levels through an established Service Level Agreement (SLA). This includes agreed availability, bandwidth, latency, stability, etc.	Transport
21	Applications of our collaborators (Alstom) validated in WP4 shall be reused in WP5 to complete functional and performance testing as well as the cross-border scenario	Alstom
22	The moving stock shall circulate at limited speed with a ceiling of 70 KMPH as stated in the GA. During the run, the speed will be set according to multiple operational constraints and might change accordingly. Based on previous experience, 45 KMPH could be envisaged.	Train
23	No GSM-R GPRS testing is foreseen for testing in the French field	Tests
24	Max output power from Infra to be decided in conjunction between Kontron and SNCF Engineering Team in line with the TRA stipulations	Radio
25	Mobile Country Code and Mobile Network Code (MCC/MNC) for test purpose are to be used among following options (208/85) , (208/90) , (208/92) and as stipulated by the ARCEP.	Tests

Table 7: WP5 - SNCF Assumptions list

Any restrictions defined as assumptions, for the prototypes in the other work packages must be considered in the test context when identifying them, since they might have an impact on the final selection of the test cases but also to the test results.

1.6 List of 5GRAIL use cases.

This table presents the list of the selected 5GRAIL use cases, split to use cases to be performed in labs Hungary and France in the scope of WP3 and WP4 respectively and in field in Germany and France in the scope of WP5.

Voice applications	WP3 Lab Nokia Hungary	WP4 Lab Kontron France	WP5 Field DB	WP5 Field SNCF
On-train outgoing voice communication from the train driver towards the controller(s) of the train	X	O	X	
On-train incoming voice communication from the controller towards a train driver	X	O	X	
Multi-Train voice communication for drivers including ground user(s)	X	O	X	
Railway Emergency Communication (voice and data (*) application)	X	O	X	
Data applications				
Automatic Train Protection communication	X	X	X	X
Automatic Train Operation communication (limited to GoA2 ATO)		X		X
TCMS (Train Control and Management System): ❑ On-Train Telemetry communications ❑ On-Train remote Equipment control	X		X	
Non-critical real time video	X		X	
Transfer of CCTV archives	X		X	
PIS (Passenger Information System)		X		
Remote control of engines (Remote vision application)		O		X

Note: *X= mandatory, O=optional*

(*): Data, as part of the Railway Emergency Communication, will not be tested in 5GRAIL.

Table 8: List of use cases for 5GRAIL

2 DESCRIPTION OF THE DIFFERENT TESTS' ENVIRONMENTS

2.1 Overview of the 5G reference lab in Hungary

The following figure is a high-level presentation of WP3 lab in Hungary:

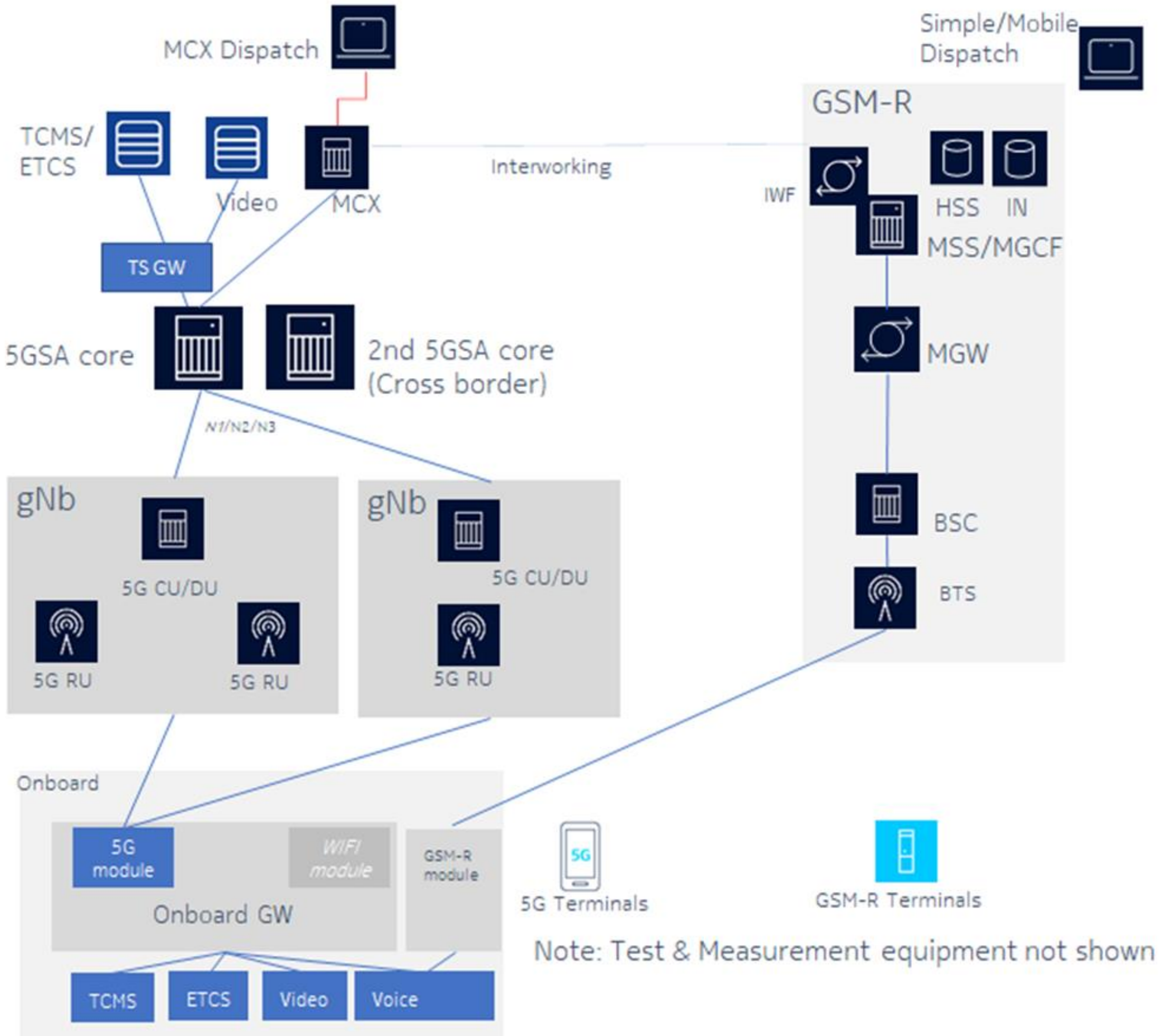


Figure 8: Overview of WP3 lab in Hungary (Ref. D3.1)

The functional view of WP3 lab is as following, including the VPN to allow applications and On-board GW providers to access for remote support and configuration:

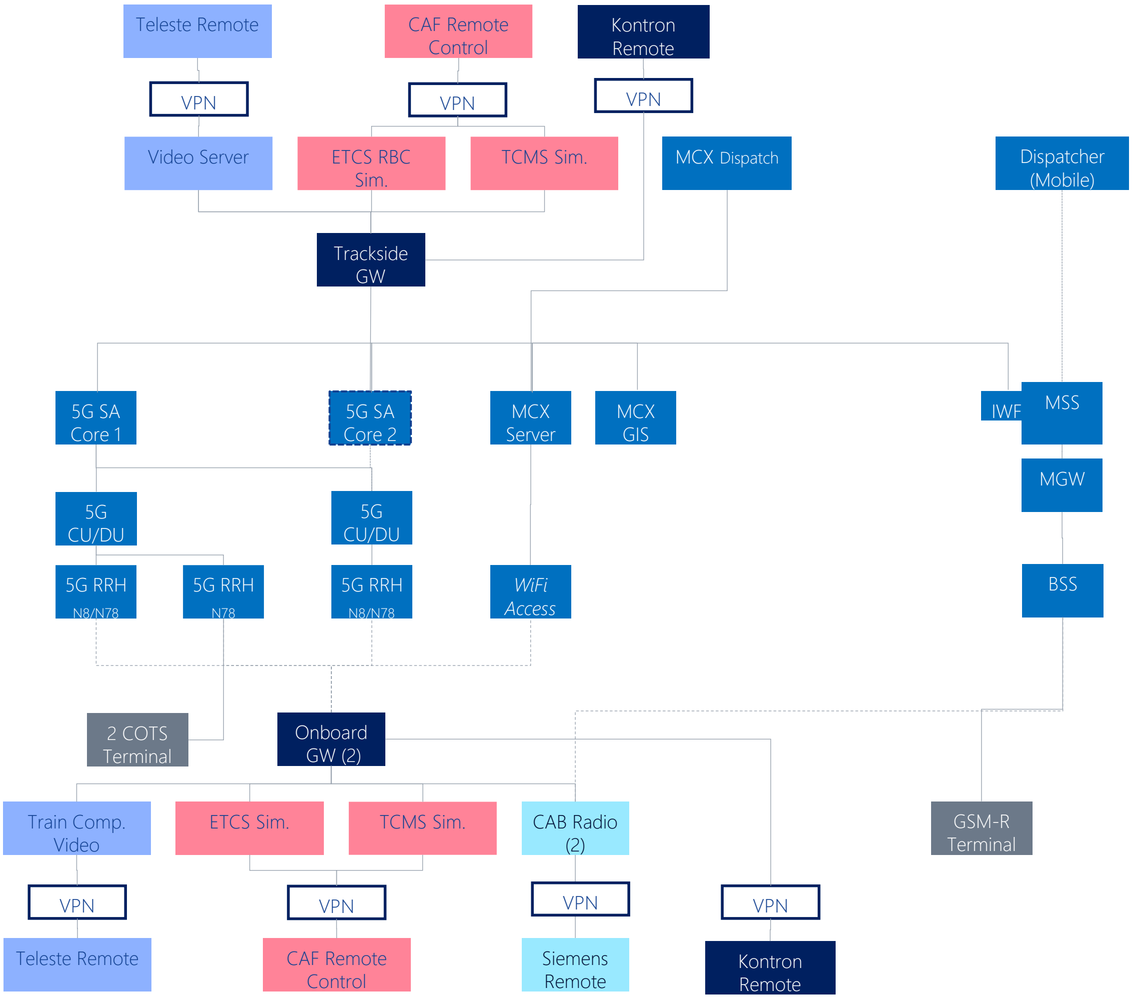


Figure 9: Functional View of WP3 lab in Hungary (Ref. D3.1)

2.1.1 Supported use cases in lab Hungary.

For a more precise view of the use cases to be performed in WP3 lab in Hungary, please refer to Table 8
Moreover, the lab in Hungary deals essentially with voice test cases but some data applications will also be tested. All applications will be integrated with FRMCS -On board Gateway, provided by Kontron (a.k.a TOBA-K). Finally, the use cases to be addressed in this lab environment, according to the GA are:

Voice over FRMCS 5G (5G radio, 5G core) using MCX/MCPTT servers as well as GSM-R network for interworking, applying 3GPP Release 16 and pre-Release 17 functionalities (e.g., location and functional alias). Consequently, the agreed in WP1 test cases are:

- Railway Emergency Group calls involving FRMCS-On-Board-Gateway, voice application and COTS terminals.

- Driver to controller and vice-versa communication, involving voice application, FRMCS-On-Board Gateway and MCPTT dispatcher and COTS terminals.
- Voice Group calls establishing in both FRMCS 5G network and GSM-R network.

FRMCS 5G QoS: The purpose of these test cases is to apply 5G end-to-end QoS concepts to differentiate critical and non-critical data over FRMCS-On Board Gateway + FRMCS 5G infrastructure and evaluate impact on QoS while degrading radio transmission, emulating speed. This will be supported by the below test cases:

- **ETCS (critical) and TCMS (non-critical) over FRMCS 5G**: Different radio conditions emulating different network conditions (perfect radio conditions, degraded radio conditions)
- **CCTV/Video (both non-critical) over FRMCS 5G**: Different radio conditions emulating different network conditions (perfect radio conditions, degraded radio conditions)

Video (non-critical)/Voice (driver to controller (dispatcher) point-to-point call): a combined applications test case with two application addressing different type of MCX services, MCData and MCPTT respectively, will be simultaneously performed in the scope of WP3 to demonstrate, radio resource management, QoS and prioritisation, in nominal and degraded conditions.

ETCS (critical)/TCMS (non-critical) are the applications, to be optionally tested in the context of prioritization between MCData applications. This feature ensures resources availability, based on FRMCS priority of the applications.

Bearer Flex scenario: The alternative used for multi-access in the scope of WP3 is two 3GPP bands / one modem (n78 sub bands, preferred also by DB for the field tests). Integration of Wi-Fi in 5GCore is a missing functionality (e.g., no N3IWF in Rel. 15 Modem). There will be no multi-connectivity test case in WP3. The selected test case to demonstrate 'bearer flex' feature is CCTV offload from train to trackside.

Cross-border scenarios in the scope of WP3 are foreseen for TCMS or other MCData application using two 5G cores and voice implemented as service continuation between two networks (FRMCS and GSM-R). These scenarios are also planned for field tests with DB in Germany, in the scope of WP5, using the GSM-R facilities of the WP3 lab for the voice cross-border scenario.

2.1.2 Specific lab conditions.

The following paragraph presents the specific lab configuration:

1) For voice related tests requiring the GPS location the CAB radio as well as the COTS handhelds have to use pre-defined GPS coordinates. As GPS coverage inside the lab is not possible, no movement scenarios would be possible. By this a testcase simulating a movement by sequence of 2 or more GPS coordinates can be executed as the clients will send those GPS coordinates to the MCX system for further processing.

2) The 5G radio will support commercially available and 3GPP defined spectrum. Spectrum used in the lab environment will be aligned with WP5 activities. The bands used are 5G n78 (20 MHz in 3.7-3.8

GHz TDD enterprise band) for lab and field, and band n8 (5MHz in 900MHz) for the lab test only. Selection of bands for the planned use cases is defined in WP1 & WP3 aligned.

3) Bearer flexibility test cases can also be performed using two n78 5G sub bands.

4) GSM-R is also available in lab for interworking use cases

5) Cross border use cases can be configured using 2x5G cores in case of any MCData application and routing the data (user plane) between the two MCX clients.

6) On board and Trackside servers for emulating ETCS/TCMS will be provided by CAF to, the Budapest's lab. Those servers will be able to perform end to end performance testing (e.g., throughput, latency)

7) On board and Trackside video camera and server for CCTV application will be provided by Teleste. Measurement possibilities exist for performance evaluation, e.g., frame/packet drops indication.

8) VPN/Remote Access Server solution will be implemented for every partner to manage their equipment remotely

2.1.3 Lab characteristics

1) No Nokia 5G PCF functionality is available yet, which is normally required to set up the 5G QoS rules. As a workaround, FRMCS 5G QoS testing will require statics QoS rules to be configured in the 5G SMF function. The principle of the QoS management for WP3 lab is explained in §4.4 Priority QoS of D3.2v2 and presented in the following figure mentioning that PCF (and its interworking with the Application / MCX Server) is not supported in 5GRAIL:

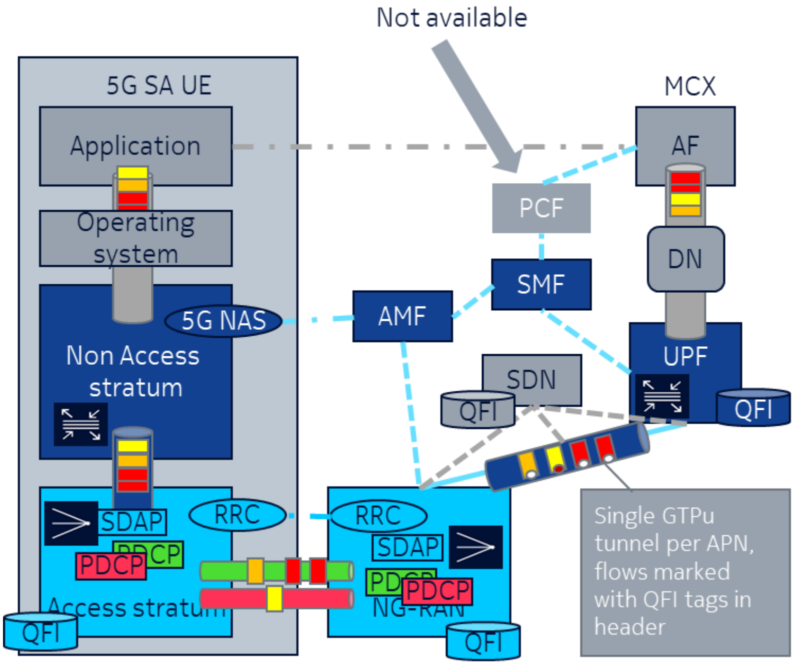


Figure 10: QoS mechanism in WP3 (Ref. D3.2v2)

Whereas it is generally assumed (by 3GPP) that these functions require dynamic PCC using a Policy Control Function (PCF), in 5GRAIL- as the agreed workaround - advanced filter mechanisms in the core network allow to differentiate traffic demands by statically assigning the required QoS with prioritization and differentiated end-to-end QoS, including on the air interface, which is often the scarcest resource.

A proposal of QoS configuration, with DSCP mapping to the 5QI values, is presented in the appendices §16.3

2) No GPS faking will be available in the Onboard GW for loose coupled data test cases (ETCS, TCMS, Video).

3) Only one MCX Server / Dispatcher is currently planned. The request for a second MCX server depends on the test case for Border Crossing.

4) Nokia supports 5QI for GBR 2,3,4,71,72,76.5QI-1 is reserved for VoNR capable devices (not supported by OB GW modem). 5QI GBR is used for Voice application. Non GBR for ETCS/TCMS and Video (ref.WP3 assumption id [13] Table 5: WP3 Assumptions and open topic list).

5) For the FRMCS – GSM-R interworking, no floor control / talker change is specified between the two systems. So, if the two systems are connected, it is not solved that only one subscriber is allowed to talk at any time across the two systems.

6) Dynamic mapping of call priority (e.g., eMLPP) is missing between FRMCS and GSMR, too.

7) In case IWF is tested with REC, REC alert is not available in GSM-R, so only REC voice can be tested. Furthermore, only FRMCS-initiated group (voice) call will be supported with IWF. No e2e security is provided.

2.1.4 Type of equipment.

The following figure presents the equipment provided by Nokia and all the partners of WP3 lab:

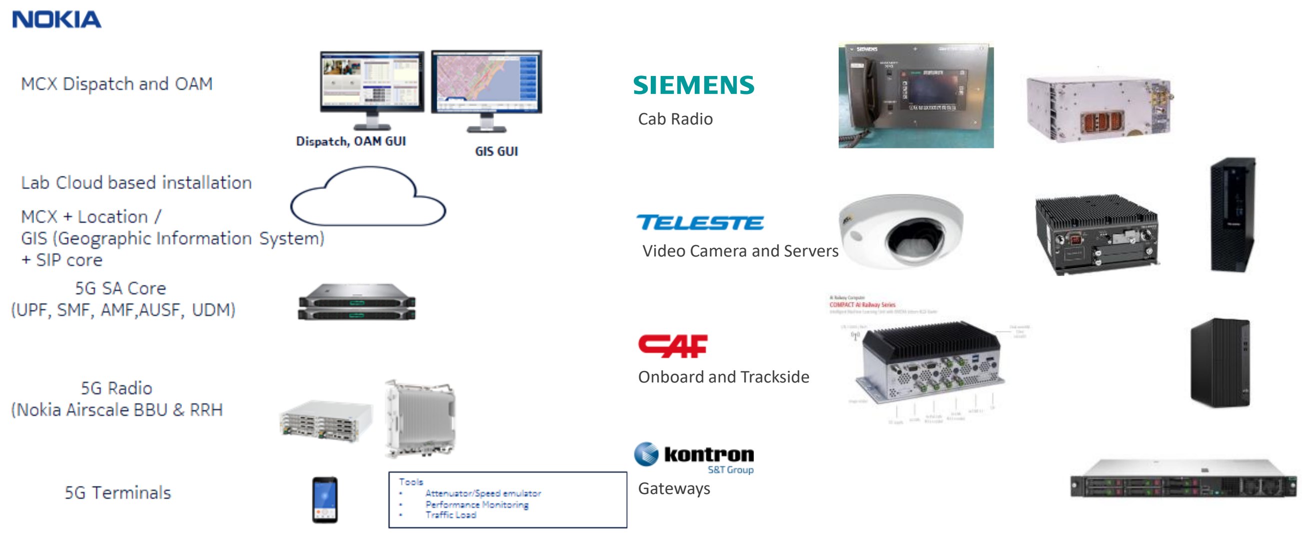


Figure 11: Global hardware view of WP3 lab (Ref. D3.1, updated)

For detailed information about each equipment, please refer to the D3.1deliverable, §2.6.1 and §2.6.2 chapters.

2.1.5 Applied 3GPP releases of 5G functionalities in the equipment.

The lab will provide a 5G telecommunication infrastructure based on 5G radio equipment. It will encompass 5G core equipment and FRMCS MCX application server based on 3GPP Release 16 and Pre 3GPP Release 17, including MCPTT functionality. for end-to-end voice application evaluation and integrated SIP server functionality

FRMCS MCX application integration in 5G Standalone Core is not yet standardized in 3GPP Release 16 and will be realized by appropriate pre standard solutions or workarounds.

Measurement tools or functionality in the applications will be used to estimate end-to-end latency & throughput, as e.g., defined by 3GPP TS 22.289 (wherever applicable for a prototype environment).

2.1.6 Testing environment set-up

All the relevant information is detailed in D3.2 First Lab Test Setup Report v1, §2 Network elements integration.

2.1.7 High level network configuration

The provision of high-level information, important parameters setting for the selected test cases, in the scope of WP3 lab, is provided in D3.2 First Lab Setup Report v1, in chapter §2.2 and in pre-configuration sub-chapters of §3 for the applications.

In appendix §16.2.1, the MC configuration of the clients referring to MCIDs and SIP IDs, per application, is provided but also information about MCServer configuration, in the scope of WP3 lab.

2.1.8 Test configuration and validation tools

WP3 lab's test and monitoring tools are presented in D3.2 First Lab Setup Report v2 in chapter §3, where we can notice that Onboard and Trackside are separated from IP point of view. Those can reach each other only via 5G radio interface.

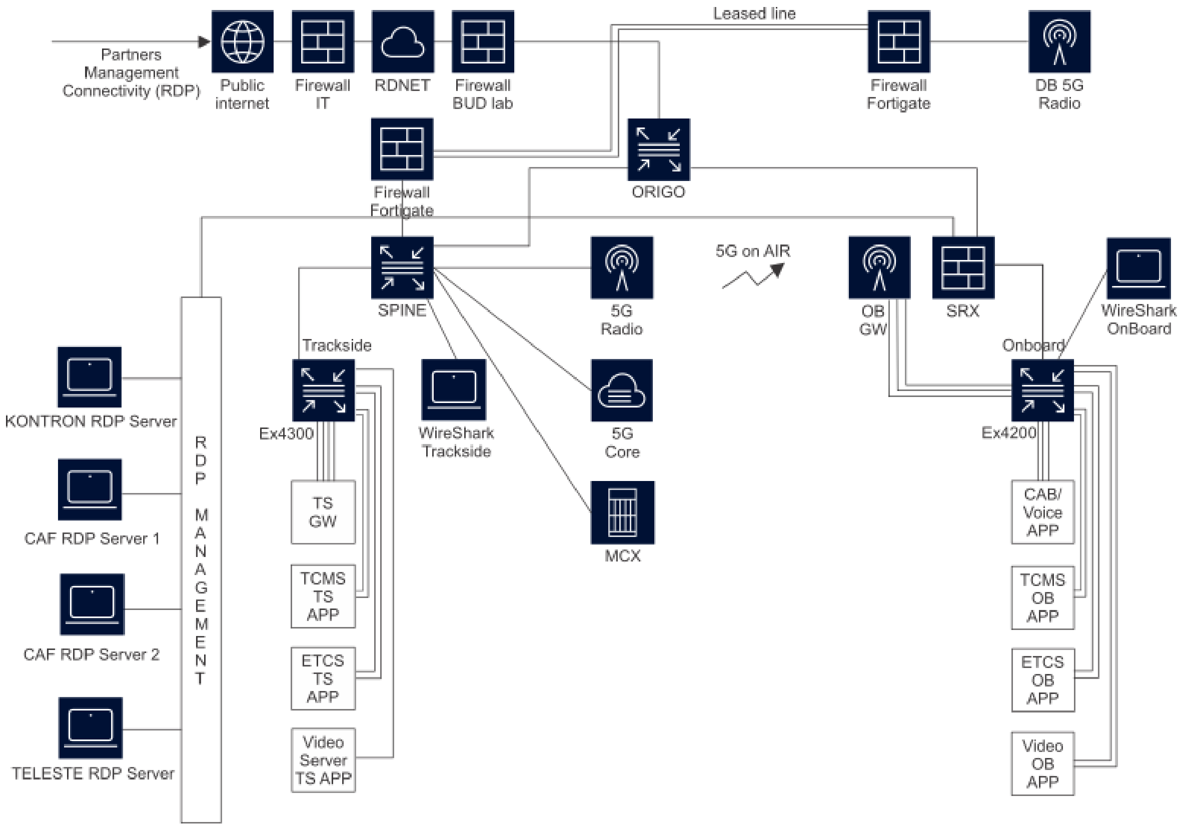


Figure 12: IP connectivity, monitoring and configuration tools in WP3 lab network (Ref. D3.2)

2.2 Overview of the 5G reference lab in France

The following figure presents the WP4 lab:

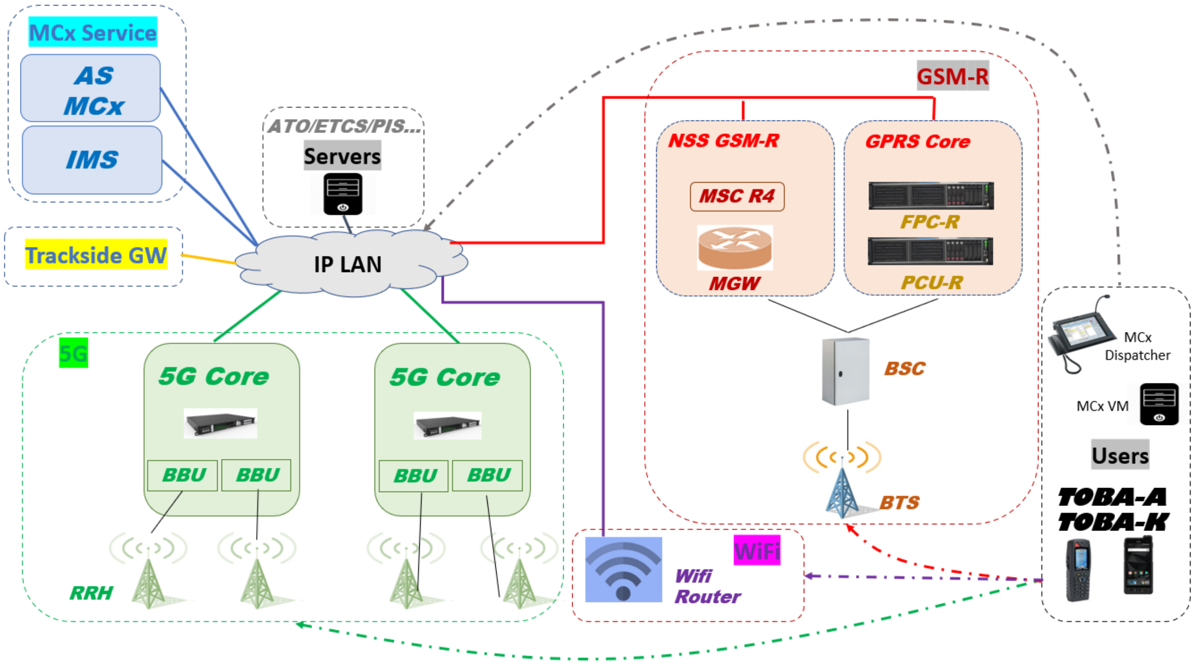


Figure 13: Global view of WP4 lab (Ref. D4.1)

The following picture presents the functional view of WP4 lab:

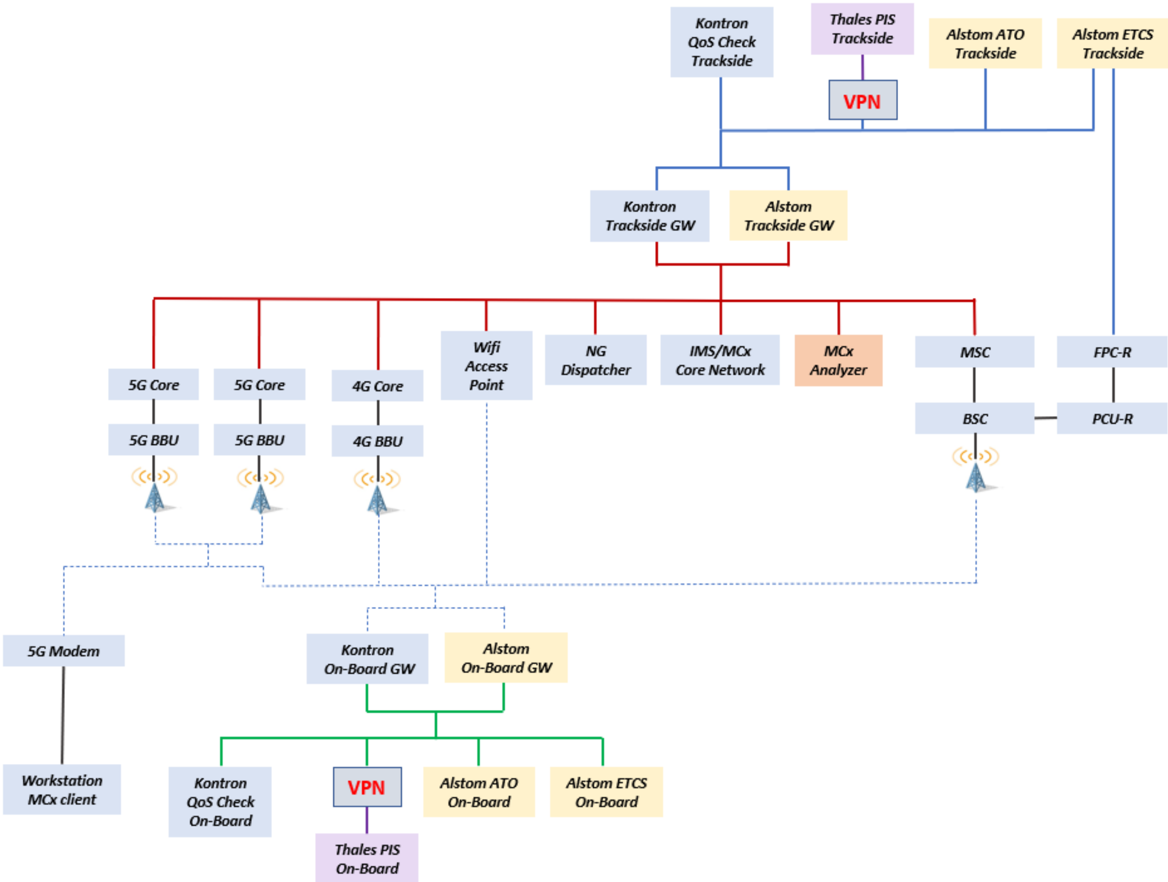


Figure 14: Global functional view of WP4 lab (Ref. D4.1)

2.2.1 Supported use cases in lab France.

For a more precise view of the test use cases to be performed in WP4's lab in France, please refer to Table 8.

Moreover, the lab in France, will be focused on the testing of data applications especially ETCS and ATO provided by Alstom but also the FRMCS-On-Board Gateway provided by Alstom (a.k.a TOBA-A), and the FRMCS-On-Board Gateway provided by Kontron (a.k.a TOBA-K). This is because a complete FRMCS architecture is available in WP4 lab. Also, a limited subset of voice test cases based on Kontron's MCX solution will be performed. Based on the GA, the use cases to address in the scope of WP4 are:

FRMCS 5G QoS: GBR flow combined with non-GBR flow over TOBA + FRMCS 5G infrastructure qualification while degrading radio transmission, emulating speed.

ETCS and ATO over FRMCS 5G: in perfect radio conditions and in degraded radio conditions

Basic voice over FRMCS 5G as listed below:

- Voice over TOBA + FRMCS 5G infrastructure in nominal and perfect lab conditions with no perturbations.

- Voice over TOBA + FRMCS 5G infrastructure in real condition simulated with Radio link degradation, speed emulation and high traffic conditions.
- Voice Group calls establishing in both 5G FRMCS and GSM-R.

Cross border scenario:

- Qualifying data continuity while TOBA moves from FRMCS 5G network to another FRMCS 5G network (2 isolated networks) using ETCS and ATO application.

Bearer flex scenario is considered as multi-connectivity (i.e., multiple transport domains) and as multi-access. However, only the subset "multi-access" will be tested, see WP2 architecture and WP3.

In addition (see WP4), two multi-connectivity use cases will be tested. From them, derive 4 test case scenarii depicting both directions of train trip : links redundancy (or fallback) 5G/4G and links aggregration, using 5G or/4G and 5G bearers simultaneously in lab and in field in the scope of WP5 in France, as presented in the following figure:

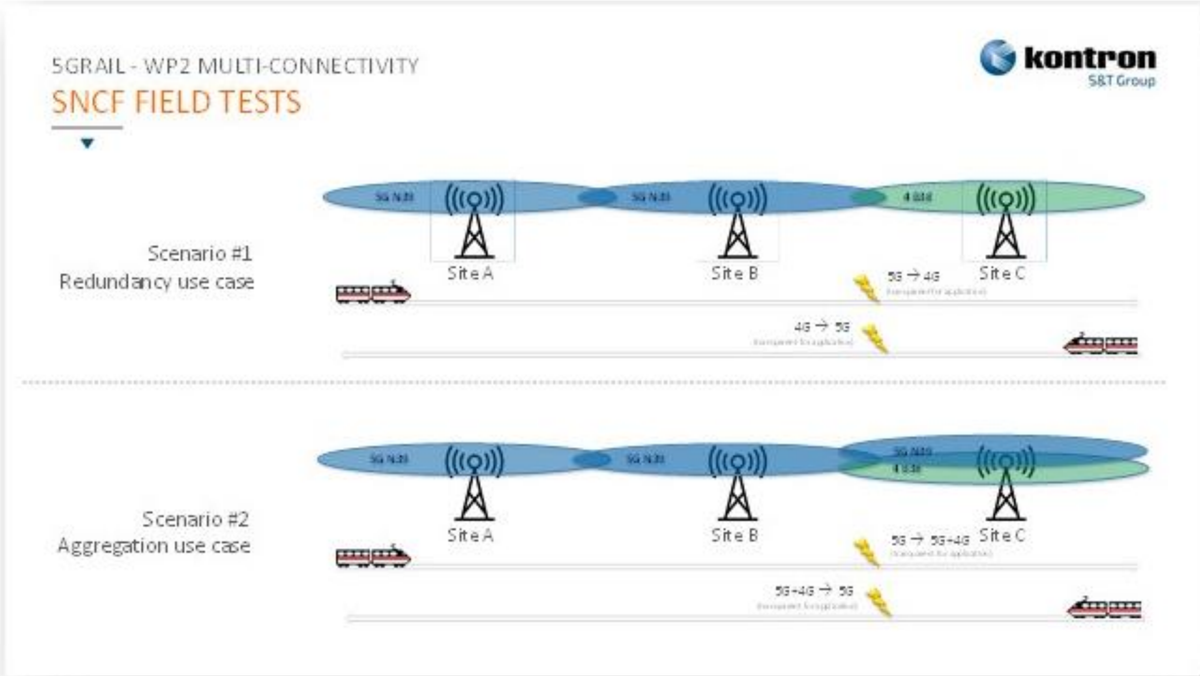


Figure 15: Multi-connectivity use cases to be tested in lab WP4 and WP5 - FR

2.2.2 Specific lab conditions

The following paragraph presents the specific lab configuration:

1) For tests requiring the GPS location, equipment has to use pre-defined GPS coordinates, as GPS coverage inside the lab is not possible, and no movement scenarios would be possible. By this way, a test case simulating a movement by sequence of 2 or more GPS coordinates can be executed, as the clients will send those GPS coordinates to the MCX system for further processing.

2) GSM-R is also available in lab for interworking use cases

3) Cross border use cases can be configured using 2x5G cores by routing the data on the N6 interface towards one MCX server

4) On board and Trackside servers for emulating ATP will be provided by Alstom. Those servers will be able to perform end to end performance testing (e.g., throughput, latency)

5) On board and Trackside servers for emulating ATO will be provided by Alstom. Those servers will be able to perform end to end performance testing (e.g., throughput, latency)

6) On board and Trackside servers for emulating PIS will be provided by Thales. Those servers will be able to perform end to end performance testing (e.g., throughput, latency)

7) VPN/Remote Access Server solution will be implemented for every partner to manage their equipment remotely

2.2.3 Lab characteristics

1) No 5G PCF functionality is available yet, which is normally required to set up the 5G QoS rules. As a workaround, FRMCS 5G QoS testing will require statics QoS rules to be configured in the 5G SMF function. As a workaround, the DSCP based method has been chosen for QoS handling in the WP4 lab, as explained in chapter §2.1.4.3 of the D4.2 v1. The following figure presents Alstom's architecture for testing DSCP method in the scope of WP4, where Thales modem is controlled by Alstom's OB-GTW. It is connected to the 5G SA network with the APN "internet".

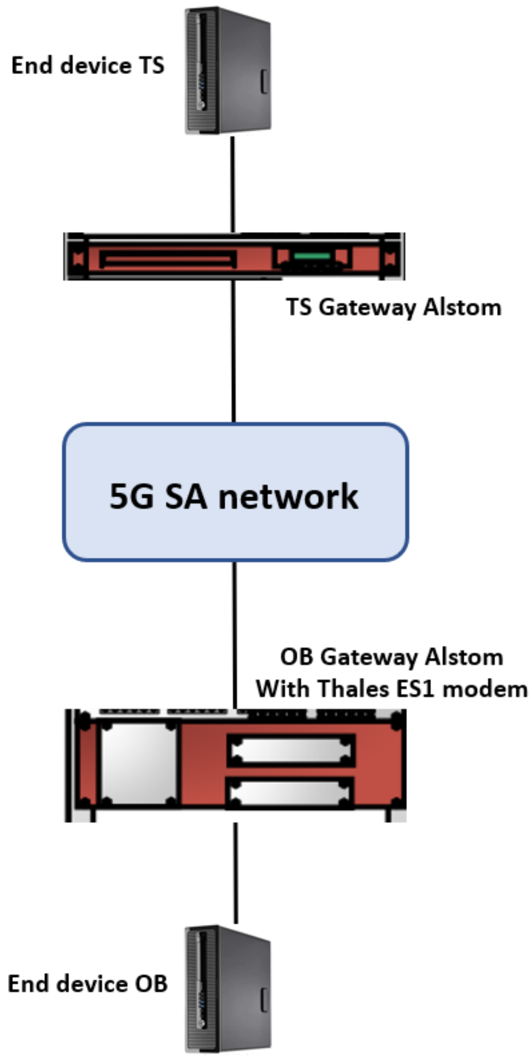


Figure 16: Architecture for DSCP tests

The static QoS rules configured in the 5G network for WP4 are presented in §16.4

2) No GPS faking will be available in the Onboard GW for loose coupled data test cases (ETCS, ATO).

3) Only one MCX Server is currently planned. The request for a second MCX server depends on the test case for Border Crossing.

2.2.4 Type of equipment

The detailed information about the equipment provided by Kontron and all WP4 partners is given in D4.1 Second Lab Integration and Architecture Report, §2.3 and completed in D4.2 Second Lab Setup Report

The overall HW view of WP4 lab with all partners equipment is presented in the following figure:

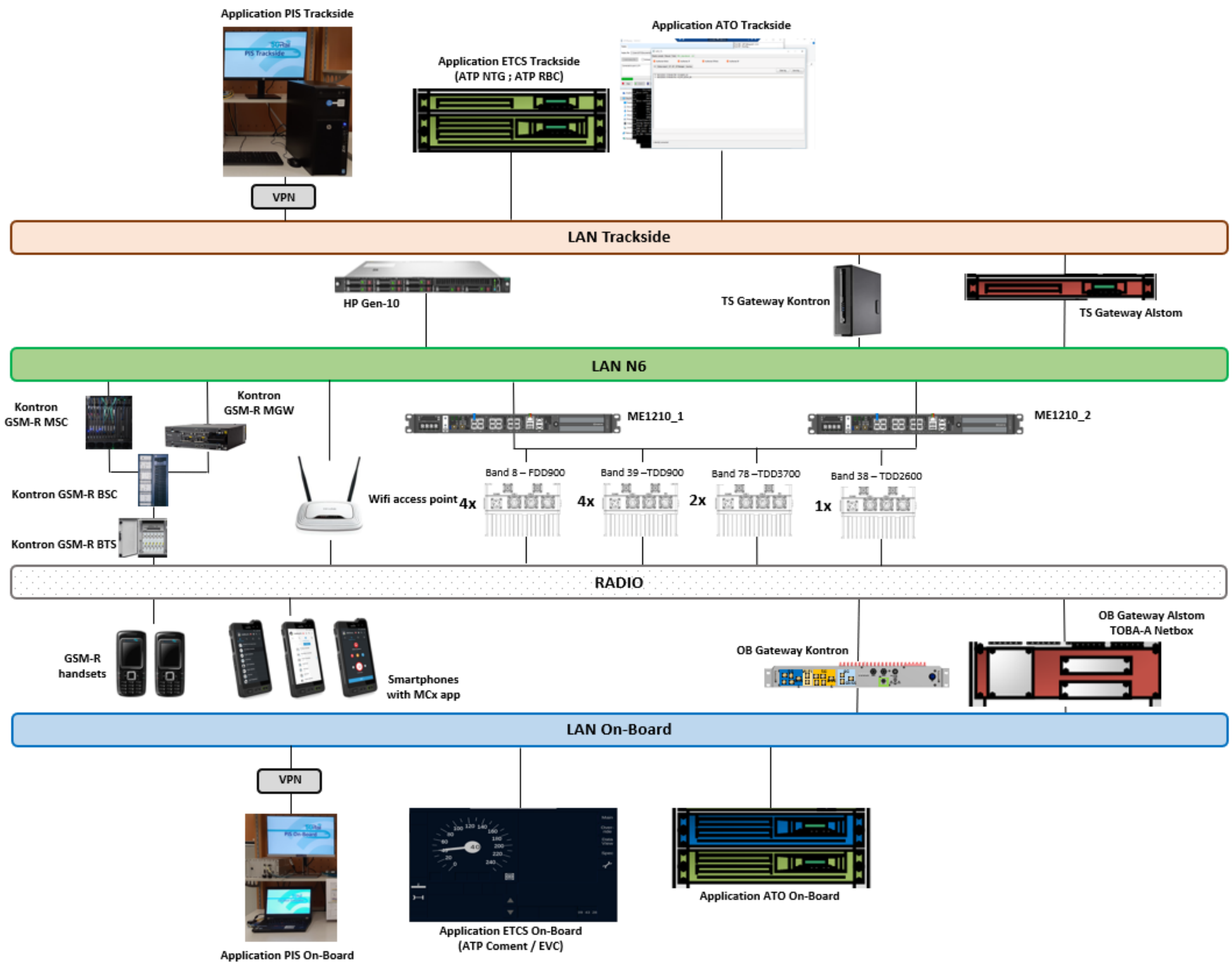


Figure 17: Global hardware view of WP4 lab (Ref. D4.2)

2.2.5 Applied 3GPP releases of 5G functionalities in the equipment.

Full 5G infrastructure including RAN, CORE and Application servers based on 3GPP Release 16 and Pre 3GPPRelease 17, including MCPTT functionality for end-to-end voice application evaluation and integrated SIP server.

Measurement tools or functionality in the applications will be used to estimate end-to-end latency & throughput, as e.g., defined by 3GPP TS 22.289 (wherever applicable for a prototype environment).

2.2.6 Testing environment set-up

The initial software line-up and hardware information is briefly presented in D4.1 deliverable, §3.2 Software and Hardware initial line-ups. A more precise and up-to-date information is given in the D4.2 deliverable, Second Lab Test Setup Report v1 in chapter §2.

2.2.7 High level network configuration

Referring to D4.1 document, chapter §3.3 Parameters, the following list of groups of parameters is presented, to be modified according to the test needs of WP4 lab configuration:

- 5G Core parameters
- 5G RAN parameters.
- 4G Core parameters
- 4G RAN parameters.
- IMS parameters
- MCX clients and server parameters
- GSM-R parameters
- IP network parameters
- On-Board and Trackside Gateways parameters
- ETCS, ATO and PIS applications parameters

The D4.2, Second Lab Test Setup Report v1 provides more details about some WP4 tests scenario selected by WP1, including specific test configuration to be used. Default parameters values appear in this document but also any change needed for each test execution. The configuration information will be completed in D4.2 v2.

In appendix §16.2.2, the MC configuration of the clients referring to MCIDs and SIPIDs, per application, is provided but also information about MCServer configuration, in the scope of WP4 lab.

2.2.8 Test configuration and validation tools

In the scope of WP4, there are two types of tools, as presented in the following figure:

- ***Test environment tools***: Create the conditions to run tests (Radio simulator tool, Load traffic generator tools…):
- ***Diagnostic tools***: Assess test status (protocol analyser, MCX analysers, KPI measurement tools…):

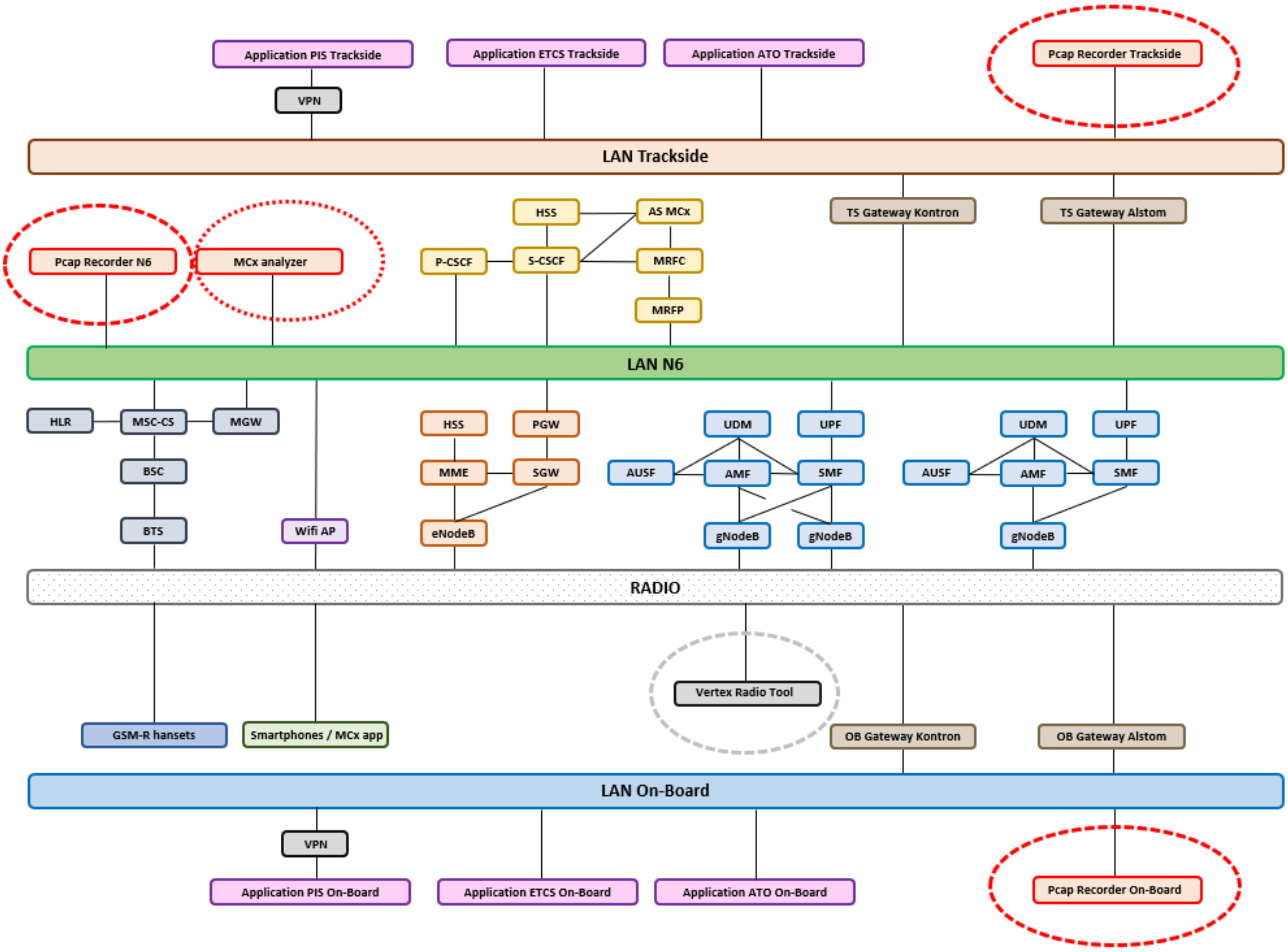


Figure 18: Validation and configuration tools in WP4 lab network (Ref. D4.2)

2.3 Field implementation in Germany

DB Netz, the infrastructure manager of DB, is planning to use a test track in the Erzgebirge region, Germany, which is known as *Digital Rail Testbed / Digitales Testfeld Bahn* and which is located between the towns of Schwarzenberg and Annaberg-Buchholz in a rural and moderately hilly area. The testbed includes a 10 km segment of railway tracks equipped with the basic infrastructure to operate a mobile test network, e.g., antenna masts, fiber-optical connectivity and a central lab with server rooms at the station of the village Scheibenberg. The radio site of the central lab location uses a 15 m high antenna mast while remote radio sites use antenna masts of 10 m height. So far, eight radio sites have been realized within the 10 km segment (see figure below). The track is intended for experimental trials with 50-80 km/h speed. In the 5GRAIL project, tests will be performed with up to 50 km/h.

The 5G radio access network in the German testbed will be running at 3.7 GHz (band n78). Three to five radio sites, including the central lab location, will be used for the 5GRAIL trials.

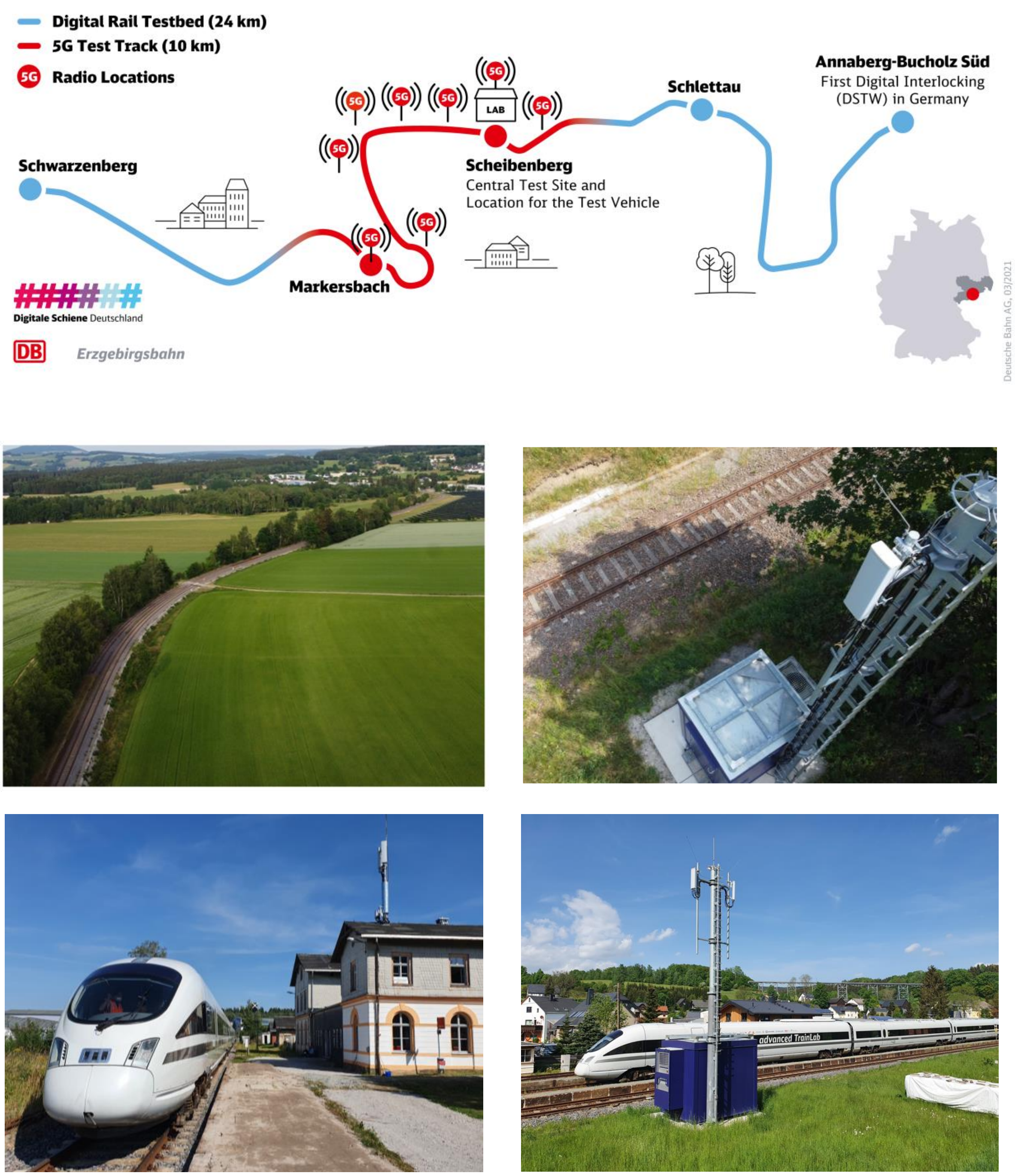


Figure 19:Test site in Germany in the scope of WP5

2.3.1 Supported use cases in field Germany.

The supported use cases in German field are as follows.

- MCPTT / Voice communication
    - 5G/FRMCS point-to-point voice call
    - 5G/FRMCS group voice call
    - 5G/FRMCS rail emergency call

- 5G/FRMCS to 2G/GSM-R interworking via lab
- MCData
  - Automatic Train Protection communication (ETCS simulation)
  - TCMS telemetry
  - Non-critical video
  - Transfer of CCTV archives

Cross-border and bearer-flex simulation test cases in the German field:

- Non-critical video or TCMS in a cross-border scenario, realized as 5G/FRMCS to 5G/FRMCS transition using two 5G (Core) networks.
- Transfer of CCTV archives in a bearer-flex scenario, realized as transition from one 5G/FRMCS bearer to a second 5G/FRMCS bearer using in the same 5G (Core) network.

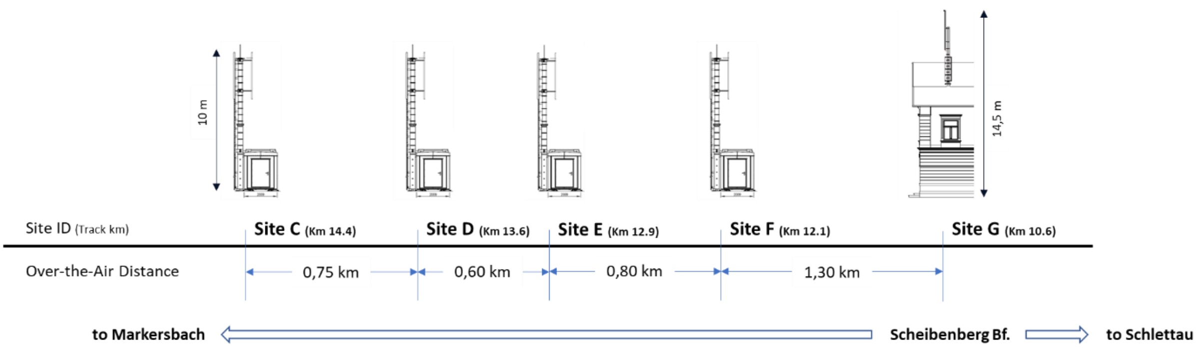
2.3.2 Specific field conditions.

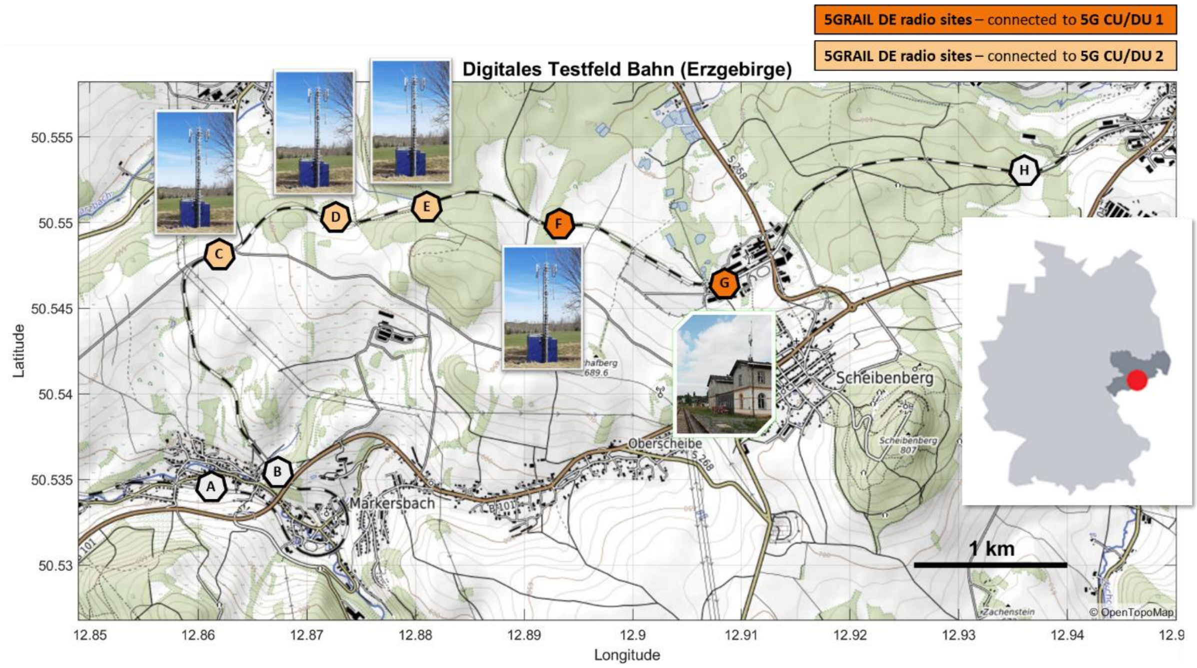
The detailed field conditions will be described in further deliverables of WP1, such as D1.4, Test report conclusion from real-world environment.

Spectrum conditions: Industrial Private 5G Network Spectrum 3.7-3.8 GHz (5G band n78) with the target to be able to use two different 20 MHz chunks within the band. As per agreement with BNetzA two different network IDs can be temporarily used for the 5GRail trials in order to realize two 5G band n78 networks at the same time. This may be needed to implement cross-border like test scenarios.

There is no GSM-R available in the German field. Hence, all GSM-R related equipment to demonstrate 2G to 5G system transition aspects for voice applications will be hosted in the Nokia lab premises in Budapest, Hungary, only.

5G RAN conditions: The 5G radio access network in the field will be realized using two 5G CU/DUs which are connected to different radio sites. In total, up to 5 radio sites will be active during 5GRail test runs. The inter-site distances and the assignment of radio sites to CU/DUs are shown in the figures below.





5G RAN – 5G CORE interconnection via remote line: The 5G radio access network in the field will be connected to the 5G Core being operated at the Nokia lab premises in Budapest, Hungary. A leased line with sufficient data rate is being used for the interconnection. The interconnection is secured by a set of firewalls at both ends of the line, see below.

5G RAN (Erzgebirge, Germany) — DB Systel FW (Erzgebirge, Germany) - - - Remote Line - - - DB Systel FW (Budapest, Hungary) — Nokia FW (Budapest, Hungary) — 5G CORE (Budapest, Hungary)

2.3.3 In-field characteristics

The in-field specificities will be updated according to WP5 progress and will be described in a further deliverable D1.4, Test report conclusion from real-world environment.

2.3.4 Type of equipment.

Aligned with WP3 lab, to be described in D1.4

2.3.5 Applied 3GPP releases of 5G functionalities in the equipment.

As per WP3 lab in Hungary

2.3.6 Testing environment set-up

As per WP3 lab in Hungary

2.3.7 Network architecture

The following figure illustrates the connection of the test site to the 5G Core and Trackside system in WP3 lab:

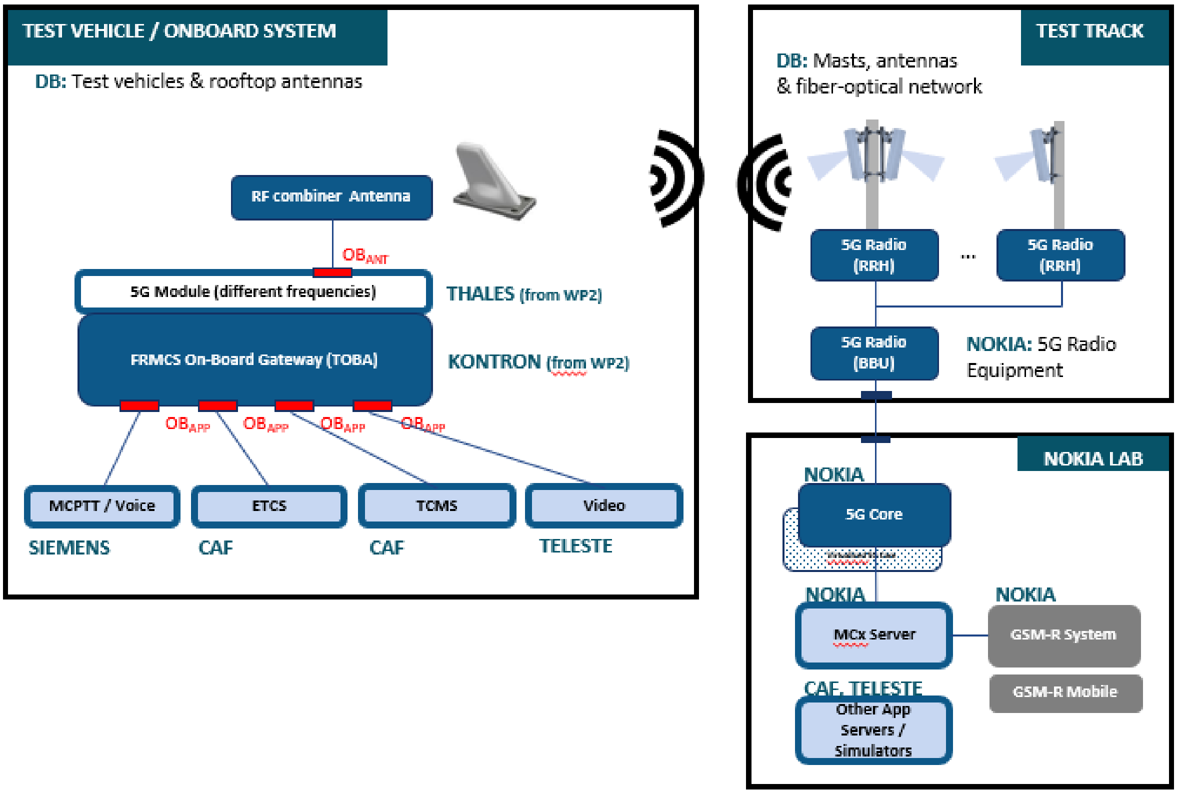


Figure 20: Interconnection of test site in Germany with WP3 lab

2.3.8 Test configuration and validation tools

The validation tools of WP3 lab will be used. If additional ones are needed, these will be subject of WP5 reports.

2.4 Field implementation in France

France (SNCF Test Site) is a portion of commercial line in the suburb of Paris region. 5G RAN is to be deployed in 3 sites with possible reuse of existing GSM-R/GPRS installation. The traffic from these three sites is concentrated in the “Command Centre” non-radio site. The train speed is up to 70 km/h. The RU, CU/DU equipment of 5G RAN, 4G BBU and RRHs as well as 5Gcore and 4Gcore, all supplied by Kontron, will be located in SNCF’s sites. The Central site (“Command Centre”), encompassing 5G CU/DU, 5GC and 4GBBU, EPC shall be connected to WP4 lab at Kontron premises in Montigny, located in the western suburbs of Paris, where Trackside equipment is installed Figure 22. The antenna and masts shall be provided by SNCF. The frequencies to be used are ideally the RMR ones. They depend on the availability of band 1900MHz RMR, used in French lab and the grant of a temporary test license from the ARCEP. Second frequency band to be used is b38 (2600 MHz).

The following figure is presenting the French testbed at Vigneux-sur-Seine with the 3 radio sites to be used for the field activities:

Figure 21:Test site in France in the scope of WP5

2.4.1 Supported use case in field France.

The supported use cases in French field are as follows.

- ETCS,
- ATO,
- Bearer flexibility 5G and 4G (links redundancy and links aggregation use cases) with ETCS application,
- Train front camera real-time video (Remote Vision, as for remote driving configuration);
- Cross-border simulation test case using two 5G cores:
    - Transition for the continuity of ATO/ETCS data and Remote Vision.

2.4.2 Specific field conditions.

The detailed field conditions are currently in progress as part of WP5 field sites preparation work. They will be described in another deliverable of WP1, namely D1.4, Test report conclusion from real-world environment.

Below is a summary of current information about the specific field conditions of the test site in France:

The line used is a portion of a commercial line with a test vehicle, going up to 70 km/h. A stretch of the track is equipped with basic infrastructure needed for network operation, e.g., radio sites with support height of 20m and with cabinets to host remote radio heads, fibre-optical connections between the sites and a command centre room to host the equipment presented in Figure 22.

Spectrum conditions: we will apply for **a temporary test license from the ARCEP in 1900 MHz RMR.**

From January 2022, WP5 started to discuss the implementation of field central site interconnection to the WP4 lab through leased line and to prepare remaining test track implementation of the 5G RAN field solution with 3 gNodeBs.

2.4.3 In-field characteristics

The total test duration per day is less than 1 hour, assuming 3-4 passes during working hours, as it takes up to 12 minutes per pass whether it is forth or back and depending on the speed of the train. Therefore, all tests in fields shall be pre-validated in lab on an a-priori basis, to minimize last minute discoveries and give enough time for integration issues to be solved beforehand.

The detailed in-field characteristics will be elaborated based on the progress of WP5. They will be described in another deliverable D1.4, Test report conclusion from real-world environment.

2.4.4 Type of equipment.

Same set of equipment used in the WP4 French lab e.g., cab radio, simulators of radio environment, traffic generators, ground dispatchers, other ground set of equipment, RBCs etc., would be used in field. This will be elaborated in D1.4.

2.4.5 Applied 3GPP releases of 5G functionalities in equipment.

As per lab WP4 in France

2.4.6 Testing environment set-up

Same as WP4 lab set-up (HW, SW baseline, etc.)

2.4.7 Network architecture

The following figure illustrates the current high level network architecture of the test site in France connected to the Trackside part of WP4 lab:

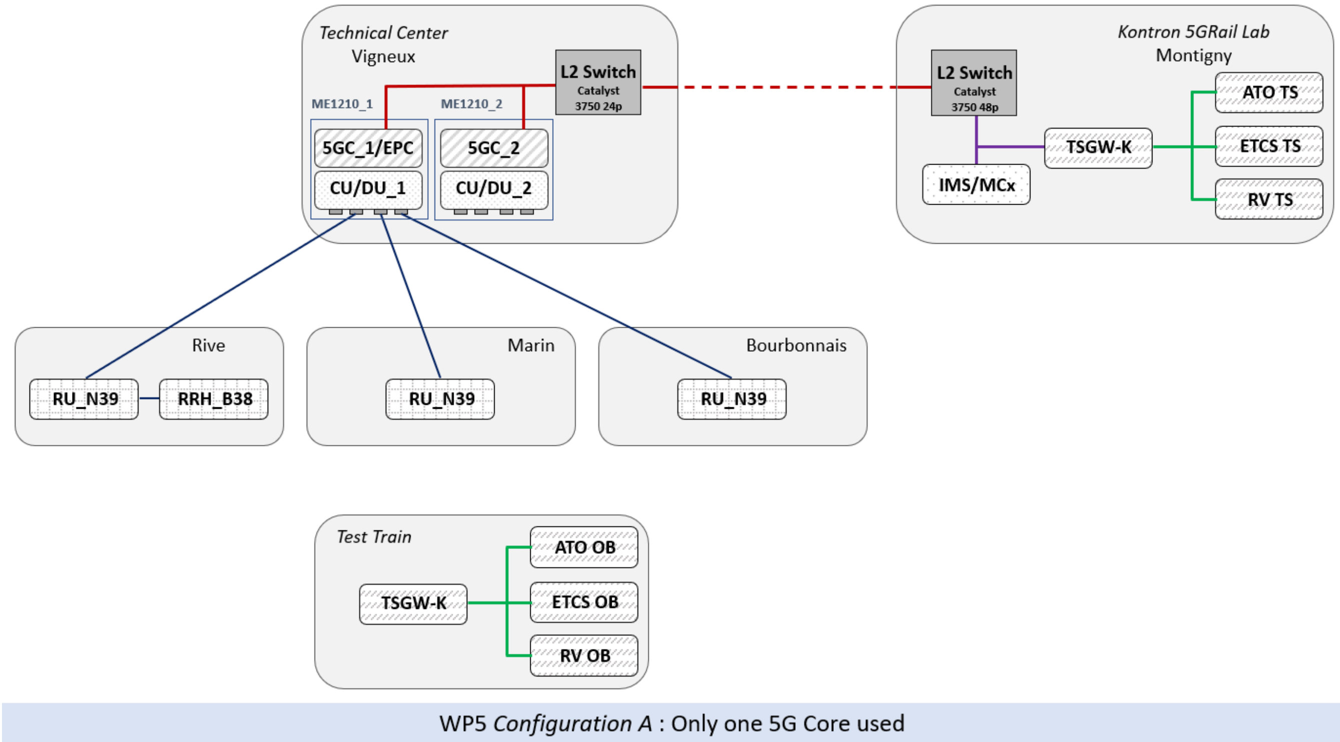


Figure 22: Interconnection of test site in France with WP4 lab

A complementary view of the interconnection between the testbed in France and WP4 lab is available in the §16.8

2.4.8 Test configuration and validation tools

Same validation tools used in Lab of WP4: Protocol analysers, spectrum analysers, logs, measurement, and post-processing tools, etc.

3 FRMCS SYSTEM PRINCIPLES

In the following, some of the main FRMCS system principles are presented. These principles will be tested with the use cases selected by the WP1 group, according to the specificities of each application.

3.1 Security

Referring to §15 [R5] and [R10], the security framework protects the FRMCS System against attacks and threats, unauthorized access to services, interception, man-in-the-middle attacks, replay attacks and intended data modification. It encompasses the protection of security attributes confidentiality, privacy, integrity, availability, and non-reputation.

The security framework protects:

- Services provided by the FRMCS System.
- Bearer flexible access including 3GPP as well as non-3GPP access; Direct interaction between FRMCS Equipment; Interaction between the FRMCS end user devices and FRMCS network.
- Interaction between FRMCS network functions.
- Stored data within the FRMCS System.
- Interworking between a FRMCS System and another FRMCS System.
- Interworking between a FRMCS System and a legacy system.

For an FRMCS system in use, the security framework service flows cover the following aspects:

- identity management.
- authentication.
- authorization.
- key management.
- data protection (regarding integrity, confidentiality, privacy, non-reputation);
- prevention of attacks.
- detection of attacks.
- reaction on detected attacks.

The minimum FRMCS security level shall be based on the implementation and usage of a minimum set of cryptographic algorithms, MCX user authentication and 5G subscription authentication methods.

Cybersecurity is optional for most of the applications within 5GRAIL.

3.2 Bearer flexibility

As mentioned in §15 [R5], the main advantage of bearer flexibility feature in the FRMCS system is to allow a certain level of independence between Railway Applications and the underlying transport system. Thanks to the bearer flexibility feature, the FRMCS -On-Bord System will be able to use a defined variety of Radio Access Technologies and Transport Domains. Bearer flexibility shall support various voice and data applications.

The rationale behind this functionality is that the lifecycle of railway applications is in general much longer than the lifecycle of telecommunication access/transport systems. Moreover, bearer flexibility aims at improving service availability and performance.

Referring to the §15 [R5], it is worth reminding some definitions and requirements in the following:

- FRMCS Bearer flexibility encompasses two capabilities: **FRMCS Multi Access and FRMCS Multipath.**
- FRMCS Multipath uses multiple transport domains on separate UEs for a given communication session
- FRMCS Multi Access uses multiple radio access technologies on a single UE

FRMCS Multipath can provide transport paths over one or multiple of the following Transport Domains: **FRMCS Transport Domain**, Non-**FRMCS Transport Domain**s (e.g., Public MNOs, Satellite, WLAN/Wi-Fi, 4G EPS (IM operated)

Examples of Access Technologies, supported by the transport stratum, when using bearer flexibility are:

- Terrestrial 3GPP access – 5G NR.
- Terrestrial Non-3GPP access – Wi-Fi/WLAN.
- Non-Terrestrial 3GPP access – 5G NR Satellite;
- Non-Terrestrial Non-3GPP access – Satellite;
- Wireline 5G access network.

The characteristics of bearer flexibility are:

- A Railway Application may use one or several access systems as appropriate.
- Connection of FRMCS Equipment to different access systems is dynamic (i.e., the most appropriate 3GPP or non-3GPP access technologies are selected, potentially using multiple access technologies for one or more Railway Applications).
- The set of access systems chosen meets the defined QoS and the service requirements e.g., FRMCS User mobility and connectivity which are necessary to guarantee the functionality.
- The introduction of a new access system should not negatively impact existing Railway Applications.
- The approach taken within FRMCS allows the integration of 3GPP and non-3GPP radio access evolution.

The bearer flexibility function is managed by the two FRMCS gateways, which implement the transport stratum, as depicted in the following figure extract of D2.1 TOBA Architecture Report

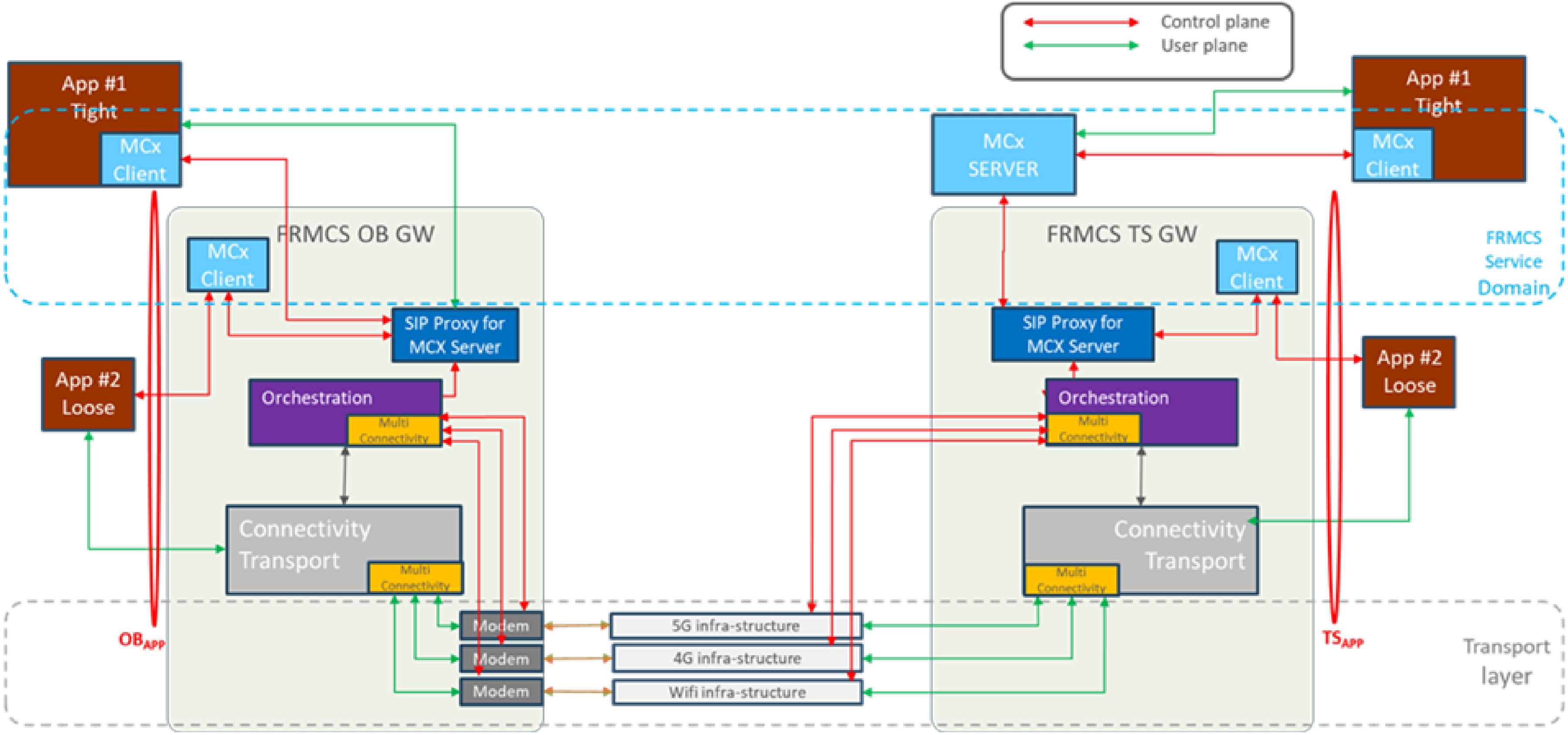


Figure 23: Kontron Multiconnectivity/Bearer Flex function (Ref. D2.1)

In the context of 5GRAIL, it is important to notice that bearer flexibility is managed by the two gateways (OB GW & TS GW) to support multi-connectivity (i.e., multiple transport domains) . However, the bearer flex test cases in the scope of WP4 and WP3 are more considered as multi-access, which is a subset of the bearer flex feature. (e.g. in case of WP4 using 5G and/or 4G bearer or as in case of WP3 using two n78 subbands).

3.3 QoS in a railway environment

As mentioned in the §15 [R5], this system principle provides the framework for Quality of Service within the FRMCS System including the railway applications. The main purpose is to specify the list of attributes applicable to the FRMCS bearer service.

Railway applications exhibit different characteristics, e.g., in terms of latency or reliability. On the other hand, the FRMCS System offers bearer services with different properties.

Railway applications require a QoS classification ranging from high to low as low is “best effort”. The most important QoS parameters that determine the quality of the transport system are latency of the user data and reliability of the communication. In addition, guaranteed bandwidth assures the continuation of critical communication.

As mentioned in the §15 [R4] v0.5.0, FRMCS system needs to provide by the transport stratum all the necessary resources to comply with the QoS requirements per each communication session. However, if the QoS requirements of all the simultaneous communication sessions cannot be fulfilled at the same time, the FRMCS system shall utilize the priorities to differentiate based on the application’s criticality. Each FRMCS priority shall be translated by the FRMCS system into an Allocation and Retention Priority (ARP). Based on the FRMCS priority, the seizing of resources by a lower ranking communication will be authorize in favour of a higher priority application, in case of lack of resources.

VOICE	ETCS	ATO	TCMS	CCTV offload	Real-time video	PIS
Critical	Critical	Medium	Medium Low	Low	Low	Low

Table 9: Priority of applications (Ref. D2.1)

The QoS will be based on FRMCS MCX services using 5G QoS so called 5QI, from FRMCS modems and 5G core, as presented in the figure below:

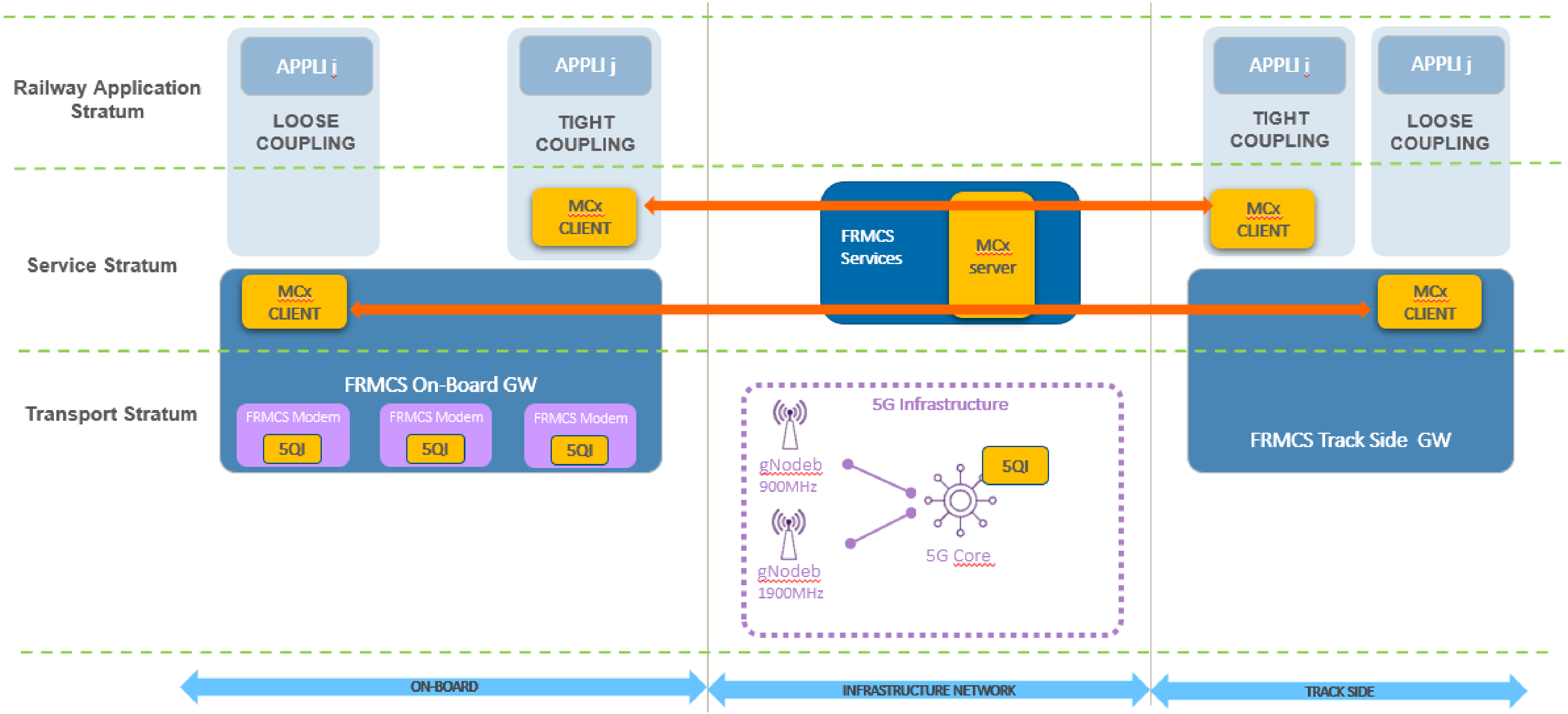


Figure 24: QoS function (Ref. D2.1)

It is important to remind that QoS is only managed for FRMCS modems (not for 4G, Wi-Fi, etc.); the framework for Quality of Service within the FRMCS System is used for 5GRAIL.

QoS functionnality needs to be ensured by both OB&TS gateways but also applications.

3.4 Interworking between GSM-R and FRMCS

Based on §15 [R5], during the migration period, coexistence and interworking of both communication systems is required. Interworking between the FRMCS System and GSM-R system shall be provided.

Circuit switched bearer services are used in GSM-R for voice. In the FRMCS context, it is necessary to support the circuit switched bearer to cover user-to-user as well as multi-user voice communication.

The IWF provides centralized support for interworking between an MCPTT system and a GSM-R system. In MCPTT systems, the identity of a GSM-R user is provided as an MCPTTID, and the identity of a GSM-R group is provided as a MCPTT group ID, which can be used by the IWF to derive the corresponding identities used in the GSM-R system.

The IWF can perform the identity mapping between an MCPTT system and a GSM-R system during exchange of signalling and media messages.

One main aspect of the interworking is the fact that different types of identities are used in FRMCS and in GSM-R. The IWF performs the conversion of the IDs used in FRMCS and those used in GSM-R. The IWF is capable to convert both physical and functional IDs in both systems.

If we assume a communication from MCX system to GSM-R system using the IWF:

- Incoming MCX ID identifies entities (users, groups) on the MCX system.
- Outgoing ID identifies (users, services) on the GSMR System

Incoming and outgoing IDs can either be a physical ID (holding a physical address according to E.164 or a MCX ID) or a functional ID (holding a functional number according to EIRENE or holding an MCX Functional Alias).

3.5 FRMCS System/FRMCS User roaming capabilities

Referring to §15 [R5], FRMCS Roaming use cases address the ability for an FRMCS User to make use of FRMCS Applications when he is provided service by a network different from his Home FRMCS Network. FRMCS Roaming capabilities are necessary to ensure that Railways Undertaking will be able to use a single FRMCS Equipment for their FRMCS Users while roaming. For train cross border operations (e.g., FRMCS Roaming situations), some registered FRMCS Functional Identities shall remain valid for the duration of the train international run, the same FRMCS Functional Identity keeping the same association to FRMCS Equipment while border crossing.

Each FRMCS Network shall maintain its own FRMCS Functional Identity addressing scheme. For FRMCS roaming, an international FRMCS Functional Identity scheme will be used, and national scheme will align on it.

If a train (e.g., an FRMCS User) is involved in cross border operation, the FRMCS System shall detect automatically if an activated FRMCS Functional Identity requires a re-association to the local applicable addressing domain.

4 FRMCS ARCHITECTURE: OBapp/TSapp DEFINITIONS

In the following, it will be reminded the various application regimes as per §15 [R4] definitions. Applications using the FRMCS System can be categorized in various Application Regimes depending on the nature and extent of usage of the OB_{APP} and TS_{APP} reference points

Application regime	OB_{APP} / TS_{APP} coupling mode	FRMCS Service Stratum client in application?	FRMCS Service Stratum client in FRMCS On-Board System / in FRMCS Trackside Gateway?
Tight	Tight	Yes	No
Loose	Loose	No	Yes
Superloose	Loose (via agent)	No	Yes

Note: *Superloose application regime is defined as per the above table as the application being OBapp-unaware and interacting through an agent (out of FRMCS specs) implementing OBapp on behalf of the application.*

The “Coupling Mode” reflects whether an application environment encompasses a FRMCS Service Stratum client (“Tight Coupling Mode”) or not (“Loose Coupling Mode”).

“Flat-IP” Coupling Mode is a sub-mode of Loose-coupling type with static configuration of the requested session. Hence, flat-IP applications can only use the static session configured in FRMCS OB_GTW and TS_GTW.

The ‘Superloose mode’, as considered by the application, can be characterized as a “flat IP”. An ‘agent’ is located between the application and the On-board Gateway, to make this mode OBapp compatible.

The specific test cases to evaluate the OBapp/TSapp compatibility of the applications and the MCX client-server communication are also described in D2.2 deliverable, TOBA Integration Report

5 TEST CONFIGURATIONS IN LAB ENVIRONMENTS

This chapter is presenting both labs set-up for each test case. In the relevant chapters, when each test case is described, there is a reference to the corresponding figure for this test.

5.1 Normal conditions test configurations in the scope of WP4 (ETCS, ATO, PIS)

The following configurations correspond to the normal conditions network set-up per application and the common radio set-up, as presented in Figure 28

- *Normal conditions test cases*: Corresponds to tests where the application is tested end to end without any external perturbation.

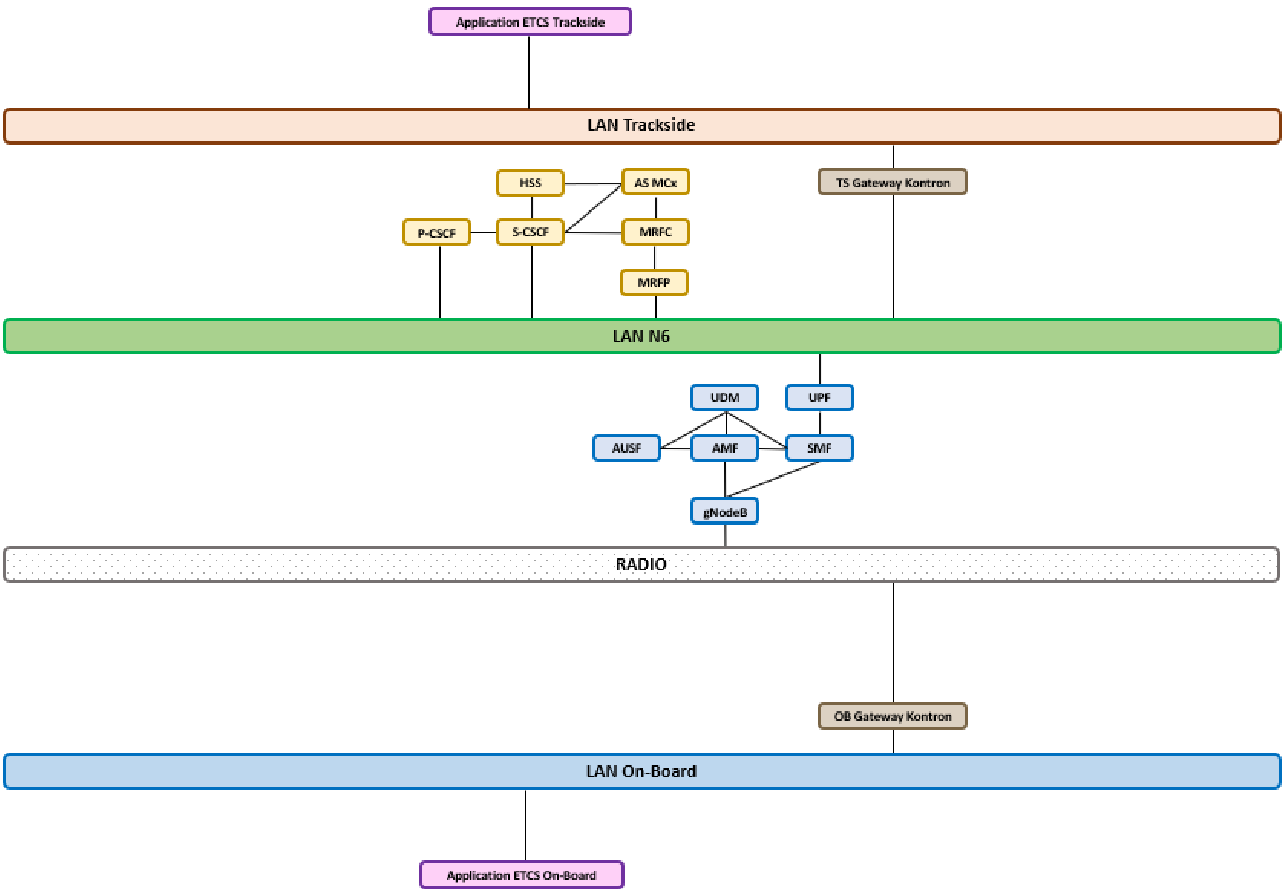


Figure 25: ETCS end to end FRMCS call in normal conditions (Ref.D4.2)

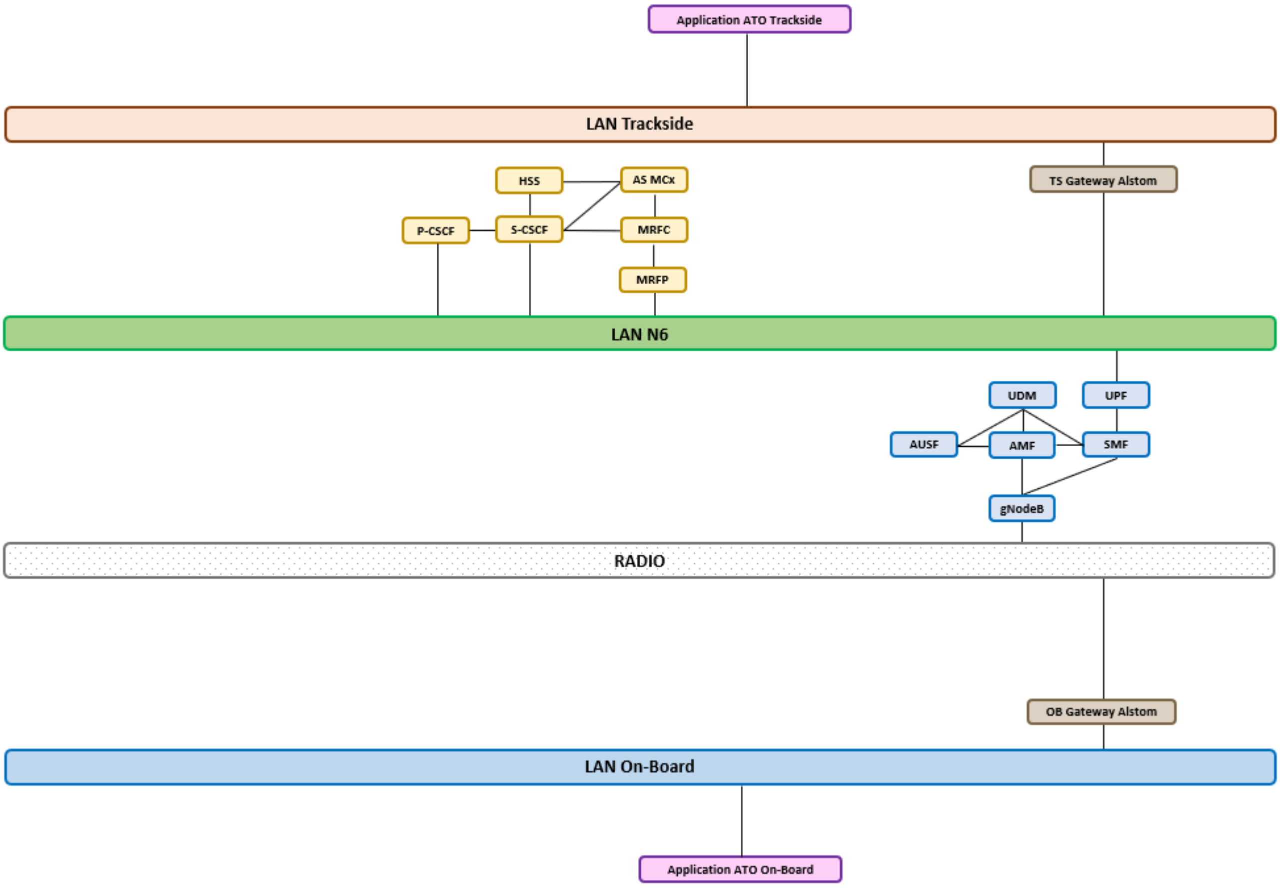


Figure 26: ATO end to end FRMCS call in normal conditions (Ref.D4.2)

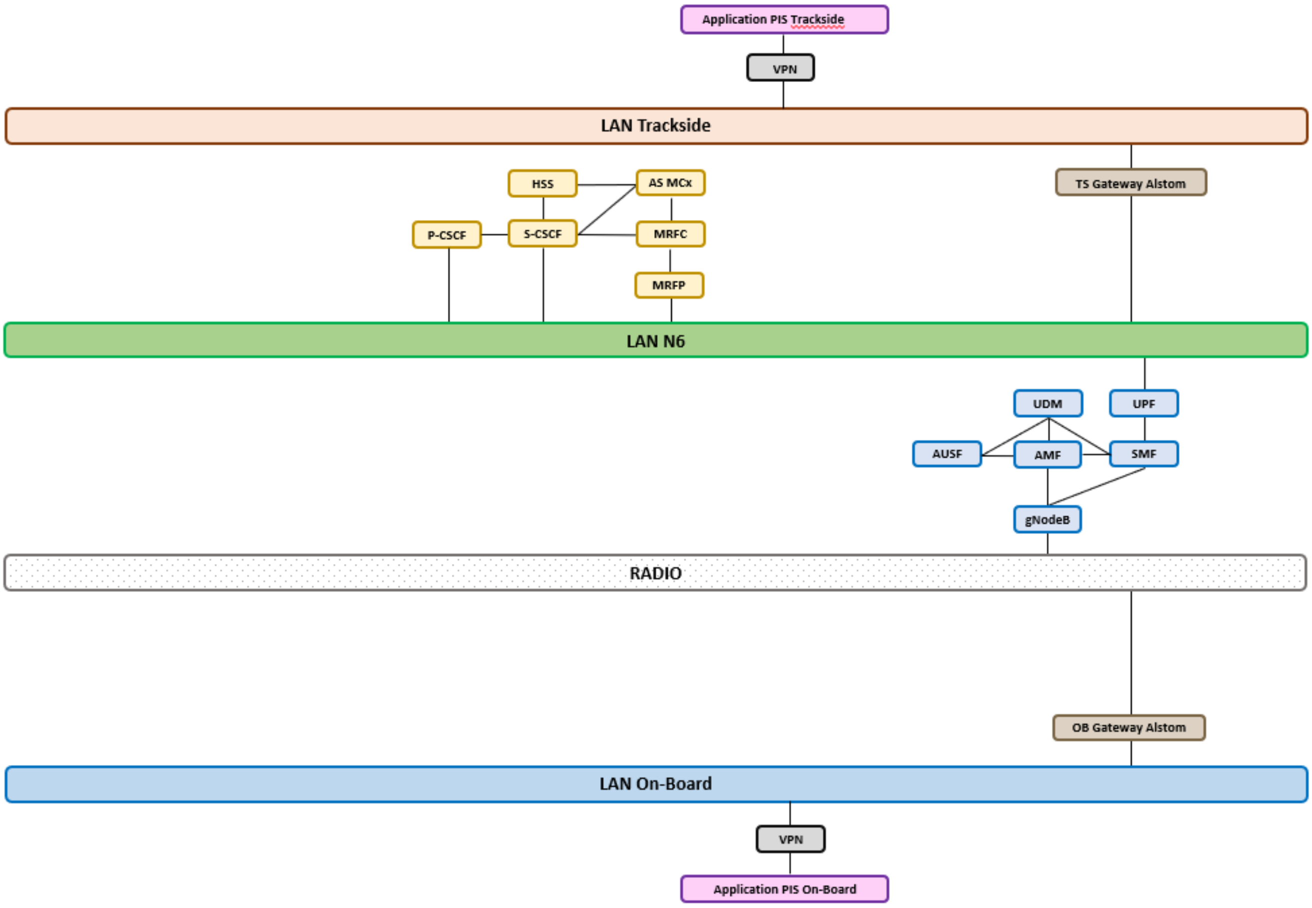


Figure 27: -PIS end to end FRMCS call in normal conditions (Ref.D4.2)

The common radio set-up to use for all these applications is the following:

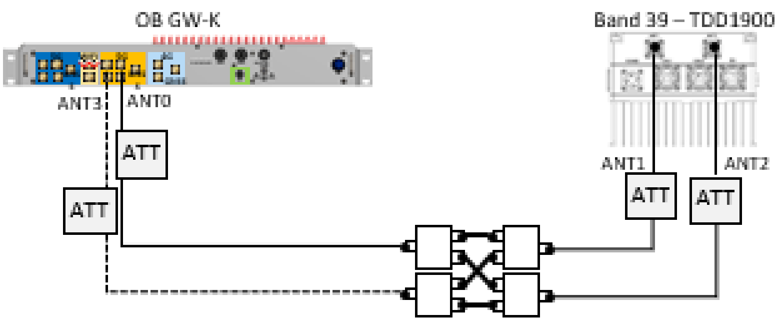


Figure 28: Radio setup of FRMCS call in normal conditions (Ref.D4.2)

5.2 5G HO tests RF configurations in the scope of WP3

For 5G handover testing, HYTEM 6x6 FULL FAN OUT Attenuation Matrix (6x6 - 93/110 dB - 3 to 6 GHz) on n78 band is used by WP3. Attenuator matrix can be controlled locally and remotely as well. Configuration can be seen the figure below where RRUs represent separate 5G cells.

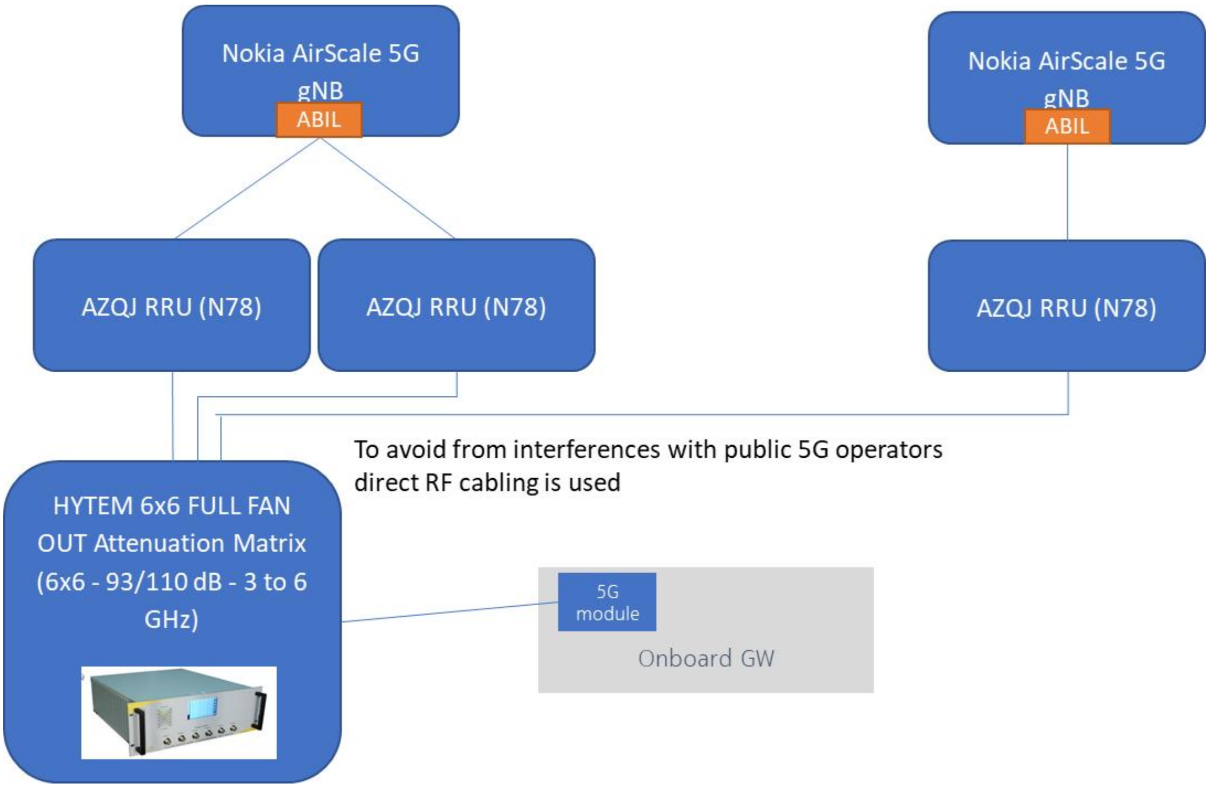


Figure 29: 5G HO RF configuration in the scope of WP3 (Ref. D3.2)

5.3 5G HO test configurations in the scope of WP4 (ETCS, ATO)

The following figures present the network configuration for the 5G HO test cases per application, where the OB GW will move from one 5G cell to another or from one gNodeB to another, using the common radio 5G HO set-up in the RMR band n39, as presented in Figure 36:

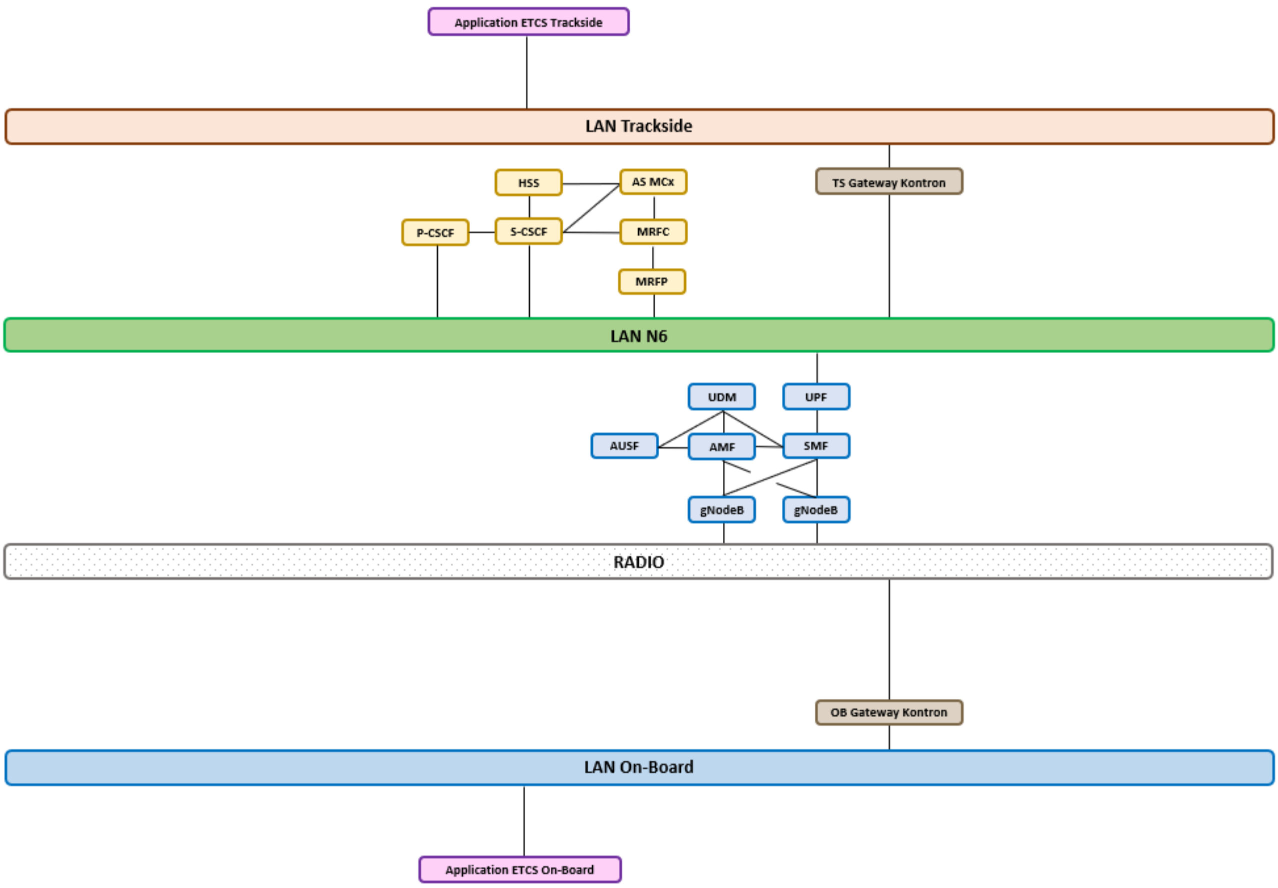


Figure 30: ETCS end-to-end FRMCS call with 5G inter gNodeB HO (Ref.D4.2)

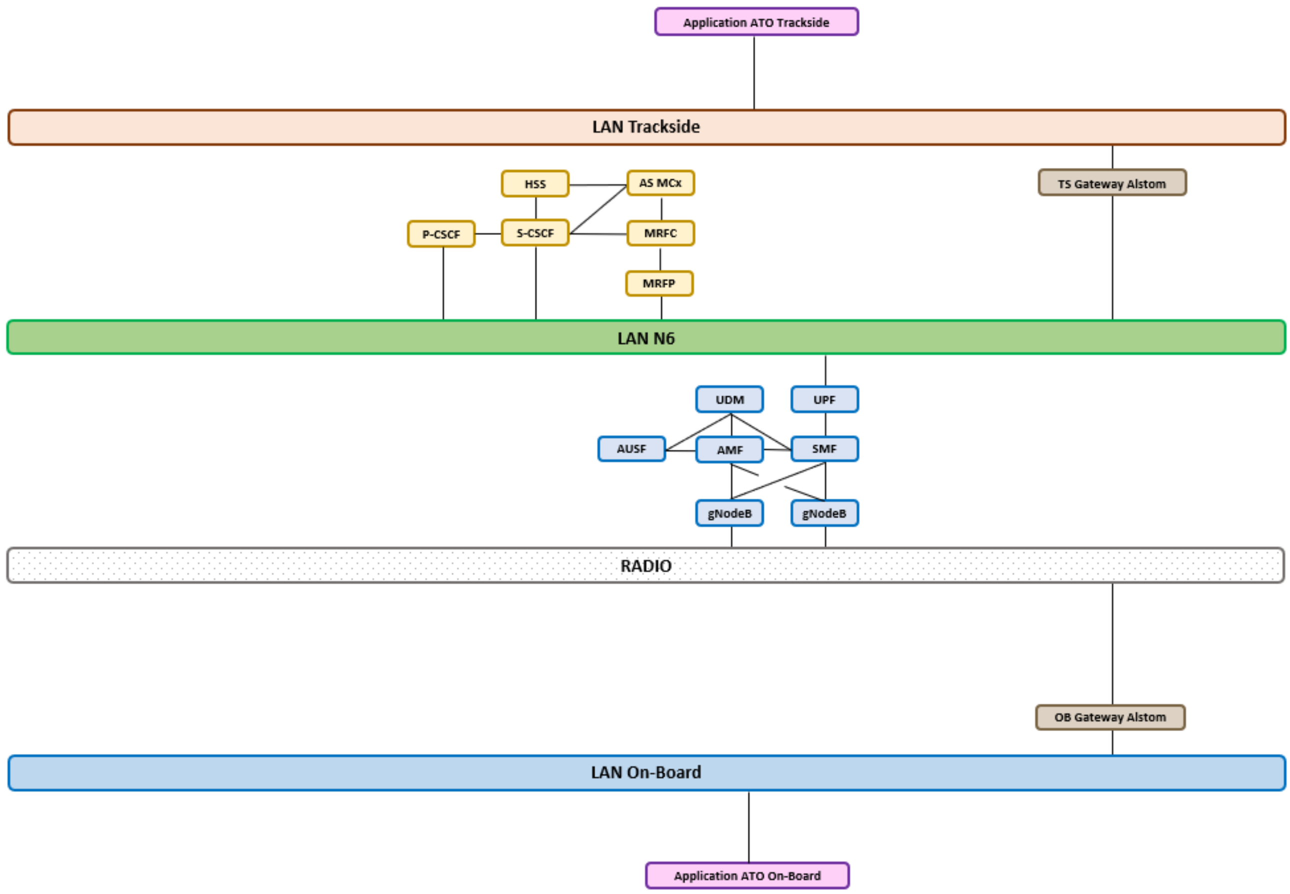


Figure 31: ATO end-to-end FRMCS call with 5G inter gNodeB HO (Ref.D4.2)

In case of inter gNodeB HO under the same 5Gcore, two Kontron ME1210 equipment are needed, as presented in the below figure. This is because, as explained in D4.1 and D4.2, ME1210 can host only one 5Gcore and one CU/DU together. In case a 2nd CU/DU is needed as per inter gNodeB HO, a 2nd ME1210 is required.

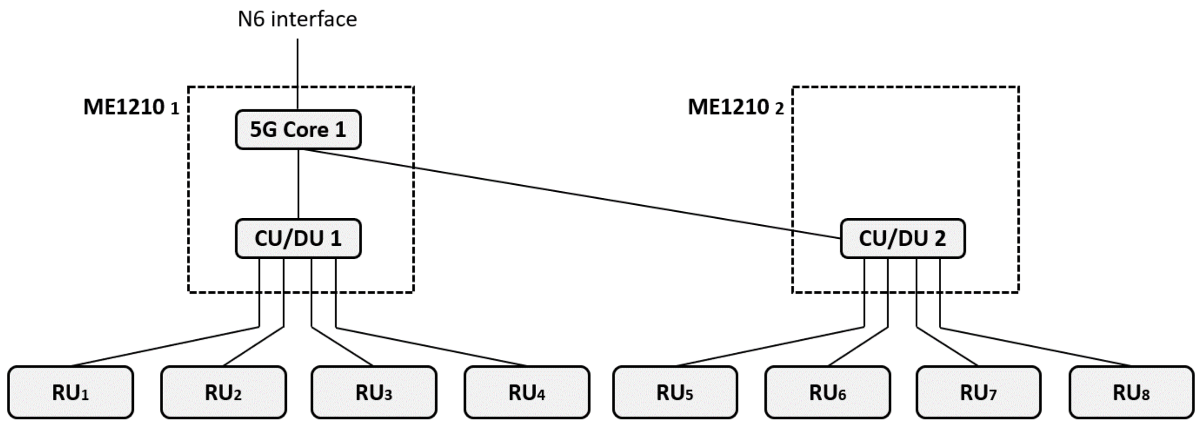


Figure 32: Configuration for inter gNodeB HO under the same 5G Core (Ref.D4.2)

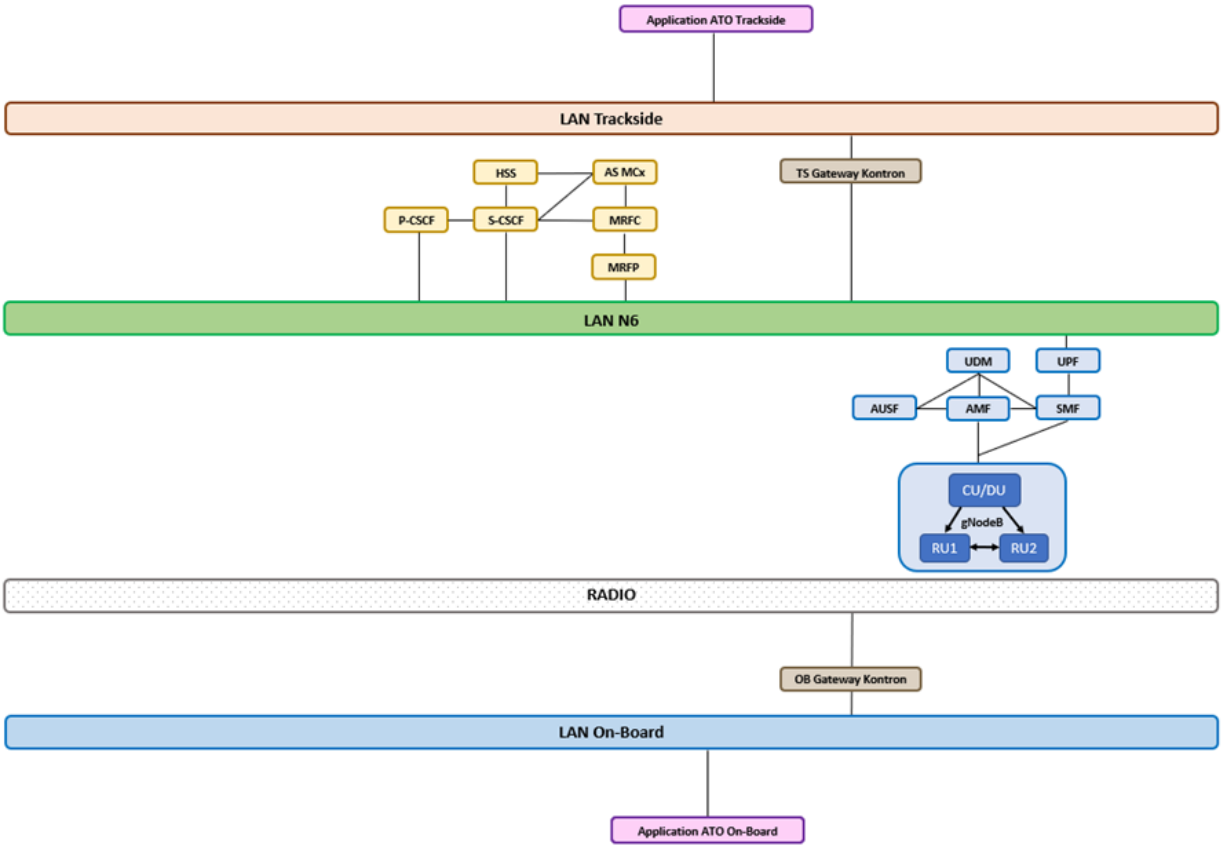


Figure 33: ATO end-to-end FRMCS call with 5G intra gNodeB HO

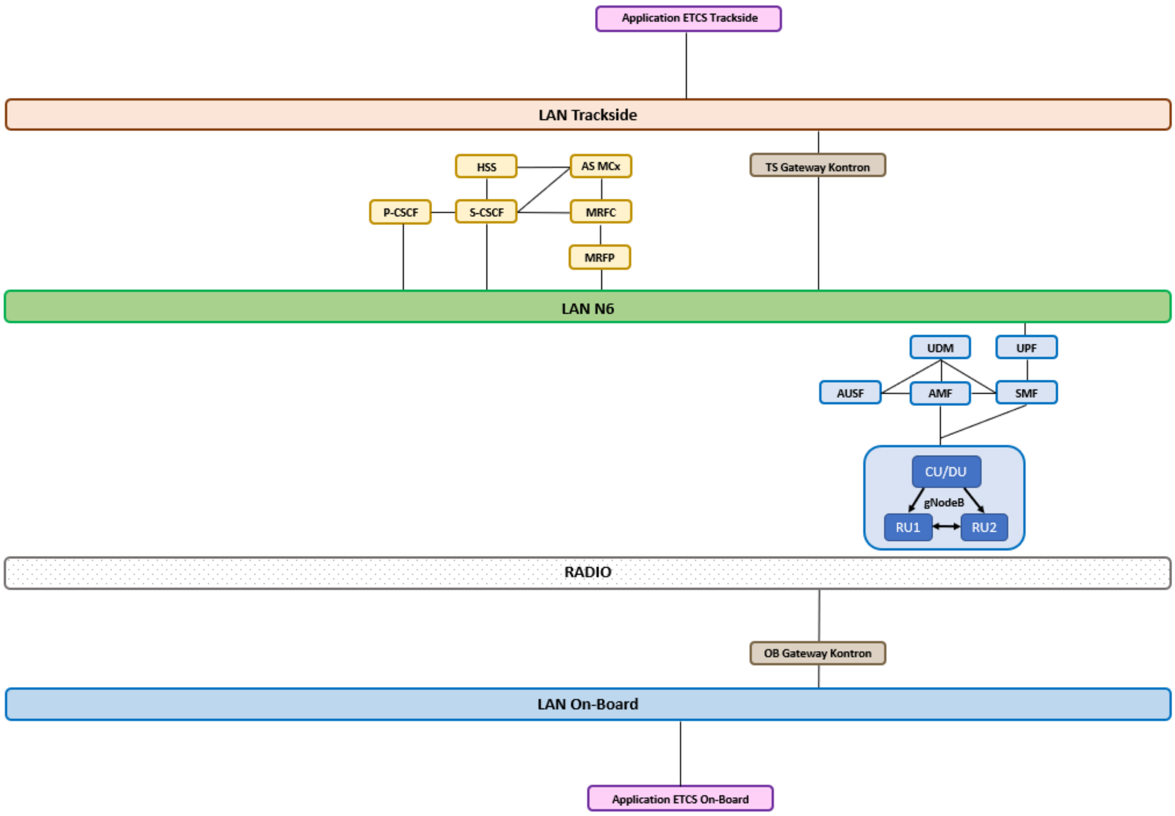


Figure 34: ETCS end-to-end FRMCS call with 5G intra gNodeB HO

In case of intra gNodeB HO, one ME1210 equipment can host the 5Gcore and CU/DU managing the two RUs (two cells), as presented in the figure below:

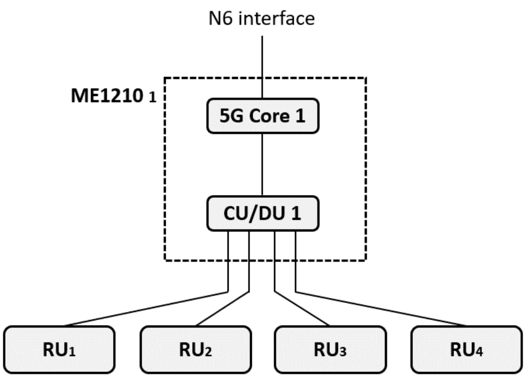


Figure 35: Configuration for intra gNodeB HO under the same 5G Core (Ref.D4.2)

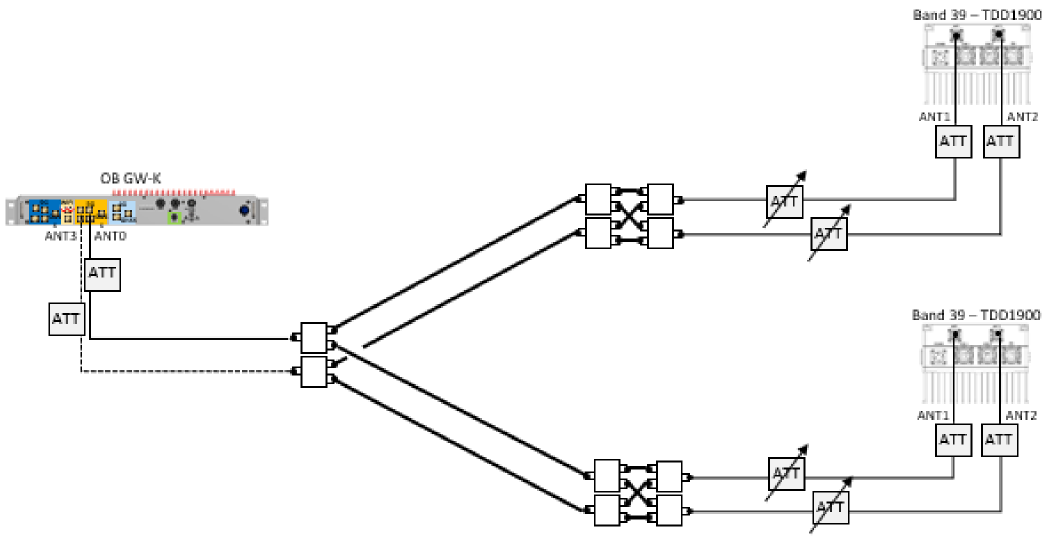


Figure 36: Radio set-up FRMCS call with 5G HO (Ref.D4.2)

5.4 Cross-border test configurations in the scope of WP4 (ETCS)

The following figure presents the network and radio set-up for the cross-border scenario with the ETCS application where, the OB GW will move from one 5G PLMN to another one. The radio set-up of this configuration is presented in Figure 38

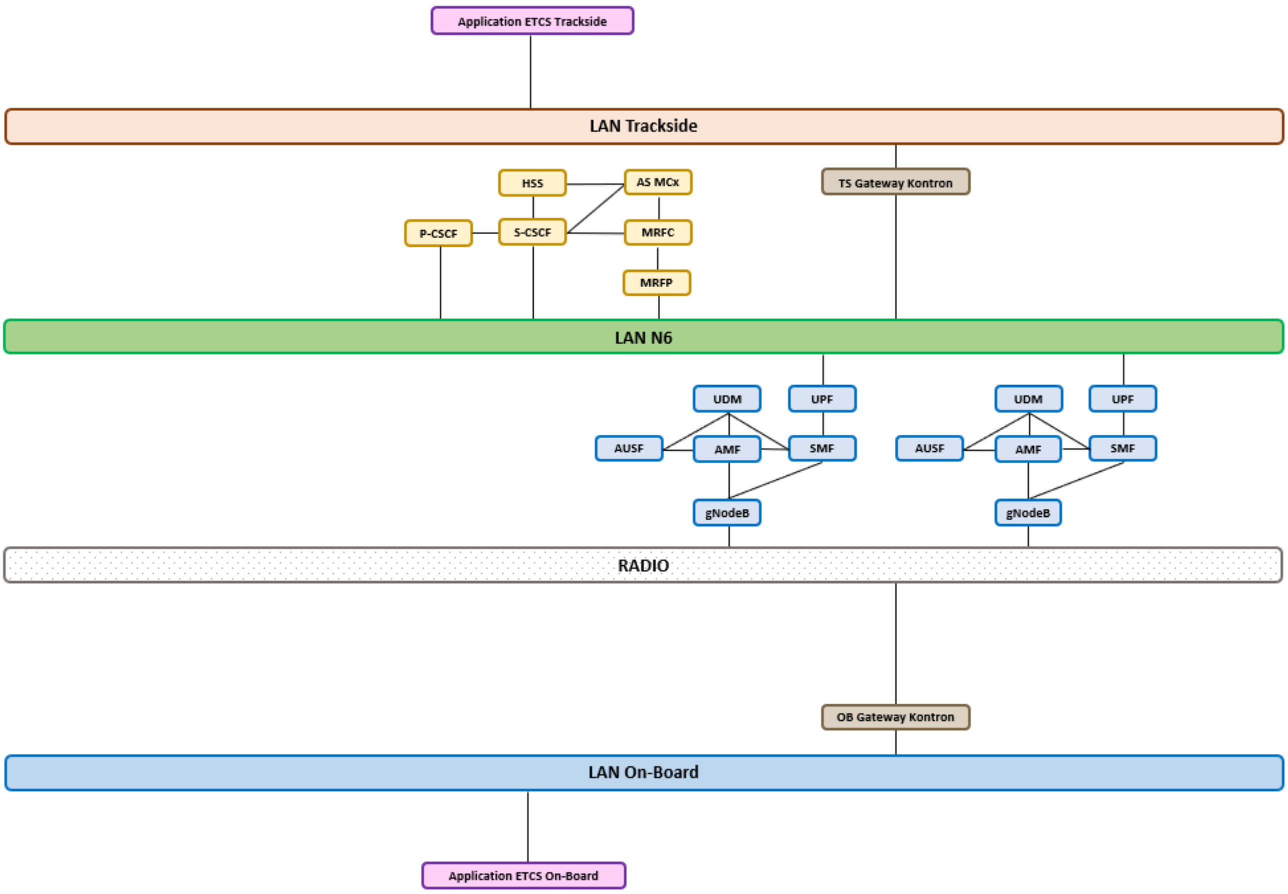


Figure 37: ETCS end-to-end FRMCS call set-up in cross-border scenario (Ref.D4.2)

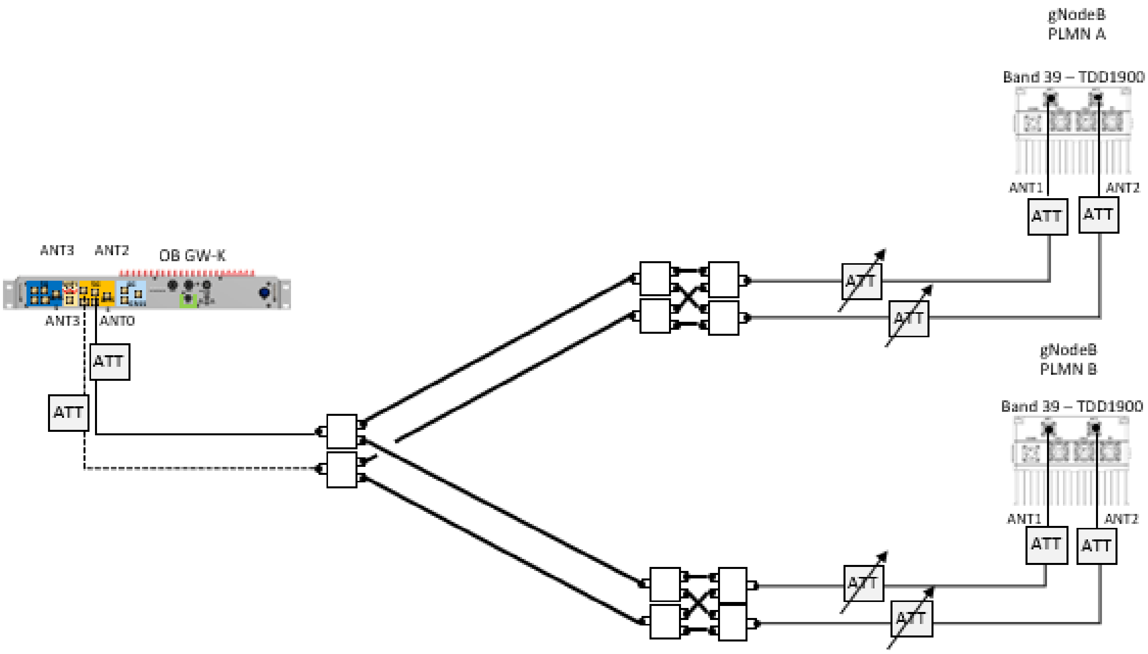


Figure 38: Radio set-up in cross-border scenario (Ref.D4.2)

5.5 Bearer-flex test configurations in the scope of WP4 (ETCS, ATO)

The following figures present the network configuration per application in case of bearer flex and the common radio set-up configuration, as per Figure 41. Two scenarios will be tested to validate the bearer flex feature:

- **Redundant use case** where a train moves from 5G only coverage to 4G only coverage and vice versa.
- **Aggregation use case** where a train moves from 5G only coverage to 4G and 5G coverage, and vice versa.

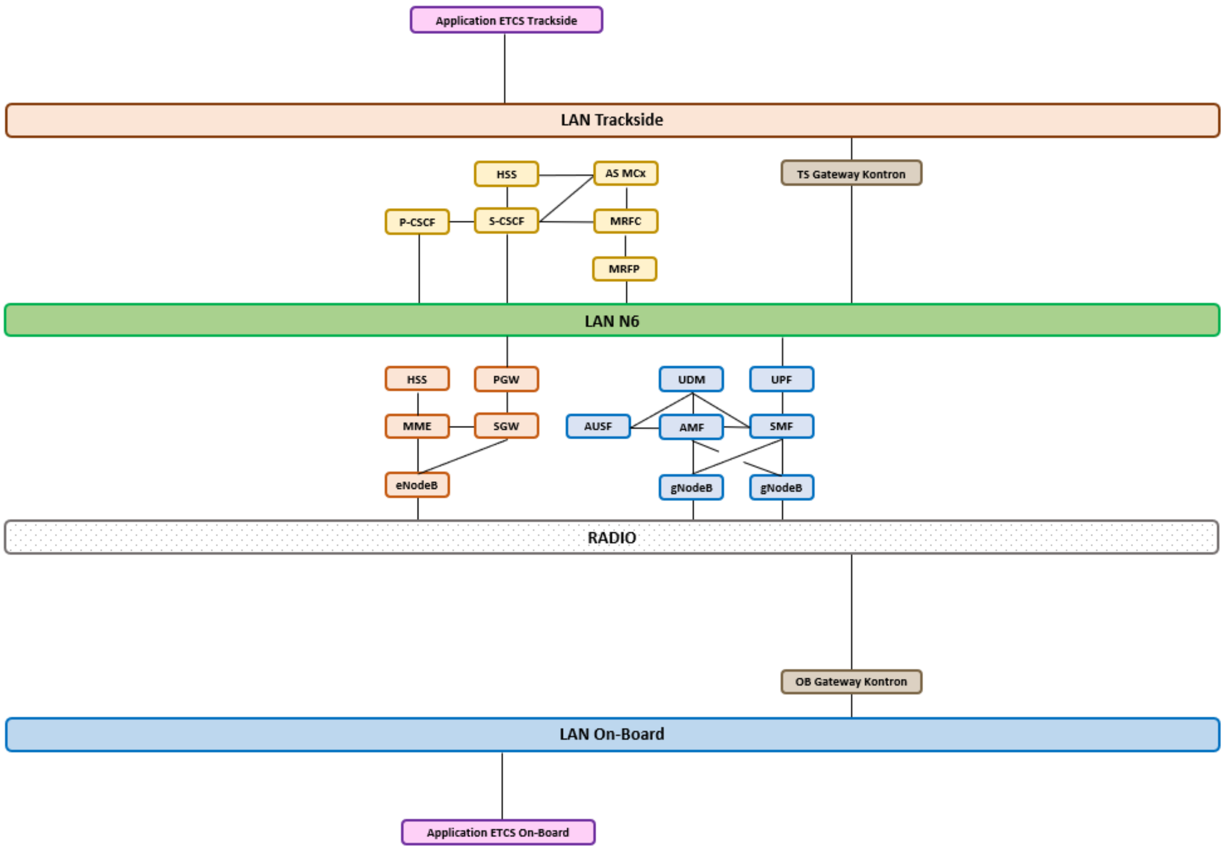


Figure 39: -ETCS end-to-end FRMCS call in bearer-flex (Ref.D4.2)

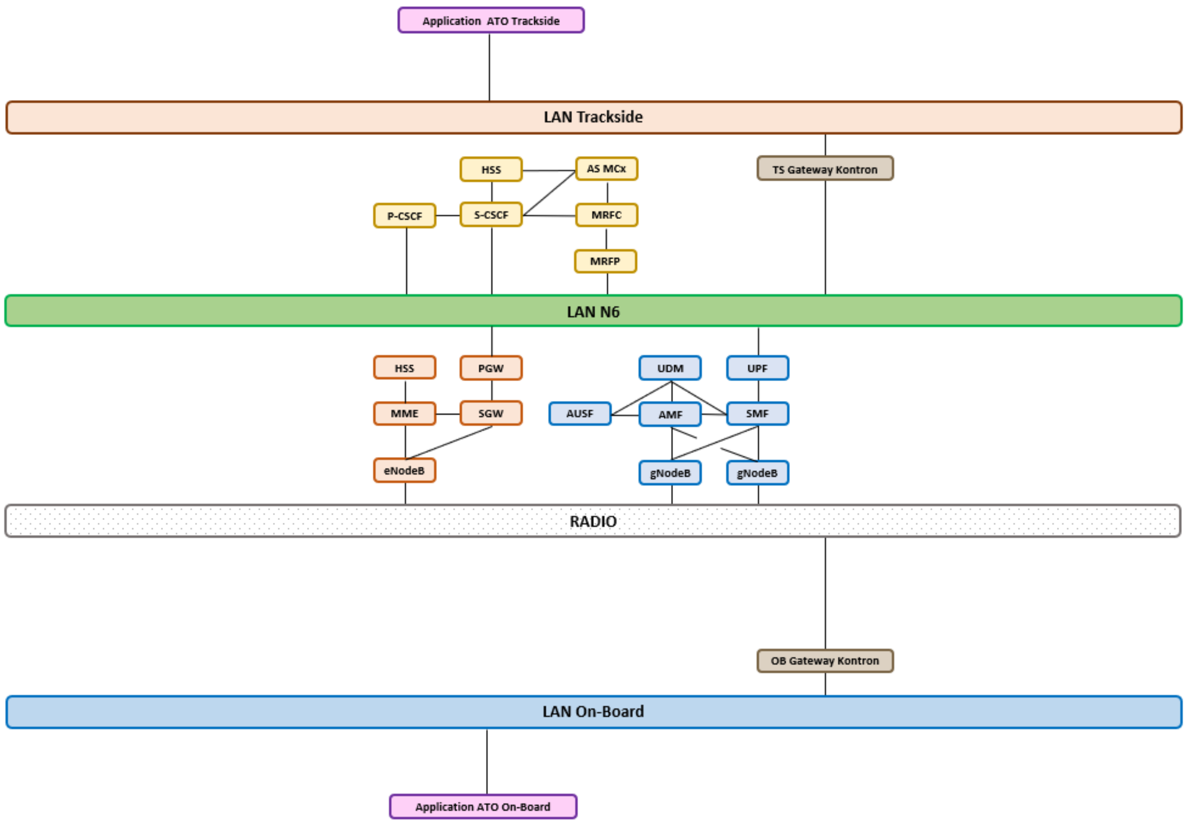


Figure 40: Configuration K - ATO end-to-end FRMCS call in bearer-flex (optional, Ref.D4.2)

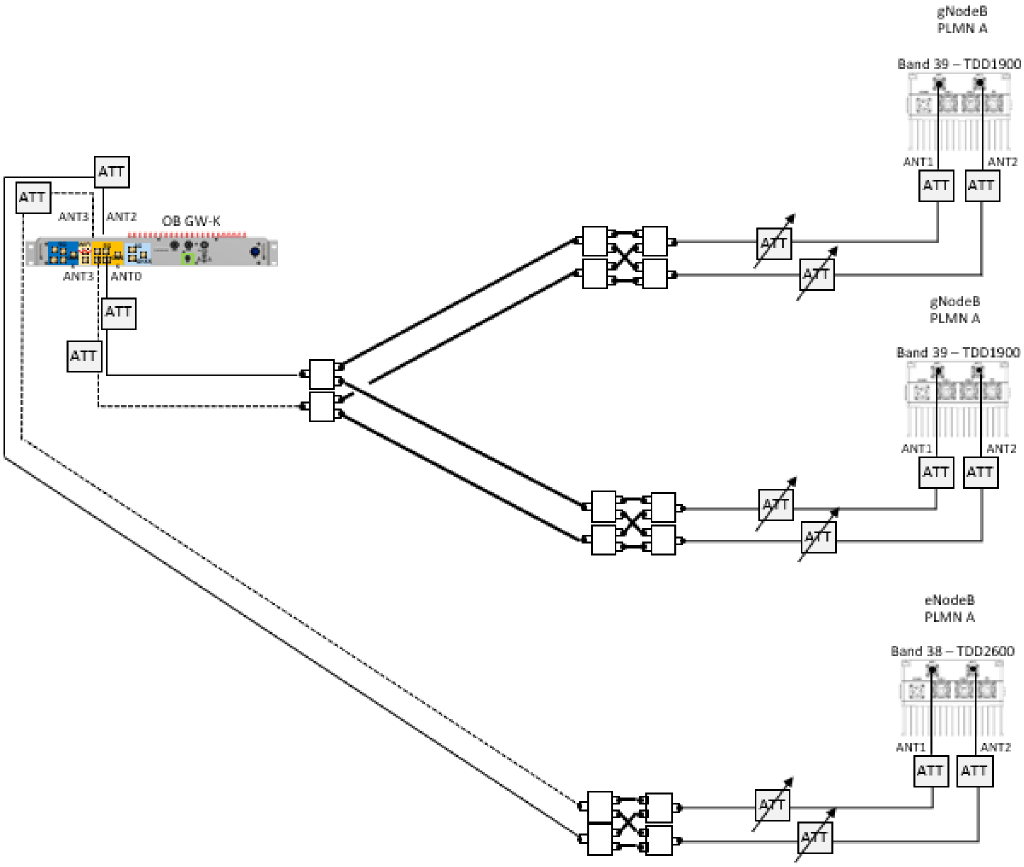


Figure 41: Configuration L-Radio set - up FRMCS call in bearer-flex (Ref.D4.2)

5.6 Radio degraded test cases in the scope of WP3

To test degraded radio condition situations RF emulator tool is used, namely Spirent Vertex Channel Emulator. This emulator is an advanced test and measurement system that accurately simulates the complex effects of signal fading and effects of speed variation on wireless transmissions.

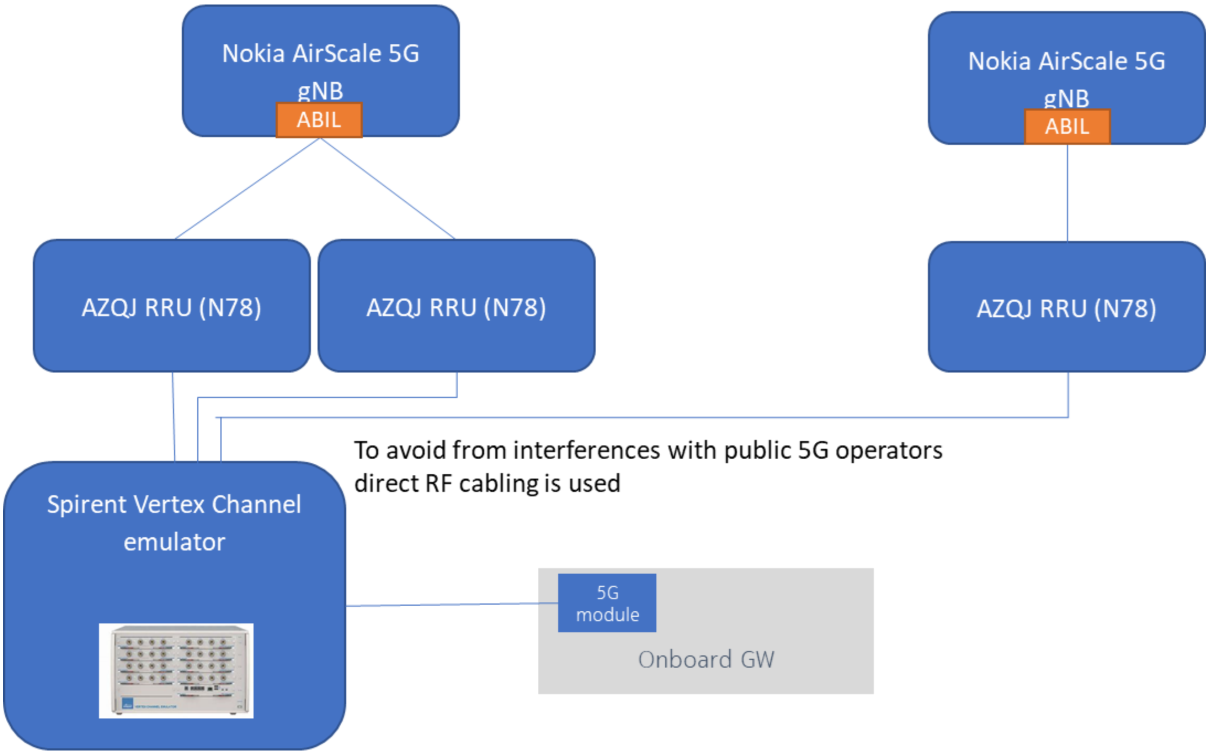


Figure 42: RF configuration setup with Spirent Vertex Channel Emulator in WP3 lab (Ref. D3.2)

5.7 Radio degraded configurations in the scope of WP4 (ETCS, ATO)

The following figures present the network configuration per application in degraded conditions and the common radio set-up configuration for these test cases, as presented Figure 45. That degraded conditions are generated by a tool which emulates real conditions of speed, fading and radio multipath:

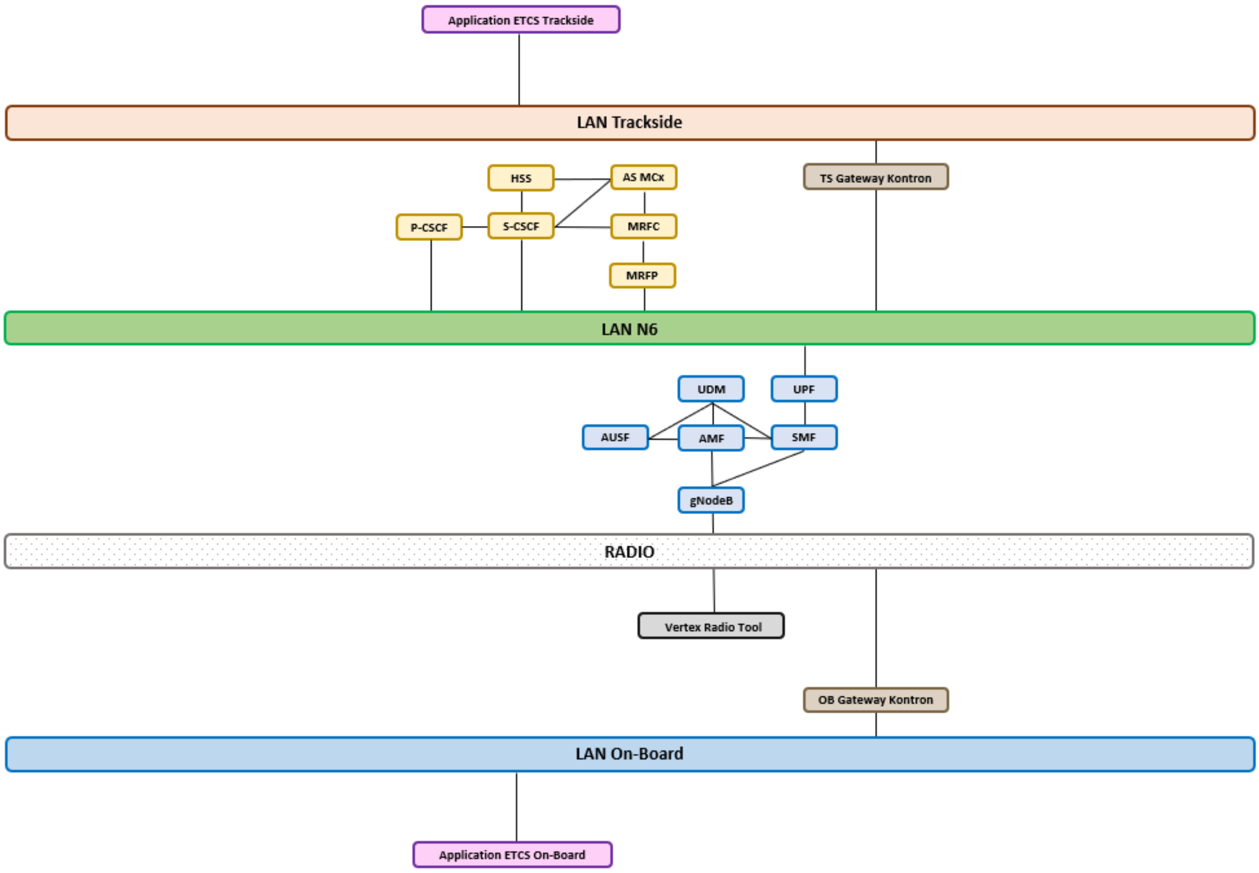


Figure 43: ETCS end-to-end FRMCS call in degraded conditions (Ref.D4.2)

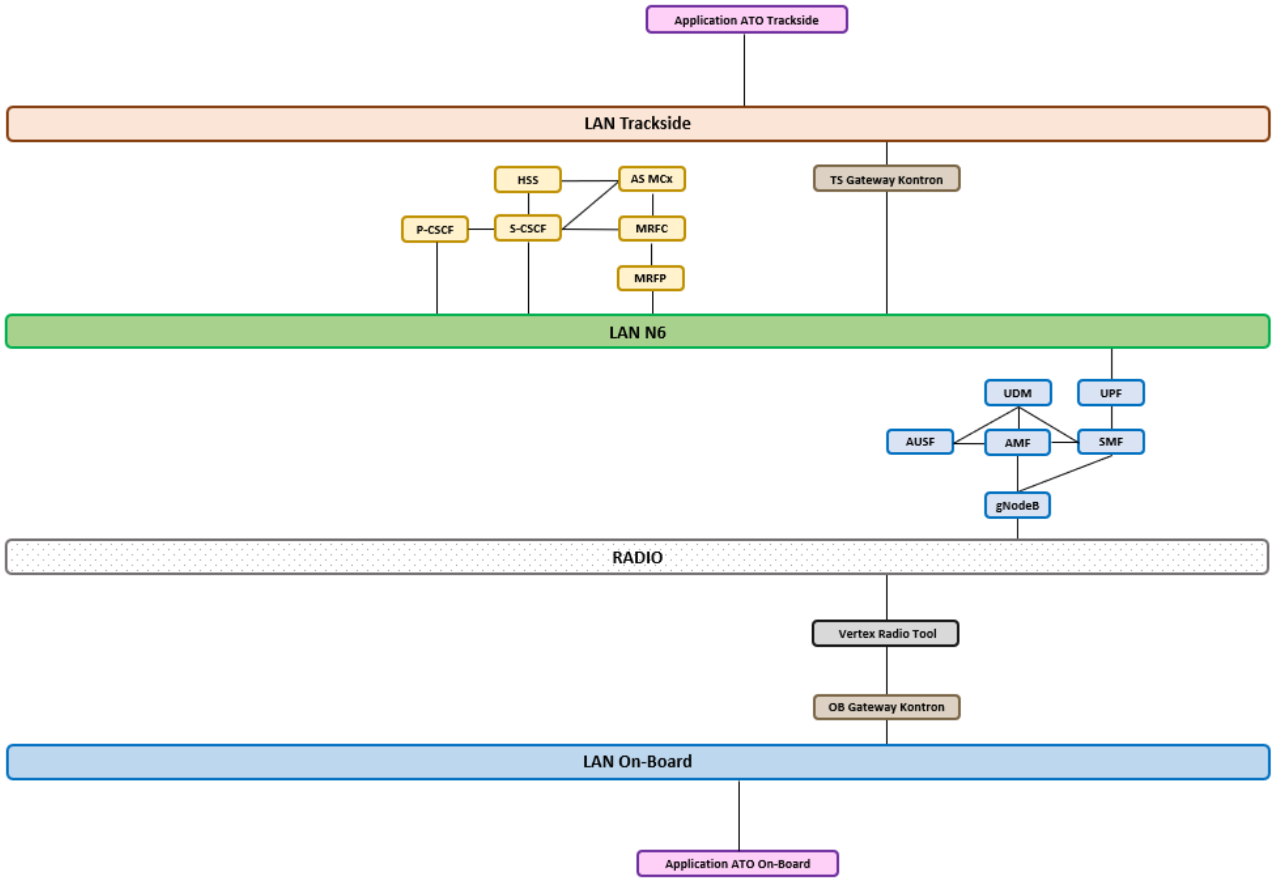


Figure 44: ATO end-to-end FRMCS call in degraded conditions (Ref.D4.2)

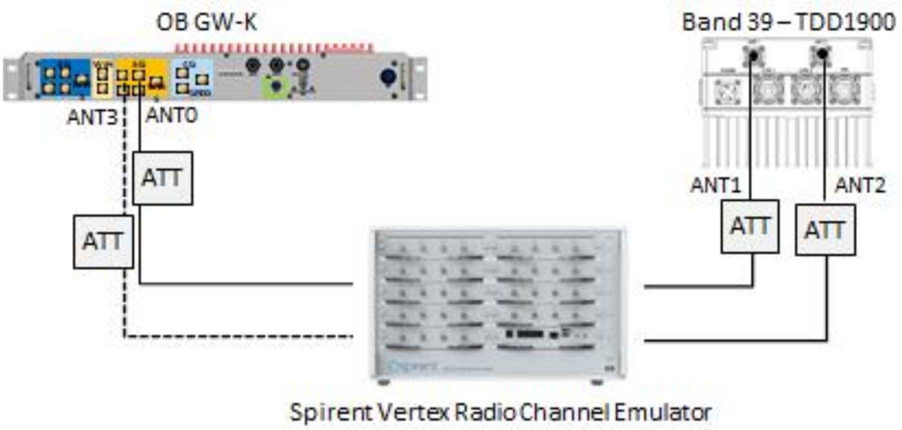


Figure 45: Radio set - up FRMCS call in degraded conditions (Ref.D4.2)

5.8 ATO in parallel with high traffic (uplink or downlink) generated by iPerf

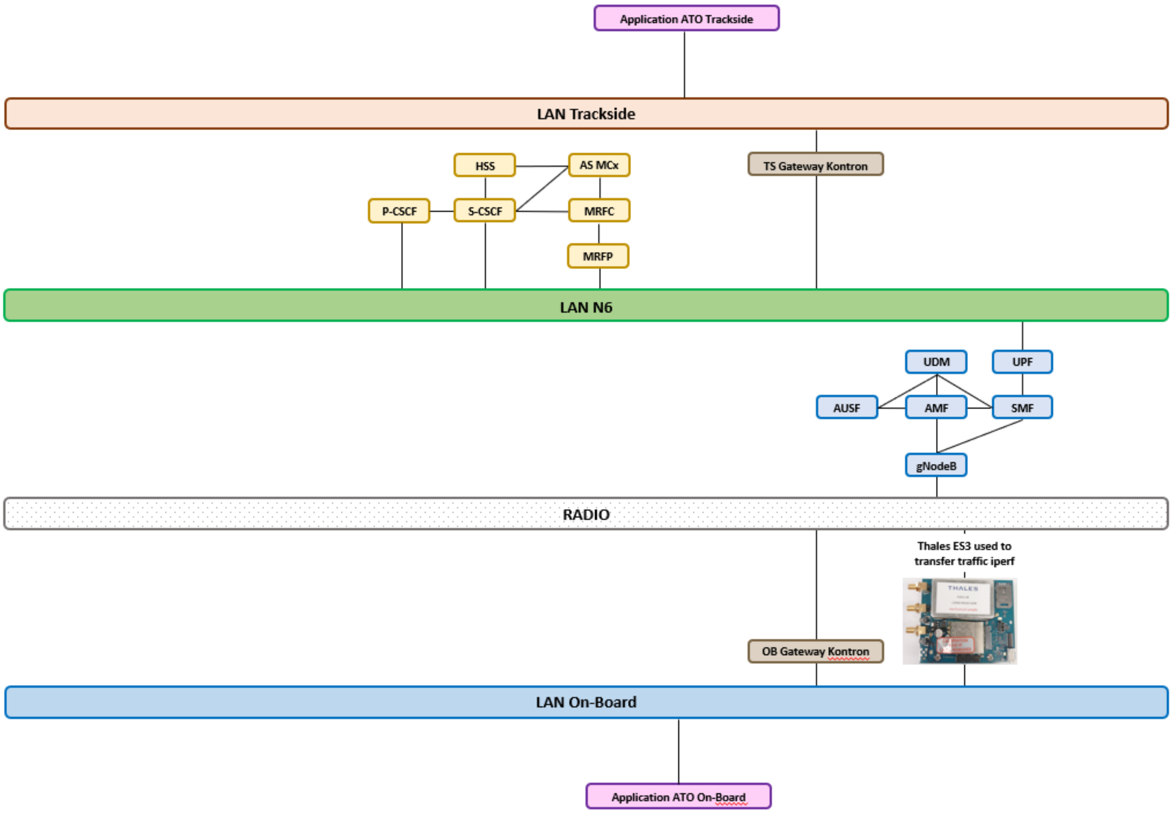


Figure 46: ATO in parallel with high traffic (uplink or downlink) generated by iperf (optional)

5.9 Configurations for optional voice communications in the scope of WP4

The figures below present the network configurations to be used for the optional voice test cases in the scope of WP4. These are:

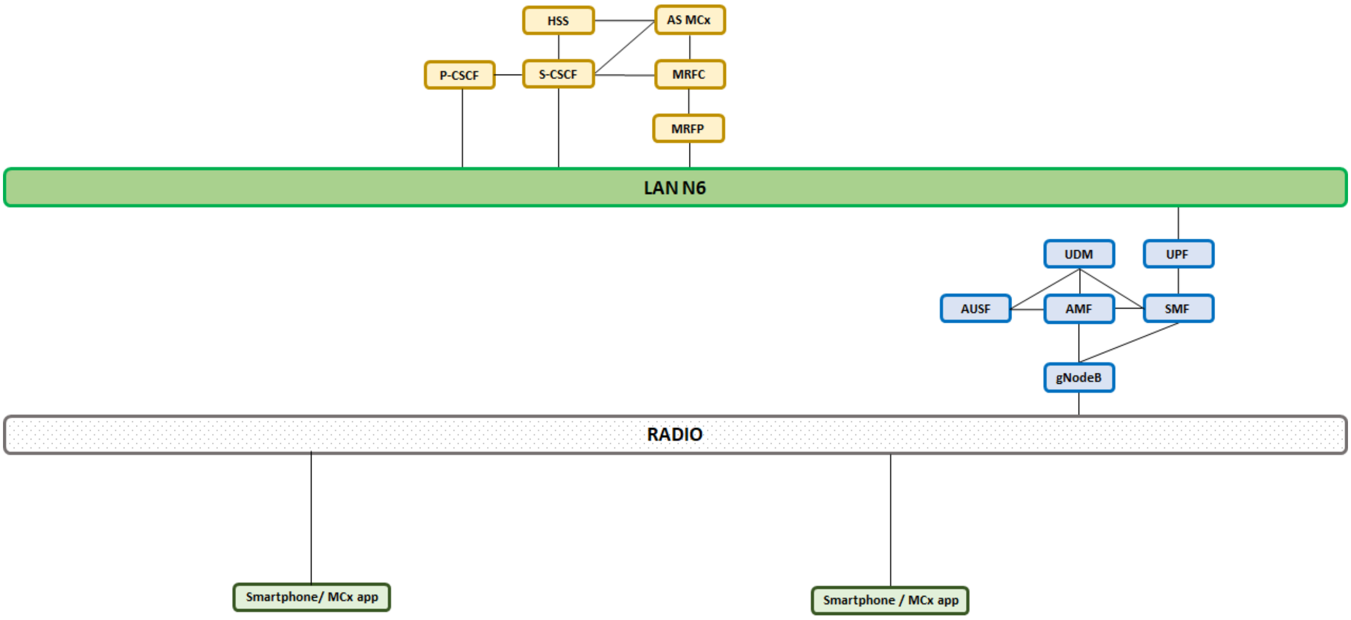


Figure 47: Private MCPTT call without floor management (Ref. WP4)

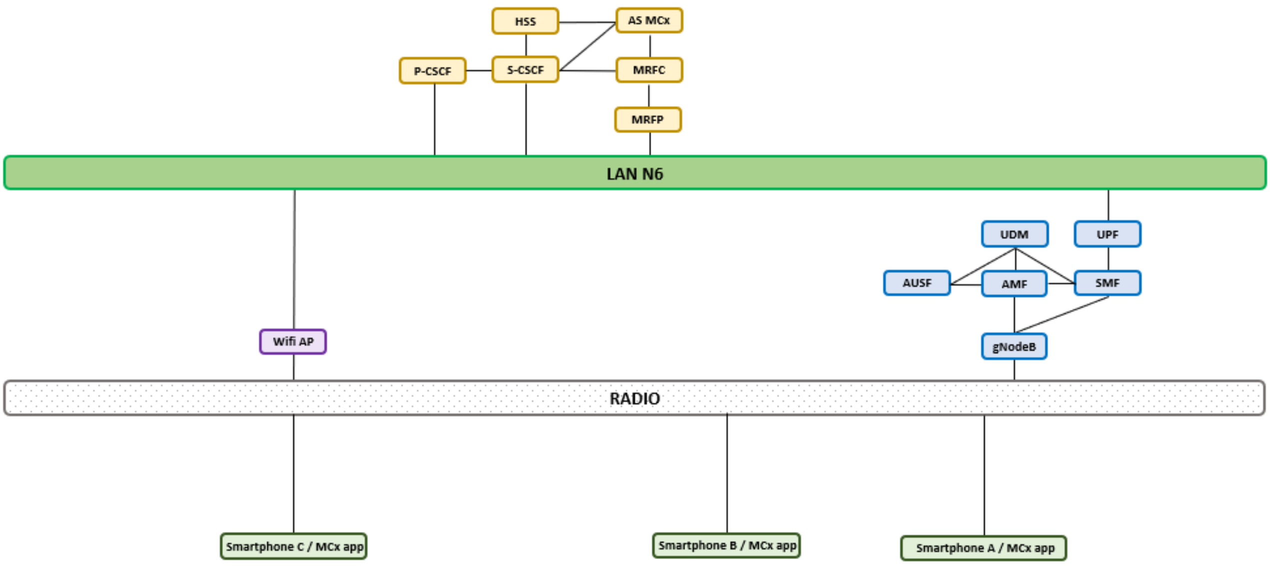


Figure 48: MCPTT group call with floor management(Ref.WP4)

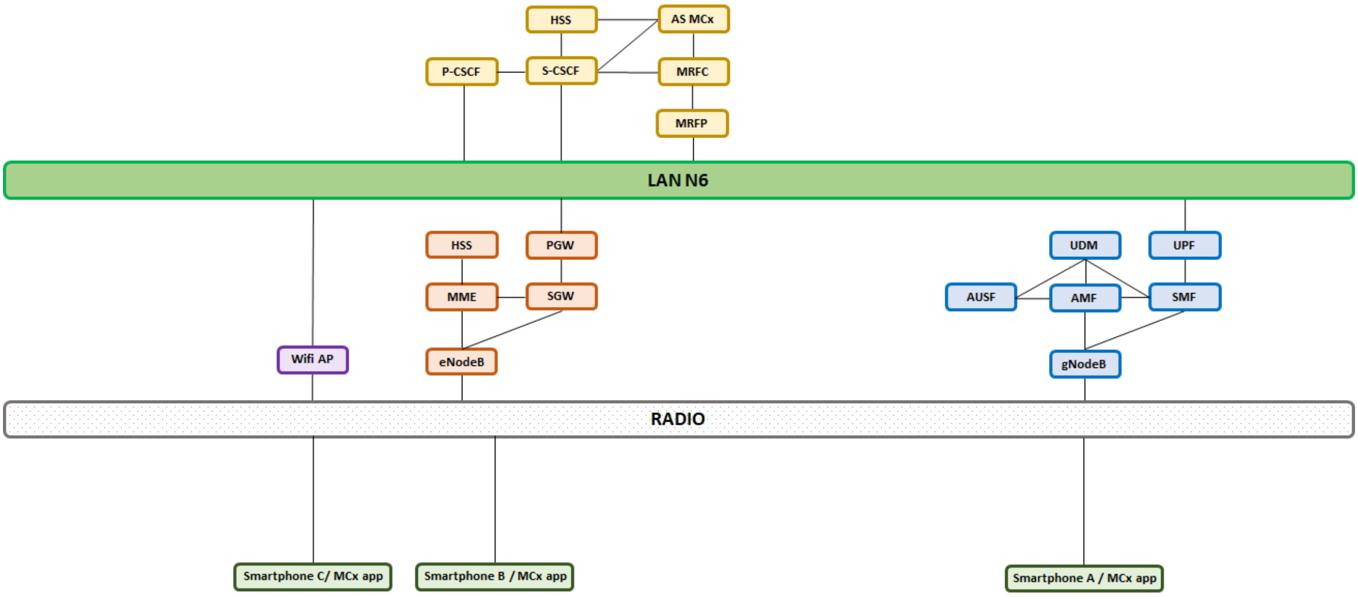


Figure 49: MCPTT emergency group call (Ref.WP4)

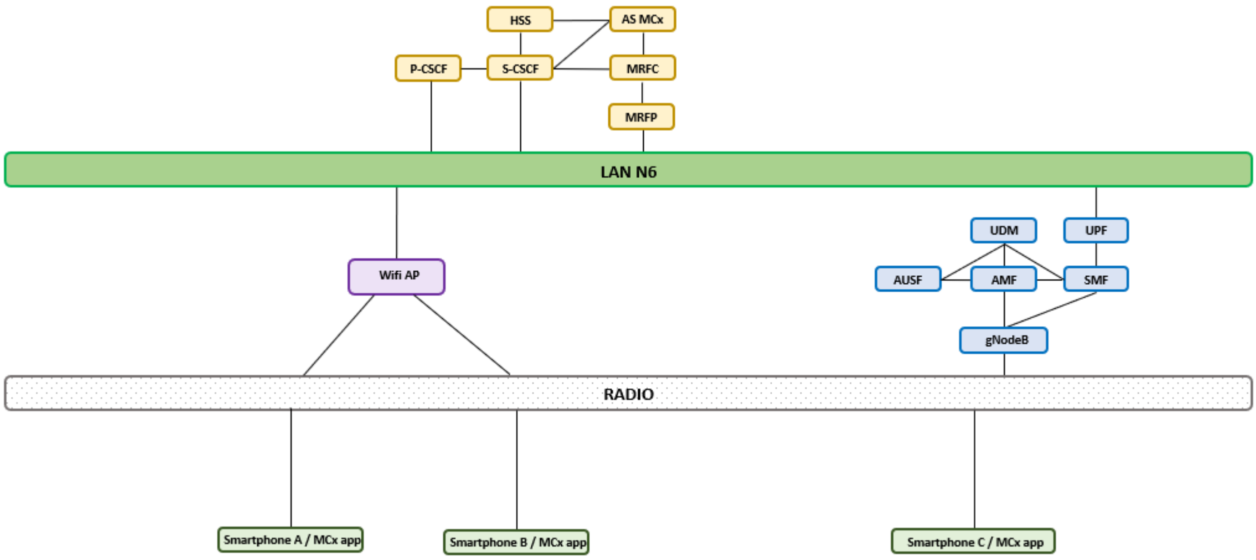


Figure 50: Private MCPTT call is ongoing, and then MCPTT emergency group call is launched.

6 OVERVIEW OF TEST CASES

The test cases to be performed in the scope of 5GRAIL, either in labs or in-field, as described in the following chapters of this test plan document, are divided in three groups:

- Voice application test cases
- Critical data applications test cases: ATP (ETCS), ATO, Remote control of engines
- Non-critical data applications test cases: TCMS, CCTV/Video, PIS

The following table summarizes the test cases to be performed in the scope of WP3 lab, led by Nokia, WP4 led by Kontron, using TOBA-K and/or TOBA-A in bands n8, n39 and n78. Moreover, in the same table will be flagged, the subset of test cases that will be performed in German testbed led by DB with TOBA-K in band n78 or in French testbed led by SNCF with TOBA-K in band n39.

Application_TC_ID	Test case	Test Environment		TOBA	Frequency	Chapter
		Lab	Field			
Voice_001	Registration of a functional identity related to the user	WP3		TOBA-K	n78	7.2.1
Voice_002	Deregistration of a functional identity	WP3		TOBA-K	n78	7.2.2
Voice_003	Authorisation of communication	WP3 (optional)		TOBA-K	n78	7.2.3
Voice_004	Authorisation of application	WP3		TOBA-K	n78	7.2.4
Voice_005	Multi - user talker control	WP3		TOBA-K	n78	7.2.5
Voice_006	Arbitration	WP3	WP5-DE	TOBA-K	n78	7.2.6
Voice_008	Initiation of a voice communication from a train driver towards a train controller responsible for the train movement area	WP3	WP5-DE	TOBA-K	n78	7.3.1
Voice_009	Initiation of a voice communication from a train controller towards a train driver	WP3	WP5-DE	TOBA-K	n78	7.4.1
Voice_010	Initiation of a multi-train voice communication from a train driver towards train drivers and ground users	WP3	WP5-DE	TOBA-K	n78	7.5.1

Voice_21	Initiation of a multi-train voice communication from a train driver towards train drivers and ground users (FRMCS and GSM-R)	WP3	WP5-DE	TOBA-K	n78	7.5.2
Voice_011	Railway Emergency Call initiated by a train controller	WP3	WP5-DE	TOBA-K	n78	7.6.1
Voice_22	Railway Emergency Call initiated by a train driver without interworking	WP3	WP5-DE	TOBA-K	n78	7.6.2
Voice_012	Railway Emergency Call initiated by a train driver including interworking	WP3	WP5-DE	TOBA-K	n78	7.6.3
Voice_013	Joining an ongoing Railway Emergency Call	WP3 (optional)		TOBA-K	n78	7.6.4
Voice_014	Leaving an ongoing Railway Emergency Call	WP3 (optional)		TOBA-K	n78	7.6.5
Voice_015	GSM-R to FRMCS system transition with service continuation	WP3	WP5-DE	TOBA-K	n78	7.6.6
Voice_017	Combined MCPTT private point-to-point voice call in parallel with MCData application	WP3	WP5-DE	TOBA-K	n78	7.8

Voice_018	Combined MCPTT private point-to-point voice call in parallel with MCData application in degraded conditions	WP3		TOBA-K	n78 & n8	7.9
Voice_019	MCPTT private point-to-point voice call (driver to controller) with HO (inter or intra) gNodeB	WP3	WP5-DE	TOBA-K	n78 & n8	7.10
Voice_020	MCPTT private point-to-point voice call (driver to controller) with HO (inter or intra) gNodeB in degraded radio conditions	WP3		TOBA-K	n78 & n8	7.11
ETCS_WP3-WP5_TC_001	Nominal communication between ETCS on board application and RBC	WP3	WP5-DE	TOBA-K	n78	8.1.1.3
ETCS_WP3-WP5_TC_005	Nominal communication between ETCS on board application and RBC, including BTS handover (same 5G network)	WP3	WP5-DE	TOBA-K	n78	8.1.1.4
ETCS_WP3-WP5_TC_002	Communication between ETCS on board application and RBC (same 5G network) in degraded radio conditions	WP3		TOBA-K	n78	8.1.2

ETCS_WP3-WP5_TC_003	Increase data transferred in the ETCS communication	WP3		TOBA-K	n78	8.1.3
ETCS_WP3-WP5_TC_004	ETCS onboard combined with other data application	WP3 (optional)	WP5-DE	TOBA-K	n78	8.1.4
TCMS_TC_001 (Telemetry)	Nominal communication between MCG on board application and GCG	WP3	WP5-DE	TOBA-K	n78	9.2.1.3
TCMS_TC_004 (Telemetry)	Nominal communication between MCG on board application and GCG, including BTS handover (same 5G network)	WP3	WP5-DE	TOBA-K	n78	9.2.1.4
TCMS_TC_002 (Telemetry)	Evaluate FRMCS On-Board System and impact on application with degrading radio conditions	WP3		TOBA-K	n78&n8	9.2.2
TCMS_TC_003 (Telemetry)	Cross border scenario with TCMS (Telemetry) or other MCData application	WP3 (optional)	WP5-DE	TOBA-K	n78	9.2.3
TCMS_RC_TC_001 (On-train remote equipment control)	Nominal communication between GCG trackside application and onboard MCG (same 5G network)	WP3		TOBA-K	n78	9.3.1
Video_TC_001	Streaming of video from train to trackside	WP3	WP5-DE	TOBA-K	n78&n8	9.4.1.3

Video_TC_003	Streaming of video from train to trackside including BTS handover (same 5G network)	WP3	WP5-DE	TOBA-K	n78&n8	9.4.1.4
Video_TC_002	Degraded communication: streaming of video from train to trackside	WP3		TOBA-K	n78&n8	9.4.2
Video_TC_004	Cross-border with streaming of video from train to trackside, using inter-gNodeB handover over AMF	WP3	WP5-DE	TOBA-K	n78	9.4.3
CCTV_TC_001	CCTV offload from train to trackside	WP3	WP5-DE	TOBA-K	n78&n8	9.5.1
CCTV_TC_002	CCTV offload from train to trackside with bearer-flex	WP3	WP5-DE	TOBA-K	n78&n8	9.5.2
ETCS_WP4-WP5 phase 1 integration tests						
ETCS_WP4-WP5_FLAT-IP_TC_001	Procedure 1: Nominal communication in level 2 between ETCS on board application and RBC (same 5G network)	WP4		TOBA-A	n8	8.2.1.18.2.1.1.3
ETCS_WP4-WP5_FLAT-IP_TC_001	Procedure 2: RBC and BTS handover on the same 5G network.	WP4		TOBA-A	n8	8.2.1.1.4
ETCS_WP4-WP5_FLAT-IP_TC_001	Procedure 3: Endurance – RBC handover in a loop during 6h or 8h.	WP4		TOBA-A	n8	8.2.1.1.5

ETCS_WP4-WP5_FLAT-IP_TC_002	Bearer flexibility	WP4		TOBA-A	n8	8.2.1.2
ETCS_WP4-WP5_FLAT-IP_TC_003	Degraded mode: TCP issues during the user plane communication	WP4		TOBA-A	n8	8.2.1.3
ETCS_WP4-WP5 phase 2 (OBapp compatible) integration tests						
ETCS_WP4-WP5_OBapp-TC_001	Check the health of the link between ETCS and TOBA - The WebSocket status is correct	WP4		TOBA-A	n8	8.2.2.1.4
		WP4	WP5-FR	TOBA-K	n39	
ETCS_WP4-WP5_OBapp-TC_001	Check the health of the link between ETCS and TOBA– The WebSocket is not responding	WP4		TOBA-A	n8	8.2.2.1.5
ETCS_WP4-WP5_OBapp-TC_002	Check the registration and the connection status – Registration	WP4		TOBA-A	n8	8.2.2.2.4
		WP4	WP5-FR	TOBA-K	n39	
ETCS_WP4-WP5_OBapp-TC_002	Check the registration and the connection status - Loss of the WebSocket once the registration is COMPLETED	WP4		TOBA-A	n8	8.2.2.2.8
ETCS_WP4-WP5_OBapp-TC_002	Check the connection status	WP4		TOBA-A	n8	8.2.2.2.9
		WP4	WP5-FR	TOBA-K	n39	
WP4_ETCS functional tests						
		WP4	WP5-FR	TOBA-K	n39	8.2.2.3.3

ETCS_WP4-WP5_TC_003	Procedure 1: Nominal communication in level2	WP4		TOBA-A	n8	
ETCS_WP4-WP5_TC_003	Procedure 2: RBC handover on the same 5G network	WP4	WP5-FR	TOBA-K	n39	0
		WP4		TOBA-A	n8	
ETCS_WP4-WP5_TC_003	Procedure 3: RBC handover on a different 5G network (cross-border scenario)	WP4	WP5-FR	TOBA-K	n39 with 1UE and 2UEs with n39, b38	8.2.2.3.5
		WP4		TOBA-A	2UEs: n8	
ETCS_WP4-WP5_TC_003	Procedure 4: RBC & BTS handover on the same 5G network	WP4	WP5-FR	TOBA-K	n39	8.2.2.3.6
ETCS_WP4-WP5_TC_003	Procedure 5.1: Redundancy use case: OB GW going from 5G to 4G coverage with on-going ETCS call continuation	WP4	WP5-FR	TOBA-K	n39&b38	8.2.2.3.7.1
		WP4		TOBA-A	n8&b38	
ETCS_WP4-WP5_TC_003	Procedure 5.2: Redundancy use case: OB GW going from 4G to 5G coverage with on-going ETCS call continuation	WP4	WP5-FR	TOBA-K	n39&b38	8.2.2.3.7.2
		WP4		TOBA-A	n8&b38	

ETCS_WP4-WP5_TC_003	Procedure 5.3: Aggregation use case: OB GW under 5G coverage, moves to a place with overlapping of 4G and 5G coverage. ETCS call continues using both bearers simultaneously.	WP4	WP5-FR	TOBA-K	n39&b38	8.2.2.3.7.3
ETCS_WP4-WP5_TC_003	Procedure 5.4: Aggregation use case: OB GW under overlapping 4G and 5G coverage is performing ETCS call using simultaneously both bearers. It moves under 5G only coverage and on-going call still continuous.	WP4	WP5-FR	TOBA-K	n39&b38	8.2.2.3.7.4
ETCS_WP4-WP5_TC_003	ETCS and iPerf UDP test. ETCS on 5G and iPerf UDP on 4G. TOBA-A moves from 5G only area to 4G/5G area. ETCS traffic continues on 5G and UDP iperf on 4G.	WP4		TOBA-A	n8&b38	8.2.2.3.7.5
ETCS_WP4-WP5_TC_003	ETCS and iPerf UDP test. ETCS on 5G and iPerf UDP on 4G. TOBA-A moves from 5G only area to 4G/5G area. ETCS traffic continues on 5G and UDP iperf on 4G.	WP4		TOBA-A	n8&b38	8.2.2.3.7.6

ETCS_WP4-WP5_TC_004	Procedure 1: Communication in level2 using Vertex tool with fading and varying speed	WP4		TOBA-K	n39	8.2.2.4.1
	Procedure 2: RBC handover on the same 5G network using Vertex tool with fading and varying speed	WP4		TOBA-K	n39	8.2.2.3.7.4
	Procedure 3: RBC & BTS handover on the same 5G network using Vertex tool with fading and varying speed	WP4		TOBA-K	n39	8.2.2.4.1
WP4_ETCS in degraded mode						
ETCS_WP4-WP5_TC_005	Procedure 1: Failure during the session establishment – RBC ID	WP4		TOBA-A	n8	8.2.2.5.3
	Procedure 3: Crash of the WebSocket during the session establishment	WP4		TOBA-A	n8	8.2.2.5.6
	Procedure 4: Crash of the WebSocket once the GTW answers O. K	WP4		TOBA-A	n8	8.2.2.5.7
	Procedure 5: Crash of the WebSocket once Session is working	WP4		TOBA-A	n8	0
	Procedure 6: Communication loss: because of the WebSocket	WP4		TOBA-A	n8	8.2.2.5.9

	Procedure 7: Communication loss: session loss and recovery	WP4		TOBA-A	n8	8.2.2.5.10
	Procedure 9: RBC loss and TCP retries	WP4		TOBA-A	n8	8.2.2.5.12
	Procedure 10: TCP issues during the user plan communication	WP4		TOBA-A	n8	8.2.2.5.13
ATO phase 1 integration tests						
ATO_FLAT-IP-TC_001:	ATO in nominal and perfect lab conditions	WP4		TOBA-A	n8	8.3.2
ATO phase 2 (OBapp) integration						
ATO_ OBapp-TC_001	Check the health of the link between ATO and the TOBA – The WebSocket status is correct	WP4		TOBA-A	n8	8.3.1.1.3
		WP4	WP5-FR	TOBA-K	n39	
	Check the health of the link between ATO and the TOBA – The WebSocket status is not responding	WP4		TOBA-A	n8	8.3.1.1.4
ATO_ OBapp-TC_002	Check the registration and the connection status – Procedure 1: Registration	WP4		TOBA-A	n8	8.3.1.2.3
		WP4	WP5-FR	TOBA-K	n39	

	Check the registration and the connection status – Procedure 4: Loss of the WebSocket once the registration is completed	WP4		TOBA-A	n8	8.3.1.2.6
	Procedure 5: Check the connection status	WP4		TOBA-A	n8	8.3.1.2.7
		WP4	WP5-FR	TOBA-K	n39	
ATO in degraded mode						
ATO -TC_004	Procedure 1: Unsuccessful session establishment	WP4		TOBA-A	n8	8.3.1.4.3
	Procedure 2: Crash of the WebSocket after the session establishment	WP4		TOBA-A	n8	8.3.1.4.4
	Procedure 3: Crash of the WebSocket once the GTW answers O. K	WP4		TOBA-A	n8	8.3.1.4.5
	Procedure 4: Crash of the WebSocket once Session is working	WP4		TOBA-A	n8	8.3.1.4.6
	Procedure 5: Communication LOSS because of the WebSocket	WP4		TOBA-A	n8	8.3.1.4.7
	Procedure 7: Communication LOSS: session loss and Applicative timeout	WP4		TOBA-A	n8	8.3.1.4.9

	Procedure 8: ATO trackside loss and ATO On-board retries	WP4		TOBA-A	n8	8.3.1.4.10
	Procedure 9: ATO On-board issues during the user plane communication	WP4		TOBA-A	n8	0
ATO functional tests						
ATO_TC_003	ATO in nominal and perfect lab conditions	WP4		TOBA-A	n8	8.3.1.3
		WP4	WP5-FR	TOBA-K	n39	
ATO_TC_005	ATO in nominal conditions performing intra gNodeB HO	WP4	WP5-FR	TOBA-K	n39	8.3.3
ATO_TC_006	ATO in nominal conditions performing inter gNodeB HO	WP4	WP5-FR	TOBA-K	n39	8.3.4
ATO_TC_007	ATO in radio degraded conditions	WP4	WP5-FR	TOBA-K	n39	8.3.5
ATO_TC_008	Bearer flexibility: 5G to 4G failover	WP4		TOBA-A TOBA-K	n8 n39	8.3.6.1
ATO_TC_008	Bearer flexibility: 4G to 5G	WP4		TOBA-A TOBA-K	n8 n39	8.3.6.2
ATO_ETCS-TC_009	ETCS on board combined with ATO application			TOBA-K	n39	8.3.7
ATO_iPerf_UL-TC_010	ATO in parallel with high uplink traffic generated by iPerf	WP4		TOBA-A	n8	8.3.8

ATO_iPerf_DL-TC_011	ATO in parallel with high downlink traffic generated by iPerf	WP4		TOBA-A	n8	8.3.9
Cybersecurity tests with ATO						
ATO-TLS_001	Check the health of the link between ATO and the TOBA with TLS activated – The WebSocket status is correct	WP4		TOBA-A	n8	12.1.1.1.3
ATO-TLS_001	Check the health of the link between ATO and the TOBA with TLS activated – The WebSocket status is not responding	WP4		TOBA-A	n8	12.1.1.1.4
ATO-TLS_002	Check the registration and the connection status with TLS activated– Registration	WP4		TOBA-A	n8	12.1.1.2.3
ATO-TLS_002	Check the registration and the connection status with TLS activated – Loss of the WebSocket once the registration is completed	WP4		TOBA-A	n8	12.1.1.2.4
ATO-TLS_002	Check the connection status with TLS activated.	WP4		TOBA-A	n8	12.1.1.2.5

ATO-TLS_003	Communication between the ATO-On board and ATO-Trackside application in nominal conditions with TLS activated.	WP4		TOBA-A	n8	12.1.1.3.3
ATO-TLS_004	Test cases in degraded mode with TLS activated– wrong root certificate	WP4		TOBA-A	n8	12.1.1.4.3
ATO-TLS_004	Test cases in degraded mode with TLS activated– wrong client certificate	WP4		TOBA-A	n8	12.1.1.4.4
ATO-TLS_005	ATO in nominal and perfect lab conditions	WP4		TOBA-A	n8	12.1.1.5
ATO-TLS_006	Degraded conditions for E2E TLS handshake	WP4		TOBA-A	n8	12.1.1.6
PIS phase 1 integration tests						
PIS-Flat IP_TC_001	Send text message with a normal priority to trains	WP4		TOBA-A	n8	9.6.1.2
PIS-Flat IP_TC_002	Send text message with a high priority to trains	WP4		TOBA-A	n8	9.6.1.3
PIS-Flat IP_TC_003	Send text message with a normal priority in degraded conditions - – 5G radio link is overloaded	WP4		TOBA-A	n8	9.6.1.4

PIS-Flat IP_TC_004	Send text message with a high priority in degraded conditions - – 5G radio link is overloaded	WP4		TOBA-A	n8	9.6.1.5
PIS-Flat IP_TC_005	Display train location information	WP4		TOBA-A	n8	9.6.1.6
PIS-Flat IP_TC_006	On-board PIS logs downloaded on the fly in degraded conditions – 5G Radio link overloaded	WP4		TOBA-A	n8	9.6.1.7
PIS-Flat IP_TC_007	Open a “trackside to on-board” management session with a high priority	WP4		TOBA-A	n8	9.6.1.8
PIS - phase 2 (OBapp compatible) integration tests						
PIS_TC_003	Registration of PIS trackside application in the FRMCS network			TOBA-A	n8	9.6.2.3
PIS_TC_004	Deregistration of PIS trackside application in the FRMCS network			TOBA-A	n8	9.6.2.4
PIS_TC_005	Registration of PIS on-board application in the FRMCS network			TOBA-A	n8	9.6.2.5
PIS_TC_006	Deregistration of PIS on-board application in the FRMCS network			TOBA-A	n8	9.6.2.6

PIS_TC_007	“Non-Critical Data” session start initiated from trackside - on-board application is registered in “auto-accept” mode			TOBA-A	n8	9.6.2.7
PIS_TC_008	“Non-Critical Data” session start initiated from trackside - on-board application is registered in “not_auto” mode			TOBA-A	n8	9.6.2.8
PIS_TC_009	“Critical Data” session start initiated from trackside - on-board application is registered in “auto-accept” mode			TOBA-A	n8	9.6.2.9
PIS_TC_010	“Critical Data” session start initiated from trackside - on-board application is registered in “not_auto” mode			TOBA-A	n8	9.6.2.10
PIS_TC_011	Close a session from trackside			TOBA-A	n8	9.6.2.11
PIS_TC_012	Close a session from on-board			TOBA-A	n8	9.6.2.12
PIS_TC_013	Send text message with a normal priority to trains			TOBA-A	n8	9.6.2.13
PIS_TC_014	Send text message with a high priority to trains			TOBA-A	n8	9.6.2.14

PIS_TC_015	Send text message with a normal priority in degraded conditions – 5G radio link is overloaded			TOBA-A	n8	9.6.2.15
PIS_TC_016	Send text message with a high priority in degraded conditions - – 5G radio link is overloaded			TOBA-A	n8	9.6.2.16
PIS_TC_017	Display train location information			TOBA-A	n8	9.6.2.17
PIS_TC_018	On-board PIS logs downloaded on the fly in degraded conditions			TOBA-A	n8	9.6.2.18
PIS_TC_019	Open a "trackside to on-board" management session with a high priority			TOBA-A	n8	9.6.2.19
PIS_TC_020	Check connection to FRMCS services			TOBA-A	n8	9.6.2.20
PIS_TC_021	On-board PIS logs downloaded on the fly in normal conditions			TOBA-A	n8	9.6.2.21
Functional test cases with Remote Vision						
RV_WP4-TC_001	Remote control of Engines in nominal lab conditions: streaming of video from moving stock to trackside	WP4 (Derisking)		TOBA-K	n39	11.1
RV_ETCS_WP4_TC_002	Remote Vision in parallel with ETCS application	WP4 (Derisking)		TOBA-K	n39	11.2

RV_ETCS_WP4_TC_003	Remote Visionin parallel with ETCS application in degraded radio conditions using Vertex emulator	WP4 derisking test cases		TOBA-K	n39	11.3
RV_WP4-TC_004	Remote Vision in cross-border scenario using 1UE	WP4 derisking test cases		TOBA-K	n39	11.4
RV_WP5-TC_001	Remote control of Engines in nominal lab conditions: streaming of video from moving stock to trackside	WP5-FR		TOBA-K	n39	13.3.3
RV_ETCS_WP5_TC_002	Combined Remote Vision and ETCS in field conditions	WP5-FR		TOBA-K	n39	13.3.4
RV_ETCS_WP5_TC_003	Cross-border with remote vision application in field conditions	WP5-FR		TOBA-K	n39	13.3.5
WP4-Optional voice test cases						
Voice-WP4_001	Private MCPTT call without floor management (optional)					10.1
Voice-WP4_002	MCPTT group call with floor management (optional)					10.2
Voice-WP4_003	MCPTT emergency group call (optional)					0
Voice-WP4_004	Private MCPTT call is ongoing, and MCPTT emergency group call is launched (optional)					10.4

Table 10: List of lab and field test cases

6.1 Presentation of test case template

The following figure presents the structure of the template applied to all test cases:

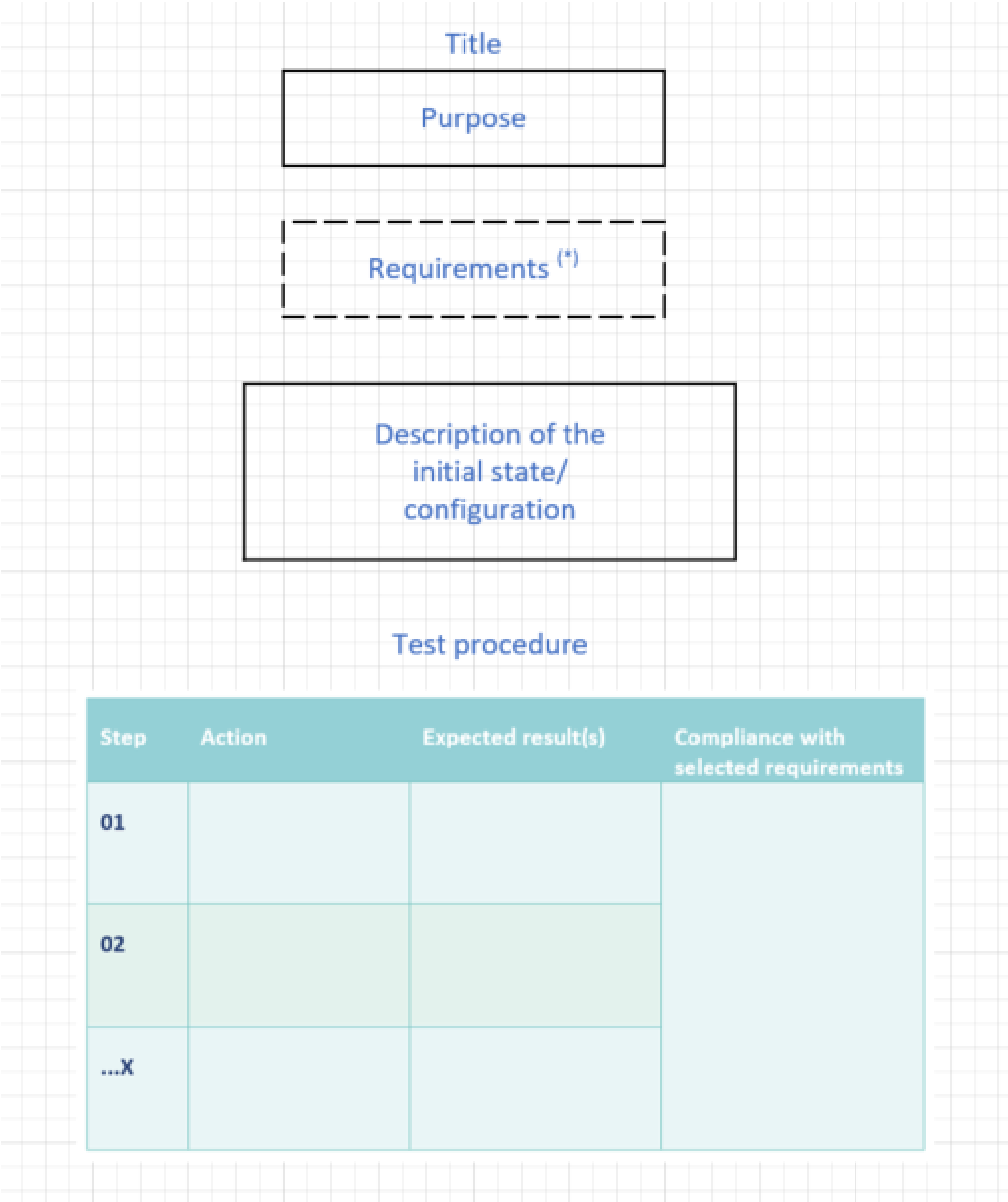


Figure 51: Test case template

Note: *The compliancy with normative documents, such as the ones of 3GPP, ETCSI, UIC, is presented in the relevant column of the test procedure. However, in some test cases, an optional chapter also called Requirements (*) is added to explain compliancy with a 5GRAIL specific implementation.*

6.2 Success criteria

Please note that whenever one expected result is not fulfilled the test case is failed.

7 VOICE APPLICATION TEST CASES DESCRIPTION

The scenarios will focus on the testing and evaluation of the voice application regarding the main FRMCS and MCX functionalities. These will be realized using 5G radio, 5GSA core, FRMCS/MCPTT application server, as well as GSM-R network for interworking testing.

The voice application is provided by Siemens for the onboard. Trackside / Dispatcher is provided by Nokia, and it will be tested in the lab of WP3 in Hungary.

7.1 Assumptions

Due to the unavailability of some necessary features to perform voice test cases and some lab limitations, assumptions proper to voice test cases have been agreed with the consortium, as following:

ID	Related Test Case number:	Assumption:
1	Voice_001	Functional identity related to the equipment type will not be tested for 5GRAIL.
2	Voice_001	Functional identity related to the user will be handled by a configuration file embedded within the Voice application software.
3	Voice_001	Validation of the functional identity related to the user will not be tested for 5GRAIL.
4	Voice_005	Queueing concept in the multi- user talker control is outside of 5GRAIL scope.
5	Voice_006	FRMCS arbitration has not been specified therefore will be handled as per EIRENE specifications.
6	Voice_008 Voice_009	Controller to train driver and train driver to the controller call are considered to be private calls for the 5G rail project.
7	Voice_010	The multi train voice communication is considered to be a group call regardless of the number of participants for the 5GRAILproject.
8	Voice_005, Voice_008, Voice_009, Voice_010, Voice_011, Voice_012	The call set up time will be measured on the client and server side (cf. D3.2.v2, §chapter 4.6 and §16.5)

9	All	An FRMCS device can be a Cab Radio, a Smartphone or a Controller Terminal registered on the FRMCS system. All voice identifiers are listed in §16.2.1 Voice (Siemens)
10	Voice_009	Initiation of a voice communication from a train controller towards a train driver can be achieved via either MC Service ID or Functional Alias
11	Voice_001, Voice_009	Functional Alias must be stored in the Cab Radio phonebook. • driver-111.voice@mcptt.nokia.com • driver-222.voice@mcptt.nokia.com • dispatcher-111.voice@mcptt.nokia.com
12	Voice_008, Voice_009	The despatcher terminal does not currently support the use of functional aliases for the Controller, which means they cannot be displayed on the GDCP of the Cab Radio during voice communication. As a result, the MC ID will be used instead.

7.2 Common functions

As common functions are considered all the preliminary steps for the accomplishment of the voice use cases (e.g., registration, deregistration, etc.) but also some ones proving the compliance with main FRMCS principles.

7.2.1 Test case n° Voice_001: Registration of a functional identity related to the user.

7.2.1.1 Purpose

The purpose of this test is to demonstrate that an FRMCS User can register a functional identity on the FRMCS system. Once the registration is completed the FRMCS User can be reached by its FRMCS functional identity.

The MCX building blocks validated with this test case are presented in§16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_001]

7.2.1.2 Description of initial state/configuration

1. The Cab Radio A equipment type is recognised by the FRMCS system. This is handled by a predefined configuration file embedded within the Voice application software.
2. The MC ID (username and password) and the MC Service ID are predefined in configuration files within the Voice application software.

3. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
4. An FRMCS device registered on the same network is available.

7.2.1.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A registers its MC ID by navigating to • Menu - Register identity Press the Accept button	Registration request is sent to the FRMCS system. Registration progress is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0]**: 8.3.5.3 **TR22.889-V16.6.0:** [R-9.3.3-001]
2	FRMCS system accepts the registration request	Registration status is displayed on the GDCP of the Cab Radio A (e.g., pui appears on the display) Audible indication is given via the loudspeaker	**TR22.889 V16.6.0** [R-9.3.3-003]
3	Navigate to • Menu - Service Authorise Press the Accept button	Service settings is displayed on the GDCP of the Cab Radio A The FRMCS system issues an access token	
4	Press the soft key 8	The list of functional aliases is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0]**: 8.3.4.1, 8.3.5.2 **[FU-7120-v0.9.2]:** 11.3.2.3.7
5	Select the functional alias from the list and press the Accept button	The FRMCS system activates the functional alias	**[FU-7120-v0.9.2]:** 11.3.2.3.8 [**MG-7900-v2.0.0]:** 64.3.3.1, 64.3.3.2
6	Press the soft key 8, select Subscribe and press the Accept button	The functional alias ID is displayed on the GDCP of the Cab Radio A	**[FU-7120-v0.9.2]:** 11.3.2.3.9 **[MG-7900 v2.0.0]**: 64.3.3.3
7	Initiate a PTP call from the FRMCS device to the FRMCS User A by dialling the FRMCS User A functional identity	The FRMCS system automatically routes the voice communication to the FRMCS User A	**TR22.889V16.6.0:** [R-9.3.2-006]
8	Call initiator terminates the call	The FRMCS system terminates the voice communication. The Idle screen is displayed on the GDCP of the Cab Radio A	

7.2.2 Test case n° Voice_002: Deregistration of a functional identity

7.2.2.1 Purpose

The purpose of this test is to demonstrate that an FRMCS User can successfully deregister a functional identity.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_002]

7.2.2.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
3. An FRMCS device registered on the same network is available.

7.2.2.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A deregisters its functional identity by navigating to Menu - Reg/De-reg…-Deregistration	The deregistration menu is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0] :** 8.3.5.3, **[FU-7120-v0.9.2] :** 11.3.2.3.12, **TR22.889-V16.6.0** [R-9.3.4-001]
2	FRMCS User A selects the functional identity and presses the Accept button	Deregistration request is sent to the FRMCS system. Deregistration progress is displayed on the GDCP of the Cab Radio A	**[MG-7900 v2.0.0]**:64.4.3.1, 64.4.3.2, **TR22.889-V16.6.0** [R-9.3.4-002]
3	FRMCS system accepts the deregistration request	Deregistration status is displayed on the GDCP of the Cab Radio A (e.g., train running number removed from the display)	**[FU-7120-v0.9.2] :** 11.3.2.3.13, **[MG-7900 v2.0.0]**:64.4.3.3, 64.4.3.4, **TR22.889-V16.6.0** [R-9.3.4-004]
4	Initiate a PTP call from the FRMCS device to the FRMCS User A by dialling the FRMCS User A functional identity	The call cannot be established	

7.2.3 Test case n° Voice_003 OPTIONAL: Authorisation of communication

7.2.3.1 Purpose

The purpose of this test is to demonstrate that the FRMCS System can be configured by the network operator to prevent unauthorised voice communication between FRMCS Users. The MC Service ID and authorisation of communication allowlist shall be used to control and regulate voice communications.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_003]

Note: *This test case will only be performed in lab just to reveal the specifications gap.*

7.2.3.2 Description of initial state/configuration

1. The FRMCS System is configured by the network operator, so that access to the voice communication is controlled through the use of MC Service IDs.
2. FRMCS User A is registered to the FRMCS System on the Cab Radio A with a functional identity.
3. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
4. FRMCS User B is registered to the FRMCS System on the FRMCS device with a functional identity.
5. The MC Service ID of the FRMCS User A is not configured by the network operator to initiate a voice communication with the FRMCS User B.

7.2.3.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A attempts to initiate a voice communication with the FRMCS User B	The FRMCS System verifies if the MC Service ID of the FRMCS User A is allowed to establish the voice communication with the FRMCS User B and the MC Service ID of the FRMCS User B is allowed to receive the communication from the FRMCS User A	**[FU- 7100 v5.0.0] :** 8.5.5.1, **[FU-7120-v0.9.2]:** 8.2.6.2.9, 8.2.6.2.12, 8.2.6.2.14, 8.2.6.2.15, 8.2.6.6.1, 8.2.6.2.18, 8.2.6.2.19. **[MG-7900 v2.0.0]**: 66.2.3.1, 66.2.3.2, **TR22.889-V16.6.0** [R-9.8.2-001], [R-9.8.2-002] **TS22.280-V16.8.0** [R-6.7.3-007a]
2	The FRMCS System determines that the MC Service ID of the FRMCS User A is not allowed to establish the voice communication with the FRMCS User B and rejects the FRMCS User A attempt	Audible indication for call rejected is given via the loudspeaker of the Cab Radio A Visual indication for call rejected is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0]:** 8.5.4.1, **[FU-7120-v0.9.2]** :8.2.6.2.21, 8.2.6.6.2 **[MG-7900 v2.0.0]**: 66.2.3.4, **TR22.889-V16.6.0** [R-9.8.2-003] **TS22.280-V16.8.0** [R-6.7.2-002]

7.2.4 Test case n° Voice_004: Authorisation of application

7.2.4.1 Purpose

The purpose of this test is to demonstrate that the FRMCS System can be configured by the network operator, so that access to the voice application can be controlled through the use of MC ID.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_004]

7.2.4.2 Description of initial state/configuration

1. The FRMCS System is configured by the network operator, so that access to the voice application is controlled through the use of MC ID.
2. The MC ID credentials are preconfigured within the voice application software.
3. The preconfigured MC ID matches the MC ID configured in the FRMCS System by the network operator.
4. The Cab Radio A is powered off.

7.2.4.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	Power on the Cab Radio A	The Cab Radio A powers up and initialises the start-up procedure. The Cab Radio A automatically self-tests The FRMCS System verifies the FRMCS User A MC ID against the configured values in the FRMCS System	**[FU-7120-v0.9.2]** :8.2.7.2.4, 8.2.7.2.5, **[MG-7900 v2.0.0]**:67.2.3.1, **TR22.889-V16.6.0** [R-9.9.2-001], [R-9.9.2-002], [R-9.9.2-003]
2	The FRMCS System determines that the MC ID do not match the values configured in the FRMCS System and denies the authorisation	Audible indication for authorisation rejected is given via the loudspeaker of the Cab Radio A Visual indication for authorisation rejected is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0]**:8.7.5.1, **[FU-7120-v0.6.0]** :8.2.7.2.2

7.2.5 Test case n° Voice_005: Multi - user talker control

7.2.5.1 Purpose

The purpose of this test is to demonstrate that multiple FRMCS Users can speak simultaneously in a multi – user voice conversation if the number of users that are granted the right to talk does not exceed the maximum number set in the FRMCS system.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_005]

7.2.5.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. FRMCS User B is registered to the FRMCS System on the Cab Radio B with a functional identity.
3. The FRMCS System is configured so that the FRMCS User A is authorised to initiate a multi-user voice communication.
4. The FRMCS System is configured so that the FRMCS User A is authorised to use a multi-user voice communication for drivers including ground user(s) application.
5. All FRMCS Users (including a Controller) are subscribed to the same valid MCPTT group ID.
6. The maximum number of simultaneous talkers is set to 2 (including the Controller) in the communication application.
7. FRMCS User B has lower talker priority than remaining FRMCS Users.

7.2.5.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a multi-user voice communication by navigating to Menu – Calls… – Other Calls… – Group Call	Visual indication to insert the MCPTT group ID is displayed on the GDCP of the Cab Radio A	
2	FRMCS User A enters the MCPTT group ID that the FRMCS User A and the other FRMCS Users are subscribed to and presses the Accept button on the GDCP of the Cab Radio A	Audible indication for call proceeding is given via the loudspeaker of the Cab Radio A Visual indication for call proceeding is displayed on the GDCP of the Cab Radio A The FRMCS system automatically routes the multi-user voice communication to the FRMCS Users subscribed to the MCPTT group ID	
3	FRMCS Users subscribed to the MCPTT group ID accept the call if not automatically answered	The multi-user voice communication is established within a setup time specified as NORMAL. Audible indication for call establishment is given via the loudspeaker of the Cab Radio A	

		Visual indication for call establishment is displayed on the GDCP of the Cab Radio A Incoming audio is connected to the loudspeaker of the Cab Radio A until the FRMCS User A picks up the Cab Radio A handset	
4	FRMCS User A picks up the Cab Radio A handset and presses the PTT button	The FRMCS System grants the FRMCS User A the initial talker permission. The Cab Radio A loudspeaker sets to reduced volume. Audible indication is given via the loudspeaker of the Cab Radio A Visual indication that the FRMCS User A can talk is displayed on the GDCP of the Cab Radio A The Cab Radio A handset is activated, and communication is possible. The voice quality is clear and loud. The FRMCS User A has a dedicated uplink until the PTT button is release or the network timer expires. Visual indication that the FRMCS User A is talking is displayed on the FRMCS devices	**[FU- 7100 v5.0.0]:** 8.2.4.1, 8.2.5.1, **[FU-7120-v0.9.2]:** 8.2.3.2.1, 8.2.3.2.2, 8.2.3.2.3, 8.2.3.3.1, 8.2.3.3.3, 8.2.3.3.6, 8.2.3.3.7, 8.2.3.3.8, 8.2.3.3.9, 8.2.3.3.13, 8.2.3.3.14, **[MG-7900 v2.0.0]**: 63.5.3.1, 63.7.3.1, **TR22.889-V16.6.0** [R-9.7.2-001], [R-9.7.2-002], [R-9.7.3-001], [R-9.7.3-002], [R-9.7.3-003], [R-9.7.3-004], [R-9.7.5-001], [R-9.7.5-002]
5	Controller presses the PTT button on his device while the FRMCS User A still holds the PTT button	The FRMCS System grants the Controller the permission to talk based on Controller's talker priority	**[FU- 7100 v5.0.0]:** 8.2.4.1, 8.2.5.1, **[FU-7120-v0.9.2]:**

		Visual indication that the Controller can talk is displayed on the Controller's terminal. The Controller has a dedicated uplink until the PTT button is release or the network timer expires. Visual indication that the Controller and the FRMCS User A are talking is displayed on the FRMCS devices	8.2.3.2.1, 8.2.3.2.2, 8.2.3.2.3, 8.2.3.3.3, 8.2.3.3.6, 8.2.3.3.7, 8.2.3.3.8, 8.2.3.3.9, 8.2.3.3.13, 8.2.3.3.14, **[MG-7900 v2.0.0]**: 63.5.3.1, 63.7.3.1, **TR22.889-V16.6.0** [R-9.7.2-001], [R-9.7.2-002], [R-9.7.3-001], [R-9.7.3-002], [R-9.7.3-003], [R-9.7.3-005], [R-9.7.5-001], [R-9.7.5-002]
6	FRMCS User B presses the PTT button on the Cab Radio B while the FRMCS User A and the Controller hold the PTT buttons	The communication application sends the request to the multi - user talker control service in the FRMCS system. Visual indication that the permission to talk has been requested is displayed on the FRMCS User B device. The multi - user talker control service in the FRMCS system receives the request to talk from the FRMCS User B The multi - user talker control service in the FRMCS system verifies the number of users who already have permission to talk. The multi - user talker control service in the FRMCS system determines the number of users with permission to talk exceeds the maximum number of	**[FU- 7100 v5.0.0]:** 8.2.4.1, 8.2.5.1 **[FU-7120-v0.9.2]:** 8.2.3.2.1, 8.2.3.2.2, 8.2.3.2.3, 8.2.3.3.3, 8.2.3.3.8, 8.2.3.3.9, 8.2.3.3.13, **[MG-7900 v2.0.0]**: 63.5.3.1, 63.5.3.2, 63.5.3.3, 63.6.3.1, 63.6.3.2, 63.6.3.4, 63.7.3.1,

		simultaneous talkers and rejects the FRMCS User B request. Visual indication that the FRMCS User B has no permission to talk is displayed on the FRMCS User B device	**TR22.889-V16.6.0** [R-9.7.2-001], [R-9.7.2-002], [R-9.7.3-001], [R-9.7.3-002], [R-9.7.3-003], [R-9.7.4-002], [R-9.7.5-001]
7	Controller terminates the call	The FRMCS system terminates the multi-user voice communication. Visual indication is displayed on all FRMCS devices. Idle screen is displayed on all FRMCS devices	

7.2.6 Test case n° Voice_006: Arbitration

7.2.6.1 Purpose

The purpose of this test is to demonstrate that a lower priority call is terminated by the FRMCS system when the higher priority call comes in.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_006]

7.2.6.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. FRMCS User B is registered to the FRMCS system on the FRMCS device with a functional identity.
3. FRMCS User C is registered to the FRMCS System on the FRMCS device with a functional identity.
4. The FRMCS System is authorised to perform arbitration of communication on the end user devices.

7.2.6.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a voice communication to the FRMCS User B	Audible indication for call proceeding is given via the loudspeaker of the Cab Radio A Visual indication for call proceeding is displayed on the GDCP of the Cab Radio A The FRMCS system automatically routes the voice communication to the FRMCS User B Functional identity of the FRMCS User A is displayed on the FRMCS User B device throughout the voice communication	
2	FRMCS User B accepts the call	The call to the FRMCS User B is established within a setup time specified as NORMAL. Audible indication for call establishment is given via the loudspeaker of the Cab Radio A Visual indication for call establishment is displayed on the GDCP of the Cab Radio A Functional identity of the FRMCS User B is displayed on the GDCP of the Cab Radio A throughout the voice communication. The FRMCS User B can be heard via the loudspeaker of the Cab Radio A	
3	FRMCS User A picks up the Cab Radio A handset	The Cab Radio A loudspeaker sets to reduced volume. The Cab Radio A handset is activated, and communication is possible. The voice quality is clear and loud	

4	FRMCS User C initiates a Railway Emergency call by pressing and holding the REC button on the FRMCS device	Audible indication for call proceeding is given. Visual indication for call proceeding is displayed. The FRMCS system terminates the ongoing call from the FRMCS User A to the FRMCS User B and routes the Railway Emergency Call to the FRMCS Users located in the Railway Emergency Area Functional identity of the FRMCS User C is displayed on the GDCP of the Cab Radio A and the FRMCS Users located in the Railway Emergency Area throughout the voice communication (1)	8.12.4.1, 8.2.11.3.2, 8.2.11.3.6, 72.2.3.2, [R-9.16.2-001]
5	The FRMCS User A and all other FRMCS Users located in the Railway Emergency Area receive and automatically accept the Railway Emergency Call	The Railway Emergency Call is established with a setup time specified as IMMEDIATE. Visual indication for call established is displayed on the GDCP of the Cab Radio A and the FRMCS Users device located in the Railway Emergency Area Functional identities of the FRMCS User A and the FRMCS users located in the Railway Emergency Area are displayed on the FRMCS User C device throughout the voice communication (1) The FRMCS User C can be heard via the handset of the Cab Radio A The voice quality is clear and loud	8.12.4.3, 8.12.5.1, [R-9.16.2-002]
6	FRMCS User C terminates the Railway Emergency Call	The FRMCS system terminates the voice communication. Visual indication is displayed on the GDCP of the Cab Radio A, the FRMCS users located in the Railway Emergency Area and the FRMCS User C	

		Idle screen is displayed on all devices (2)	

Notes: *(1) There is an MCX specifications gap because it is not defined how the functional identities of all the other participants of a group call are displayed in each participant's terminal*

(2) There is gap in the specifications to be clarified in the MCX specifications or in the SRS, if after release of a high priority call (e.g., Emergency call), participants switch to the point-to-point call

7.2.7 Test case n° Voice_007: QoS negotiation

QoS will be treated in each test case and not in the common functions. This explains why Voice_007 test case is suppressed. The QoS negotiation as treated inside each test case, is not related to the DSCP and 5QI configuration. It mainly means voice quality and evaluation of MCPTT KPIs, as presented in §16.5

7.3 On-train outgoing voice communication from the train driver towards the controller(s) of the train

7.3.1 Test case n° Voice_008: Initiation of a voice communication from a train driver towards a train controller responsible for the train movement area

7.3.1.1 Purpose

The purpose of this test is to demonstrate that a train driver can initiate a voice communication with a train controller responsible for the train movement area and that the call initiator can terminate the voice communication.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_008]

7.3.1.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. The FRMCS System is configured so that the FRMCS User A is authorized to initiate the voice communication to the Controller.
3. The FRMCS System is configured so that the FRMCS User A is authorised to use the On-train outgoing voice communication from the Driver towards the Controller application.
4. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.

7.3.1.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a voice communication to a Controller responsible for the train movement area by pressing a corresponding button on the GDCP of the Cab Radio A	Audible indication for call proceeding is given via the loudspeaker of the Cab Radio A Visual indication for call proceeding is displayed on the GDCP of the Cab Radio A The FRMCS system automatically routes the voice communication to the Controller responsible for the train movement area. Functional identity of the FRMCS User A is displayed on the Controller's terminal throughout the voice communication	**[FU- 7100 v5.0.0]:** 5.1.4.1, 5.1.4.2, 5.1.5.1, 5.1.5.2, **[FU-7120-v0.9.2]:** 10.4.2.1, 10.4.2.2, 10.4.2.5, 10.4.2.7, 10.4.3.1, **[MG-7900 v2.0.0]**: 6.2.3.2, **TR22.889-V16.6.0** [R-6.3.2-001], [R-6.3.2-002], [R-6.3.2-005]
2	Controller accepts the call by manual interaction	The call to the Controller is established within a setup time specified as NORMAL. Audible indication for call establishment is given via the loudspeaker of the Cab Radio A Visual indication for call establishment is displayed on the GDCP of the Cab Radio A Functional identity of the Controller is displayed on the GDCP of the Cab Radio A throughout the voice communication. The Controller can be heard via the loudspeaker of the Cab Radio A The voice quality is clear and loud	**[FU- 7100 v5.0.0]:** 5.1.5.3, **[FU-7120-v0.9.2]:** 10.4.2.8, **[MG-7900 v2.0.0]**: 6.2.3.1, 6.2.3.3, **TR22.889-V16.6.0** [R-6.3.2-004], [R-6.3.2-005]
3	FRMCS User A picks up the Cab Radio A handset	The Cab Radio A loudspeaker sets to reduced volume. The Cab Radio A handset is activated, and communication is possible. The voice quality is clear and loud	**[FU- 7100 v5.0.0]:** 5.1.4.3, **TR22.889-V16.6.0** [R-6.3.2-007 a]

4	FRMCS User A terminates the call by placing the Cab Radio A handset down on the cradle	The FRMCS system terminates the voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7900 v2.0.0]:** 6.4.3.1, 6.4.3.2, **TR22.889-V16.6.0** [R-6.3.3-001]

7.4 On-train incoming voice communication from the controller towards a train driver

7.4.1 Test case n° Voice_009: Initiation of a voice communication from a train controller towards a train driver

7.4.1.1 Purpose

The purpose of this test is to demonstrate that a train controller can initiate a voice communication with a train driver and that the call initiator can terminate the voice communication.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_009]

7.4.1.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system with a functional identity.
2. The FRMCS System is configured so that the Controller is authorized to initiate the voice communication to the FRMCS User A.
3. The FRMCS System is configured so that the Controller is authorised to use the On-train ingoing voice communication from the Controller towards the Driver application.
4. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.

7.4.1.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	Controller initiates a voice communication with an FRMCS User A.	The FRMCS system automatically routes the voice communication to the FRMCS User A Audible indication for call incoming is given via the loudspeaker of the Cab Radio A Visual indication for call incoming is displayed on the GDCP of the Cab Radio A Functional identity of the Controller is displayed on the GDCP of the Cab Radio A throughout the voice communication	**[FU- 7100 v5.0.0]:** 5.2.4.1, 5.2.4.2, 5.2.5.1, 5.2.5.4, **[FU-7120-v0.9.2]:** 10.5.2.1, **[MG-7900 v2.0.0]**: 7.2.3.2, **TR22.889-V16.6.0** [R-6.15.2-001]

2	The FRMCS User A accepts the call	The call to the train driver is established within a setup time specified as NORMAL. Visual indication for call established is displayed on the GDCP of the Cab Radio A The Controller can be heard via the loudspeaker of the Cab Radio A. The voice quality is clear and loud. Functional identity of the FRMCS User A is displayed on the Controller's terminal throughout the voice communication	**[FU- 7100 v5.0.0]:** 5.2.5.3, **[FU- 7100 v5.0.0]:** 10.5.2.2, **[MG-7900 v2.0.0]**: 7.2.3.1, 7.2.3.3
3	FRMCS User A picks up the Cab Radio A handset	The Cab Radio A loudspeaker sets to reduced volume. The Cab Radio A handset is activated, and communication is possible. The voice quality is clear and loud	
4	Controller terminates the call	The FRMCS system terminates the voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[MG-7900 v2.0.0]**: 7.3.3.7, 7.3.3.8, **TR22.889-V16.6.0** [R-6.15.3-001]

7.5 Multi-User voice communication for drivers including ground users.

7.5.1 Test case n° Voice_010: Initiation of a multi-user voice communication from a train driver towards train drivers and ground users (FRMCS Users only)

7.5.1.1 Purpose

The purpose of this test is to demonstrate that a train driver can initiate a multi-user voice communication towards train drivers registered to the FRMCS System and a train controller subscribed to the same valid MCPTT Group ID. The multi-user voice communication can be terminated by the call initiator.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_010]

7.5.1.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. FRMCS User B is registered to the FRMCS System on the FRMCS device with a functional identity.
3. The FRMCS System is configured so that the FRMCS User A is authorised to initiate a multi-user voice communication.
4. The FRMCS System is configured so that the FRMCS User A is authorised to use a multi-user voice communication for drivers including ground user(s) application.
5. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
6. All FRMCS Users (including a Controller) are subscribed to the same valid MCPTT Group ID.

7.5.1.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a multi-user voice communication by navigating to Menu – Calls… – Other Calls… – Group Call	Visual indication to insert the MCPTT Group ID is displayed on the GDCP of the Cab Radio A	
2	FRMCS User A enters the MCPTT Group ID that the FRMCS A and the other FRMCS Users are subscribed to and presses the Accept button on the GDCP of the Cab Radio A	Audible indication for call proceeding is given via the loudspeaker of the Cab Radio A Visual indication for call proceeding is displayed on the GDCP of the Cab Radio A The FRMCS system automatically routes the multi-user voice communication to the FRMCS Users subscribed to the MCPTT Group ID	**[FU- 7100 v5.0.0]:** 5.3.4.1, 5.3.5.1, 5.3.5.2, **[FU-7120-v0.9.2]:** 10.6.3.1, 10.6.3.2, 10.6.3.3, **[MG-7900 v2.0.0]**: 8.2.3.2, **TR22.889-V16.6.0** [R-6.2.2-001], [R-6.2.2-003], [R-6.2.2-006]

3	FRMCS Users subscribed to the MCPTT Group ID accept the call if not automatically answered	The multi-user voice communication is established within a setup time specified as NORMAL. Audible indication for call establishment is given via the loudspeaker of the Cab Radio A Visual indication for call establishment is displayed on the GDCP of the Cab Radio A Incoming audio is connected to the loudspeaker of the Cab Radio A until the FRMCS User A picks up the Cab Radio A handset. The voice quality is clear and loud	**[FU- 7100 v5.0.0]:** 5.3.5.3, **[MG-7900 v2.0.0]**: 8.2.3.1, 8.2.3.3, 8.2.3.4, **TR22.889-V16.6.0** [R-6.2.2-005], [R-6.2.2-006], [R-6.2.2-008]
4	FRMCS User A picks up the Cab Radio A handset and presses the PTT button	The Cab Radio A loudspeaker sets to reduced volume. Audible indication is given via the loudspeaker of the Cab Radio A Visual indication that the FRMCS User A can talk is displayed on the GDCP of the Cab Radio A The Cab Radio A handset is activated, and communication is possible. The voice quality is clear and loud. The FRMCS User A has a dedicated uplink until the PTT button is release or the network timer expires	**TR22.889-V16.6.0** [R-6.2.2-008]
5	FRMCS User A releases the PTT button	Visual indication to use Push to Talk is displayed on the GDCP of the Cab Radio A	**TR22.889-V16.6.0** [R-6.2.2-008]
6	FRMCS User B leaves the multi-user voice communication by pressing a corresponding button on the FRMCS device	Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. The multi-user voice communication remains active for other participants	**[FU- 7100 v5.0.0]:** 5.3.4.3, **[MG-7900 v2.0.0]**: 8.4.3.3, **TR22.889-V16.6.0** [R-6.2.3-002]

7	FRMCS User A terminates the call by pressing the Cancel button of the Cab Radio A	The FRMCS system terminates the multi-user voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0]:** 5.3.4.3, **[FU-7120-v0.9.2]:** 10.6.3.15, **[MG-7900 v2.0.0]**: 8.4.3.5, **TR22.889-V16.6.0** [R-6.2.3-008]

7.5.2 Test case n° Voice_021: Initiation of a multi-user voice communication from a train driver towards train drivers and ground users. (FRMCS and GSM-R Users)

7.5.2.1 Purpose

The purpose of this test is to demonstrate that a train driver registered to the FRMCS system can initiate a multi-user voice communication towards train drivers registered to the FRMCS and GSM-R Systems and a train controller subscribed to the same valid MCPTT Group ID. The multi-user voice communication can be terminated by the call initiator.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_021]

7.5.2.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. GSM-R User B is registered to the GSM-R System on the Cab Radio B with a functional identity.
3. The FRMCS System is configured so that the FRMCS User A is authorised to initiate a multi-user voice communication.
4. The FRMCS System is configured so that the FRMCS User A is authorised to use a multi-user voice communication for drivers including ground user(s) application.
5. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
6. All FRMCS and GSM-R Users (including a Controller) are subscribed to the same valid MCPTT Group ID.

7.5.2.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a multi-user voice communication by navigating to Menu – Calls… – Other Calls… – Group Call	Visual indication to insert the MCPTT Group ID is displayed on the GDCP of the Cab Radio A	
2	FRMCS User A enters the MCPTT Group ID that the FRMCS A and the other Users are subscribed to and presses the Accept button on the GDCP of the Cab Radio A	Audible indication for call proceeding is given via the loudspeaker of the Cab Radio A Visual indication for call proceeding is displayed on the GDCP of the Cab Radio A The FRMCS system automatically routes the multi-user voice communication to the FRMCS and GSM-R Users subscribed to the MCPTT Group ID	**[FU- 7100 v5.0.0]:** 5.3.4.1, 5.3.5.1, 5.3.5.2, **[FU-7120- v0.9.2]:** 10.6.3.1, 10.6.3.2, 10.6.3.3, **[MG-7900 v2.0.0]**: 8.2.3.2, **TR22.889-V16.6.0** [R-6.2.2-001], [R-6.2.2-003], [R-6.2.2-006]
3	The Users subscribed to the MCPTT Group ID accept the call if not automatically answered	The multi-user voice communication is established within a setup time specified as NORMAL. Audible indication for call establishment is given via the loudspeaker of the Cab Radio A Visual indication for call establishment is displayed on the GDCP of the Cab Radio A Incoming audio is connected to the loudspeaker of the Cab Radio A	**[FU- 7100 v5.0.0]:** 5.3.5.3, **[MG-7900 v2.0.0]**: 8.2.3.1, 8.2.3.3, 8.2.3.4, **TR22.889-V16.6.0** [R-6.2.2-005], [R-6.2.2-006], [R-6.2.2-008]

		until the FRMCS User A picks up the Cab Radio A handset. The voice quality is clear and loud	
4	FRMCS User A picks up the Cab Radio A handset and presses the PTT button	The Cab Radio A loudspeaker sets to reduced volume. Audible indication is given via the loudspeaker of the Cab Radio A Visual indication that the FRMCS User A can talk is displayed on the GDCP of the Cab Radio A The Cab Radio A handset is activated, and communication is possible. The voice quality is clear and loud. The FRMCS User A has a dedicated uplink until the PTT button is release or the network timer expires	**TR22.889-V16.6.0** [R-6.2.2-008]
5	FRMCS User A releases the PTT button	Visual indication to use Push to Talk is displayed on the GDCP of the Cab Radio A	**TR22.889-V16.6.0** [R-6.2.2-008]
6	GSM-R User B picks up the Cab Radio B handset and presses the PTT button	The Cab Radio B loudspeaker sets to reduced volume. Audible indication is given via the loudspeaker of the Cab Radio B Visual indication that the GSM-R User B can talk is displayed on the GDCP of the Cab Radio B The Cab Radio B handset is activated, and communication is possible. The voice quality is clear and loud. The GSM-R User A has a dedicated uplink until the PTT button is release or the network timer expires	

7	GSM-R User B releases the PTT button	Visual indication to use Push to Talk is displayed on the GDCP of the Cab Radio B	
8	GSM-R User B leaves the multi-user voice communication by pressing the Cancel button on the GDCP of the Cab Radio 2	Visual indication is displayed on the GDCP of the Cab Radio B Idle screen is displayed on the GDCP of the Cab Radio B The multi-user voice communication remains active for other participants	**[FU- 7100 v5.0.0]:** 5.3.4.3, **[MG-7900 v2.0.0]**: 8.4.3.3, **TR22.889-V16.6.0** [R-6.2.3-002]
9	FRMCS User A terminates the call by pressing the Cancel button on the GDCP of the Cab Radio A	The FRMCS system terminates the multi-user voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0]:** 5.3.4.3, **[FU-7120-v0.9.2]:** 10.6.3.15, **[MG-7900 v2.0.0]**: 8.4.3.5, **TR22.889-V16.6.0** [R-6.2.3-008]

7.6 Railway Emergency Communication

7.6.1 Test case n° Voice_011: Railway Emergency Call initiated by a train controller.

7.6.1.1 Purpose

The purpose of this test is to demonstrate that a train controller can initiate a Railway Emergency Call. The Railway Emergency Call can be terminated by the call initiator. The definition of the REC area and the procedure of affiliation is described in the appendices §16.9

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_011]

7.6.1.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. FRMCS User B is registered to the FRMCS System on the FRMCS device with a functional identity.
3. The FRMCS System is configured so that the Controller is authorised to initiate a Railway Emergency Call.
4. The FRMCS System is configured so that the Controller is authorised to use a Railway Emergency Call application.
5. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
6. All FRMCS Users are subscribed to the same valid MCPTT Group ID.

7.6.1.3 Test procedure

***Note**: In addition to the below mentioned requirements, compliance is also fulfilled with MG-7900 (section §20) and TR22.889-V16.6.0 (section §6.4). It is worth mentioning that Railway Emergency Communication is an ongoing specification topic.*

Step	Action	Expected result(s)	Compliance with selected requirements
1	Controller initiates a Railway Emergency Call	The FRMCS system automatically routes the Railway Emergency Call to the Users in the targeted area. Audible indication for Railway Emergency Call is given via the loudspeaker of the Cab Radio A and FRMCS device. Visual indication for Railway Emergency Call is displayed on the GDCP of the Cab Radio A and the FRMCS device.	**[FU- 7100 v5.0.0]:** 5.15.4.1, 5.15.4.4, 5.15.5.1, 5.15.5.2, 5.15.5.3, 5.15.5.4, **[FU-7120-v0.9.2]:** 10.8.2.1, 10.8.2.4, 10.8.2.10, 10.8.2.19, 10.8.3.7

2	FRMCS Users in the targeted area automatically accept the call	The Railway Emergency Call is established with a setup time specified as IMMEDIATE. Visual indication for call established is displayed on the GDCP of the Cab Radio A and the FRMCS device. The Controller can be heard via the loudspeaker of the Cab Radio A and the FRMCS device. The voice quality is clear and loud.	**[FU- 7100 v5.0.0]:** 5.15.4.5, 10.8.3.8
3	Controller terminates the Railway Emergency Call	The FRMCS system terminates the Railway Emergency Call Visual indication is displayed on the GDCP of the Cab Radio A, the FRMCS device and the Controller's terminal. Idle screen is displayed on all devices.	**[FU- 7100 v5.0.0]:** 5.15.4.8, 5.15.5.6

7.6.2 Test case n° Voice_022: Railway Emergency Call initiated by a train driver without interworking.

7.6.2.1 Purpose

The purpose of this test is to demonstrate that a train driver can initiate a Railway Emergency Call. The FRMCS system will automatically routes the Railway Emergency voice communication to all FRMCS users in the targeted area. The Railway Emergency Call can be terminated by the call initiator. The definition of the REC area and the procedure of affiliation is described in the appendices §16.10

7.6.2.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS System on the Cab Radio A with a functional identity.
2. FRMCS User B is registered on the FRMCS System on the FRMCS device with a functional identity.
3. The FRMCS System is configured so that the FRMCS User A is authorised to initiate a Railway Emergency Call.
4. The FRMCS System is configured so that the FRMCS User A is authorised to use a Railway Emergency Call application.

5. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
6. All Users are subscribed to the same valid MCPTT Group ID.

7.6.2.3 Test procedure

***Note**: In addition to the below mentioned requirements, compliance is also fulfilled with MG-7900 (section §20) and TR22.889-V16.6.0 (section §6.4). It is worth mentioning that Railway Emergency Communication is an ongoing specification topic.*

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a Railway Emergency Call by pressing the REC button on the GDCP of the Cab Radio A	Audible indication for call proceeding is given. Visual indication for call proceeding is displayed. The FRMCS system automatically routes the Railway Emergency Call to the Users in the targeted area and the Controller responsible for the train movement area. Audible indication for Railway Emergency Call is given via the loudspeaker of the Cab Radio A Visual indication for Railway Emergency Call is displayed on the GDCP of the Cab Radio A	5.15.4.4, 5.15.5.1, 5.15.5.2, 5.15.5.3, 5.15.5.4, 10.8.2.3, 10.8.2.4, 10.8.2.10, 10.8.2.19, 10.8.3.1, 10.8.3.2, 10.8.3.5, 10.8.3.6
2	All FRMCS Users and the Controller responsible for the train movement area automatically accept the call	The Railway Emergency Call is established with a setup time specified as IMMEDIATE. Visual indication for call established is displayed on the FRMCS device and the GDCP of the Cab Radio A Visual indication to use Push to Talk is displayed on the FRMCS device	5.15.4.5, 10.8.3.8
3	FRMCS User A presses PTT button	The FRMCS device is activated, and communication is possible. The voice quality is clear and loud	

4	FRMCS User A releases the PTT button	Visual indication to use Push to Talk is displayed on the FRMCS device	
5	FRMCS User B presses the PTT button on the FRMCS device	The FRMCS User B handset is activated, and communication is possible. The voice quality is clear and loud	
6	FRMCS User B releases the PTT button	Visual indication to use Push to Talk is displayed on the FRMCS User B device	
7	FRMCS User A terminates the Railway Emergency Call	The FRMCS system terminates the Railway Emergency Call Visual indication is displayed on the Cab Radio A, FRMCS device and the Controller's terminal. Idle screen is displayed on all devices	5.15.4.8, 5.15.5.6

7.6.3 Test case n° Voice_012: Railway Emergency Call initiated by a train driver including interworking.

7.6.3.1 Purpose

The purpose of this test is to demonstrate that a train driver can initiate a Railway Emergency Call. The FRMCS system will automatically routes the Railway Emergency voice communication to all users in the targeted area including GSM-R users. The Railway Emergency Call can be terminated by the call initiator. The definition of the REC area and the procedure of affiliation is described in the appendices §16.10

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_012]

7.6.3.2 Description of initial state/configuration

7. FRMCS User A is registered to the FRMCS System on the FRMCS device with a functional identity.
8. GSM-R User B is registered on the network as a Lead Driver (FC-01) of a Cab Radio B.

9. The FRMCS System is configured so that the FRMCS User A is authorised to initiate a Railway Emergency Call.
10. The FRMCS System is configured so that the FRMCS User A is authorised to use a Railway Emergency Call application.
11. The Cab Radio B is powered on, and the Idle screen is displayed on the GDCP.
12. All Users are subscribed to the same valid MCPTT Group ID.

7.6.3.3 Test procedure

***Note**: In addition to the below mentioned requirements, compliance is also fulfilled with MG-7900 (section §20) and TR22.889-V16.6.0 (section §6.4). It is worth mentioning that Railway Emergency Communication is an ongoing specification topic.*

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a Railway Emergency Call by pressing the REC button on the FRMCS device	Audible indication for call proceeding is given. Visual indication for call proceeding is displayed. The FRMCS system automatically routes the Railway Emergency Call to the Users in the targeted area and the Controller responsible for the train movement area. Audible indication for Railway Emergency Call is given via the loudspeaker of the Cab Radio B Visual indication for Railway Emergency Call is displayed on the GDCP of the Cab Radio B	5.15.4.4, 5.15.5.1, 5.15.5.2, 5.15.5.3, 5.15.5.4, 10.8.2.3, 10.8.2.4, 10.8.2.10, 10.8.2.19, 10.8.3.1, 10.8.3.2, 10.8.3.5, 10.8.3.6
2	GSM-R User B and the Controller responsible for the train movement area automatically accept the call	The Railway Emergency Call is established with a setup time specified as IMMEDIATE. Visual indication for call established is displayed on the FRMCS device and the GDCP of the Cab Radio B	5.15.4.5, 10.8.3.8

		Visual indication to use Push to Talk is displayed on the FRMCS device	
3	FRMCS User A presses PTT button	The FRMCS device is activated, and communication is possible. The voice quality is clear and loud	
4	FRMCS User A releases the PTT button	Visual indication to use Push to Talk is displayed on the FRMCS device	
5	GSM-R User B picks up the Cab Radio B handset and presses PTT button	The Cab Radio B loudspeaker sets to reduced volume. The Cab Radio B handset is activated, and communication is possible. The voice quality is clear and loud	
6	GSM-R User B releases the PTT button	Visual indication to use Push to Talk is displayed on the GDCP of the Cab Radio B	
7	FRMCS User A terminates the Railway Emergency Call	The FRMCS system terminates the Railway Emergency Call Visual indication is displayed on the FRMCS device, the GDCP of the Cab Radio B and the Controller's terminal. Idle screen is displayed on all devices	5.15.4.8, 5.15.5.6

7.6.4 Test case n° Voice_013 OPTIONAL: Joining an ongoing Railway Emergency Call

7.6.4.1 Purpose

The purpose of this test is to demonstrate that a train driver that moves into an area where a Railway Emergency voice communication is active, automatically joins the ongoing voice communication.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_013]

7.6.4.2 Description of initial state/configuration

1. FRMCS User B is registered to the FRMCS system on the FRMCS device with a functional identity.
2. FRMCS User A is registered to the FRMCS System on the Cab Radio A with a functional identity.
3. The FRMCS device is powered on, and in an ongoing Railway Emergency Call.
4. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
5. FRMCS User A is in a different group call area to the other FRMCS Users.

7.6.4.3 Test procedure

***Note**: In addition to the below mentioned requirements, compliance is also fulfilled with MG-7900 (section §20) and TR22.889-V16.6.0 (section §6.4). It is worth mentioning that Railway Emergency Communication is an ongoing specification topic*

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A enters the same group call area as the other FRMCS Users	The FRMCS system automatically routes the Railway Emergency Call to the FRMCS User A Audible indication for Railway Emergency Call is given via the loudspeaker of the Cab Radio A Visual indication for incoming Railway Emergency Call is displayed on the GDCP of the Cab Radio A	5.15.4.5, 5.15.5.3, 5.15.5.4, 10.8.2.7, 10.8.2.10
2	The FRMCS User A receives and automatically joins the Railway Emergency Call	Incoming audio is connected to the loudspeaker of the Cab Radio A The voice quality is clear and loud Visual indication is displayed on the FRMCS device and the Controller’s terminal	

7.6.5 Test case n° Voice_014 OPTIONAL: Leaving an ongoing Railway Emergency Call

7.6.5.1 Purpose

The purpose of this test is to demonstrate that a train driver that moves out of an area where a Railway Emergency voice communication is active, automatically leaves the ongoing voice communication.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_014]

7.6.5.2 Description of initial state/configuration

1. FRMCS User B is registered to the FRMCS System on the FRMCS device with a functional identity.
2. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
3. All devices are powered on, and in an ongoing Railway Emergency Call.
4. All FRMCS Users are subscribed to the same valid MCPTT group ID.

7.6.5.3 Test procedure

***Note**: In addition to the below mentioned requirements, compliance is also fulfilled with MG-7900 (section §20) and TR22.889-V16.6.0 (section §6.4). It is worth mentioning that Railway Emergency Communication is an ongoing specification topic.*

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A leaves the group call area	The FRMCS system automatically terminates the Railway Emergency Call on the FRMCS User A Cab Radio Audible indication is given via the loudspeaker of the Cab Radio A Visual indication is displayed on the GDCP of the Cab Radio A The Railway Emergency Call remains active for other participants. The Controller is informed the FRMCS User A has left the alerted area. The Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7100 v5.0.0]:** 5.15.4.6, 5.15.4.7, **[FU-7120-v0.9.2]:**10.8.2.7, 10.8.2.8, 10.8.2.10, 10.8.2.11

7.6.6 Test case n° Voice_015: GSM-R to FRMCS system transition with service continuation

7.6.6.1 Purpose

The purpose of this test is to demonstrate that a train driver can manually switch the network in case the current network becomes unavailable.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [Voice_015]

7.6.6.2 Description of initial state/configuration

1. FRMCS User A is registered to the FRMCS System on the FRMCS device with a functional identity.
2. GSM-R User B is registered on the network as a Lead Driver (FC-01) of a Cab Radio B.
3. The FRMCS System is configured so that the FRMCS User A is authorised to initiate a Railway Emergency Call.
4. The FRMCS System is configured so that the FRMCS User A is authorised to use a Railway Emergency Call application.

5. The Cab Radio B is powered on, and the Idle screen is displayed on the GDCP.
6. All Users are subscribed to the same MCPTT group ID.

7.6.6.3 Test procedure

***Note**: In addition to the below mentioned requirements, compliance is also fulfilled with MG-7900 (section §20) and TR22.889-V16.6.0 (section §6.4). It is worth mentioning that Railway Emergency Communication is an ongoing specification topic.*

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a Railway Emergency Call	Audible indication for call proceeding is given. Visual indication for call proceeding is displayed. The FRMCS system automatically routes the Railway Emergency Call to the Users in the targeted area including the GSM-R User B and the Controller responsible for the train movement area. Audible indication for Railway Emergency Call is given via the loudspeaker of the Cab Radio B Visual indication for Railway Emergency Call is displayed on the GDCP of the Cab Radio B	5.15.4.4, 5.15.5.1, 5.15.5.2, 5.15.5.3, 5.15.5.4, 10.8.2.3, 10.8.2.4, 10.8.2.10, 10.8.2.19, 10.8.3.1, 10.8.3.2, 10.8.3.5, 10.8.3.6
2	GSM-R User B and the Controller responsible for the train movement area automatically accept the call	The Railway Emergency Call is established with a setup time specified as IMMEDIATE. Visual indication for call established is displayed on the FRMCS device and the GDCP of the Cab Radio B Visual indication to use Push to Talk is displayed on the FRMCS device	5.15.4.5, 10.8.3.8

3	FRMCS User A and presses PTT button	The FRMCS device is activated, and communication is possible. The voice quality is clear and loud	
4	FRMCS User A releases the PTT button	Visual indication to use Push to Talk is displayed on the FRMCS device	
5	GSM-R User B picks up the Cab Radio B handset and presses PTT button	The Cab Radio B loudspeaker sets to reduced volume. The Cab Radio B handset is activated, and communication is possible. The voice quality is clear and loud	
6	GSM-R User B releases the PTT button	Visual indication to use Push to Talk is displayed on the GDCP of the Cab Radio B	
7	GSM-R system becomes unavailable	Audible indication is given via the loudspeaker of the Cab Radio B Visual indication is displayed on the GDCP of the Cab Radio B	
8	GSM-R User B presses the network switch button on the GDCP of the Cab Radio B	Cab Radio B switches from the GSM-R system to the FSMCS system	
9	GSM-R User B registers to the FRMCS system	Registration request is sent to the FRMCS system. Registration progress is displayed on the GDCP of the Cab Radio B	
10	FRMCS system accepts the registration request	Registration status is displayed on the GDCP of the Cab Radio B (e.g., train running number appears on the display) Audible indication is given via the loudspeaker. The FRMCS system automatically routes the ongoing Railway Emergency voice communication to the GSM-R User B	5.15.4.5, 5.15.5.3, 5.15.5.4, 10.8.2.7, 10.8.2.10

		Audible indication for Railway Emergency Call is given via the loudspeaker of the Cab Radio B Visual indication for Railway Emergency Call is displayed on the GDCP of the Cab Radio B	
11	The GSM-R User B receives and automatically joins the Railway Emergency Call as an FRMCS User B now	Incoming audio is connected to the loudspeaker of the Cab Radio B Visual indication is displayed on the Controller's terminal.	
12	FRMCS User A presses PTT button	The FRMCS device is activated, and communication is possible. The voice quality is clear and loud	
13	FRMCS User A releases the PTT button	Visual indication to use Push to Talk is displayed on the FRMCS device	
14	FRMCS User B picks up the Cab Radio B handset and presses PTT button	The Cab Radio B loudspeaker sets to reduced volume. The Cab Radio B handset is activated, and communication is possible. The voice quality is clear and loud	
15	FRMCS User B releases the PTT button	Visual indication to use Push to Talk is displayed on the GDCP of the Cab Radio B	
16	FRMCS User A terminates the Railway Emergency Call	The FRMCS system terminates the Railway Emergency Call. Visual indication is displayed on the FRMCS device, the GDCP of the Cab Radio B and the Controller's terminal. Idle screen is displayed on all devices	5.15.4.8, 5.15.5.6

7.7 Test case n° Voice_016: 5G to 5G voice cross-border

5G to 5G voice cross-border will not be performed neither in the lab, nor in field due to the lack of stable specifications, during the lifetime of 5GRAILproject. However, an inter-technology GSM-R to FRMCS test case with service continuation, will be performed instead.

7.8 Test case n° Voice_017: Combined MCPTT private point-to-point voice call (driver to controller) in parallel with MCData application in nominal scenario

7.8.1 Purpose

The purpose of this test is to demonstrate system behaviour using simultaneously two applications requesting different MCX services, such as MCPTT service for voice application and MCData service for the data application. The expected outcome of this test case is that in nominal radio conditions, each application keeps the standalone performances.

The combined scenario encompasses a driver to controller MCPTT point-to-point call and an On-board to trackside MCData communication, using MCData IPCon.

The above combined scenario will be performed in WP3 lab, using an MCData application either ETCS or Video and TOBA-K, as FRMCS On-board gateway, on n78 band. The MCData application selection will be done during the test execution.

Initial state/configuration of both applications shall be applied before launching the combined scenario. The QoS (DSCP) configuration of each application is impacting the results of the combined scenarios, mainly in the degraded conditions.

7.8.2 Description of initial state/configuration of the MCPTT point-to-point call

1. FRMCS User A is registered to the FRMCS system on the Cab Radio A with a functional identity.
2. The FRMCS System is configured so that the FRMCS User A is authorized to initiate the voice communication to the Controller.
3. The FRMCS System is configured so that the FRMCS User A is authorised to use the On-train outgoing voice communication from the Driver towards the Controller application.
4. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
5. Voice application is configured as a GBR application with 5QI=2 and ARP=7, for normal usage.

7.8.3 Description of initial state/configuration of nominal MCData application scenario

1. MCData application equipment are installed and configured.
2. FRMCS Gateway is connected and configured to MCData equipment and to 5G network.
3. MCData Trackside equipment are connected and configured.
4. MCData application onboard and trackside equipment are connected and power on in nominal state.

5. Video which is the MCData candidate for this test is configured as a non-GBR application with 5QI=7

7.8.3.1 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A initiates a voice communication to a Controller responsible for the train movement area by pressing a corresponding button on the GDCP of the Cab Radio A	Audible indication for call proceeding is given via the loudspeaker of the Cab Radio A Visual indication for call proceeding is displayed on the GDCP of the Cab Radio A The FRMCS system automatically routes the voice communication to the Controller responsible for the train movement area.	**[FU- 7100 v5.0.0]:** 5.1.4.1, 5.1.4.2, 5.1.5.1, 5.1.5.2, **[FU-7120-v0.9.2]:** 10.4.2.1, 10.4.2.2, 10.4.2.5, 10.4.2.7, 10.4.3.1, **[MG-7900 v2.0.0]**: 6.2.3.2, **TR22.889-V16.6.0** [R-6.3.2-001], [R-6.3.2-002], [R-6.3.2-005]
2	Controller accepts the call by manual interaction	The call to the Controller is established within a setup time specified as NORMAL. Audible indication for call establishment is given via the loudspeaker of the Cab Radio A Visual indication for call establishment is displayed on the GDCP of the Cab Radio A The Controller can be heard via the loudspeaker of the Cab Radio A The voice quality is clear and loud	**[FU- 7100 v5.0.0]:** 5.1.5.3, **[FU-7120-v0.9.2]:** 10.4.2.8, **[MG-7900 v2.0.0]**: 6.2.3.1, 6.2.3.3, **TR22.889-V16.6.0** [R-6.3.2-004], [R-6.3.2-005]
3	FRMCS User A picks up the Cab Radio A handset	The Cab Radio A loudspeaker sets to reduced volume.	**[FU- 7100 v5.0.0]:** 5.1.4.3,

		The Cab Radio A handset is activated, and communication is possible. The voice quality is clear and loud	**TR22.889-V16.6.0** [R-6.3.2-007 a]
4	In parallel with the on-going voice communication, MCData application is launched by opening WebSocket and performing all loose coupled OBapp steps up to session start message.	Data transmission link between OB GW and TS GW is ready.	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003] [R-12.10.2-028] §12.20.5.
5	Establish a communication session between MCData onboard and trackside equipment (User request)	MCData communication session established, validated in the Wireshark logs without impact on the voice communication	
6	Start data transfer between MCData application onboard and trackside equipment	Data transfer is on-going between onboard and trackside, based on application logs, where the monitored parameters are Throughput, round trip time, message losses	
7	Compare the monitored parameter's values of the combined scenario with the nominal ones for ETCS or Video application.	No impact on the performance of the MCData communication is expected due to the simultaneous presence of the voice call, in comparison with the nominal "standalone" MCData communication.	
8	Perform an end of communication (End of simulation).	Check data communication is ended.	
9	At the same time, FRMCS User A terminates the call by placing the Cab Radio A handset down on the cradle	The FRMCS system terminates the voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7900 v2.0.0]:** 6.4.3.1, 6.4.3.2, **TR22.889-V16.6.0** [R-6.3.3-001]

7.9 Test case n° Voice_018: Combined MCPTT private point-to-point voice call (driver to controller) in parallel with MCData application in degraded conditions

7.9.1 Purpose

It is particularly interesting to repeat the combined scenario, MCPTT voice (configured as GBR) and MCData application (configured as non-GBR), in degraded conditions, using Vertex emulator. In such conditions the QoS, prioritisation and radio resource management of voice application, as the most critical one, will be revealed, thanks to the QoS (DSCP) configuration of both applications.

7.9.2 Description of initial state/configuration

1. The initial state/configuration pre-requisites are applied, as per nominal conditions MCPTT private call (driver to controller). (cf.§7.8.2)
2. The initial state/configuration pre-requisites are applied, as per nominal MCData application conditions. (cf.§7.8.3)
3. This test case will be performed with TOBA-K in n78 and n8, to evaluate the frequency impact on the results, if any.

7.9.2.1 Test procedure

The test procedure is identical to the nominal, as described in §7.8.3.1, up to step 6, where both applications are launched correctly in parallel. In step 7, degradation conditions are created. In steps 8 and 9 both voice and MCData application are closed.

Step	Action	Expected result(s)	Compliance with selected requirements
7	Perform progressive degradation of radio conditions creating fading, multipath and speed variation, using Vertex tool, as presented in Figure 42	In case of highly degraded conditions, at least the monitored parameters, such as throughput, round trip time, message losses for ETCS, are maintained in the acceptable operational values.	
8	Perform an end of communication (End of simulation).	Check data communication is ended.	
9	At the same time, FRMCS User A terminates the call by placing the Cab Radio A handset down on the cradle	The FRMCS system terminates the voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7900 v2.0.0]:** 6.4.3.1, 6.4.3.2, **TR22.889-V16.6.0** [R-6.3.3-001]

7.10 Test case n° Voice_019: MCPTT private point-to-point voice call (driver to controller) with HO (inter or intra) gNodeB.

7.10.1 Purpose

The purpose of this test is to demonstrate that a train driver can initiate a voice communication with a train controller responsible for the train movement area and can maintain it without drops and with a good quality even in mobility conditions (inter/intra gNodeB HO). The call initiator can terminate the voice communication, as in nominal conditions.

7.10.2 Description of initial state/configuration

Same initial conditions are applied as for the nominal static conditions (cf. §7.3.1.2)

7.10.3 Test procedure

All the steps up to step 3 are executed as per nominal conditions, described in §7.3.1.3. Starting from step 4, mobility conditions are created. In step 5, the call is closed by the initiator, as per nominal conditions.

Step	Action	Expected result(s)	Compliance with selected requirements
4	Trigger an (inter/intra) gNodeB handover by modifying the signal strength of the node, using RF attenuators, as presented in Figure 29.	The communication between driver and controller is not dropped and performed with good quality conditions.	
5	FRMCS User A terminates the call by placing the Cab Radio A handset down on the cradle	The FRMCS system terminates the voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7900 v2.0.0]:** 6.4.3.1, 6.4.3.2, **TR22.889-V16.6.0** [R-6.3.3-001]

7.11 Test case n° Voice_020: MCPTT private point-to-point voice call (driver to controller) with HO (inter or intra) gNodeB in degraded radio conditions.

7.11.1 Purpose

The purpose of this test is to demonstrate that a train driver can initiate a voice communication with a train controller responsible for the train movement area and can maintain it without drops even during degraded conditions simulated using Vertex tool.

This test can be repeated in n8 and n78 to compare the impact of frequency band in the results.

7.11.2 Description of initial state/configuration

Same initial conditions are applied as for the nominal case. (cf. §7.3.1.2)

7.11.3 Test procedure

All the steps up to step 3 are executed as per nominal conditions, described in §7.3.1.3. Starting from step 4, degraded radio conditions are created. In step 5, the call is closed by the initiator, as per nominal conditions.

Step	Action	Expected result(s)	Compliance with selected requirements
4	Perform progressive degradation of radio conditions creating fading, multipath and speed variation, by using Vertex tool, as presented in Figure 42	The communication between driver and controller is not dropped and performed with good quality conditions.	
5	FRMCS User A terminates the call by placing the Cab Radio A handset down on the cradle	The FRMCS system terminates the voice communication. Visual indication is displayed on the GDCP of the Cab Radio A and the Controller's terminal. Idle screen is displayed on the GDCP of the Cab Radio A	**[FU- 7900 v2.0.0]:** 6.4.3.1, 6.4.3.2, **TR22.889-V16.6.0** [R-6.3.3-001]

8 CRITICAL DATA APPLICATIONS TEST CASES DESCRIPTION

These scenarios are focused on critical data applications evaluation, such as ETCS, ATO, within FRMCS ecosystem using on board and trackside protypes, by testing the selected FRMCS functionalities and MCX features.

(ATP) ETCS application will be tested in both labs in the scope of WP3 and WP4. ETCS provided by CAF will be tested in WP3 lab in Budapest. (ATP) ETCS provided by Alstom will be tested in WP4 lab in Montigny. ATP application from CAF will be tested with FRMCS-On-Board Gateway provided by Kontron. ATP application from Alstom will be tested in lab with FRMCS-On-board Gateways of both providers.

Some of these test cases will be repeated in real field conditions, in the scope of WP5 in Germany and/or in France.

8.1 Automatic Train Protection communication – CAF application

Automatic Train Protection is the application which performs some or all the functions that ensure the safe movement of a train. ATP supervises the train ensuring that speed and movement limits are kept and the train proceeds only when it is allowed to do so.

- **CAF-ETCS**

The following figure illustrates ETCS and TCMS architecture, as integrated in the lab environment of WP3, in Budapest

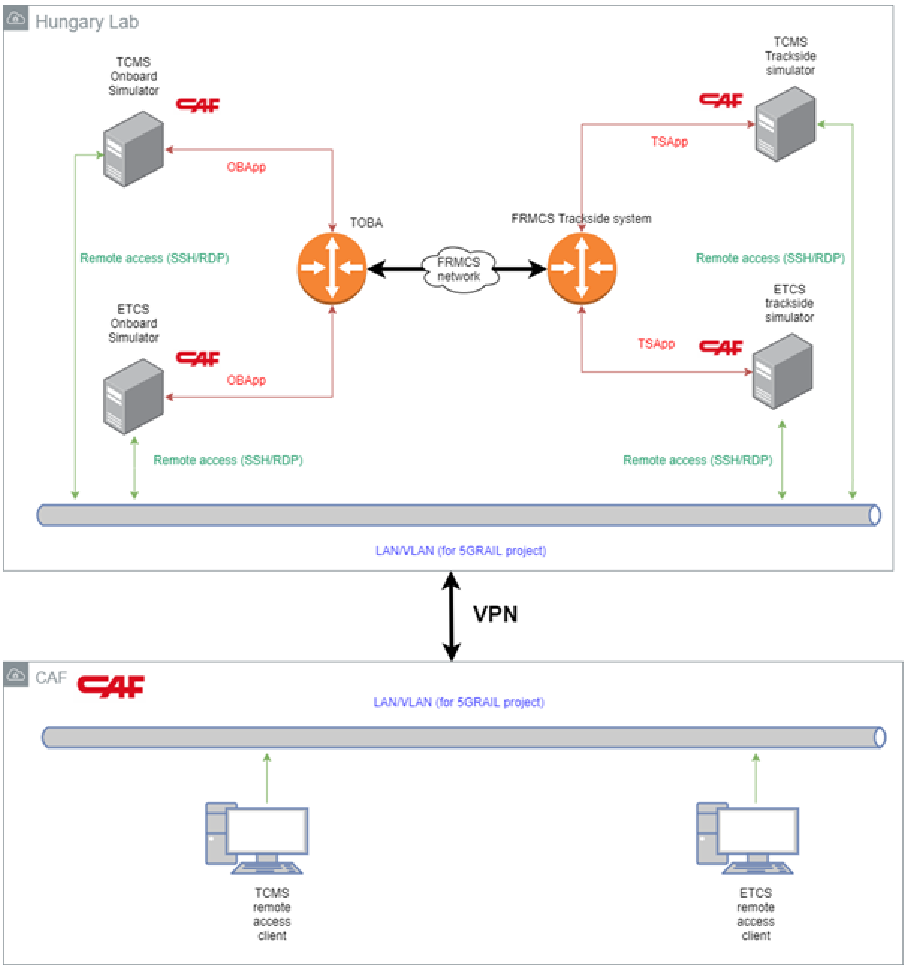


Figure 52: ETCS and TCMS use cases CAF's test environment architecture (Ref. D3.1)

The detailed overall architecture of ETCS application provided by CAF, as also the interaction with the On-board gateway, through the API, is presented in the following figure:

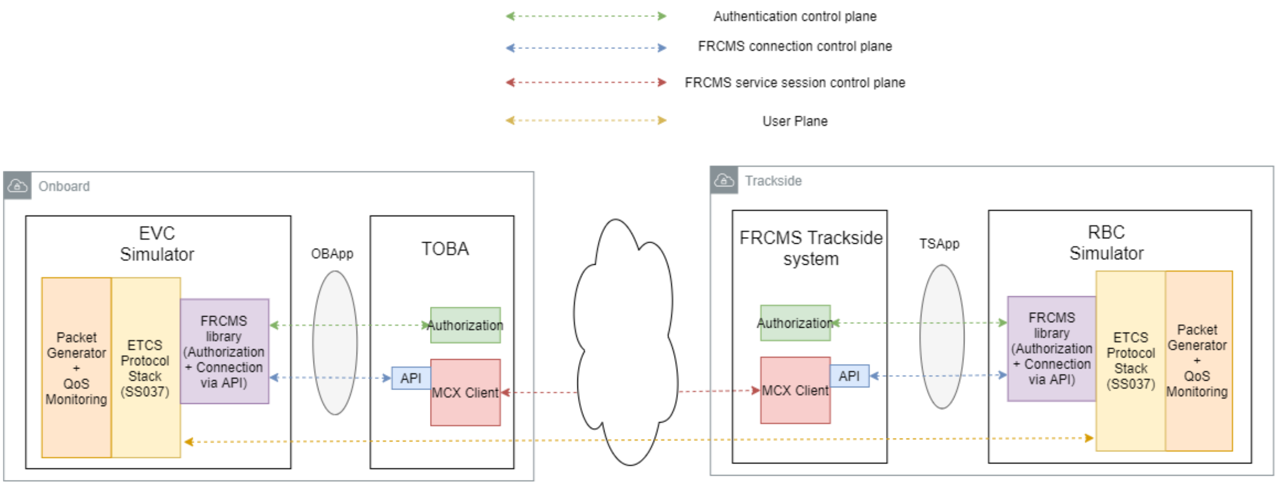


Figure 53: Detailed overall ETCS architecture (Ref. D2.1)

8.1.1 ETCS_WP3-WP5: Nominal communication between ETCS on board application and RBC (same 5G network)

8.1.1.1 Purpose

The purpose of this test is to check a nominal data transfer between ETCS on board application and RBC on the same 5G network:

- Establishment of communication:
- Data transfer
- End of communication

8.1.1.2 Description of initial state/configuration

ETCS equipment are installed and configured.

FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.

ETCS Trackside equipment are connected and configured.

ETCS onboard and trackside equipment are connected and power on in nominal state.

8.1.1.3 Test procedure_ ETCS_WP3-WP5_TC_001: Nominal communication between ETCS on board application and RBC (same 5G network)

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [ETCS_WP3-WP5_TC_001]

<table>
<tr><th>Step</th><th>Action</th><th>Expected result(s)</th><th>Compliance with selected requirements</th></tr>
<tr><td>01</td><td>Open WebSocket and perform all loose coupled OBapp steps up to session start message.</td><td>Data transmission link between OB GW and TS GW is ready.</td><td rowspan="2">[FU- 7100 v5.0.0]: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported)
8.8.1.1, 8.8.2.1
8.12.1.1, 8.12.2.1

And

3GPP TR22.889 V17.4.0:
[R-12.9-003]</td></tr>
<tr><td>02</td><td>Establish a communication session between ETCS onboard and trackside equipment (User request)</td><td>ETCS communication session established, validated in the Wireshark logs. Euroradio safe connection is established (AU1, AU2, AU3 and AR key exchange can be seen in the Wireshark trace)</td></tr>
</table>

03	Start data transfer between ETCS onboard and trackside equipment	Check data transfer between onboard and trackside, based on application logs. End-to-End QoS parameters will be monitored in the applications. The QoS parameters will take into account the full path, from application to application, including the delays on the FRMCS GW, network, and applications protocol stack. The parameters that will be monitored are informative, and just help in the analysis process to find the differences between nominal and degraded test scenarios. The monitored parameters are: **Throughput**, using separately EVC and RBC metric, to estimate the amount of data sent by each entity **Round Trip Time**: The EVC will timestamp packets, and those packets will be sent to the RBC and the RBC will rebound them to the EVC. The time between packet sent and packet acknowledgement will be monitored. **Message losses:** Each application will detect if there has been an application message loss in the communication. Euroradio safe connection relies in TCP protocol. However, a message can be lost if there is a failure in the safe connection and	[R-12.10.2-028] §12.20.5.

		needs to reconnect. These retransmissions are handled by the application. All the above parameters observed during this procedure are considered as the nominal ones.	
04	Perform an end of communication (End of simulation)	Check communication is ended. Euroradio safe connection can be observed in the Wireshark trace.	

8.1.1.4 Test procedure_ ETCS_WP3-WP5_TC_005: Nominal communication between ETCS on board application and RBC, including BTS handover (same 5G network)

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [ETCS_WP3-WP5_TC_005]

Step	Action	Expected result(s)	Compliance with selected requirements
04	Steps 1 to 3 are performed, as in the previous procedure TC_001a. When data transfer is on-going, trigger a BTS handover by modifying the signal strength of the BTS, using RF attenuators, as presented in Figure 29.	Monitor communication exchanges to check the impact or not, by comparing the monitored parameters values with the previous nominal procedure.	
05	Perform an end of communication (End of simulation)	Check communication is ended. Euroradio safe connection can be observed in the Wireshark trace.	

8.1.2 ETCS_WP3-WP5_TC_002: Communication between ETCS on board application and RBC (same 5G network) in degraded radio conditions

8.1.2.1 Purpose

The purpose of this test is to evaluate FRMCS network performance in various radio conditions as well as to evaluate the capability of the GW to choose the appropriate bearer, based on the radio conditions, for the ETCS application to be able to keep the nominal behaviour.

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [ETCS_WP3-WP5_TC_002]

The following steps are performed:

- Establishment of communication:
- Data transfer
- Create degraded radio conditions in lab environment.
- Data transfer continue.
- End of communication

8.1.2.2 Description of initial state/configuration

ETCS equipment are installed and configured.

FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.

ETCS Trackside equipment are connected and configured.

ETCS onboard and trackside equipment are connected and power on in nominal state.

8.1.2.3 Test procedure: Communication in degraded radio conditions

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open WebSocket and perform all loose coupled OBapp steps up to session start message.	Data transmission link between OB GW and TS GW is ready.	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003]
02	Establish a communication session between ETCS onboard and trackside equipment (User request)	ETCS communication session established, validated in the Wireshark logs. Euroradio safe connection is established (AU1, AU2, AU3 and AR	

		key exchange can be seen in the Wireshark trace)	[R-12.10.2-028] §12.20.5.
03	Start data transfer between ETCS onboard and trackside equipment	Check the differences in the values in comparison with the nominal case	
04	Initiate network performance monitoring: - FRMCS End-to-End- - Application: number of messages received per second in Trackside	Baseline performance is similar to expected in regular conditions	
05	Perform a degradation of radio conditions creating fading, multipath, or speed variation, as presented in Figure 42	Check communication performance on FRMCS and application against nominal communication QoS reference.	
06	Perform an end of communication (End of simulation)	Check communication is ended	

8.1.3 ETCS_WP3-WP5_TC_003: Increase data transferred in the ETCS communication.

8.1.3.1 Purpose

The purpose of this test is to check that even if the load of data sent by the ETCS application increases, the FRMCS system is still able to handle it. Average ETCS data transfer is around 200 Bytes/s in actual ETCS deployments. The objective of this test is to validate that there is room for more data transfer in the future ETCS application versions. In order to do so, the data transfer will increase up to 4 kbps only for ETCS application. The steps that need to be performed are the following ones:

- Establishment of communication
- Data transfer (4 kbps)
- End of communication

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [ETCS_WP3-WP5_TC_003]

8.1.3.2 Description of initial state/configuration

ETCS equipment are installed and configured.

FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.

ETCS Trackside equipment are connected and configured.

ETCS onboard and trackside equipment are connected and power on in nominal state.

8.1.3.3 Test procedure

<table>
<tr><th>Step</th><th>Action</th><th>Expected result(s)</th><th>Compliance with selected requirements</th></tr>
<tr><td>01</td><td>Open WebSocket and perform all loose coupled OBapp steps up to session start message.</td><td>Data transmission link between OB GW and TS GW is ready.</td><td rowspan="4">[FU- 7100 v5.0.0]:5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported)
8.8.1.1, 8.8.2.1
8.12.1.1, 8.12.2.1

And

3GPP TR22.889 V17.4.0:
[R-12.9-003]
[R-12.10.2-028]

§12.20.5</td></tr>
<tr><td>02</td><td>Establish a communication session between ETCS onboard and trackside equipment (User request)</td><td>ETCS communication session established, validated in the Wireshark logs.</td></tr>
<tr><td>03</td><td>Start data transfer between ETCS onboard and trackside equipment but with a higher load of the ETCS data (4kpbs)</td><td>Check that the communication is still ongoing. Identify impact on latency, packet loss, or number of packet retransmissions</td></tr>
<tr><td>04</td><td>Perform an end of communication (End of simulation)</td><td>Check communication is ended</td></tr>
</table>

8.1.4 ETCS_WP3-WP5_TC_004: ETCS onboard combined with other data application.

8.1.4.1 Purpose

The purpose of this test is to check a nominal data transfer between ETCS on board application and RBC on the same 5G network when another non-critical data application (e.g., TCMS or Video) is also transmitting data in parallel using the same FRMCS GW. Referring to the ETCS application, the steps that will be performed are the following ones:

- Establishment of communication
- Data transfer
- End of communication

The MCX building blocks validated with this test case are presented in §16.6 Applicability of MCX building blocks to the test cases of WP3 [ETCS_WP3-WP5_TC_004]

8.1.4.2 Description of initial state/configuration

ETCS equipment are installed and configured.

Other Data application is installed and configured.

FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.

ETCS Trackside equipment are connected and configured.

Other MCData trackside application is installed and configured.

ETCS onboard and trackside equipment are connected and power on in nominal state.

8.1.4.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open WebSocket and perform all loose coupled OBapp steps up to session start message.	Data transmission link between OB GW and TS GW is ready.	**[FU- 7100 v5.0.0]:**5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported) 8.8.1.1, 8.8.2.1
02	Establish a communication session between ETCS onboard and trackside equipment (User request)	ETCS communication session established, validated in the Wireshark logs.	

03	Start data transfer between ETCS onboard and trackside equipment	Check that the communication is still ongoing, identify impact on latency, packet loss or packet retransmission, etc.	8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003] [R-12.10.2-028] §12.20.5
04	In parallel, establish a communication between the On-board and trackside equipment of another MCData application	Communication between onboard and trackside is OK (name resolution, ...)	
05	Check that both communications still in progress	Expected results will be explained in D3.3 First Lab Test Report deliverable	
06	Check QoS information received correspond to the one expected by default for ETCS and other Data application	Expected results will be explained in D3.3 First Lab Test Report deliverable	
07	Create overload conditions in the network. (e.g., by increasing ETCS traffic or by other means)	Expected results will be explained in D3.3 First Lab Test Report deliverable. Priority of ETCS has to be maintained.	
08	Perform an end of communications (End of simulation)	Check both communications are ended	

***Note**: The focus in WP3 lab is given to voice test cases. For that reason, we consider the combined scenario of voice/Video as mandatory in the scope of WP3 and the combined ETCS/TCMS or Video as an optional one.*

8.2 Automatic Train Protection communication – ALSTOM application

This test case, as described in the following, will be performed in the lab of WP4 and the application is provided by Alstom.

- **ALSTOM - ETCS**

Below is the architecture of ETCS application, as integrated in the lab environment of WP4, at Kontron’s premises in Montigny.

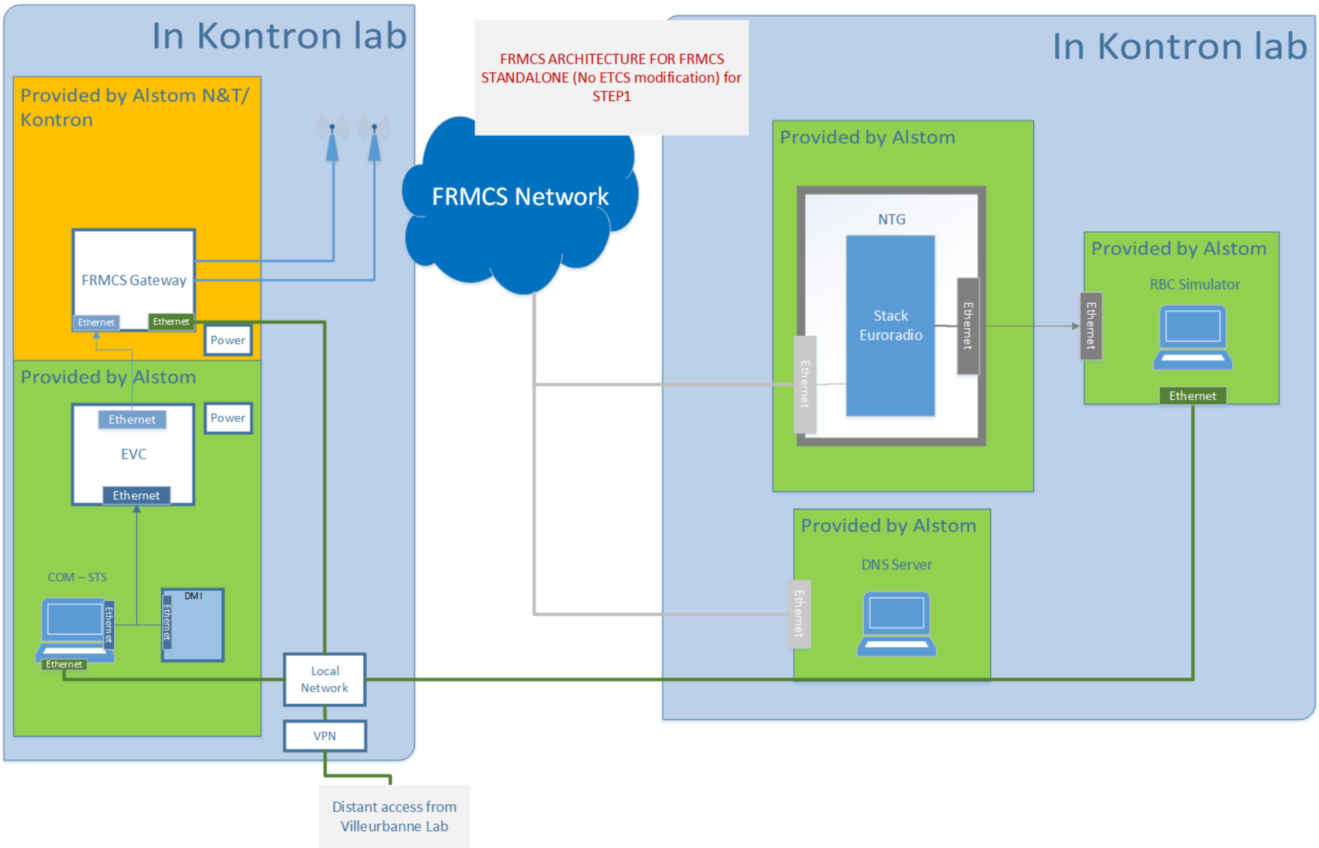


Figure 54: ETCS from Alstom in WP4 lab environment (Ref. D4.1)

The application prototype is divided in 2 phases: Step 1 and Step 2. The test plan is specific and different for each phase. In Step 1 the application will only use the 'flat IP' mode. In Step 2, the OBapp will be available. The 'flat IP' mode and OBapp/TSapp coupling modes are defined in §4 FRMCS ARCHITECTURE OBapp/TSapp DEFINITIONS

8.2.1 STEP 1 – Flat IP

'Flat IP' test cases will be performed only to de-risk integration of the application in the FRMCS environment. MCX framework is assumed for all applications. The flat-IP test cases were only performed with FRMCS On-board Gateway from Alstom.

8.2.1.1 ETCS_WP4-WP5_FLAT-IP_TC_001: Nominal communication in level 2 between ETCS on board application and RBC (same 5G network)

8.2.1.1.1 PURPOSE

The purpose of this test is to check communication in level 2 between ETCS on board application and RBC on the same 5G network:

- Establishment of communication:
- Data transfer
- End of communication

8.2.1.1.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.
- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.

8.2.1.1.3 TEST PROCEDURE 1: COMMUNICATION NOMINAL TEST

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish a communication between ETCS onboard and trackside equipment (User requests a connection via the DMI or the train cross a specific beacon with packet 131)	User plane Communication between onboard and trackside is OK	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003] [R-12.10.2-028] §12.20.5.
02	Check communication are correctly set	The applicative logs are as expected: the ‘connection confirm’ message is received.	
03	Check Data transfer between onboard and Trackside	Data are correctly transferred between onboard and trackside	
04	Perform an end of communication (Crossing a beacon, user request or end of simulation)	Communication is ended	

8.2.1.1.4 TEST PROCEDURE 2: RBC AND BTS HANDOVER ON THE SAME 5G NETWORK

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish a communication between ETCS on board and trackside equipment (User requests a connection via the DMI or the train cross a specific beacon with packet 131)	Communication between onboard and trackside is OK.	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003] [R-12.10.2-028] §12.20.5.
02	Perform RBC handover (using a balise scenario)	No impact on the on-going communication	
03	Manually trigger a BTS handover, using an RF set-up, as presented in Figure 36	No impact on the on-going communication	

8.2.1.1.5 TEST PROCEDURE 3: ENDURANCE - RBC HANDOVER IN A LOOP DURING 6H OR 8H ON THE SAME 5G NETWORK

Step	Action	Expected result(s)	Compliance with selected requirements
02	Establish a communication between ETCS onboard and trackside equipment (User requests a connection via the DMI or the train cross a specific beacon with packet 131)	Communication between onboard and trackside is OK.	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the ATP system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003] [R-12.10.2-028] §12.20.5.
03	Perform multiple RBCs handover (using a balise scenario) during several hours (approximately 6h or 8h). There are only hundred meters between the beacons to perform handover every 3 minutes (approximately)	Communication exchanges continue, without interruption	

Performance measurements on TCP protocol are done during the user plane communication. The two selected KPIs §15 [25] are the following:

- **Latency:**

Measure the time between message emission and acknowledgement reception on ethernet link between ERTMS application and TOBA GTW.

The test is PASSED if for 99% of messages this time is less than a 1 second.

- **Reliability:**

Check the number of retries at TCP level for applicative data messages and for keep alive messages.

The test is PASSED if the number of retries is less than “total TCP frames / 10000”.

8.2.1.2 ETCS_WP4-WP5_FLAT-IP_TC_002: Bearer flexibility

8.2.1.2.1 PURPOSE

The purpose of this test is to check that the communication is not impacted by a switch of bearer

- Establishment of communication:
- Data transfer
- End of communication

8.2.1.2.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.
- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.

8.2.1.2.3 TEST PROCEDURE: SWITCH OF MOBILE (ON DIFFERENT BEARER)

Note*: The detailed bearer flex test cases will be described in the OBapp context*

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish a communication between ETCS onboard and trackside equipment (User requests a connection via the DMI or the train cross a specific beacon with packet 131)	User plane Communication between onboard and trackside is OK	**3GPP TR22.889 V17.4.0:** §12.9.3 (case 1) §12.9.5: [R-12.9-001], [R-12.9-002], [R-12.9-003], [R-12.9-012]
02	Check communication are correctly set	The applicative logs are as expected	
03	Check Data transfer between onboard and Trackside	Data are correctly transferred between onboard and trackside	
04	Mobile switch, and the second mobile is on a different bearer	The second mobile is camped on a different bearer	
05	Check that the data transfer between onboard and Trackside is still on going.	The communication is not impacted by the switch	
06	Perform an end of communication (Crossing a beacon, user request or end of simulation)	Communication is ended	

8.2.1.3 ETCS_WP4-WP5_FLAT-IP_TC_003: Test cases in degraded mode

8.2.1.3.1 PURPOSE

The purpose of this test is:

- to check that the communication is not impacted by TCP degradation.
- to check that TCP connection is established between end-to-end devices without any proxy.

8.2.1.3.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.

- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.

8.2.1.3.3 TEST PROCEDURE: TCP ISSUES DURING THE USER PLANE COMMUNICATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish a communication between ETCS onboard and trackside equipment (User requests a connection via the DMI or the train cross a specific beacon with packet 131)	User plane Communication between onboard and trackside is OK	**[FU- 7100 v5.0.0]**: 5.9.4.3
02	Check communication are correctly set	The applicative logs are as expected	
03	Check Data transfer between onboard and Trackside	Data are correctly transferred between onboard and trackside	
04	Add a TCP issue (TCP delay, or loss of TCP socket due to NTG disconnection) or by applying a filtering rule, using a firewall.		
05	Check Data transfer between onboard and Trackside	Data are correctly transferred between onboard and trackside	
06	Perform an end of communication (Crossing a beacon, user request or end of simulation)	Communication is ended	

8.2.2 STEP 2 - OBAPP

8.2.2.1 ETCS_WP4-WP5_OBapp-TC_001: Check the health of the link between ETCS and TOBA

8.2.2.1.1 PURPOSE

The purpose of this test is to check that the link between ETCS and TOBA is correctly set up and working properly.

8.2.2.1.2 REQUIREMENTS

In the framework of 5GRail, a proprietary non-specified solution is applied. The detailed description of the API implementation is explained in D2.1 TOBA Architecture Report– OBapp – Loose coupled interface.

8.2.2.1.3 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.
- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.

8.2.2.1.4 TEST PROCEDURE 1: THE WEBSOCKET STATUS IS CORRECT

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket connection	No error returned.	D2.1 TOBA Architecture Report – OBapp – Loose coupled interface
02	Check the status	The status indicates that the WebSocket is correctly opened	

8.2.2.1.5 TEST PROCEDURE 2: THE WEBSOCKET IS NOT RESPONDING

Step	Action	Expected result(s)	Compliance with selected requirements
01	Change the WebSocket port in TOBA-A		
02	Open the WebSocket connection	The WebSocket is not responding	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
03	Once the timeout (40s) is reached: check the status	The status indicates that the WebSocket cannot be open	

8.2.2.1.6 TEST PROCEDURE 3: THE WEB-SOCKET IS OPEN WITH A WRONG CERTIFICATE

***Note**: This test case is deleted between two consecutive versions of the test plan because it was decided that ETCS will not be tested in cybersecurity context, ATO will be the cybersecurity demonstrator application.*

8.2.2.2 ETCS_WP4-WP5_OBapp-TC_002: Check the registration and the connection status.

8.2.2.2.1 PURPOSE

The purpose of this test is to check if the registration and the connection status is correct between ETCS application and the FRMCS OB_{APP}.

8.2.2.2.2 REQUIREMENTS

In the framework of 5GRail, a proprietary non-specified solution is applied for local binding and registration procedure. The detailed description of the implementation is described in in D2.1 TOBA Architecture Report– OBapp – Loose coupled interface FRMCS_GTW_REGISTER.

8.2.2.2.3 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.
- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.

8.2.2.2.4 TEST PROCEDURE 1: REGISTRATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket connection. Check the status	The status indicates that the WebSocket is correctly opened	D2.1 TOBA Architecture Report -v2– OBapp – Loose coupled interface - FRMCS_GTW_REGISTER
02	Register ETCS Application	Check the registration answer	
03	Check the connection status	The connection status is OK	

8.2.2.2.5 TEST PROCEDURE 2: REGISTRATION WITH AN INCORRECT APPLICATION TYPE

***Note**: This test case is deleted between two consecutive versions of the test plan, because the application type is hard coded in both gateway prototypes and consequently the pre-requisites of the test are not fulfilled.*

8.2.2.2.6 TEST PROCEDURE 3: REGISTRATION FAILURE: THE GTW IS NOT RESPONDING

***Note**: This test case is deleted between the versions of the test plan, because the implementation of this test case needs modifications in the gateways.*

8.2.2.2.7 TEST PROCEDURE 4: LOSS OF THE WEBSOCKET DURING THE REGISTRATION PROCESS:

***Note**: This test case is deleted because one step of the test cannot be performed. The registration procedure takes place very quickly and there is no time to create context of loss of WebSocket.*

8.2.2.2.8 TEST PROCEDURE 5: LOSS OF THE WEBSOCKET ONCE THE REGISTRATION IS COMPLETED

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket connection. Check the status	The status indicates that the WebSocket is correctly opened	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface - FRMCS_GTW_REGISTER
02	Register ETCS application.	The registration status is OK	
03	Unplug the cable between TOBA and EVC. The WebSocket is not responding anymore	No errors, the application is still up and running	
04	The timeout is reached (500ms)	The connection status is KO	

8.2.2.2.9 TEST PROCEDURE 6: CHECK THE CONNECTION STATUS

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket connection. Check the status	The status indicates that the WebSocket is correctly opened	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface - FRMCS_GTW_REGISTER FRMCS_GTW_SERVICE_REQUEST
02	Register ETCS application.	The registration status is OK (in the application logs)	
03	Check the connection status (polling)	The connection status is OK (in the application logs)	
04	Disconnect the mobiles to lose the connection with the MCX server		
05	Check the new connection status in the logs of the application.	The connection status is KO (in the application logs) The connection status is failed	
06	Reconnect the mobiles	The connection status is OK. The application detects the availability of the radio link, and the connection status becomes ‘connected’.	

8.2.2.3 ETCS_WP4-WP5_TC_003: Communication in level 2 between ETCS onboard application and RBC

8.2.2.3.1 PURPOSE

The purpose of this test is to check the communication in level 2 between ETCS on board application and RBC on the same 5G network:

- Establishment of communication:
- Session start
- User plane communication
- End of communication

8.2.2.3.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.
- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.
- The connection status is OK.
- The configuration A, ETCS end to end FRMCS call in nominal conditions, with the corresponding radio set-up

8.2.2.3.3 TEST PROCEDURE 1: NOMINAL COMMUNICATION IN LEVEL2

The test will be repeated with TOBA-A and TOBA-K in n8 and n39 respectively in WP4 lab. TOBA-K in n39 band usage is of particular interest for this test because it will be repeated in field testbed.

<table>
<tr><th>Step</th><th>Action</th><th>Expected result(s)</th><th>Compliance with selected requirements</th></tr>
<tr><td>01</td><td>Establishment of a new session for communication (session start message)</td><td>The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP.

Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)</td><td rowspan="5">D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – FRMCS_GTW_SESSION_STATUS

FRMCS_GTW_SESSION_END</td></tr>
<tr><td>02</td><td>Check that the user plane communication is established.</td><td>The data transfer using the RBC IP</td></tr>
<tr><td>03</td><td>Terminate the user plane communication</td><td>No error returned</td></tr>
<tr><td>04</td><td>Terminate the session</td><td>The content of the session status “deleted” message (session ID) is correct</td></tr>
<tr><td>05</td><td>Check that the FRMCS GTW is responding to the connection status request</td><td>Connection status is OK</td></tr>
</table>

Since application and gateways are prototypes, it was agreed to refer as a baseline to the QoS of ETCS over GPRS, as presented in Subset – 093 v4.0.0. The following application KPIs are suggested (§15 [24], Table 2 Summary of QoS requirements (PS mode))

QoS Parameter	Value
Transaction Transfer Delay (TTD) OBU originated 100 octets. RBC originated 320 octets. RBC originated 560 octets (optional, if MAs in operation are smaller than or equal to 320 octets) (Refer to chapter 6.7.5 of Subset – 093 v4.0.0)	≤ 2.6s (99%) ≤ 3.0s (99%) ≤ 3.5s (99%)

Table 11: ETCS Application KPIs as per Subset – 093 v4.0.0

8.2.2.3.4 TEST PROCEDURE 2: RBC HANDOVER ON THE SAME 5G NETWORK

The test will be repeated with TOBA-A and TOBA-K in n8 and n39respectively in WP4 lab. TOBA-K in n39 band usage is of particular interest for this test because it will be repeated in field testbed.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC1 (session start message)	The FRMCS GTW is correctly answering OK with the session ID1. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface - – GTW_SESSION_STATUS FRMCS_GTW_SESSION_END
02	Check that the user plane communication is established.	Data transfer using the RBC1 IP	
03	Establishment of a new session for communication with RBC2 (session start message).	The FRMCS GTW is correctly answering OK with the session ID2 and RBC2 @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	
04	Check that the user plane communication is established.	Data transfer using the RBC2 IP	
05	Terminate the user plane communication with the RBC1	No error returned	
06	Terminate the session1	The content of the session status “deleted” message (session ID1) is correct	
07	Check that the user plane communication is still established with the RBC2.	Data transfer using the RBC2 IP	

08	Terminate the user plane communication with the RBC2	No error returned	
09	Terminate the session2	The content of the session status "deleted" message (session ID2) is correct	
10	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	

8.2.2.3.5 TEST PROCEDURE 3: RBC HANDOVER ON A DIFFERENT 5G NETWORK: CROSS- BORDER USE CASE

This test will be performed in WP4 lab with TOBA-A in n8 and 2x 5G UEs and with TOBA-K with 1x5G UE in n39 and 1x4G UE in b38 band. Both gateways cross-border implementation is making usage of *multi-connectivity feature*, when using 2UEs. (cf§15. [16] §5.2.2.4.14), Figure 40)

The cross-border test case when performed with TOBA-K and 1x5G UE in n39, is implemented as a *Radio degraded* kind of test case.

The overall performances in lab in case of TOBA-K in n39 are of particular interest due to the repetition of this test case in field conditions.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC1 (session start message)	The FRMCS GTW is correctly answering OK with the session ID1 and RBC1 @IP. Check that the FRMCS GTW is sending "working" notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface - – GTW_SESSION_STATUS §5.2.2.4.14 Support border-crossing capabilities
02	Check that the user plane communication is established.	Data transfer using the RBC1 IP	
03	Establishment of a new session for communication with RBC2 (session start message), based on a beacon simulation request to the On-Board application.	The FRMCS GTW is correctly answering OK with the session ID2 and RBC2 @IP.	

	RBC2 is on a different network	Check that the FRMCS GTW is sending "working" notification before the timeout (12sec)	
04	Check that the user plane communication is established.	Data transfer using the RBC2 @IP	
05	Terminate the user plane communication with the RBC1, on beacon request for close connection to the On-Board application.	No error returned	
06	Terminate the session1. The train becomes out of coverage from network, where RBC1 belongs	The content of the session status "deleted" message (session ID1) is correct	
07	Check that the user plane communication is still established with the RBC2.	Data transfer using the RBC2 IP. The communication is not impacted by the network handover	
08	Terminate the user plane communication with the RBC2	No error returned	
09	Terminate the session2	The content of the session status "deleted" message (session ID2) is correct	
10	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	

8.2.2.3.6 TEST PROCEDURE 4: RBC & BTS HANDOVER ON THE SAME 5G NETWORK

In this test case BTS handovers will occur in parallel but desynchronized compared to RBC handovers. The HO network set-up (cf. Figure 30and Figure 34)and the corresponding radio set-up are the configurations to be used for the BTS handover. Two procedures are described for HO intra-gNodeB or inter-gNodeB

8.2.2.3.6.1 INTRA-GNODEB HO

8.2.2.3.6.1.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The configuration set-up is presented in Figure 34 with two 5G cells either in n39 band because this test case will also be repeated in field.
- 2nd 5G cell is off, so that the On-board GTW is connected to the 1st 5G cell

Step	Action	Expected result(s)	Compliance with selected requirements
01	Perform multiple RBCs handover (using a balise scenario) during several hours (approximately 6 or 8h). There are only hundred meters between the beacons to perform handover every 3 minutes (approximately) At the same time perform multiple BTS handover, while ETCS application is on-going, multiple intra-gNodeB handover are performed where the 2nd 5G cell is switched on and progressively the radio power of the 1st 5G cell is manually decreased. The frequencies of BTS handovers and RBC handovers are different.	Communication exchanges continue, without interruption. Check on the CU/DU of the gNodeB that intra-gNodeB HO has been performed	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	Compare the log with the logs of the nominal conditions test case	Verify the impact, if any, on the application KPIs with comparison to the endurance ETCS test case in nominal conditions	

8.2.2.3.6.2 INTER GNODEB HO

8.2.2.3.6.2.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The configuration set-up is presented in Figure 30 with two gNodeBs in n39 band.
- 2nd gNodeB is off, so that the On-board GTW is connected to the 1st gNodeB.

__Note__: This test case will only be performed in the WP4 lab where three ME1210 are available. In the field set-up this scenario corresponds to the cross-border scenario.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Perform multiple RBCs handover (using a balise scenario) during several hours (approximately 6 or 8h). There are only hundred meters between the beacons to perform handover every 3 minutes (approximately) At the same time perform multiple BTS handover, while ETCS application is on-going, multiple inter-gNodeB handover are performed where the 2nd gNodeB is switched on and progressively the radio power of the 1st gNodeB is manually decreased. The frequencies of BTS handovers and RBC handovers are different.	Communication exchanges continue, without interruption. Check that inter-gNodeB HO has been correctly performed	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	Compare the log with the logs of the nominal conditions test case	Verify the impact, if any, on the application KPIs with comparison to the endurance ETCS test case in nominal conditions	

8.2.2.3.7 TEST PROCEDURE 5: BEARER FLEXIBILITY

As explained in §2.2.1, Figure 15, there are two use cases from which derive four test case scenario to include both directions of the movement of the train, to be performed to validate bearer flex feature. Here are the configurations to be used for the network set-up and the radio set-up.

The suggested use cases will be repeated with TOBA-A in n8 band and TOBA-K in n39 5G band, as this band will be used in field tests and b38 (2600MHz), which is the 4G band to be used as a 2nd bearer in the bearer flex scenario.

Priority is given on testing ETCS with bearer flex in the field test cases.

8.2.2.3.7.1 TEST PROCEDURE 5.1: REDUNDANCY USE CASE: OB - GW GOING FROM 5G TO 4G COVERAGE WITH ON-GOING ETCS CALL CONTINUATION

The purpose of this test is to evaluate the impact on the performance of the ETCS application, when moving from 5G to 4G coverage, to simulate the direct train trip (cf. Figure 15) but also how the gateways handle the failover of coverage.

The test with be performed in WP4 lab with TOBA-A in n8 and TOBA-K in n39 band, as 5G bearers and b38 as 4G bearer.

For this test case to be repeated in field with TOBA-K in n39 and b38, as 4G bearer, the gNodeB of Rive site needs to be switched off.

8.2.2.3.7.1.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- 5G cell (gNodeB) is on and 4G cell (eNodeB) is off.
- On-Board gateways are connected to 5G and 4G, when both available.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC (session start message) on 5G network	The FRMCS GTW is correctly answering OK with the session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS D2.1 § 2.2.5 Bearer Flexibility
02	Check that the user plane communication is established.	Data transfer using the RBC IP	
03	Switch on the 4G cell (eNodeB) and progressively attenuate the 5G cell (gNodeB), in order to simulate the changeover to 4G coverage	No impact on the ongoing communication	
04	Terminate the user plane communication with the RBC	No error returned	
05	Terminate the session	The content of the session status “deleted” message (session ID) is correct	
06	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	
07	Compare the logs between nominal and the current bearer flex 5G to 4G logs	Check that there is no impact on the application KPIs due to the changeover to 4G coverage with comparison to the nominal conditions.	

8.2.2.3.7.2 TEST PROCEDURE 5.2: REDUNDANCY USE CASE: OB - GW GOING FROM 4G TO 5G COVERAGE.

The purpose of this test is to evaluate the impact in the performance of the ETCS application, when moving from 4G to 5G coverage, to simulate the train trip in the opposite direction (cf. Figure 15) but also how the gateways handle the failover of coverage.

The test with be performed in WP4 lab with TOBA-A in n8 and TOBA-K in n39 band, as 5G bearers and b38 as 4G bearer.

For this test case to be repeated in field with TOBA-K in n39 and b38, as 5G bearer, the gNodeB of Rive site needs to be switched off.

8.2.2.3.7.2.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- 5G cell (gNodeB) is off and 4G cell (eNodeB) is on
- On-Board gateways are connected to 5G and 4G, when both available.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC (session start message) on 4G network	The FRMCS GTW is correctly answering OK with the session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS D2.1 § 2.2.5 Bearer Flexibility
02	Check that the user plane communication is established.	Data transfer using the RBC IP	
03	Switch on the 5G cell (gNodeB) and progressively attenuate the 4G cell (eNodeB), in order to simulate the changeover to 5G coverage	No impact on the ongoing communication	
04	Terminate the user plane communication with the RBC	No error returned	
05	Terminate the session	The content of the session status “deleted” message (session ID) is correct	
06	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	

07	Compare the logs between nominal and the current bearer flex 4G to 5G logs	Check that there is no impact on the application KPIs due to the changeover to 5G coverage with comparison to the nominal conditions.	

8.2.2.3.7.3 TEST PROCEDURE 5.3: AGGREGATION USE CASE: OB – GW UNDER 5G COVERAGE MOVES TO A LOCATION OF SIMULTANEOUS COVERAGE (5G+ 4G). ETCS CALL IS USING SIMULTANEOUSLY BOTH BEARERS

The purpose of this test is to evaluate the impact on the performance of the ETCS application, when moving from 5G to aggregated (5G+4G) coverage, to simulate the direct train trip (cf. Figure 15) but also to demonstrate how the gateway handles this change of coverage.

For one application session, two GRE tunnel are created on both bearers and the application flow is split over the two bearers, when both 5G and 4G coverage are available.

This test case is performed with TOBA-K in n39 and b38 band in WP4 lab, to prepare field testing with the same configuration.

8.2.2.3.7.3.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- One 5G cell (gNodeB) is on.
- The 2nd 5Gcell (gNodeB) and one 4G cell (eNodeB) are both off.
- On-Board gateway is connected to 5G and 4G, when both available.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC (session start message) on 5G network	The FRMCS GTW is correctly answering OK with the session ID and RBC @IP. Check that the FRMCS GTW is sending "working" notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS D2.1 § 2.2.5 Bearer Flexibility
02	Check that the user plane communication is established.	Data transfer using the RBC IP	

03	Switch on the 2nd 5G cell and the 4G cell simultaneously. The 1st 5G cell is progressively attenuated, in a way to simulate the changeover from the 5G to the aggregated 5G+4G coverage	No impact on the ongoing communication	
04	Terminate the user plane communication with the RBC	No error returned	
05	Terminate the session	The content of the session status "deleted" message (session ID) is correct	
06	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	
07	Compare the log between nominal and the current bearer flex 5G to (5G+4G) logs	Check that there is no impact on the application KPIs due to the changeover of the 5G coverage to the aggregated 5G+4G coverage.	

8.2.2.3.7.4 TEST PROCEDURE 5.4: AGGREGATION USE CASE: OB – GW IS MOVING FROM AN AGGREGATED COVERAGE (5G+4G) TO A PLACE WITH 5G ONLY COVERAGE WITH ETCS CALL IS STILL ON-GOING.

The purpose of this test is to evaluate the impact in the performance of the ETCS application, when moving from an aggregated (5G+4G) coverage to a 5G only coverage, to simulate the opposite direction of the train trip (cf. Figure 15) but also to demonstrate how the gateway handles this change of coverage.

For one application session, two GRE tunnel are created on both bearers and the application flow is split over the two bearers, under simultaneous 5G and 4G coverage.

This test case is performed with TOBA-K in n39 and b38 band in WP4 lab, to prepare field testing with the same configuration.

8.2.2.3.7.4.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- 5G cell (gNodeB) and 4G cell (eNodeB) are both on.

- The 2nd 5Gcell (gNodeB) is off.
- On-Board gateway is connected to 5G and 4G, when both available.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC (session start message) on aggregated network (4G and 5G) simultaneously	The FRMCS GTW is correctly answering OK with the session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS D2.1 § 2.2.5 Bearer Flexibility
02	Check that the user plane communication is established.	Data transfer using the RBC IP	
03	Power on 2nd 5G cell then, using the same RF attenuator, decrease the RF power level of 4G and 1st 5G cell simultaneously	No impact on the ongoing communication	
04	Terminate the user plane communication with the RBC	No error returned	
05	Terminate the session	The content of the session status “deleted” message (session ID) is correct	
06	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	
07	Compare the log between nominal and the current bearer flex (5G+4G) to 5G logs	Check that there is no impact on the application by monitoring the KPIs, due to the switchover between (5G+4G) to 5G with comparison to the nominal test case.	

8.2.2.3.7.5 ETCS AND IPERF UDP TEST. ETCS AND IPERF UDP ON 5G. TOBA-A MOVES FROM 5G ONLY AREA TO 4G/5G AREA. ETCS TRAFFIC CONTINUE ON 5G AND UDP IPERF ON 4G.

The purpose of this test is to demonstrate that the coverage changes (e.g., 4G+5G to 5G only) has no impact on the ETCS on-going session. Moreover, that the gateway can handle simultaneously both bearers when available.

This test will only be performed in lab with TOBA-A in n8 band and b38 as a 4G bearer.

8.2.2.3.7.5.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- 5G cell (gNodeB) and 4G cell (eNodeB) are both on.
- The 2nd 5Gcell (gNodeB) is off.
- TOBA-A is connected to both 4G and 5G.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC (session start message) on 5G network	The FRMCS GTW is correctly answering OK with the session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS D2.1 § 2.2.5 Bearer Flexibility
01B	Establishment of a parallel generic data session (e.g., using iPerf) between on-board and trackside device, to use 4G as primary link and 5G as secondary link	Corresponding FRMCS session is in “working” state	
02	Check that the user plane communication is established.	Data transfer O.K for ETCS and iPerf	
03	Switch on the 2nd 5G cell and the 4G cell simultaneously. The 1st 5G cell is progressively attenuate, in a way to simulate the changeover from 5G to the aggregated 5G+4G coverage.	No impact on the ongoing ETCS communication. The on-going generic data communication is switched to 4G link, it is transparent for the application.	

04	Terminate the user plane communication with the RBC	No error returned	
04B	Terminate the generic data session	No error returned	
05	Terminate the session	The content of the session status "deleted" message (session ID) is correct	
06	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	
07	Compare the log between nominal and the current bearer flex (5G+4G) to 5G logs	Check that there is no impact on the application by monitoring the KPIs, due to the switchover between (5G+4G) to 5G with comparison to the nominal test case.	

8.2.2.3.7.6 ETCS AND IPERF UDP TEST. ETCS ON 5G, IPERF ON 4G. TOBA-A MOVES FROM 4G/5G AREA TO 5G ONLY AREA. IPERF & ETCS TRAFFIC CONTINUE ON 5G.

This test case is just representing the opposite direction of the trip. As previously, it will only be performed in WP4 lab with TOBA-A in n8 band and b38 as a 4G bearer.

8.2.2.3.7.6.1 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- One 5G cell (gNodeB) is on.
- The 2nd 5Gcell (gNodeB) and one 4G cell (eNodeB) are both off.
- TOBA-A is connected to both 4G and 5G.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC (session start message) on aggregated network (4G and 5G) simultaneously	The FRMCS GTW is correctly answering OK with the session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS D2.1 § 2.2.5 Bearer Flexibility
01B	Establishment of a parallel generic data session (e.g., using iPerf) between on-board and trackside device, to use 4G as primary link and 5G as secondary link	Corresponding FRMCS session is in “working” state	
02	Check that the user plane communication is established.	Data transfer OK for ETCS and iPerf (generic data).	
03	Power on the 2nd 5G cell then using the same RF attenuator, decrease the RF power level of 4G and the 1st 5G cell simultaneously.	No impact on the ongoing ETCS communication. The ongoing generic data communication is switched to 5G link, it is transparent for the application.	
04	Terminate the user plane communication with the RBC	No error returned	
04B	Terminate the generic data session	No error returned	
05	Terminate the session	The content of the session status “deleted” message (session ID) is correct	
06	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	
07	Compare the log between nominal and the current bearer flex (5G + 4G) to 5Glogs	Check that there is no impact on the application KPIs due to the changeover of the (5G + 4G) coverage to 5G with comparison to the nominal test case.	

8.2.2.4 ETCS_WP4-WP5_TC_004: Communication in Level2 in degraded radio conditions between ETCS on board and RBC

The degraded radio conditions in lab environment are explained in §5.7 and correspond to these network set-up and degraded conditions radio set-up.

These test case procedures have been performed with TOBA-K in n39 band to better prepare the field testing, since measured pathloss were applied for the Vertex configuration.

8.2.2.4.1 TEST PROCEDURE 1: COMMUNICATION IN LEVEL 2 USING VERTEX TOOL WITH FADING AND VARYING SPEED

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP. Check that the FRMCS GTW is sending "working" notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS GTW_SESSION__END
02	Check that the user plane communication is established.	The data transfer using the RBC IP	
03	Trigger degraded radio conditions by using the Vertex tool to emulate speed variations, fading and multipath conditions	Impact on selected KPIs latency and reliability with comparison to the nominal conditions	
04	Terminate the user plane communication	No error returned	
05	Terminate the session	The content of the session status "deleted" message (session ID) is correct	
06	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	
07	Compare the logs between the nominal and the current degraded scenario	Check the impact on the application KPIs	

8.2.2.4.2 TEST PROCEDURE 2: RBC HANDOVER ON THE SAME 5G NETWORK USING VERTEX TOOL WITH FADING AND VARYING SPEED.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication with RBC1 (session start message)	The FRMCS GTW is correctly answering OK with the session ID1. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface - – GTW_SESSION_STATUS GTW_SESSION_END
02	Check that the user plane communication is established.	Data transfer using the RBC1 IP	
03	Trigger degraded radio conditions by using the Vertex tool to emulate speed variations, fading and multipath conditions	Check that the session is maintained with operational performances.	
04	Establishment of a new session for communication with RBC2 (session start message)	The FRMCS GTW is correctly answering OK with the session ID2 and RBC2 @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	
05	Check that the user plane communication is established.	Data transfer using the RBC2 IP	
06	Keep varying the speed and fading conditions using the Vertex tool	The communication is not dropped.	
07	Terminate the user plane communication with the RBC1	No error returned	
	Terminate the session1	The content of the session status “deleted” message (session ID1) is correct	
08	Check that the user plane communication is still established with the RBC2.	Data transfer using the RBC2 IP	
09	Terminate the user plane communication with the RBC2	No error returned	

10	Terminate the session2	The content of the session status "deleted" message (session ID2) is correct	
11	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	

8.2.2.4.3 TEST PROCEDURE 3: RBC AND BTS HANDOVER ON THE SAME 5G NETWORK USING VERTEX TOOL WITH FADING AND VARYING SPEED

Step	Action	Expected result(s)	Compliance with selected requirements
01	Perform multiple RBCs handover (using a balise scenario) during several hours (approximately 6 or 8h). There are only hundred meters between the beacons to perform handover every 3 minutes (approximately) At the same time perform multiple BTS handover, while ETCS application is on-going, multiple intra-gNodeB handover are performed where the 2nd 5G cell is switched on and progressively the radio power of the 1st 5G cell is manually decreased. The frequencies of BTS handovers and RBC handovers are different.	Communication exchanges continue, without interruption. Check on the CU/DU of the gNodeB that intra-gNodeB HO has been performed	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	During the continuous RBC and BTS handover, trigger degraded radio conditions by using the Vertex tool to emulate speed variations, fading and multipath conditions	Check that the session is maintained with operational performances.	
03	Compare the log with the logs of the nominal conditions test case	Verify the impact, if any, on the application KPIs with comparison to the endurance ETCS test case in nominal conditions	

8.2.2.5 ETCS_WP4-WP5_TC_005: Test cases in degraded mode

8.2.2.5.1 PURPOSE

The purpose of this test is to check that the failures that may occur are correctly managed by the system.

8.2.2.5.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.
- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.
- The connection status is OK.

8.2.2.5.3 TEST PROCEDURE 1: FAILURE DURING THE SESSION ESTABLISHMENT – RBC ID

Step	Action	Expected result(s)	Compliance with selected requirements
01	Send a session start message with an unknown RBC ID	The FRMCS GTW is not answering OK	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface FRMCS_GTW_SESSION STATUS
02	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	

8.2.2.5.4 TEST PROCEDURE 2: FAILURE DURING THE SESSION ESTABLISHMENT – WRONG EVC APPLICATION ID

__Note__: This test case is deleted because the EVC ID is hard coded and consequently the test case cannot be performed

8.2.2.5.5 TEST PROCEDURE 2: DELAY DURING THE SESSION ESTABLISHMENT

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message) takes more than 12 sec.	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP. Check that the FRMCS GTW is not sending "working" notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface FRMCS_GTW_SESSION STATUS
02	The session end is sent	Disconnect Indication is sent to the application.	

8.2.2.5.6 TEST PROCEDURE 3: CRASH OF THE WEBSOCKET DURING THE SESSION ESTABLISHMENT

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The session is not established before the timeout of 12 sec.	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	Disconnect the cable between ETCS-OB and OB-GTW before the timeout (12 sec).	The WebSocket is closed after sending the 'session start' message and before receiving FRMCS_GTW_SESSION_STATUS	

8.2.2.5.7 TEST PROCEDURE 4: CRASH OF THE WEBSOCKET ONCE THE GTW ANSWERS OK

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is answering OK	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	The WebSocket is closed	Check the timeout value (500 ms)	

8.2.2.5.8 TEST PROCEDURE 5: CRASH OF THE WEBSOCKET ONCE SESSION IS WORKING

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is answering OK	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	Wait until that the session status (sent by the FRMCS GTW) is “Working”	The content of the session status “working” message is correct	
03	The WebSocket is not responding.	Check the timeout value (500 ms)	

8.2.2.5.9 TEST PROCEDURE 6: COMMUNICATION LOSS: BECAUSE OF THE WEBSOCKET

Step	Action	Expected result(s)	Compliance with selected requirements
01	Check that the user plane communication is established.	The data transfer using the RBC IP	
02	The WebSocket is not responding anymore	Check the timeout value (500 ms)	

8.2.2.5.10 TEST PROCEDURE 7: COMMUNICATION LOSS: SESSION LOSS AND RECOVERY

Note: *This test case is deleted because it cannot be performed in the context of 5GRAIL where the prototype is not HW redundant*

8.2.2.5.11 TEST PROCEDURE 8: COMMUNICATION LOSS: SESSION LOSS WITHOUT RECOVERY

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface - - – GTW_SESSION_STATUS
02	Check that the user plane communication is established.	The data transfer using the RBC IP	
03	The FRMCS TS is not responding	The session status is Lost	
04	The session end is sent	End of the communication	

8.2.2.5.12 TEST PROCEDURE 9: RBC LOSS AND TCP RETRIES

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – FRMCS_GTW_SESSION STATUS
03	Check that the user plane communication is established.	Data transfer is performed using the RBC IP	
04	Stop the RBC	Loss of EVC / RBC communication	

05	Wait until the TCP timeout is reached (at least 20 sec)	TCP timeout is reached	
06	Check the session status	The session status is still “working”	
07	The session end is sent	End of the communication	

8.2.2.5.13 TEST PROCEDURE 10: TCP ISSUES DURING THE USER PLANE COMMUNICATION

The purpose of this test is to check that the failures that may occur in the transfer of TCP frame are correctly managed by the system.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP. Check that the FRMCS GTW is sending “working” notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – FRMCS_GTW_SESSION STATUS
02	Check that the user plane communication is established.	The data transfer using the RBC IP	
03	Add a TCP issue, by applying a filtering rule, using a firewall. (TCP delay or loss of TCP socket due to NTG disconnection) on the network		
04	Check that the user plane communication is still on going	Data are correctly exchanges between on board and trackside	

8.3 Automatic Train Operation communication (limited to GoA2 ATO)

Automatic Train Operation is the application which performs some or all the functions of automatic speed regulation, accurate stopping, door opening and closing, performance level regulation, and other functions assigned to a train driver or train attendant.

Some ATO systems require radio communication to interchange performance and/or safety relevant data between a train and the corresponding trackside control centre.

The (FRMCS) users in this case are the ATO application both on-board of the train and in the control centre at the trackside (ground system).

ATO systems may require communication between on-board applications of different trains (on-network).

8.3.1 ATO OBapp/TSapp compatibility test cases

The following test cases were performed during the integration phase of the ATO application:

8.3.1.1 ATO_OBapp-TC_001: Check the health of the link between ATO and the TOBA

8.3.1.1.1 PURPOSE

The purpose of this test is to check that the link between ATO and TOBA is correctly set-up and working properly.

8.3.1.1.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
- FRMCS Gateway is connected and configured to ATO equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
- The ATO-onboard equipment is connected and power on in nominal state.

8.3.1.1.3 TEST PROCEDURE 1: THE WEBSOCKET STATUS IS CORRECT

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket	No error returned	D2.1 TOBA Architecture Report – OBapp – Loose coupled interface
02	Check the status	The status indicates that the WebSocket is correctly opened	
03	Close the WebSocket		
04	Check the status	The status indicates that the WebSocket is not opened	

8.3.1.1.4 TEST PROCEDURE 2: THE WEBSOCKET IS NOT RESPONDING

Step	Action	Expected result(s)	Compliance with selected requirements
01	Change the WebSocket port in TOBA-A		
02	Try to open the WebSocket	The WebSocket is not responding.	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
03	Once the timeout of 30s is reached: check the status of the WebSocket	The status indicates that the WebSocket cannot be open	

8.3.1.2 ATO_OBapp-TC_002: Check the registration and the connection status.

8.3.1.2.1 PURPOSE

The purpose of this test is to check if the registration and the connection status is correct between the ATO application and the FRMCS OB_{APP}.

8.3.1.2.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
- FRMCS Gateway is connected and configured to ATO equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
- The ATO-onboard equipment is connected and power on in nominal state.

8.3.1.2.3 TEST PROCEDURE 1: REGISTRATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket Check the status	The status indicates that the WebSocket is correctly opened	D2.1 TOBA Architecture Report - v2– OBapp – Loose coupled interface - FRMCS_GTW_REGISTER FRMCS_GTW_SERVICE_REQUEST
02	Register the ATO-Onboard and ATO-Trackside Application	Check the registration answer with reference to the FRMCS_GTW_REGISTER function. The GTW must return a new local ID (app_uuid) unique chosen by itself if the request is succeeded. The parameter is of type 'String'. The expected call flow will be compared with 3GPP TS33.180 Figure 5.1.1-1:	
03	Check the connection status based on the FRMCS_GTW_SERVICE_REQUEST	The connection status is OK, means that connection status = connected, in the application logs.	
04	Check the duration of the registration process, as a KPI	A value is provided based on measurements of Wireshark traces	

8.3.1.2.4 TEST PROCEDURE 2: REGISTRATION FAILURE: THE GTW IS NOT RESPONDING

Note: *This test case is deleted between two consecutive versions of the test plan, because the implementation of this test case needs modifications in the gateways.*

8.3.1.2.5 TEST PROCEDURE 3: LOSS OF THE WEBSOCKET DURING THE REGISTRATION PROCESS:

Note: *This test case is deleted because one step of the test cannot be performed. The registration procedure takes place very quickly and there is no time to create context of loss of WebSocket.*

8.3.1.2.6 TEST PROCEDURE 4: LOSS OF THE WEBSOCKET ONCE THE REGISTRATION IS COMPLETED:

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket Check the status	The status indicates that the WebSocket is correctly opened	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface - FRMCS_GTW_REGISTER
02	Try to register the ATO-Onboard and ATO-Trackside application.	The registration status is OK	
03	Disconnect the link between the ATO-OB and the TOBA GTW		
04	Check the status of the WebSocket	WebSocket is not responding anymore	
05	The timeout of 30s is reached. The application starts to retry	The connection status is KO	

8.3.1.2.7 TEST PROCEDURE 5: CHECK THE CONNECTION STATUS

Step	Action	Expected result(s)	Compliance with selected requirements
01	Open the WebSocket Check the status	The status indicates that the WebSocket is correctly opened	D2.1 TOBA Architecture Report v3– OBapp – Loose coupled interface - FRMCS_GTW_SERVICE_REQUEST The Session state diagram of an outgoing session is followed during the loss and recovery of the radio link as per fig.35 of D2.1v2
02	Register ATO-Onboard and ATO-Trackside application.	The registration status is OK	
03	Check the connection status (polling)	The connection status is OK. Connection service request = connected	
04	Disconnect the mobiles to lose the connection with the MCX server		
05	Check the new connection status in the logs of the application.	The connection status is failed	
06	Reconnect the mobiles	The application detects the availability of the radio link, and the connection status becomes ‘connected’.	

8.3.1.3 ATO-TC_003: Communication between the ATO-onboard and ATO-Trackside application

8.3.1.3.1 PURPOSE

The purpose of this test is to check that the communication between the ATO-OB and the ATO-TS is provided by the 5G network during the test.

The steps, as described for ATO phase 1, Flat-IP version (cf. §8.3.2), are also followed for this test case.

8.3.1.3.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
- FRMCS Gateway is connected and configured to ATO equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
- The ATO-onboard equipment is connected and power on in nominal state.

8.3.1.3.3 TEST PROCEDURE: NOMINAL COMMUNICATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID	D2.1 TOBA Architecture Report v3– OBapp – Loose coupled interface – FRMCS_GTW_SESSION_START and FRMCS_GTW_SESSION_END
02	Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”	The content of the session status “working” message (session ID) is correct	
03	Check that the user plane communication is established by performing a TCP dump.	The data is properly transfer	
04	Terminate the session	The content of the session status “deleted” message (session ID) is correct, as per FRMCS_GTW_SESSION_END message	
05	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	

8.3.1.4 ATO-TC_004: Test cases in degraded mode

8.3.1.4.1 PURPOSE

The purpose of this test is to check that the failures that may occur are correctly managed by the system.

8.3.1.4.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
- The ATO-onboard equipment is connected and power on in nominal state.

8.3.1.4.3 TEST PROCEDURE 1: UNSUCCESSFUL SESSION ESTABLISHMENT

Step	Action	Expected result(s)	Compliance with selected requirements
01	Send a session start message with and unknown ATO-Trackside ID	The FRMCS GTW is not answering OK	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface FRMCS_GTW_SESSION_START
02	Check that the FRMCS GTW is responding to the connection status request	Connection status is OK	

8.3.1.4.4 TEST PROCEDURE 2: CRASH OF THE WEBSOCKET AFTER THE SESSION ESTABLISHMENT

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)		D2.1 TOBA Architecture Report– OBapp – Loose coupled interface FRMCS_GTW_SESSION_START FRMCS_GTW_SESSION_STATUS
02	Disconnect the link between ATO-OB and OB-GTW		
03	The WebSocket is closed after sending the 'session start' message and before receiving FRMCS_GTW_SESSION_STATUS	Check that the applicative retry is correct	
04	Check that the time of 30s has expired.	The 'Session start' is not working'	

8.3.1.4.5 TEST PROCEDURE 3: CRASH OF THE WEBSOCKET ONCE THE GTW ANSWERS OK

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is answering OK	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	The WebSocket is closed	Check that the applicative retry is correct Check the timeout of 30s has expired	

8.3.1.4.6 TEST PROCEDURE 4: CRASH OF THE WEBSOCKET ONCE SESSION IS WORKING

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is answering OK	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface
02	Wait until that the session status (sent by the FRMCS GTW) is “Working”	The content of the session status “working” message (session ID and the ATO-Trackside @IP) is correct	
03	The WebSocket is closed	Check that the applicative retry is correct. Check the timeout	

8.3.1.4.7 TEST PROCEDURE 5: COMMUNICATION LOSS BECAUSE OF THE WEBSOCKET

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – FRMCS_GTW_SESSION_STATUS
02	Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is "Working"	The content of the session status "working" message (session ID and the ATO-Trackside @IP) is correct	
03	Check that the user plane communication is established.	The data transfer using the ATO-Trackside IP	
04	Disconnect the ATO-OB from the GTW-OB		
05	The web socket is not responding anymore	Check that the applicative retry is correct. Check the timeout of 30s has expired	

8.3.1.4.8 TEST PROCEDURE 6: COMMUNICATION LOSS: SESSION LOSS AND RECOVERY

***Note**: This test case is deleted because it cannot be performed in the context of 5GRAIL where the prototype is not HW redundant*

8.3.1.4.9 TEST PROCEDURE 7: COMMUNICATION LOSS: SESSION LOSS AND APPLICATIVE TIMEOUT

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID	D2.1 TOBA Architecture Report v3– OBapp – Loose coupled interface - - – FRMCS_GTW_SESSION_STATUS
02	Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is "Working"	The content of the session status "working" message (session ID and the ATO-Trackside @IP) is correct	
03	Disconnect the interface between the OB-GTW and the TS part.		
04	Check that the user plane communication is established.	The data transfer using the ATO-Trackside IP	
05	The FRMCS TS is not responding	The session status is lost	
06	Wait until the applicative timeout is reached	Applicative timeout is reached Applicative tries to delete the session	
06	Check that the FRMCS GTW is still responding to the connection status request	The connection status message is received	

8.3.1.4.10 TEST PROCEDURE 8: ATO-TRACKSIDE LOSS AND ATO-ON-BOARD RETRIES

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID	D2.1 TOBA Architecture Report v3– OBapp – Loose coupled interface – FRMCS_GTW_SESSION STATUS
02	Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is "Working"	The content of the session status "working" message (session ID and the ATO-Trackside @IP) is correct	
03	Check that the user plane communication is established.	The data transfer using the ATO-Trackside IP	
04	Block the radio transmission between OB-board and TS for about 10s to 20s	Loss of ATO-Trackside communication	
05	Re-connect the ATO-Trackside	The data transfer resumes using the ATO-Trackside IP	
06	Check that the session status is not lost, and the communication can be established over the same session ID	The connection status is received with the same session ID as before	

8.3.1.4.11 TEST PROCEDURE 9: ATO-ON BOARD ISSUES DURING THE USER PLANE COMMUNICATION

The purpose of this test is to check that the failures that may occur on the radio network are correctly managed by the system.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID	D2.1 TOBA Architecture Report v3– OBapp – Loose coupled interface – FRMCS_GTW_SESSION STATUS
02	Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”	The content of the session status “working” message (session ID and the ATO-Trackside @IP) is correct	
03	Check that the user plane communication is established.	The data transfer using the ATO-Trackside IP	
04	Add a TCP issue, by applying a filtering rule, using a firewall.	ATO-Onboard tries to reconnect with ATO-Trackside	
05	Check that the user plane communication is still on going	Data are correctly exchanged between on board and trackside	

8.3.2 ATO_FLAT-IP-TC_001: ATO in nominal and perfect lab conditions

The test scenario aims to evaluate the ATO application over FRMCS-On Board Gateway and FRMCS 5G infrastructure in nominal and perfect lab conditions with no perturbations. It will be performed in WP4 lab at Kontron’s premises, where Alstom’s equipment is installed.

The ATO architecture provides an overview of the proposed application architecture, including the sub-assemblies that will be used to pass data between ATO-OB and ATO-TS under the FRMCS protocol.

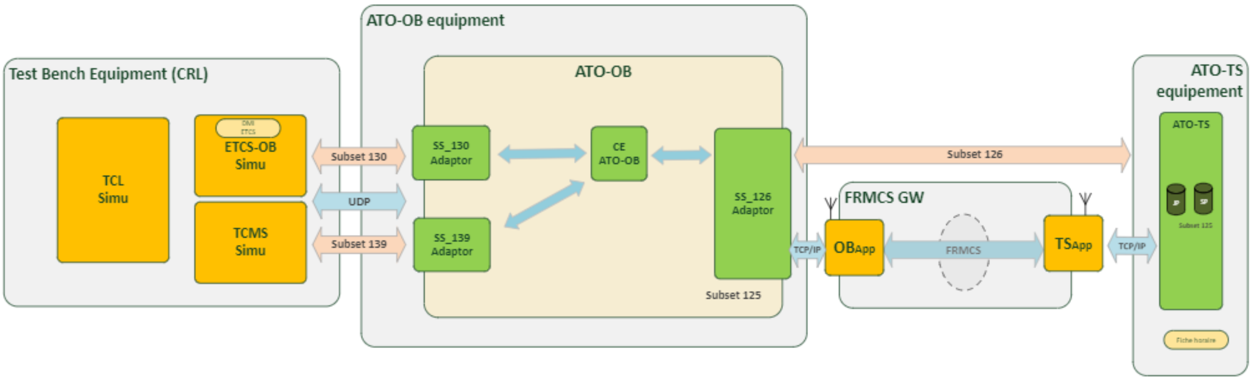


Figure 55: ATO over FRMCS (Ref. D4.1)

These are the ATO network set-up and radio configuration for normal conditions.

8.3.2.1 Purpose

This test will allow us to check the communication between the ATO-on-board and ATO-trackside through the 5G network.

So, during the test we shall be capable of:

- Establish the communication,
- Transfer the data,
- And end the communication.

The test will be performed with TOBA-A in n8 and TOBA-K in n39 bands. The observed application KPIs of this test, will be used as a reference of comparison for degraded or combined with another applications scenario.

The following figure illustrates the steps of the test case description:

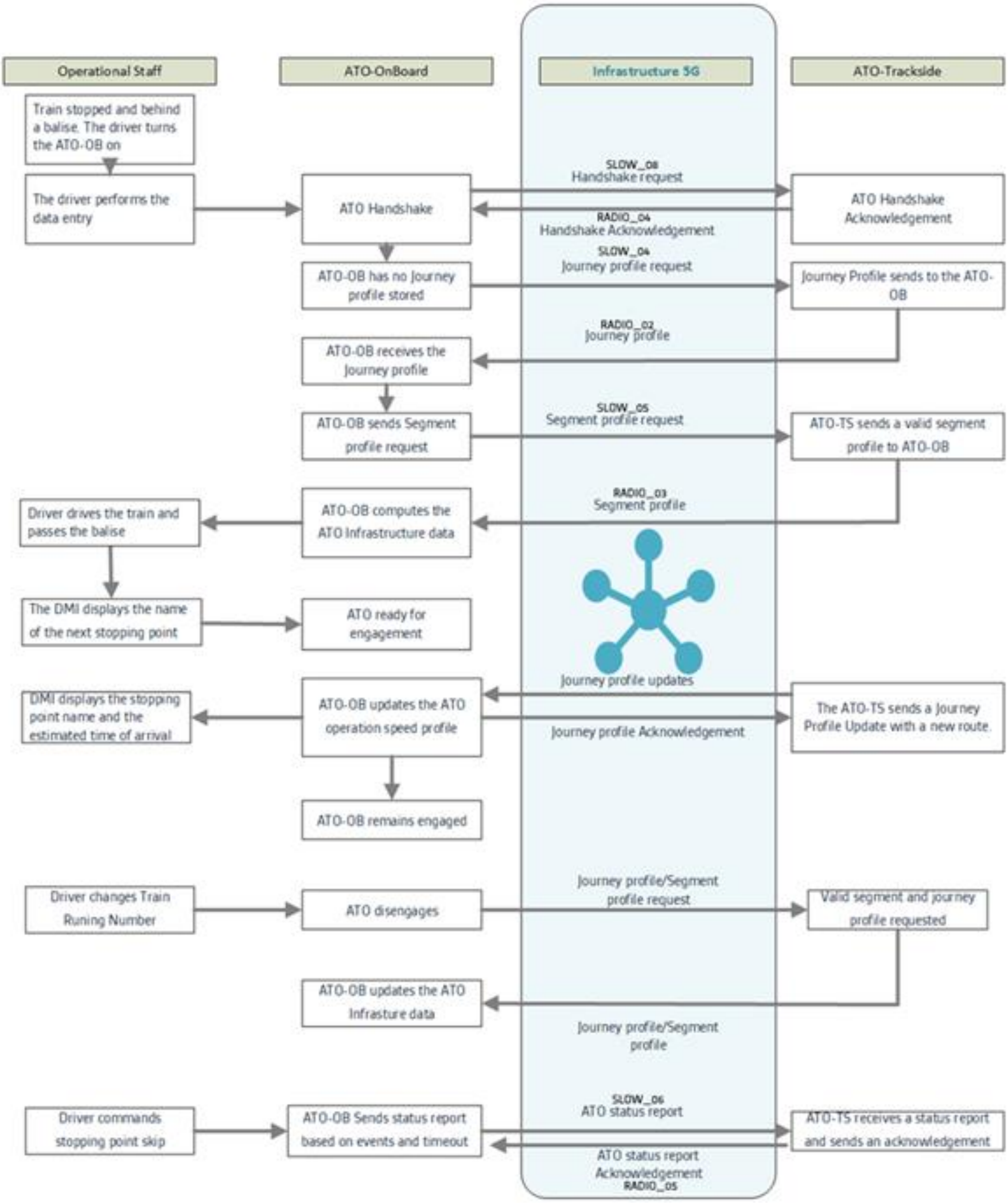


Figure 56: Flow diagram of ATO over FRMCS with application's KPIs

8.3.2.2 Description of initial state/configuration

ATO is in GoA2
ATO-onboard, ATO_REPLAY (TE) and ATO-trackside are installed and configured into the computer for rolling stock.
FRMCS gateway is connected and configured to the ATO equipment and to the 5G network.
ATO-onboard and ATO-trackside equipment are connected and power ON in nominal state.
Launch all softs: @ATO-Onboard, @ATO-Trackside and ATO-Replay

Open and launch the test scenarios:

1. Check the handshake between ATO-onboard and ATO-trackside.
   - Check in the PROBE the handshake request (M_ATO_SLOW_08) issued by the ATO-onboard with SS126.
   - Check in the ATO-trackside the content of the received Handshake request.
   - Check at ATO-trackside level the handshake acknowledgment (M_RADIO_04)
   - Check at ATO-onboard level if the handshake acknowledgment is coherent with the message sent by the ATO-trackside.

2. Check the Journey Profile between ATO-onboard and ATO-trackside.
   - Check in the PROBE the Journey Profile request (M_ATO_SLOW_04) issued by the ATO-onboard with SS126.
   - Check in the ATO-trackside the content of the received Journey Profile request.
   - Check at ATO-trackside level if the Journey Profile (M_RADIO_02)
   - Check at ATO-onboard level if the Journey Profile is coherent with the message sent by the ATO-trackside.

3. Check the Segment Profile between ATO-onboard and ATO-trackside.
   - Check in the PROBE the segment Profile request M_ATO_SLOW_05 issued by the ATO-onboard with SS126.
   - Check in the ATO-trackside the content of the received segment Profile request.
   - Check at ATO-trackside level if the segment Profile (M_RADIO_03)
   - Check at ATO-onboard level if the segment Profile is coherent with the message sent by the ATO-trackside.

4. Check the status report between ATO-onboard and ATO-trackside.
   - Check in the PROBE the status report M_ATO_SLOW_06 issued by the ATO-onboard with SS126.
   - Check in the ATO-trackside the content of the received status report.
   - Check at ATO-trackside level if the status report acknowledgment (M_RADIO_05) is coherent with SS 126
   - Check at ATO-onboard level if the status report acknowledgment is coherent with the message sent by the ATO-trackside.

5. Save the log after the end of the test scenario.

8.3.2.3 Test procedure

Note*:1) In the following table, PROBE is the name of the Alstom ATO diagnostic/debugging tool.*

2) Expected results in ***bold characters*** *are the proposed application KPIs*

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch all softs: by opening the cmd files Start_5GRAIL_OB and Start_5GRAIL_TE.	All applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS)	**[FU- 7100 v5.0.0]**: 6.20.1, 6.20.2, 6.20.4, 6.20.5. 8.3.1, 8.3.2, 8.3.4, 8.3.5 8.4.1, 8.4.2, 8.4.4, 8.4.5 8.12.1, 8.12.2, 8.12.4, 8.12.5 **3GPP TR22.889 V17.4.0:** 12.9.3, 12.9.5, 12.10.2.5,
02	In the scenario, an establishment of a new session is performed by sending a 'session start' message Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it	If everything is OK, ATO_On-Board will send a handshake request to the ATO trackside.	
03	Check in the PROBE, ATO_trackside and SS126 the Handshake request issued by the ATO-onboard. In the log observe the SLOW_08 and in the Probe we can observe the date and the time this message was sent		
04	Check in the ATO-trackside the content of the received Handshake request		
05	Check the PROBE, ATO_trackside and SS126 the handshake Acknowledgement issued by the ATO-trackside		
06	Check at ATO-onboard level if the handshake Acknowledgement is coherent with the message sent by the ATO-trackside. In the Probe we can observe the RADIO_04 with the date and the time the message was sent	we should observe the same message as on ATO-trackside. **Now we should be able to observe the time between the moment we send the SLOW_08 and RADIO_04, which represents the time needed for the ATO-OB to establish an applicative session with the ATO-TS.**	

07	Check the PROBE, ATO_trackside and SS126 the Journey Profile request issued by the ATO-onboard		
08	Check the ATO-trackside and PROBE the content of the received Journey profile request		
09	Check the PROBE and ATO_trackside the journey profile issued by the ATO-trackside	During the **7 seconds** after emission of the message, we shall receive a repetitive Journey profile from the ATO-Trackside	
10	Check at ATO-onboard level if the Journey profile is coherent with the message sent by the ATO-trackside. In the probe we can observe the RADIO_02 with the date and the time the message was sent	We should observe the same message as on ATO-trackside. **Now we should be able to observe the time between the moment we send the SLOW_04 and RADIO_02, which represents the time for the ATO-OB to get its journey profile (i.e., the list of track segments the train has to go through and in which time constraints).**	
11	Check in the PROBE the segment profile request issued by the ATO-onboard. In the probe we can observe the SLOW_05 with the date and the time the message was sent		
12	Check in the ATO-trackside the content of the received segment profile request	During the **7 seconds** after emission of the message, we shall receive a repetitive Segment profile from the ATO-Trackside	
13	Check in the PROBE, ATO_trackside and SS126 the segment profile issued by the ATO-trackside		
14	Check at ATO-onboard level if the segment profile is coherent with the message sent by the ATO-trackside. In the probe we can observe the RADIO_03 with the date and the time the message was sent	we should observe the same message as on ATO-trackside. **Now we should be able to observe the time between the moment we send the first SLOW_05**	

		and receive the last RADIO_03. This represents the time for the ATO-OB to get all the static information about the track segments the train has to go through (e.g., the gradient, the curve, … of the track). This information are required for the ATO-OB to be able to operate and manage the automatic train operation	
15	Check in the PROBE the status report issued by the ATO-onboard. In the probe we can observe the SLOW_06 with the date and the time the message was sent	After **26 + 4 seconds** if we don't have any events, we shall send another Status report	
16	Check in the ATO-trackside the content of the received status report		
17	Check in the PROBE the status report acknowledgment issued by the ATO-trackside	During the **7 seconds** after emission of the message, we shall receive a Status report acknowledge from the ATO-Trackside	
18	Check at ATO-onboard level status report acknowledgment is coherent with the message sent by the ATO-trackside. In the probe we can observe the RADIO_05 with the date and the time the message was sent	we should observe the same message as on ATO-trackside. **Now we should be able to observe the time between the moment we send the SLOW_06 and RADIO_05. This represents the time for the ATO-OB to see its status report being acknowledged. The higher the time, the higher the latency/lower the throughput provided to the ATO by the network is.**	

8.3.3 ATO-TC_005: ATO in nominal conditions performing intra gNodeB HO.

8.3.3.1 Purpose

The purpose of this test is to evaluate the impact of intra gNodeB HO in the performance of the ATO application.

So, during the test we will trigger change of cells within the same gNodeB and simultaneously perform:

- Establishment of the communication,
- Transfer of data,
- And end of the communication

The test will be performed with TOBA-K in n39 due to usage of this configuration also for field testing.

8.3.3.2 Description of initial state/configuration

- The configuration set-up is presented in Figure 33 and Figure 35with two 5G cells in n39.
- 2nd cell is off, so that the On-board GTW is connected to the 1st cell.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch all softs: by opening the cmd files Start_5GRAIL_OB and Start_5GRAIL_TE	All applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS)	**[FU- 7100 v5.0.0]**: 6.20.1, 6.20.2, 6.20.4, 6.20.5. 8.3.1, 8.3.2, 8.3.4, 8.3.5 8.4.1, 8.4.2, 8.4.4, 8.4.5 8.12.1, 8.12.2, 8.12.4, 8.12.5 **3GPP TR22.889 V17.4.0:** 12.9.3, 12.9.5, 12.10.2.5,
02	In the scenario, an establishment of a new session is performed by sending a 'session start' message. Go to the application ATO_REPLAY and load the scenario TEST_5G.STrm then launch it	If everything is OK, ATO_On-Board will send a handshake request to the ATO trackside. If not, nothing will happen	
04	After successful establishment of the ATO-OB session and end of reception of journal profile and segment profile, the 2nd 5G cell is switched on and progressively the radio power of the 1st cell is manually decreased, as shown in Figure 36.	Check on the CU/DU of the gNodeB that intra-gNodeB HO has been performed	

05	Compare the log with the logs of the nominal conditions test case	Verify the impact, if any, on the application KPIs, as defined in the steps of the ATO nominal conditions	

8.3.4 ATO-TC_006: ATO in nominal conditions performing inter-gNodeB HO.

8.3.4.1 Purpose

The purpose of this test is to evaluate the impact of inter gNodeB HO in the performance of the ATO application.

So, during the test we will trigger change between two gNodeBs and simultaneously perform:

- Establishment of the communication,
- Transfer of data,
- And end of the communication

The test will be performed with TOBA-K in n39 band because this is the configuration to be used for field testing, especially in the cross-border scenario HO conditions.

8.3.4.2 Description of initial state/configuration

- The configuration set-up is presented in Figure 31 and Figure 32 with two 5G gNodeBs in n39 band.
- 2nd gNodeB is off, so that the On-board GTW is connected to the 1st gNodeB.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch all softs: by opening the cmd files Start_5GRail_OB and Start_5GRail_TE.	All applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS)	**[FU- 7100 v5.0.0]**: 6.20.1, 6.20.2, 6.20.4, 6.20.5. 8.3.1, 8.3.2, 8.3.4, 8.3.5 8.4.1, 8.4.2, 8.4.4, 8.4.5 8.12.1, 8.12.2, 8.12.4, 8.12.5 **3GPP TR22.889 V17.4.0:** 12.9.3, 12.9.5, 12.10.2.5,
02	In the scenario, an establishment of a new session is performed by sending a ‘session start’ message. Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it	If everything is OK, ATO_On-Board will send a handshake request to the ATO trackside. If not, nothing will happen	

04	During the ATO data transfer, the 2nd gNodeB is turned on and progressively the radio power of the 1st gNode B is manually decreased.	Check that inter-gNodeB HO has been correctly performed	
05	Compare the log with the logs of the nominal conditions test case	Verify the impact, if any, on the application KPIs, as defined in the steps of the ATO nominal conditions	

8.3.5 ATO-TC_007: ATO in radio degraded conditions.

These are the configurations used for ATO degraded network set-up and radio set-up to be used in WP4 lab.

8.3.5.1 Purpose

The purpose of this test is:

- to check that the communication between ATO_On-Board and ATO_Trackside is not operationally impacted by the degraded conditions.
- to compare the time between the moment we transmit the messages from the ATO_On-board to the ATO_trackside in normal condition and degraded conditions.

This test will be performed with TOBA-K in n39 band and 31dBm. It is of particular interest, as this is the configuration to apply for field tests.

8.3.5.2 Description of initial state/configuration

ATO is in GoA 2

Vertex emulator is used to create degraded conditions.

ATO-onboard, ATO_REPLAY (TE) and ATO-trackside are installed and configured into the computer for rolling stock.

FRMCS gateway is connected and configured to the ATO equipment and to the 5G network.

ATO-onboard and ATO-trackside equipment are connected and power ON in nominal state.

Launch all softs: @ATO-Onboard, @ATO-Trackside and ATO-Replay

Open and launch the test scenarios.

Check the behaviour between the ATO-onboard and ATO-trackside through the nominal and degraded condition.

- after the end of the test scenario, In the Probe, save the log of nominal condition.
- after the end of the test scenario, in the Probe, save the log of degraded condition.
- And then compare both information to see the change of behaviour of the ATO brought by the degradation.

8.3.5.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch all softs: by opening the cmd files Start_5GRail_OB and Start_5GRail_TE.	All applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS,	**[FU- 7100 v5.0.0]**: 6.20.1, 6.20.2, 6.20.4, 6.20.5. 8.3.1, 8.3.2, 8.3.4, 8.3.5 8.4.1, 8.4.2, 8.4.4, 8.4.5 8.12.1, 8.12.2, 8.12.4, 8.12.5 **3GPP TR22.889 V17.4.0:** 12.9.3, 12.9.5, 12.10.2.5,
02	In the scenario, an establishment of a new session is performed by sending a 'session start' message. Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm, then launch it	If everything is OK, ATO_On-Board will send a handshake request to the ATO trackside. If not, nothing will happen	
03	Degraded conditions are created by using the Vertex tool. Check the PROBE and save the log after the end of the test scenario		
04	Compare the log between nominal and degraded conditions	Verify the impact on the application KPIs, as defined in the steps of the ATO nominal conditions	

8.3.6 ATO-TC_008: Bearer flex test cases with ATO

As explained in §2.2.1, there are two use cases from which derive four test case scenario to include both directions of the movement of the train, to be performed to validate bearer flex feature with the ATO application. Here are the configurations to be used for the network set-up and the radio set-up.

The bearer flex use cases are presented in Figure 15: Multi-connectivity use cases to be tested in lab WP4 and WP5 - FR.

The suggested use cases will be repeated with TOBA-A and TOBA-K in n39 5G band, as this band will be used in field tests and b38 (2600MHz), which is the 4G band to be used as a 2nd bearer in the bearer flex scenario.

Priority is given on testing ETCS with bearer flex, as required for field test cases. ATO in bearer flex scenarios will be kept optional for WP5.

8.3.6.1 Bearer flexibility: 5G to 4G Failover

8.3.6.1.1 PURPOSE

The purpose of this test is to evaluate the impact in the performance of the ATO application, when moving from 5G to 4G coverage, to simulate the direct train trip.

8.3.6.1.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- 5G cell (gNodeB) is on and 4G cell (eNodeB) is off.

8.3.6.1.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch all softs: by opening the cmd files Start_5GRail_OB and Start_5GRail_TE.	All applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS D2.1 § 2.2.5 Bearer Flexibility
02	In the scenario, an establishment of a new session is performed by sending a 'session start' message. Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it. The session is established under the 5G coverage.	If everything is OK, ATO_On-Board and ATO_Trackside will exchange the following messages: handshake request, Handshake Acknowledgment, Journey profile request and the journey profile, the segment profile request, the status report and status report Acknowledgment. **Cf:** all the message of the nominal test case If not, nothing will happen	

03	After ATO-OB, journey profile and segment profile have been received, switch on the 4G cell (eNodeB) and progressively attenuate the 5G cell (gNodeB), in order to simulate the changeover to 4G coverage		
04	Check the PROBE and save the logs after the end of the test scenario		
05	Compare the logs between nominal and the current bearer flex 5G to 4G logs	Check that there is no impact on the application KPIs due to the changeover to 4G coverage with comparison to the nominal conditions.	

8.3.6.2 Bearer flexibility: 4G to 5G Failover

8.3.6.2.1 PURPOSE

The purpose of this test is to evaluate the impact in the performance of the ATO application, when moving from 4G to 5G coverage, to simulate the train trip in the opposite direction.

So, during the test we will trigger transition of 4G cells to 5G cells and simultaneously perform:

- Establishment of the communication,
- Transfer of data,
- And end of the communication

8.3.6.2.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The RF configuration set-up is presented in Figure 41
- 5G cell (gNodeB) is off and 4G cell (eNodeB) is on

8.3.6.2.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch all softs: by opening the cmd files Start_5GRAIL_OB and Start_5GRAIL_TE.	All applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface D2.1 § 2.2.5 Bearer Flexibility
02	In the scenario, an establishment of a new session is performed by sending a 'session start' message. Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it The communication is established under the 4G coverage.	If everything is OK, ATO_On-Board and ATO_Trackside will exchange the following messages: handshake request, Handshake Acknowledgment, Journey profile request and the journey profile, the segment profile request, the status report and status report Acknowledgment. **Cf:** all the messages of the nominal test case If not, nothing will happen	
03	After ATO-OB, journey profile and segment profile have been received, switch on the 5G cell (gNodeB) and progressively attenuate the 4G cell (eNodeB), in order to simulate the changeover to 5G coverage		
04	Check the PROBE and save the logs after the end of the test scenario		
05	Compare the logs between nominal and the current bearer flex 4G to 5G logs	Check that there is no impact on the application KPIs due to the changeover to 5G coverage with comparison to the nominal conditions.	

8.3.7 ATO_ETCS-TC_009: ETCS onboard combined with ATO application.

8.3.7.1 Purpose

The purpose of this test is to check the behaviour of a nominal data transfer between ETCS on board application and RBC on the same 5G network when another also-critical data application (e.g., ATO) is transmitting data in parallel using the same FRMCS GW. The following steps will be performed for both applications:

- Establishment of communication:
- Session start
- User plane communication
- End of communication

8.3.7.2 Description of initial state/configuration

The initial conditions are fulfilled for both applications.

For ETCS:

- ETCS equipment are installed and configured.
- FRMCS Gateway is connected and configured to ETCS equipment and to 5G network.
- ETCS Trackside equipment are connected and configured.
- ETCS onboard and trackside equipment are connected and power on in nominal state.
- The connection status is OK.

For ATO:

- ATO is in GoA2
- ATO-onboard, ATO_REPLAY (TE) and ATO-trackside are installed and configured into the computer for rolling stock.
- FRMCS gateway is connected and configured to the ATO equipment and to the 5G network.
- ATO-onboard and ATO-trackside equipment are connected and power ON in nominal state.
- Launch all softs: @ATO-Onboard, @ATO-Trackside and ATO-Replay

8.3.7.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establishment of a new session for communication between EVC and RBC (session start message)	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP. Check that the FRMCS GTW is sending "working" notification before the timeout (12sec)	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – FRMCS_GTW_SESSION_START FRMCS_GTW_SESSION_STATUS
02	Check that the user plane communication is established.	The data transfer is ongoing using the RBC IP	
03	In parallel, start ATO application. Launch all softs: by opening the cmd files Start_5GRail_OB and Start_5GRail_TE	All applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS,	
04	Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it	If everything is OK, ATO_onboard and ATO_Trackside will exchange the following messages: handshake request, Handshake Acknowledgment, Journey profile request and the journey profile, the segment profile request, the status report and status report Acknowledgment Cf: all the message of the nominal test case If not, nothing will happen	
05	Check that both applications perform properly as in nominal conditions	Check if individual KPIs of both applications in nominal conditions still been respected, or one application is impacted.	
06	Perform an end of communication for both applications (End of simulations)	Check communications are ended	

8.3.8 ATO_iPerf_UL-TC_010: ATO in parallel with high uplink traffic generated by iPerf.

8.3.8.1 Purpose

The purpose of this test is to evaluate the impact on the ATO KPIs due to radio resource sharing between the ATO application and iPerf creating a high uplink traffic.

8.3.8.2 Description of the initial state/configuration

The configuration to be used is presented in Figure 46

Step	Action	Expected result(s)	Compliance with selected requirements
01	Connect ES3 modem in band n39 and perform attach	ES3 is attached to the 5G core network.	
02	Start iPerf uplink transfer on ES3	The uplink traffic is established with a stable data rate.	
03	Check the iPerf KPIs, before launching ATO.		
04	In parallel, launch all softs: by opening the cmd files Start_5GRail_OB and Start_5GRail_TE	All sub-applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS)	**[FU- 7100 v5.0.0]**: 6.20.1, 6.20.2, 6.20.4, 6.20.5. 8.3.1, 8.3.2, 8.3.4, 8.3.5 8.4.1, 8.4.2, 8.4.4, 8.4.5 8.12.1, 8.12.2, 8.12.4, 8.12.5 **3GPP TR22.889 V17.4.0:** 12.9.3, 12.9.5, 12.10.2.5,
05	An establishment of a new ATO session is performed by sending a 'session start' message. Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it	If everything is OK, ATO_On-Board will send a handshake request to the ATO trackside. If not, nothing will happen	
06	After successful establishment of the ATO-OB session and end of reception of journal profile and segment profile, ATO application is ongoing together with generated iPerf uplink traffic		
07	Compare the logs with the logs of the nominal conditions ATO test case	Verify the impact, on the application KPIs, as defined in the steps of the ATO nominal conditions	

8.3.9 ATO_iPerf_DL-TC_011: ATO in parallel with high downlink traffic generated by iPerf.

8.3.9.1 Purpose

The purpose of this test is to evaluate the impact on the ATO KPIs due to radio resource sharing between the ATO application and iPerf creating a high downlink traffic.

8.3.9.2 Description of the initial state/configuration

The configuration to be used is presented in Figure 46

Step	Action	Expected result(s)	Compliance with selected requirements
01	Connect ES3 modem in band n39 and perform attach	ES3 is attached to the 5G core network.	
02	Start iPerf downlink transfer on ES3	The uplink traffic is established with a stable data rate.	
03	Check the iPerf KPIs, before launching ATO.		
04	In parallel, launch all softs: by opening the cmd files Start_5GRail_OB and Start_5GRail_TE.	All sub-applications are going to open (ATO_CE simulator, ATO_PROBE, SS130, SS139, SS126, ATO_SLOW, ATO_FAST, DO, ATO_REPLAY, ATO_TS)	**[FU- 7100 v5.0.0]**: 6.20.1, 6.20.2, 6.20.4, 6.20.5. 8.3.1, 8.3.2, 8.3.4, 8.3.5 8.4.1, 8.4.2, 8.4.4, 8.4.5 8.12.1, 8.12.2, 8.12.4, 8.12.5 **3GPP TR22.889 V17.4.0:** 12.9.3, 12.9.5, 12.10.2.5,
05	An establishment of a new ATO session is performed by sending a 'session start' message. Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it	If everything is OK, ATO_On-Board will send a handshake request to the ATO trackside. If not, nothing will happen	
06	After successful establishment of the ATO-OB session and end of reception of journal profile and segment profile, ATO application is ongoing together with generated iPerf downlink traffic		
07	Compare the logs with the logs of the nominal conditions ATO test case	Verify the impact, on the application KPIs, as defined in the steps of the ATO nominal conditions	

9 NON-CRITICAL DATA APPLICATIONS TEST CASES

These test scenarios concern non-critical applications such as TCMS, non-critical real time video, CCTV and PIS. Except PIS that will be tested in the lab of WP4, all the other non-critical applications will be performed in WP3 lab in Hungary.

Some of these test cases will be repeated in real field conditions, in the scope of WP5 in Germany.

9.1 TCMS applications

For TCMS, 2 use cases are considered: **a) On-train telemetry communications b) On-train remote equipment control.**

For the TCMS case specifically the following architecture will be used to interact with the FRCMS system:

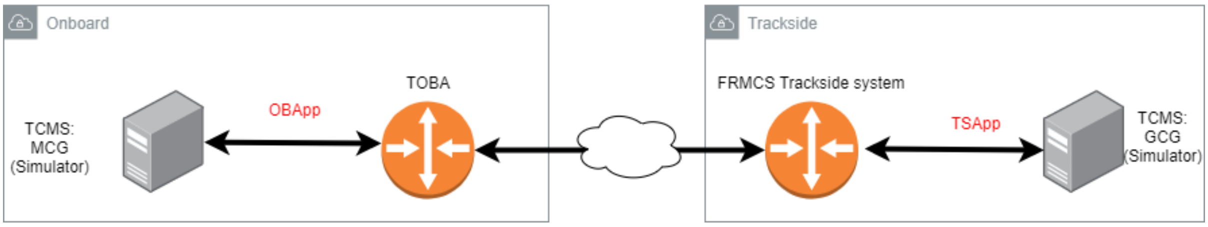


Figure 57: Overall TCMS architecture (Ref. D2.1)

As it can be seen, on the onboard side, the TCMS application consists on one simulated Hardware (potentially a laptop) with a software which simulates the TCMS Mobile Communication Service (MCG) according to IEC 61375-2-6 [01] standard. This MCG will interact with TOBA using the OBapp interface.

On the trackside side, the TCMS application has its counterpart with a similar setup which consists on a simulated Hardware (potentially a laptop) with a software which simulates the TCMS Ground Communication Service (GCG) according to IEC 61375-2-6 [01] standard. The Trackside will potentially contain additional supporting deployments such as a (s)FTP server and MQTT broker to fill with the use cases described in WP1.

The detailed architecture of the TCMS application and its interaction with the On-board FRMCS Gateway and the FRMCS Trackside System is described in the figure below:

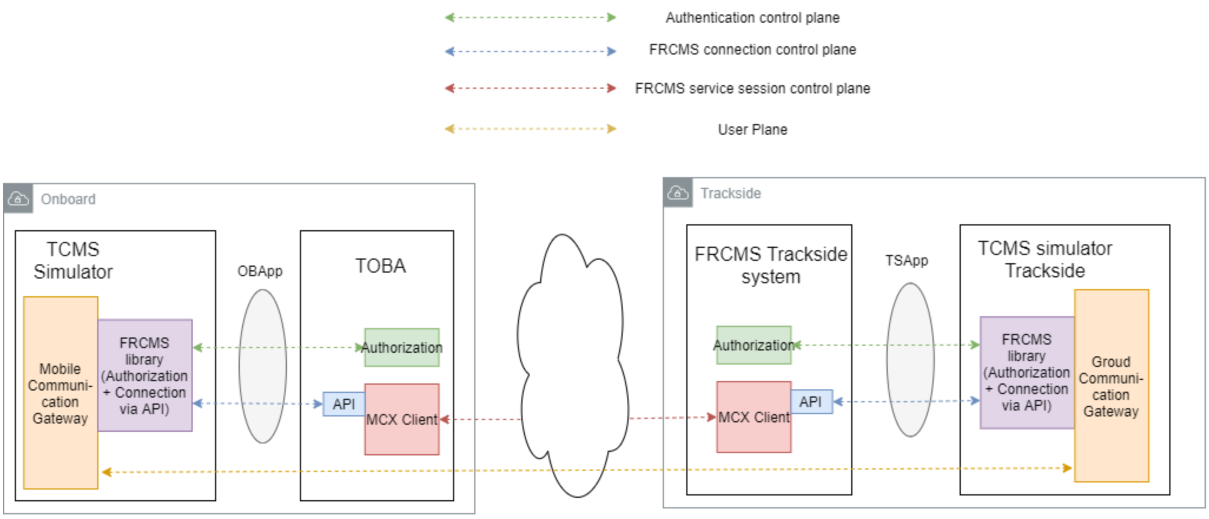


Figure 58: Detailed TCMS architecture (Ref. D2.1)

9.2 On-Train Telemetry communications

9.2.1 TCMS_TC_001: Nominal communication between MCG on board application and GCG (same 5G network)

9.2.1.1 Purpose

The purpose of this test is to check IP communication between MCG on board application and GCG on the same 5G network:

- Establishment of communication:
- Data transfer
- End of communication

9.2.1.2 Description of initial state/configuration

The initial state covers the following steps:

- MCG simulation equipment are installed and configured.
- FRMCS Gateway is connected and configured to MCG and GCG equipment and to 5G network.
- GCG simulation equipment are connected and configured.
- MCG and GCG simulation equipment are connected and power on in nominal state.
- MCG and GCG are registered in the MCX framework.

Additionally, for testing purposes the following aspects specific for the Telemetry use case are assumed:

- GCG offers the topic passengerCount
- Process data is published every 0.5 seconds for the passengerCount topic.
- The following tables detail the contents:

Topic name	Type	Representation	Publishing Frequency
passengerCount	JSON Object	JSON	Every 0.5 seconds

Key	Type
timeStamp	uint32
numPassenger	uint16

Optionally, the rate and packet size could vary in order to obtain more accurate performance metrics.

9.2.1.3 Test procedure _TC_001a: Nominal communication between MCG on board application and GCG

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish a communication MCG and GCG (started by MCG) using OBApp interface	Communication between MCG onboard and GCG on trackside is OK.	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the TCMS system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:**
02	Check communication are correctly set	Wireshark logs will be used to ensure connectivity has been reached. Expected results will be explained in D3.3 First Lab Test Report deliverable	

02	Telemetry data is published from MCG (MQTT Bridge) to GCG (MQTT Broker) passengerCount topic.	The broker receives the published messages.	[R-12.9-003] [R-12.10.2-028] §12.20.5.
03	Initiate network performance monitoring applications: - Application: number of messages received per second in Trackside	Baseline performance is similar to expected in regular conditions (potentially 2 packets per second are expected).	

9.2.1.4 Test procedure_TC_001b: Nominal communication between MCG on board application and GCG, including BTS handover (same 5G network)

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish a communication MCG and GCG (started by MCG) using OBApp interface	Communication between MCG onboard and GCG on trackside is OK.	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the TCMS system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003] [R-12.10.2-028] §12.20.5.
02	Check communication are correctly set	Wireshark logs will be used to ensure connectivity has been reached. Expected results will be explained in D3.3 First Lab Test Report deliverable	
02	Telemetry data is published from MCG (MQTT Bridge) to GCG (MQTT Broker) passengerCount topic.	The broker receives the published messages.	
03	Initiate network performance monitoring applications: - Application: number of messages received per second in Trackside	Baseline performance is similar to expected in regular conditions (potentially 2 packets per second are expected).	

04	Trigger a BTS handover by modifying the signal strength of the BTS, using RF attenuators, as presented in Figure 29.	Check communication performance on application against baseline (nominal, potentially 2 packets/s). The expected behaviour is not to have a significant packet loss from baseline due to BTS handover.	

9.2.2 TCMS_TC_002: Evaluate FRMCS On-Board System and impact on application with degrading radio conditions.

9.2.2.1 Purpose

The purpose of this test is to evaluate FRMCS network performance in various network environments as well as to test the capability to take decisions on choosing another bearer or other choices to adapt to the current available capabilities.

9.2.2.2 Description of initial state/configuration

The initial state covers the following steps:

- MCG simulation equipment are installed and configured.
- FRMCS Gateway is connected and configured to MCG and GCG equipment and to 5G network.
- GCG simulation equipment are connected and configured.
- MCG and GCG simulation equipment are connected and power on in nominal state.
- MCG and GCG are registered in the MCX framework.

Additionally, for testing purposes the following aspects specific for the Telemetry use case are assumed:

- GCG offers the topic passengerCount
- Process data is published every 0.5 seconds for the passengerCount topic.
- The following tables detail the contents:

Topic name	Type	Representation	Publishing Frequency
passengerCount	JSON Object	JSON	Every 0.5 seconds

Key	Type
timeStamp	uint32
numPassenger	uint16

Optionally, the rate and packet size could vary in order to obtain more accurate performance metrics.

9.2.2.3 Test procedure: Network performance test

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish communication between MCG and GCG (started by MCG) using OBApp interface.	Communication between onboard and trackside is OK (GCG name is resolved via OBApp, ...)	**[FU- 7100 v5.0.0]**: §6.9.1, §6.9.2, 8.8.2.1, 8.12.2.1, 8.10.1.1 **[MG-7900 v2.0.0]:** §42.2, §42.3
02	Telemetry data is published from MCG (MQTT Bridge) to GCG (MQTT Broker) passengerCount topic.	The broker receives the published message.	
03	Initiate network performance monitoring applications: - Application: number of messages received per second in Trackside	Baseline performance is similar to expected in regular conditions (potentially 2 packets per second).	
04	Perform a degradation of radio transmission, emulating speed, as presented in Figure 42	Check communication performance on application against baseline (nominal, potentially 2 packets/s). The expected behaviour is not to have a significant packet loss from baseline.	

9.2.3 TCMS_TC_003 OPTIONAL: Cross border scenario with TCMS

9.2.3.1 Purpose

The purpose of this test is to evaluate FRMCS network performance when there is a cross border happening, using TCMS Telemetry Service as an example. Other MCData application (e.g., Video) can also be tested based on the lab feedback.

9.2.3.2 Description of initial state/configuration

The initial state covers the following steps:

- MCG simulation equipment are installed and configured.
- FRMCS Gateway is connected and configured to MCG and GCG equipment and to 5G network.
- GCG simulation equipment are connected and configured.
- MCG and GCG simulation equipment are connected and power on in nominal state.
- MCG and GCG are registered in the MCX framework.

Additionally, for testing purposes the following aspects specific for the Telemetry use case are assumed:

- GCG offers the topic passenger Count.
- Process data is published every 0.5 seconds for the passenger Count topic.
- The following tables detail the contents:

Topic name	Type	Representation	Publishing Frequency
passengerCount	JSON Object	JSON	Every 0.5 seconds

Key	Type
timeStamp	uint32
numPassenger	uint16

Optionally, the rate and packet size could vary in order to obtain more accurate performance metrics.

9.2.3.3 Test procedure: Network performance test

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish communication between MCG and GCG (started by MCG) using OBApp interface. The communication is established in the home network PLMN A	Communication between onboard MCG and trackside is OK (GCG name is resolved via OBApp, ...)	**[FU- 7100 v5.0.0]**: §6.9.1, §6.9.2, 8.8.2.1, 8.12.2.1, 8.10.1.1 **[MG-7900 v2.0.0]:** §42.2, §42.3
02	Telemetry data is published from MCG (MQTT Bridge) to GCG (MQTT Broker) passengerCount topic.	The broker receives the published message.	
03	Initiate network performance monitoring applications: - Application: number of messages received per second in Trackside	Baseline performance is similar to expected in regular conditions (2 packets per second).	
04	Perform a simulated cross-border, as described in the dedicated cross-border chapter §1.4 with reference to WP3 implementation.	Check the visiting that we are able to start connection from the visiting network to reach the home server and the expected behaviour is similar to the nominal conditions.	

9.3 On-train remote equipment control

9.3.1 TCMS_RC_TC_001: Nominal communication between GCG trackside application and onboard MCG (same 5G network)

9.3.1.1 Purpose

The purpose of this test is to check IP communication between GCG trackside application and onboard MCG on the same 5G network:

- Establishment of communication:
- Data transfer
- End of communication

9.3.1.2 Description of initial state/configuration

- MCG simulation equipment are installed and configured.
- FRMCS Gateway is connected and configured to MCG and GCG equipment and to 5G network.
- GCG simulation equipment are connected and configured.
- MCG and GCG simulation equipment are connected and power on in nominal state.

9.3.1.3 Test procedure: Communication nominal test

Step	Action	Expected result(s)	Compliance with selected requirements
01	Establish a communication GCG and MCG (started by GCG) using OBApp interface.	Communication between onboard MCG and trackside GCG is OK	**[FU- 7100 v5.0.0]**: 5.9.1.1, 5.9.2.1, 5.9.3.1, 5.9.4.1, 5.9.4.2, 5.9.4.4 5.9.5.1, 5.9.5.2 (partially, no logs or updates for the TCMS system supported) 8.8.1.1, 8.8.2.1 8.12.1.1, 8.12.2.1 And **3GPP TR22.889 V17.4.0:** [R-12.9-003] [R-12.10.2-028] §12.20.5.
02	Check communication are correctly set	Wireshark logs will be used to ensure connectivity has been reached. Expected results will be explained in D3.3 First Lab Test Report deliverable	
03	If required, check QoS information received correspond to the one expected by default for TCMS application	Expected results will be explained in D3.3 First Lab Test Report deliverable	
04	Check Data transfer between GCG and MCG (GCG sends HTTP message for remote equipment turn on and receives MCG reply) The KPI is the successful sent of message from Trackside to onboard.	GCG receives HTTP reply from MCG with the status of the power on.	

9.4 Non-critical real time video

9.4.1 Nominal communication: streaming of video from train to trackside.

9.4.1.1 Purpose

Purpose of this test case is to test live streaming of CCTV video from the onboard video management system into the trackside video management system in nominal communication. This application facilitates the data communication for real time transmission of video for non-critical railway operation.

Non-critical real time video is considered as an effective mitigation measure to optimize the performance and safety of the railway system. The application can be used for example for:

- Passenger Information
- Help Points
- Ticketing
- To transfer video in parallel with voice communication
- Supervision of railway assets and passengers

9.4.1.2 Description of initial state/configuration

- Onboard system is up and running.
- Onboard system has at least one camera installed, the camera view pointing to moving pictures/objects (no static picture view)
- Onboard camera is integrated with the onboard Video Management System (VMS), which is interfacing with FRMCS GW through OBapp.
- Trackside VMS system is up and running.
- Onboard system is configured in the Trackside VMS system.
- Trackside VMS is interfacing with Trackside FRCMS GW through TSapp
- FRCMS can provide sufficient bandwidth for single camera view (at least 4 Mbps)
- VMS user is logged in to the trackside VMS client software.

Note: *The results of validation of the API for OBapp/TSapp compatibility of the application are described in the D2.2 deliverable.*

9.4.1.3 Video_TC_001: Streaming of video from train to trackside.

Step	Description	Action	Expected result(s)	Compliance with selected requirements
01	Trackside VMS and Onboard VMS are registered to FRMCS GW	Trackside VMS and Onboard VMS registers to the FRMCS GW	Registration to the FRMCS GW is successful	**FU-7100 v5.0.0:** §6.13 **3GPP TR22.889 V17.4.0:** [R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003] [R-7.1.3-001] [R-7.1.4-001] [R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7
02	Trackside VMS system constantly checks Onboard system availability.	Trackside VMS interface with the FRMCS GW through TSapp interface for communication allocation.	FRMCS GW acknowledges (or deny) Trackside VMS requests	
03	FRMCS GW provides communication	FRMCS GW allocates communication	Communication session is established	
04	Train camera is indicated as available in trackside VMS	Train camera status is available in the cameras tree (green)	Camera is indicated as available (green)	
05	Trackside VMS user is requesting video feed from the onboard camera.	Trackside VMS send request to Onboard system over the FRMCS GW.	FRMCS GW forwards requests to Onboard system	
06	Onboard VMS provides camera stream.	FRMCS GW receives camera stream and tunnels it through MCX into available RF modem.	Trackside FRMCS GW receives camera stream through RF modem	
07	Viewing of live camera stream at trackside VMS system	Trackside FRMCS GW provides camera stream into trackside VMS	Operator is able to see the camera feed at trackside VMS. The video view and object move within the view is smooth, no major jerks or picture blinking, trackside VMS indicates around 20-25 fps on the display overlay. No stream error messages in the application logs.	

9.4.1.4 Video_TC_003: Streaming of video from train to trackside, including BTS handover (same 5G network)

Step	Description	Action	Expected result(s)	Compliance with selected requirements
01	Trackside VMS and Onboard VMS are registered to FRMCS GW	Trackside VMS and Onboard VMS registers to the FRMCS GW	Registration to the FRMCS GW is successful	**FU-7100 v5.0.0:** §6.13 **3GPP TR22.889 V17.4.0:** [R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003] [R-7.1.3-001] [R-7.1.4-001] [R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7
02	Trackside VMS system constantly checks Onboard system availability.	Trackside VMS interface with the FRMCS GW through TSapp interface for communication allocation.	FRMCS GW acknowledges (or deny) Trackside VMS requests	
03	FRMCS GW provides communication	FRMCS GW allocates communication	Communication session is established	
04	Train camera is indicated as available in trackside VMS	Train camera status is available in the cameras tree (green)	Camera is indicated as available (green)	

05	Trackside VMS user is requesting video feed from the onboard camera.	Trackside VMS send request to Onboard system over the FRMCS GW.	FRMCS GW forwards requests to Onboard system	
06	Onboard VMS provides camera stream.	FRMCS GW receives camera stream and tunnels it through MCX into available RF modem.	Trackside FRMCS GW receives camera stream through RF modem	
07	Viewing of live camera stream at trackside VMS system	Trackside FRMCS GW provides camera stream into trackside VMS	Operator is able to see the camera feed at trackside VMS. The video view and object move within the view is smooth, no major jerks or picture blinking, trackside VMS indicates around 20-25 fps on the display overlay. No stream error messages in the application logs.	
08	Create BTS Handover conditions	Trigger a BTS handover by modifying the signal strength of the BTS, using RF attenuators.	Potentially, some short visual effects on the video could be observed, freeze, jerks or picture blinking, trackside VMS could indicate less than 20-25 fps on the display overlay. Potentially stream error messages could be available in the application logs.	

9.4.2 Video_TC_002 Degraded communication: streaming of video from train to trackside.

9.4.2.1 Purpose

Purpose of this test case is to test live streaming of CCTV video from the onboard video management system into the trackside video management system in degraded communication. This application facilitates the data communication for real time transmission of video for non-critical railway operation.

Non-critical real time video is considered as an effective mitigation measure to optimize the performance and safety of the railway system. The application can be used for example for:

- Passenger Information
- Help Points
- Ticketing
- To transfer video in parallel with voice communication
- Supervision of railway assets and passengers

9.4.2.2 Description of initial state/configuration

- Onboard system is up and running.
- Onboard system has at least one camera installed, the camera view pointing to moving pictures/objects (no static picture view)
- Onboard camera is integrated with the onboard Video Management System (VMS), which is interfacing with FRMCS GW through OBapp.
- Trackside VMS system is up and running.
- Onboard system is configured in the Ground VMS system.
- Trackside VMS is interfacing with Trackside FRCMS GW through TSapp
- FRCMS when the test starts, can provide sufficient bandwidth for single camera view (at least 4 Mbps) before degraded network conditions occur.
- Degraded network conditions occur (i.e., not sufficient bandwidth, long network delay, jitter)

9.4.2.3 Test procedure

Step	Application Prototype	Action	Expected result(s)	Compliance with selected requirements
01	Trackside VMS and Onboard VMS are registered to FRMCS GW	Trackside VMS and Onboard VMS registers to the FRMCS GW	Registration to the FRMCS GW is successful	**FU-7100 v5.0.0:** §6.13 **3GPP TR22.889 V17.4.0:** [R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003]
02	Trackside VMS system constantly checks Onboard system availability.	Trackside VMS interface with the FRMCS GW through TSapp interface for communication allocation.	FRMCS GW acknowledges (or deny) Trackside VMS requests	

03	FRMCS GW provides communication	FRMCS GW allocates communication	Communication session is established	[R-7.1.3-001] [R-7.1.4-001] [R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7
04	Train camera is indicated as available in trackside VMS	Train camera status is available in the cameras tree (green)	Camera is indicated as available (green)	
05	Trackside VMS user is requesting video feed from the onboard camera.	Trackside VMS send request to Onboard system over the FRMCS GW.	FRMCS GW forwards requests to Onboard system	
06	Onboard VMS provides camera stream.	FRMCS GW receives camera stream and tunnels it through MCX into available RF modem.	Trackside FRMCS GW receives camera stream through RF modem	
07	Viewing of live camera stream at trackside VMS system	Trackside FRMCS GW provides camera stream into trackside VMS	The user can see the camera feed at trackside VMS. The video view and object move within the view is smooth, no major jerks or picture blinking, trackside VMS indicates around 20-25 fps on the display overlay. No stream error messages in the application logs.	
08	Degraded network conditions occur, using the Vertex emulator as in Figure 42	Trackside VMS try to decode video stream based on available data received.	Visual effects on the video could be observed, freeze, jerks or picture blinking, trackside VMS could indicate less than 20-25 fps on the display overlay. Stream error messages could be available in the application logs.	

9.4.3 Video_TC_004: Cross-border with streaming of video from train to trackside, using inter-gNodeB handover over AMF.

9.4.3.1 Purpose

The purpose of this test is to demonstrate that the performance of Video application is not impacted in border-crossing conditions, which are implemented in the WP3 framework as inter-gNodeB handover over AMF (using NG interface). In that case only one IP address is used, as if it was one PLMN, although there are two 5G cores implemented. This application facilitates the data communication for real time transmission of video for non-critical railway operation.

Non-critical real time video is considered as an effective mitigation measure to optimize the performance and safety of the railway system. The application can be used for example for:

- Passenger Information
- Help Points
- Ticketing
- To transfer video in parallel with voice communication
- Supervision of railway assets and passengers

9.4.3.2 Description of initial state/configuration

- Onboard system is up and running.
- Onboard system has at least one camera installed, the camera view pointing to moving pictures/objects (no static picture view)
- Onboard camera is integrated with the onboard Video Management System (VMS), which is interfacing with FRMCS GW through OBapp
- Trackside VMS system is up and running.
- Onboard system is configured in the Ground VMS system.
- Trackside VMS is interfacing with Trackside FRCMS GW through TSapp
- FRCMS when the test starts, can provide sufficient bandwidth for single camera view (at least 4 Mbps) before cross border scenario conditions occurs.
- Cross border scenario occurs (as described in the dedicated cross-border chapter §1.4)

Step	Description	Action	Expected result(s)	Compliance with selected requirements
01	Trackside VMS and Onboard VMS are registered to FRMCS GW	Trackside VMS and Onboard VMS registers to the FRMCS GW	Registration to the FRMCS GW is successful	**FU-7100 v5.0.0:** §6.13 **3GPP TR22.889 V17.4.0:** [R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003] [R-7.1.3-001] [R-7.1.4-001] [R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7
02	Trackside VMS system constantly checks Onboard system availability.	Trackside VMS interface with the FRMCS GW through TSapp interface for communication allocation.	FRMCS GW acknowledges (or deny) Trackside VMS requests	
03	FRMCS GW provides communication	FRMCS GW allocates communication	Communication session is established	
04	Train camera is indicated as available in trackside VMS	Train camera status is available in the cameras tree (green)	Camera is indicated as available (green)	

05	Trackside VMS user is requesting video feed from the onboard camera.	Trackside VMS send request to Onboard system over the FRMCS GW.	FRMCS GW forwards requests to Onboard system	
06	Onboard VMS provides camera stream.	FRMCS GW receives camera stream and tunnels it through MCX into available RF modem.	Trackside FRMCS GW receives camera stream through RF modem	
07	Viewing of live camera stream at trackside VMS system	Trackside FRMCS GW provides camera stream into trackside VMS	Operator can see the camera feed at trackside VMS. The video view and object move within the view is smooth, no major jerks or picture blinking, trackside VMS indicates around 20-25 fps on the display overlay. No stream error messages in the application logs.	
08	Create cross-border conditions	Trigger an inter-gNodeB handover between gNodeBs belonging to two AMFs, by modifying the signal strength of the gNodeB of the home network, using RF attenuators. The scenario is explained in §1.4	Potentially, some short visual effects on the video could be observed, freeze, jerks or picture blinking, trackside VMS could indicate less than 20-25 fps on the display overlay. Potentially stream error messages in the application logs.	

9.5 Transfer of CCTV archives

To enable end-to-end CCTV system implementation, “Trackside” and “On-board” CCTV components are interconnected with the FRMCS infrastructure via the interfaces TSAPP (Trackside) and OBAPP (On-Board), as illustrated in the following figure:.

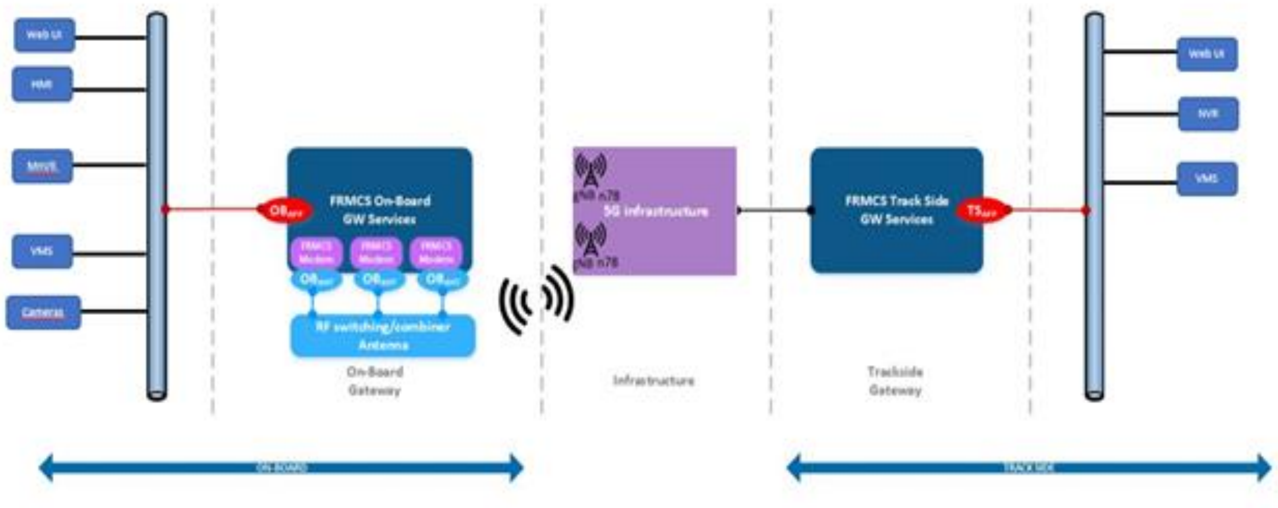


Figure 59: CCTV system architecture overview. (Ref.D2.1)

9.5.1 CCTV_TC_001: CCTV offload from train to trackside

9.5.1.1 Purpose

In a CCTV offload system, FRMCS provides means for transferring video surveillance data between a mobile communication unit in the train and ground communication units located at the depot and at the stations and/or stops alongside the predetermined route of the train. Whenever the train approaches the stations and/or stops or arrives at the depot, FRMCS facilitates the communication between the mobile and ground communication unit. The mobile communication unit in the train forwards the video surveillance data from the onboard video recorder to Trackside VMS.

9.5.1.2 Description of initial state/configuration

- Onboard system is up and running.
- Onboard system has at least one camera installed, the camera view pointing to moving pictures/objects (no static picture view)
- Onboard camera is integrated with the onboard Video Management System (VMS), which is interfacing with FRMCS GW through OBapp.
- Trackside VMS system is up and running.
- Onboard system is configured in the Trackside VMS system.

- Onboard system is configured for the offload and gets trigger to start offload process or is manually started (manual trigger)

***Note:** The results of validation of the API for OBapp/TSapp compatibility of the application are described in the D2.2 deliverable.*

9.5.1.3 Test procedure

<table>
<tr><th>Step</th><th>Description</th><th>Action</th><th>Expected result(s)</th><th>Compliance with selected requirements</th></tr>
<tr><td>01</td><td>CCTV offload monitoring</td><td>Onboard VMS system requests communication for CCTV offload from onboard FRMCS GW, (when it discovers based on location or by other means or is manually started (manual trigger)) that station and/or depot is close enough to start CCTV offload).</td><td>FRMCS GW allows communication</td><td rowspan="4">FU-7100 v5.0.0:
§6.22
3GPP TR22.889 V17.4.0:
[R-7.2.2-001]
[R-7.2.2-002]
3GPP TS22.289 V17.0.0
[R4.1.2-1]
[R4.1.2-2]
[R4.1.2-3]
[R4.1.2-4]</td></tr>
<tr><td>02</td><td>Allocation of Frequency</td><td>Onboard FRMCS GW allocates available 5G link for Onboard VMS.</td><td>FRMCS GW allocates frequency</td></tr>
<tr><td>03</td><td>Connection establishment</td><td>Trackside FRMCS GW and Onboard GW establish connection as soon as possible.</td><td>Connection established</td></tr>
<tr><td>04</td><td>Start and termination of CCTV offload</td><td>Onboard VMS starts CCTV offload and continues until signal is no longer available. Trackside VMS stores received data. Offload is terminated upon no signal is available (i.e., terminated by FRMCS GW or train has left offload zone.)</td><td>CCTV data that was managed to be offloaded are available in Trackside VMS
Check video offload For the results evaluation, it is to be considered that Max offload speed is around 10MB/s, assuming the best network conditions and a single camera, and it is around 1MB/s when degraded conditions occur.</td></tr>
</table>

9.5.2 CCTV_TC_002: CCTV offload from train to trackside with bearer-flex

9.5.2.1 Purpose

In a CCTV offload system, FRMCS provides means for transferring video surveillance data between a mobile communication unit in the train and ground communication units located at the depot and at the stations and/or stops alongside the predetermined route of the train. Whenever the train approaches the stations and/or stops or arrives at the depot, FRMCS facilitates the communication between the mobile and ground communication unit with the frequency available at stations and depots.

FRMCS facilitates the communication between the mobile and ground communication unit outside of the depots or stops as well using other links / sub-bands with the frequency available along track. With this use case the bearer flexibility is demonstrated as multi access use case using two sub bands for track and station coverage.

The mobile communication unit in the train forwards the video surveillance data from the onboard video recorder to Trackside VMS.

9.5.2.2 Description of initial state/configuration

- Onboard system is up and running.
- Onboard system has at least one camera installed, the camera view pointing to moving pictures/objects (no static picture view)
- Onboard camera is integrated with the onboard Video Management System (VMS), which is interfacing with FRMCS GW through OBapp.
- Trackside VMS system is up and running.
- Onboard system is configured in the Trackside VMS system.
- Onboard system is configured for the offload and gets trigger to start offload process or is manually started (manual trigger)
- FRMCS facilitates the communication with different frequencies (sub-bands) along track and train stops/depot.

9.5.2.3 Test procedure

Step	Description	Action	Expected result(s)	Compliance with selected requirements
01	CCTV offload monitoring	Onboard VMS system requests communication for CCTV offload from onboard FRMCS GW, (when it discovers based on location or by other means or is manually started (manual trigger)).	FRMCS GW allows communication	**FU-7100 v5.0.0:** §6.22 **3GPP TR22.889 V17.4.0:** [R-7.2.2-001] [R-7.2.2-002] **3GPP TS22.289 V17.0.0** [R4.1.2-1] [R4.1.2-2] [R4.1.2-3] [R4.1.2-4]
02	Allocation of Frequency	Onboard FRMCS GW allocates link with frequencies (sub-bands) available along track for Onboard VMS.	FRMCS GW allocates frequency	
03	Connection establishment	Trackside FRMCS GW and Onboard GW establish connection as soon as possible.	Connection established	
04	Start of CCTV offload	Onboard VMS starts CCTV offload and continues until signal is no longer available. Trackside VMS stores received data.	CCTV data that was managed to be offloaded are available in Trackside VMS Check video offload speed	
05	Change of Frequency	Onboard FRMCS GW changes/allocates link with frequencies (sub-bands) available along train stop/depot for Onboard VMS.	FRMCS GW allocates frequency	
06	CCTV offload continues	Onboard VMS continues CCTV offload until signal is no longer available. Trackside VMS stores received data.	CCTV data that was managed to be offloaded are available in Trackside VMS Check video offload speed. Look for the data retransmissions if any in the application logs.	

9.6 PIS

In the following, functional test cases for the PIS application, provided by Thales GTS France, will be presented. These test cases will be performed in WP4 lab. PIS is a non-critical trackside-initiated application using loose-coupled mode, in the final version of the application prototype.

PIS Lab is located at Thales premises at Vélizy-le-Bois in France and is connected to WP4 lab at Kontron’s premises in Montigny, via a secured remote connection.

The following figure is an overview of the PIS application architecture in the FRMCS ecosystem:

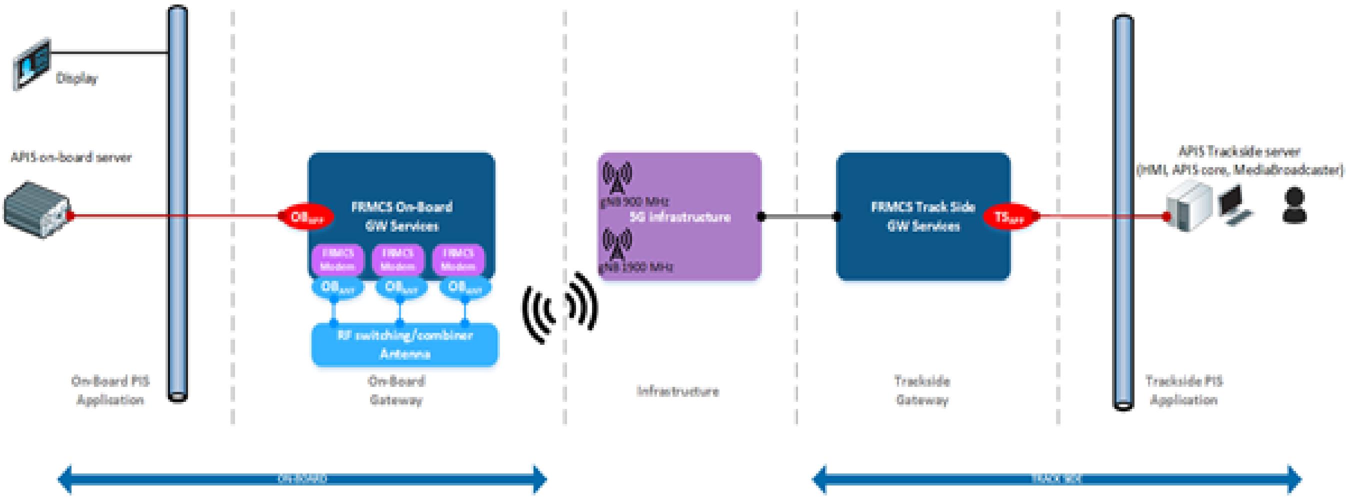


Figure 60: PIS application architecture overview. (Ref. D2.1)

The figure below describes the PIS lab and illustrates the secured Internet remote connection configured between Thales and WP4 lab to ensure the confidentiality of PIS information

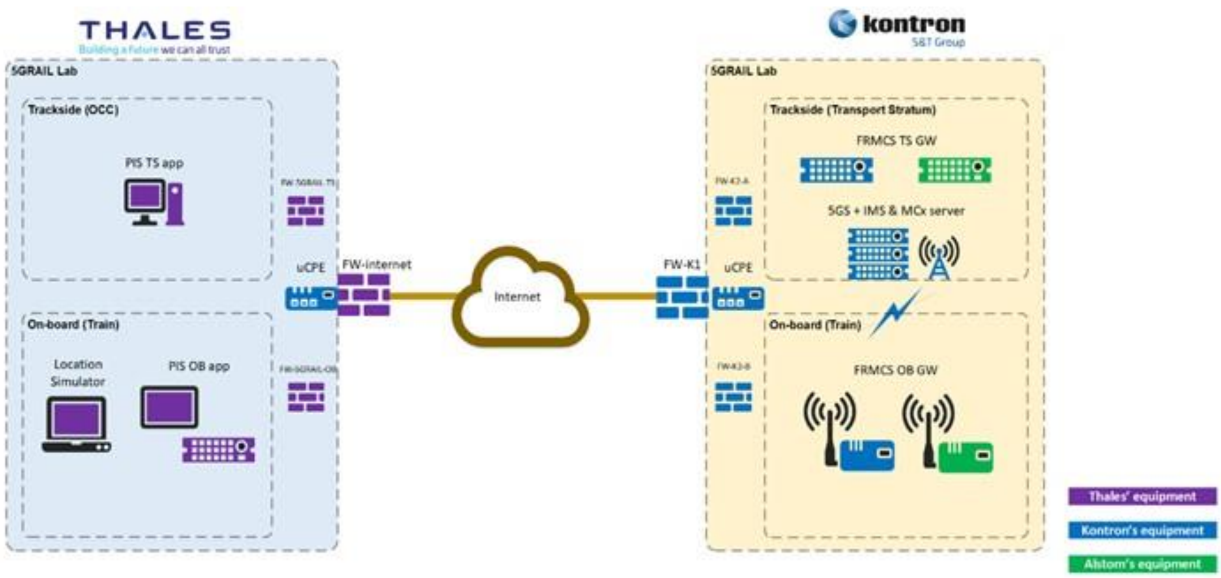


Figure 61: High level view of interconnection of PIS LAB at Thales-Vélizy and WP4 lab (Ref. D4.2)

In the following chapters, describing PIS test cases, the notation using "$" is a Linux terminal command that does not require "super user" privileges to be executed:

```
$ command
```

On the contrary, the notation using "#" is a Linux terminal command that requires "super privileges" to be executed:

```
# Command
```

9.6.1 Flat-IP coupling mode test cases

'Flat IP' coupling mode is the v1-phased approach of PIS application. 'Flat IP' definition and the main application regimes are defined in §4 FRMCS ARCHITECTURE: OBapp/TSapp DEFINITIONS.

Note: *The flat-IP coupling mode PIS test cases were only performed with Alstom On-board Gateway (a.k.a TOBA-A)*

9.6.1.1 QoS configuration for PIS application

PIS flow matrix							QoS			
Rules id	Src @IP	Hostname Src	Hostname Dst	Dst @IP	Protocol	Dst Port	DSCP value/name	5QI	FRMCS comm_profile	Comment
15	192.168.254.10/27	PIS trackside	PIS on-board	192.168.254.130/28	TCP	2223	23	5	*8*	Sending E2E text messages with a high priority
16	192.168.254.10/27	PIS trackside	PIS on-board	192.168.254.130/28	TCP	2222	19	6	*7*	Sending E2E text messages with a normal priority Train mission DB sync to display accurate location information
17	192.168.254.130/28	PIS on-board	PIS trackside	192.168.254.10/27	UDP	514	8	8	*6*	Offloading of the on-board log files
18	192.168.254.10/27	PIS trackside	PIS on-board	192.168.254.130/28	TCP	22	8	8	*6*	PIS O&M

Table 12: Mapping of DSCP and 5QI values for PIS application

9.6.1.2 PIS-Flat IP_TC_001: Send text message with a normal priority to trains.

9.6.1.2.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send text messages to trains.

9.6.1.2.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,

- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5G Core Network has provided an IP address to the gateway),
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- PIS application is configured in the 5G system to use non-critical (i.e., corresponding to "Non-Critical Data") 5QI, as presented in Table 12
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.1.2.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	Start trace tool and save traces	Wireshark logs saved for TS and OB side	
02	From the PIS trackside HMI, the Passenger Information Controller: 1. Selects a train "train 1" and the device "device 1". 2. Selects a normal priority. 3. Writes the message "This is a normal PIS message in flat-ip" 4. Presses "send" button. Keep the default value of the duration proposed by the HMI.	The message "This is a normal PIS message in flat-ip" and the priority selected by the Passenger Information Controller are displayed on the on-board display during the selected duration. **The delay between PIS trackside and on-Board display should be less than 7 seconds.** (Note that 6 seconds are allowed for sub-system radio link trackside-on-Board)	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10
03	Verification QoS	Check 5Qi value according to Table 12	

04	Precise trace name to retrieve	5GRail_WP4_Thales_D4_2_PIS_PHASE3_TC_001_TS.png 5GRail_WP4_Thales_D4_2_PIS_PHASE3_TC_001_TS.pcapng 5GRail_WP4_Thales_D4_2_PIS_PHASE3_TC_001_OB.png 5GRail_WP4_Thales_D4_2_PIS_PHASE3_TC_001_OB.pcapng 5GRail_WP4_Kontron_D4.2_Thales_Alstom_PIS_DSCP_Test_15_16_17_18.txt	

Note: *Due to WP4 lab configuration Figure 61, VPN additional delay needs to be measured and removed from the KPI value.*

9.6.1.3 PIS-Flat IP_TC_002: Send text message with a high priority to trains.

9.6.1.3.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send text messages with a high priority to trains.

9.6.1.3.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,

- PIS application is configured in the 5G system to use critical (i.e., corresponding to "Critical Data") 5QI, as presented in Table 12
- The scheduler of the FRMCS trackside and on-board gateways is configured to manage PIS flows with a high priority corresponding to "Critical Data",
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.1.3.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	Start trace tool and save traces	Wireshark logs saved for TS and OB side	
02	From the PIS trackside HMI, the Passenger Information Controller: 1. Selects a train. 2. Selects a critical priority. 3. Writes the message "This is a high priority PIS message in flat-ip" 4. Presses "send" button. Keep the default value of the duration proposed by the HMI.	The message "This is a high priority PIS message in flat-ip" and the priority selected by the Passenger Information Controller are displayed on the on-board display during the selected duration. **The delay between PIS trackside and on-Board display should be less than 7 seconds.** (Note that 6 seconds are allowed for sub-system radio link trackside-on-Board)	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10
03	Verification QoS	Check 5QI value according to Table 12	
04	Precise trace name to retrieve	5GRail_WP4_Thales_D4_2_PIS_PHASE3_TC_002_TS.png	

Note: *Due to WP4 lab configuration Figure 61, VPN additional delay needs to be measured and removed from the KPI value.*

9.6.1.4 PIS-Flat IP_TC_003: Send text message with a normal priority in degraded conditions.

9.6.1.4.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send text messages to trains in degraded conditions.

5G radio link overload is considered as degraded conditions scenario.

9.6.1.4.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The initial state covers the following steps:
- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- PIS application is configured in the 5G system to use non - critical (i.e., corresponding to “Non-Critical Data”) 5QI, as presented in Table 12
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.1.4.3 TEST PROCEDURE: 5G RADIO LINK IS OVERLOADED

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS trackside Gateway	Generate traffic to overload the 5G radio link) (e.g., simulate the transfer of CCTV archives)	Radio link is overloaded	

02	THALES PIS	From the PIS trackside HMI, the Passenger Information Controller:
		1. Selects a train.
		2. Selects a normal priority.
		3. Writes the message he/she wants to send.
		4. Presses "send" button
			The message is rejected by the FRMCS system.
			
			PIS trackside application logs into its log file that the message cannot be sent to the train.
			
			Edit the log file with the Linux command "tail":
			
			`# tail -10 /tsPis/logs`
			
			The last lines shall be:
			
			`Trying to send message <message-file>.`
			
			`Cannot send message. Either host is down, or FRMCS reject the communication.`
				[FU- 7100 v5.0.0]:
				
				6.9.1.1
				
				8.7.1.1, 8.7.4.1, 8.7.5.1
				
				8.8.1.1, 8.8.4.1, 8.8.5.1
				
				[3GPP TR 22.889 v17.3.0]:
				
				12.10

9.6.1.5 PIS-Flat IP_TC_004: Send text message with a high priority in degraded conditions.

9.6.1.5.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send priority text messages to trains in degraded conditions.

5G radio link overload is considered as degraded conditions scenario.

9.6.1.5.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,

- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- PIS application is configured in the 5G system to use critical (i.e., corresponding to "Critical Data") 5QI, as presented in Table 12
- FRMCS trackside and on-board Gateways internal traffic flow scheduler is configured to manage PIS messages with a high priority (i.e., corresponding to "Critical Data"),
- Remote connection between Thales lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.1.5.3 TEST PROCEDURE: 5G RADIO LINK IS OVERLOADED

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS on-board Gateway	Generate traffic to overload the 5G radio link (e.g., simulate the transfer of CCTV archives)	Radio link is overloaded	
02	THALES PIS	From the PIS trackside HMI, the Passenger Information Controller: 1. Selects a train 2. Selects a critical priority 3. Writes the message "This is a high priority PIS message in flat-ip in degraded conditions" 4. Presses "send" button Keep the default value of the duration proposed by the HMI.	The message "This is a high priority PIS message in flat-ip in degraded conditions" and the priority selected by the Passenger Information Controller are displayed on the on-board display during the selected duration. **The delay between PIS trackside and on-Board display should be less than 7 seconds.** (Note that 6 seconds are allowed for sub-system radio link trackside-on-Board)	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10

<u>Note:</u> *Due to WP4 lab configuration Figure 61, VPN additional delay needs to be measured and removed from the KPI value.*

9.6.1.6 PIS-Flat IP_TC_005: Display train location information

9.6.1.6.1 PURPOSE

The purpose of this test is to validate the ability to synchronize the "secondary" on-board Train Mission Database with "primary" trackside database, to provide accurate information to the passengers in the train about the location of the train.

9.6.1.6.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured and started,
- PIS trackside and on-board software are configured and are running,
- Trackside and on-board Mission Database are operational,
- FRMCS trackside and onboard Gateways are installed, configured and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway ,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway),
- PIS application is configured in the 5G system to use non - critical (i.e., corresponding to "Non-Critical Data") 5QI, as presented in Table 12
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- On-board location simulator equipment is installed, configured and started,
- On-board location simulator provides to on-board PIS application the information about the location of the train. It is directly connected to on-board PIS equipment,
- Remote connection between Thales lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.1.6.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	From the PIS trackside equipment, the Passenger Information Controller sends from trackside the Train Mission Database to on-board using the command: `# /tsPis/transmission.sh 192.168.254.10 /tsPis/rerB`	On-board and trackside files have the same size. Date and time of the on-board file correspond to the date and time of the update.	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.4.1.1, 8.4.4.1, 8.4.5.2 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]**: 12.10
02	From the PIS on-board server, restart the PIS software by executing the command: `# /obPis/obPis restart && /obPis/obPis run`	The location of the train is displayed on the on-board display.	

9.6.1.7 PIS-Flat IP_TC_006: On-board PIS logs downloaded on the fly in degraded conditions

9.6.1.7.1 PURPOSE

The purpose of this test is to validate the ability to send on the fly with a high priority the on-board PIS logs to trackside, in degraded conditions.

5G radio link overload is considered as degraded conditions scenario.

9.6.1.7.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,

- On-board logs centralization in trackside is configured,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- PIS log flows are configured in the 5G system to use critical (i.e., corresponding to "Critical Data") 5QI, as presented in Table 12
- FRMCS trackside and on-board Gateways internal traffic flow scheduler is configured to treat PIS log messages with a high priority (i.e., corresponding to "Critical Data"),
- Remote connection between Thales lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.1.7.3 TEST PROCEDURE: 5G RADIO LINK IS OVERLOADED

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS on-board Gateway	Generate traffic to overload the 5G radio link (e.g., simulate the transfer of CCTV archives)	Radio link is overloaded	
02	THALES PIS	On-board PIS logs are sent on the fly to trackside	On-board PIS logs are received on trackside in real time. It can be verified by executing the Linux command "tail" from PIS trackside server: `# tail -f /var/log/congatec-qa3-64/obpis`	**[FU- 7100 v5.0.0]**: 6.9.1.1 6.20.4.1, 6.20.5.2, 6.20.5.3 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]**: 12.10

9.6.1.8 PIS-Flat IP_TC_007: Open a "trackside to on-board" management session with a high priority

9.6.1.8.1 PURPOSE

The purpose of this test is to validate the ability to open a "trackside to on-board" management session with a critical priority during a significant time (e.g., 15 minutes) for PIS O&M operations.

The connection shall be resilient even with non-optimal radio conditions.

9.6.1.8.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5G Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- PIS O&M traffic flows are configured in the 5G system to use critical (i.e., corresponding to “Critical Data”) 5QI, as presented in the Table 12
- The traffic flow scheduler of the FRMCS trackside and on-board gateways is configured to manage PIS O&M flows with a high priority corresponding to “Critical Data”,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.1.8.3 TEST PROCEDURE

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	THALES PIS	Start Wireshark and terminal logs	Wireshark and output Linux terminal saved	
02	KONTRON	From the radio simulator, execute the relevant scenario in order to disturb the radio conditions.	FRMCS on-board gateway is still connected to 5GS	

03	THALES PIS	From trackside PIS equipment, PIS maintainer opens an SSH connection to on-board PIS equipment using on-board PIS O&M IP address. Execute the script KeepAliveCon.sh to maintain the SSH connection alive for 15 minutes. `# ./KeepAliveCon.sh`	No disconnection of the trackside to on-board SSH connection for 15 minutes.	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10

9.6.2 Loose coupling mode test cases

'Loose coupling' mode is the final version of PIS application. The main applications regimes definitions are presented in §4 FRMCS ARCHITECTURE: OBapp/TSapp DEFINITIONS.

9.6.2.1 PIS_TC _001: Mutual authentication of PIS trackside application with FRMCS trackside Gateway

Note: *This test case will not be executed since it was foreseen for the PIS, being cybersecurity demonstrator, which is not the case anymore.*

9.6.2.2 PIS_TC _002: Mutual authentication of PIS on-board application with FRMCS onboard Gateway

Note: *This test case will not be executed since it was foreseen for the PIS, being cybersecurity demonstrator, which is not the case anymore.*

9.6.2.3 PIS_TC_003: Registration of PIS trackside application in the FRMCS network

9.6.2.3.1 PURPOSE

The purpose of this test is to validate the ability to register PIS trackside application in the FRMCS network.

9.6.2.3.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the API implementation is explained in D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW REGISTER).

9.6.2.3.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside equipment is installed, configured, and started,
- FRMCS trackside Gateway is installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- FRMCS trackside Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment are time synchronized (date & time),
- PIS trackside application and FRMCS trackside Gateway are mutually authenticated,
- Wireshark tool is running on PIS trackside equipment; it is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.3.4 TEST PROCEDURE 1: SUCCESSFUL REGISTRATION OF PIS TRACKSIDE APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements

01	Execute PIS trackside software to start the registration procedure by sending an FRMCS_GTW_REGISTER request to the FRMCS trackside Gateway with data in JSON format according to format according to Table 13.
	`# /frmcs/frmcsAgent.py msgTsPis connect`
	`# /frmcs/frmcsAgent.py msgTsPis register msg.ts.pis 5 loose auto_reject`
		PIS trackside application receives an FRMCS_GTW_REGISTER answer containing data in JSON format indicating that PIS trackside application is registered in the FRMCS network. An example of JSON data is given in Figure 62.
		The data received by the PIS trackside application shall contain the parameter “app_uuid” corresponding to the identifier of PIS trackside application in the FRMCS network.
		The answer is decoded by the application and logged into application’s log file (“/frmcs/logs.log”).
		The file “/frmcs/apps/msgTsPis/status.xml” is updated, especially the parameter “<app_uuid>” contains the identifier returned by the FRMCS trackside GW and the “<register><status>” parameter is set to “True”:
		`<?xml version="1.0" encoding="utf-8"?>`
		`<status>`
		`    <messageId>2</messageId>`
		`    <connected>True</connected>`
		`    <register>`
		`        <status>True</status>`
			D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW REGISTER).

		<originator_id>msg.ts.pis</originator_id> <application_type>5</application_type> <mode>loose</mode> <incoming_auto>auto_reject</incoming_auto> **<app_uuid>0ed34711-48b0-4083-87ea-056a9c2fa1a6</app_uuid>** </register> <sessions></sessions> </status>	

Table 13: TC_003 - Parameters and values used for FRMCS_GTW_REGISTER request to register successfully PIS trackside application in the FRMCS network.

Name of the parameter	Value of the parameter
application_type	5 (as defined in chapter 10.3 of D2.1 v2)
originator_id	msg.ts.pis
mode	“loose”
incoming_auto	auto_reject

```
{"jsonrpc": "2.0",
    "result": {    "app_uuid": "123e4567-e89b-12d3-a456-426614174000” }
    "id": 1}
```

Figure 62: Example of data in FRMCS_GTW_REGISTER answer in JSON format (extract from D2.1)

9.6.2.3.5 TEST PROCEDURE 2: UNSUCCESSFUL REGISTRATION OF PIS TRACKSIDE APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Execute PIS trackside software to start the registration procedure by sending an FRMCS_GTW_REGISTER request to the FRMCS trackside Gateway with data in JSON format according to Table 14. The aim of this test is to specify a coupling	PIS trackside application receives an FRMCS_GTW_REGISTER answer containing data according to Table 15 in JSON format indicating that PIS trackside application is not registered in the FRMCS	D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW REGISTER).

	mode not supported by the FRMCS network in order to force the FRMCS network to reject the registration.
	`# /frmcs/frmcsAgent.py msgTsPis connect`
	`# /frmcs/frmcsAgent.py msgTsPis register msg.ts.pis 5 flat-loose auto_reject`
		network. An example of JSON data is given Figure 63
		The data received by the PIS trackside application shall contain the reason for the non-registration “Mode not supported for this application”.
		The answer is decoded by the application and logged into application’s log file (“/frmcs/logs.log”).	

Table 14: TC_003 - Parameters and values used for FRMCS_GTW_REGISTER request to register unsuccessfully PIS trackside application in the FRMCS network.

Name of the parameter	Value of the parameter
application type	5 (as defined in chapter 10.3 of D2.1)
originator_id	msg.ts.pis
mode	“flat-Loose”
incoming_auto	auto_reject

Table 15: TC_003 - Parameters and values of the FRMCS_GTW_REGISTER answer for an unsuccessful registration.

Name of the parameter	Value of the parameter
code	-1
message	“TSapp API error”
data	“Mode not supported for this application”


```
{"jsonrpc": "2.0",
   "error": {      "code": -1,
                   "message": "OBapp API error",
                   "data": "Mode not supported for this application"}
   "id": 1}
```


Figure 63: Example of data in FRMCS_GTW_REGISTER answer in JSON format (extract from D2.1) rejecting the request of registration.

9.6.2.4 PIS_TC_004: Deregistration of PIS trackside application in the FRMCS network

9.6.2.4.1 PURPOSE

The purpose of this test is to validate the ability to deregister PIS trackside application in the FRMCS network.

9.6.2.4.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the API implementation is explained in D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW DEREGISTER).

9.6.2.4.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside equipment is installed, configured, and started,
- FRMCS trackside Gateway is installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- FRMCS trackside Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment are time synchronized (date & time),
- PIS trackside application is registered in the FRMCS network,
- Wireshark tool is running on PIS trackside equipment; it is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.4.4 TEST PROCEDURE 1: SUCCESSFUL DEREGISTRATION OF PIS TRACKSIDE APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Execute PIS trackside software to start the deregistration procedure by sending an FRMCS_GTW_DEREGISTER request to the FRMCS trackside Gateway with data in JSON format containing the “app_uuid” received by the	PIS trackside application receives an FRMCS_GTW_DEREGISTER answer containing data in JSON format indicating that PIS trackside application is deregistered from the FRMCS network. An example of JSON data is given in Figure 65.	D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW DEREGISTER).

	FRMCS network in 9.6.2.3.4.
	An example of data in JSON format is given in Figure 64.
	The command to execute the deregistration process is:
	`# /frmcs/frmcsAgent.py msgTsPis deregister`
		The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").
		In file "/frmcs/apps/msgTsPis/status.xml", the value of the parameter "<register><status>" is set to "False":
		`<register>`
		…
		`<status>False</status>`
		…
		`</register>`	


```
{   "jsonrpc": "2.0",
    "method": "deregister",
    "params": {
                  "app_uuid": "123e4567-e89b-12d3-a456-426614174000"
    }
    "id": 2}
```


Figure 64: Example of data in JSON format for FRMCS_GTW_DEREGISTER request (extract from D2.1).


```
{"jsonrpc": "2.0",
    "result": { }
    "id": 2}
```


Figure 65: Successful deregistration data in JSON format in FRMCS_GTW_DEREGISTER answer (extract from D2.1).

9.6.2.4.5 TEST PROCEDURE 2: UNSUCCESSFUL DEREGISTRATION OF PIS TRACKSIDE APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements

01	Edit the file "/frmcs/apps/msgTsPis/status.xml" and alter the value of the XML tag "<app_uuid>" by adding a digit at the end:
	`<app_uuid>XXX-XXX-XXX</app_uuid>`
	becomes
	`<app_uuid>XXX-XXX-XXX0</app_uuid>`		

02	Execute PIS trackside software to start the deregistration procedure by sending an FRMCS_GTW_DEREGISTER request to the FRMCS trackside Gateway with data in JSON format. An example is given by Figure 64.The aim of this test is to specify an "app_uuid" unknown from the FRMCS network in order to force the FRMCS network to reject the deregistration. The command to execute the deregistration process is: `# /frmcs/frmcsAgent.py msgTsPis deregister`	PIS trackside application receives an FRMCS_GTW_DEREGISTER answer containing data in JSON format indicating that PIS trackside application is not deregistered from the FRMCS network. An example of JSON data is given in Figure 66 The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").	D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW DEREGISTER).


```
{"jsonrpc": "2.0",
   "error": {      "code": -1,
                   "message": "OBapp API error",
                   "data": "app_uuid unknown"}
   "id": 2}
```


Figure 66: Example of data in FRMCS_GTW_DEREGISTER answer in JSON format (extract from D2.1) rejecting the request of deregistration.

9.6.2.5 PIS_TC_005: Registration of PIS on-board application in the FRMCS network

9.6.2.5.1 PURPOSE

The purpose of this test is to validate the ability to register PIS on-board application in the FRMCS network.

9.6.2.5.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the API implementation is explained in D2.1 TOBA Architecture Report – OBapp – Loose coupled interface (FRMCS_GTW_REGISTER).

9.6.2.5.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS on-board equipment is installed, configured, and started,
- FRMCS on-board Gateway is installed, configured, and started,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- FRMCS on-board Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS on-board equipment, FRMCS on-board equipment are time synchronized (date & time),
- PIS on-board application and FRMCS on-board Gateway are mutually authenticated,
- Wireshark tool is running on PIS trackside equipment; is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e. all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.5.4 TEST PROCEDURE 1: SUCCESSFUL REGISTRATION OF PIS ON-BOARD APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Execute PIS on-board software to start the registration procedure by sending an FRMCS_GTW_REGISTER request to the FRMCS on-board Gateway with data in JSON format according to Table 16: # /frmcs/frmcsAgent.py msgObPis connect # /frmcs/frmcsAgent.py msgObPis register msg.ob.pis 5 loose auto_accept	PIS on-board application receives an FRMCS_GTW_REGISTER answer containing data in JSON format indicating that PIS on-board application is registered in the FRMCS network. An example of JSON data is given in Figure 62. The data received by the PIS on-board application shall contain the parameter “app_uuid” corresponding to the identifier of PIS on-board application in the FRMCS network. The answer is decoded by the application and logged into application’s log file (“/frmcs/logs.log”). The file “/frmcs/apps/msgObPis/status.xml” is updated, especially the parameter “<app_uuid>” contains the identifier returned by the FRMCS on-board GW and the “<register><status>” parameter is set to “True”: <?xml version="1.0" encoding="utf-8"?>	D2.1 TOBA Architecture Report – OBapp – Loose coupled interface (FRMCS_GTW_REGISTER).

		<status> <messageId>2</messageId> <connected>True</connected> <register> **<status>True</status>** <originator_id>msg.ob.pis</originator_id> <application_type>5</application_type> <mode>loose</mode> <incoming_auto>auto_accept</incoming_auto> **<app_uuid>0ed34711-48b0-4083-87ea-056a9c2fa1a7</app_uuid>** </register> <sessions></sessions> </status>	

Table 16: TC_005 - Parameters and values used for FRMCS_GTW_REGISTER request to register successfully PIS On-board application in the FRMCS network.

Name of the parameter	Value of the parameter
application type	5 (as defined in chapter 10.3 of D2.1)
originator_id	msg.ob.pis
mode	“Loose”
incoming_auto	auto_accept

9.6.2.5.5 TEST PROCEDURE 2: UNSUCCESSFUL REGISTRATION OF PIS ON-BOARD APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Execute PIS software to start the registration procedure by sending an FRMCS_GTW_REGISTER request to the FRMCS On-board Gateway with data in JSON format according to Table 17 The aim of this test is to specify a coupling mode not supported by the	PIS On-board application receives an FRMCS_GTW_REGISTER answer containing data according to Table 18 in JSON format indicating that PIS On-board application is not registered in the FRMCS network. An example of JSON data is given Figure 67. The data received by the PIS On-board application shall contain the	D2.1 TOBA Architecture Report – OBapp – Loose coupled interface (FRMCS_GTW_REGISTER).

	FRMCS network in order to force the FRMCS network to reject the registration.
	
	`# /frmcs/frmcsAgent.py msgObPis connect`
	
	`# /frmcs/frmcsAgent.py msgObPis register msg.ob.pis 5 flat-loose auto_accept`
		reason for the non-registration "Mode not supported for this application".
		
		The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").	

Table 17: TC_003 - Parameters and values used for FRMCS_GTW_REGISTER request to register unsuccessfully PIS On-board application in the FRMCS network.

Name of the parameter	Value of the parameter
application type	5 (as defined in chapter 10.3 of D2.1)
originator_id	msg.ob.pis
mode	"Flat-loose"
incoming_auto	auto_accept

Table 18: TC_003 - Parameters and values of the FRMCS_GTW_REGISTER answer for an unsuccessful registration.

Name of the parameter	Value of the parameter
code	-1
message	"TSapp API error"
data	"Mode not supported for this application"

```
{"jsonrpc": "2.0",
   "error": {      "code": -1,
                   "message": "OBapp API error",
                   "data": "Mode not supported for this application"}
   "id": 1}
```


Figure 67: Example of data in FRMCS_GTW_REGISTER answer in JSON format (extract from D2.1) rejecting the request of registration.

9.6.2.6 PIS_TC_006: Deregistration of PIS on-board application in the FRMCS network

9.6.2.6.1 PURPOSE

The purpose of this test is to validate the ability to deregister PIS on board application in the FRMCS network.

9.6.2.6.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the API implementation, using WebSocket over TLS, is explained in D2.1 TOBA Architecture Report– OBapp – Loose coupled interface (FRMCS_GTW DEREGISTER).

9.6.2.6.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS on-board equipment is installed, configured, and started,
- FRMCS on-board Gateway is installed, configured, and started,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- FRMCS on-board Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS on-board equipment, FRMCS on-board equipment are time synchronized (date & time),
- PIS on-board application is registered in the FRMCS network,
- Wireshark tool is running on PIS trackside equipment; is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.6.4 TEST PROCEDURE 1: SUCCESSFUL DEREGISTRATION OF PIS ON BOARD APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements

01	Execute PIS on-board software to start the deregistration procedure by sending an FRMCS_GTW_DEREGISTER request to the FRMCS on-board Gateway with data in JSON format containing the “app_uuid” received by the FRMCS network in 9.6.2.5.4. An example of data in JSON format is given in Figure 64.
	
	The command to execute the deregistration process is:
	
	`# /frmcs/frmcsAgent.py msgObPis deregister`
		PIS on-board application receives an FRMCS_GTW_DEREGISTER answer containing data in JSON format indicating that PIS on-board application is deregistered from the FRMCS network. An example of JSON data is given in Figure 65.The answer is decoded by the application and logged into application’s log file (“/frmcs/logs.log”).
		
		In file “/frmcs/apps/msgObPis/status.xml”, the value of the parameter “<register><status>” is set to “False”:
		
		`<register>`
		…
		`<status>False</status>`
		…
		`</register>`
			D2.1 TOBA Architecture Report– OBapp – Loose coupled interface (FRMCS_GTW DEREGISTER)

9.6.2.6.5 TEST PROCEDURE 2: UNSUCCESSFUL DEREGISTRATION OF PIS ON BOARD APPLICATION

Step	Action	Expected result(s)	Compliance with selected requirements
01	Edit the file “/frmcs/apps/msgObPis/status.xml” and alter the value of the XML tag “<app_uuid>” by adding a digit at the end: `<app_uuid>XXX-XXX-XXX</app_uuid>`		

	becomes `<app_uuid>XXX-XXX-XXX0</app_uuid>`		
02	Execute PIS on-board software to start the deregistration procedure by sending an FRMCS_GTW_DEREGISTER request to the FRMCS on-board Gateway with data in JSON format. An example is given by Figure 64.The aim of this test is to specify an "app_uuid" unknown from the FRMCS network in order to force the FRMCS network to reject the deregistration. The command to execute the deregistration process is: `# /frmcs/frmcsAgent.py msgObPis deregister`	PIS on-board application receives an FRMCS_GTW_DEREGISTER answer containing data in JSON format indicating that PIS on-board application is not deregistered from the FRMCS network. An example of JSON data is given in Figure 66.The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface (FRMCS_GTW DEREGISTER)

9.6.2.7 PIS_TC_007: "Non-Critical Data" session start initiated from trackside - on-board application is registered in "auto-accept" mode.

9.6.2.7.1 PURPOSE

The purpose of this test is to validate the ability to establish a "Non-Critical Data" session from PIS trackside application to PIS on-board application within the FRMCS network where FRMCS on-board Gateway automatically accepts the incoming session.

9.6.2.7.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the functions is explained in D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_SESSION_START) and (FRMCS_APP _SESSION_STATUS_CHANGED).

9.6.2.7.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS on-board equipment is installed, configured and started,
- FRMCS on-board Gateway is installed, configured and started,

- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- FRMCS on-board Gateway is connected to 5G system,
- PIS trackside equipment is installed, configured and started,
- FRMCS trackside Gateway is installed, configured and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- FRMCS trackside Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS on-board and trackside equipment, FRMCS on-board and trackside equipment are time synchronized (date & time),
- PIS trackside application is registered in the FRMCS network,
- PIS on-board application is registered in the FRMCS network in auto accept mode,
- Wireshark tool is running on PIS on-board and trackside equipment; it is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.7.4 TEST PROCEDURE 1: SUCCESSFUL SESSION ESTABLISHMENT

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS trackside Gateway	Check the initial status of the gateway to confirm that the application is already registered	Application registered	
02	THALES PIS	Execute PIS trackside software to open a session with FRMCS network in order to join PIS on-board counterpart by sending an FRMCS_GTW_SESSION_START request with data in JSON according to Table 19 An example of data in JSON format is given in Figure 68. The command to open a "non-critical" session is: `# /frmcs/frmcsAgent.py msgTsPis start-session NCData 192.168.254.1306 2222 7`	PIS trackside application receives an FRMCS_GTW_SESSION_START answer from the FRMCS trackside Gateway containing data in JSON format indicating the session is open with the FRMCS network. An example of data in JSON format is given in Figure 69 The data received by the PIS trackside application shall contain the parameter "session_uuid" corresponding to the identifier of this opened session in FRMCS network and the IP address of	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface (FRMCS_GTW SESSION_START)

		<u>Note</u>: the IP address of the FRMCS trackside Gateway is defined in the file /tsPis/config.xml by the parameter <ipGateway></ipGateway>.	PIS on-board counterpart in the “ip_dest” parameter. The answer is decoded by the application and logged into application’s file (“/frmcs/logs.log”).	

Table 19: TC_007 - Parameters and values used for FRMCS_GTW_SESSION start request to open a “Non Critical Data” session.

Name of the parameter	Value of the parameter
app_uuid	Defined by the FRMCS network and returned by the FRMCS trackside Gateway during registration process in the message FRMCS_GTW_REGISTER answer.
id_dest	Depending on IP plan of WP4
comm_profile	“Non-Critical Data”

```
{   “jsonrpc”: “2.0”,
    “method”: “session_start”,
    “params”: {     “app_uuid”: “123e4567-e89b-12d3-a456-426614174000”,
                    “destination”: {
                            “addr”: “id031123.ty01.etcs”,
                            “protocol”: 6,
                            “port”: 5678
                            },
                    “comm_profile”: 1       }
    “id”: 3}
```

Figure 68: Example of data in FRMCS_GTW_SESSION_START request in JSON format (extract from D2.1)

```
<-- {“jsonrpc”: “2.0”,
        “result”: {     “session_uuid”: “9816177b-7447-415e-8de9-
78f5b19f091c”}
                        “ip_dest”: “172.16.1.20” }

        “id”: 3}
```

Figure 69: Example of data in FRMCS_GTW_SESSION_START answer in JSON format (extract from D2.1)

9.6.2.7.5 TEST PROCEDURE 2: SUCCESSFUL CONNECTION BETWEEN TRACKSIDE AND ON-BOARD APPLICATIONS

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ ALSTOM FRMCS trackside Gateway	Check the status of the links and also that the session can fulfil the QoS requested by the application	FRMCS trackside Gateway sends an FRMCS_APP_SESSION_STATUS_CHANGED notification indicating the on-board counterpart can be joined. The data are in JSON format (see Table 20), an example is given in Figure 70.	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface (FRMCS_APP SESSION_STATUS _CHANGED)

02	THALES PIS	Once the PIS trackside application receives the FRMCS_APP_SESSION_STATUS_CHANGED indicating the on-board counterpart can be joined, the connectivity between each part of the application (trackside and on-board) can be checked by using ping command (ICMP-ECHO requests).
		To verify that PIS on-board app can be joined, execute the command
		`# watch cat /frmcs/apps/msgTsPis/status.xml`
		Wait for the “<session><status> tag value to be “Working”. Once it’s “working”, to verify the “trackside-onboard” connectivity, execute from PIS trackside server the command:
		`# /frmcs/frmcsAgent.py msgObPis get-dest-ip NCData | ping`
			100% ICMP-ECHO replies received with appropriate latency. PIS trackside application logs into its log file the information that the connection with the on-board counterpart is operational (tag <session><status> in /frmcs/apps/msgTsPis/status.xml).	

Table 20: TC_007 - Parameters and values used for FRMCS_APP_SESSION_STATUS_CHANGED request to register successfully PIS trackside application in the FRMCS network.

Name of the parameter	Value of the parameter
session_uuid	Value returned in the FRMCS_GTW_SESSION_START answer
session_status	working
details	Additional details on the status (not relevant in this test case).


```
-->·{ → "jsonrpc":·"2.0",¶
   →    "method":·"session_status_changed",¶
   →    "params":{  →  "session_uuid":·"9816177b-7447-415e-8de9-
78f5b19f091c",¶
   →       →       →  "session_status":·"failed",¶
   →       →       →  "details":·"radio·link·not·available"}·}¶
.../...¶
```


Figure 70: Example of data in FRMCS_APP_SESSION_STATUS_CHANGED in JSON format (extract from D2.1)

9.6.2.8 PIS_TC_008: “Non-Critical Data” session start initiated from trackside - on-board application is registered in “not auto” mode.

9.6.2.8.1 PURPOSE

The purpose of this test is to validate the ability to establish a “Non-Critical Data” session from PIS trackside application to PIS on-board application within the FRMCS network where FRMCS on-board Gateway will ask to PIS on-board application to accept or reject the incoming session.

9.6.2.8.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the functions is explained in D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_SESSION_START), (FRMCS_APP _SESSION_STATUS_CHANGED) and FRMCS_APP_INCOMING SESSION_REQ.

9.6.2.8.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS on-board equipment is installed, configured, and started,
- FRMCS on-board Gateway is installed, configured, and started,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- FRMCS on-board Gateway is connected to 5G system,
- PIS trackside equipment is installed, configured, and started,
- FRMCS trackside Gateway is installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- FRMCS trackside Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS on-board and trackside equipment, FRMCS on-board and trackside equipment are time synchronized (date & time),
- PIS trackside application is registered in the FRMCS network,
- PIS on-board application is registered in the FRMCS network in not auto mode,
- PIS trackside application has opened a “Non-Critical Data” session with the FRMCS network (i.e., session_uuid provided by the FRMCS network to PIS trackside application),
- Wireshark tool is running on PIS on-board and trackside equipment; it is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.8.4 TEST PROCEDURE 1: SUCCESSFUL CONNECTION BETWEEN TRACKSIDE AND ON-BOARD APPLICATIONS

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS trackside Gateway	After sending FRMCS_GTW_SESSION_START answer to PIS trackside application. The FRMCS trackside Gateway sends an FRMCS_APP_INCOMING_SESSION to inform the FRMCS on-board Gateway that PIS trackside application wants to connect with its on-board counterpart. FRMCS_APP_INCOMING_SESSION request contains data in JSON format according to (an example of data in JSON format is given in in Figure 71	FRMCS_APP_INCOMING_SESSION received by the FRMCS on-board Gateway.	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface (FRMCS_APP_INCOMING_SESSION_REQUEST)
02	THALES PIS on-board application	PIS on-board application receives the FRMCS_APP_INCOMING_SESSION request from the FRMCS on-board Gateway containing data in JSON format according to Table 21 (an example of data in JSON format is given in Figure 71	PIS on-board application accepts the incoming session and sends an FRMCS_APP_INCOMING_SESSION answer with result OK according to Table 22 PIS on-board application logs into its log file the request of incoming connection and the acceptation of the request.	
03	KONTRON/ALSTOM trackside Gateway	FRMCS trackside Gateway receives FRMCS_APP_INCOMING_SESSION answer with result OK.	FRMCS trackside Gateway sends to PIS trackside application FRMCS_APP_SESSION_STATUS_CHANGED	
04	THALES PIS	Once the PIS trackside application receives the FRMCS_GTW_SESSION_ST	100% ICMP-ECHO replies received with appropriate latency. PIS trackside	

		ATUS_CHANGE, the connectivity between each part of the application (trackside and on-board) can be checked by using ping command (ICMP-ECHO requests).
		
		To verify that PIS on-board app can be joined, execute the command
		
		`# watch tail /frmcs/apps/msgTsPis /status.xml`
		
		Wait for the “<session><status> tag value to be “Working”.
		
		Once it’s “working”, to verify the “trackside-onboard” connectivity, execute from PIS trackside server the command:
		
		`# /frmcs/frmcsAgent.py msgTsPis get-dest-ip NCData | ping`
			application logs into its log file the information that the connection with the on-board counterpart is operational.
			
			PIS on-board application accepts the incoming session and sends an FRMCS_APP_INCOMING_SESSION answer with result OK. The session appears in the file /frmcs/apps/msgTsPis/status .xml, in the tag <status><session>, under a name starting with “auto”.	

Table 21: TC_008 - Parameters and values used for FRMCS_APP_INCOMING_SESSION request.

Name of the parameter	Value of the parameter
session_uuid	Session identifier for the incoming session
source	msg.ts.pis


```
{   "jsonrpc": "2.0",
    "method": "incoming_session",
    "params": {     "session_uuid": "a458b45c5-a458b45c5",
                    "source": "id031123.ty01.etcs",
                    }
   "id": 1}
```


Figure 71: Example of data in FRMCS_APP_INCOMING_SESSION request in JSON format (extract from D2.1)

Table 22: TC_008 - Parameters and values used for FRMCS_APP_INCOMING_SESSION request to accept an incoming session.

Name of the parameter	Value of the parameter
return	"OK"

9.6.2.8.5 TEST PROCEDURE 2: UNSUCCESSFUL CONNECTION BETWEEN TRACKSIDE AND ON-BOARD APPLICATIONS

Step	Application Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS trackside Gateway	After sending FRMCS_GTW_SESSION_START answer to PIS trackside application. The FRMCS trackside Gateway sends an FRMCS_APP_INCOMING_SESSION to inform the FRMCS on-board Gateway that PIS trackside application wants to connect with its on-board counterpart.	FRMCS_APP_INCOMING_SESSION received by the FRMCS on-board Gateway.	D2.1 TOBA Architecture Report– OBapp – Loose coupled interface (FRMCS_APP_INCOMING_SESSION_REQUEST)
02	THALES PIS on-board application	PIS on-board application receives the FRMCS_APP_INCOMING_SESSION request containing data in JSON format according to Table 21 (an example of data in JSON format is given in Figure 71.	PIS on-board application rejects the incoming session and sends an FRMCS_APP_INCOMING_SESSION answer with result NOK according to Table 23. PIS on-board application logs into its log file the request of incoming connection and the reject of the request.	

03	KONTRON/ALSTOM trackside Gateway	FRMCS trackside Gateway receives FRMCS_APP_INCOMING_SESSION answer with result NOK.	FRMCS trackside Gateway sends to PIS trackside application FRMCS_APP _SESSION_STATUS_CHANGED indicating the on-board counterpart cannot be joined	
04	THALES PIS	PIS trackside application receives FRMCS_GTW_SESSION_STATUS_CHANGE indicating the on-board counterpart reject the connection.	PIS trackside application logs into its log file the information that the connection with the on-board counterpart has been rejected.	

Table 23: TC_008 - Parameters and values used for FRMCS_APP_INCOMING_SESSION request to reject an incoming session.

Name of the parameter	Value of the parameter
return	"NOK"

9.6.2.9 PIS_TC_009: "Critical Data" session start initiated from trackside - on-board application is registered in "auto-accept" mode.

9.6.2.9.1 PURPOSE

The purpose of this test is to validate the ability to establish a "Critical Data" session from PIS trackside application to PIS on-board application within the FRMCS network where FRMCS on-board Gateway automatically accepts the incoming session.

9.6.2.9.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the functions is explained in D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_SESSION_START) and (FRMCS_APP _SESSION_STATUS_CHANGED).

9.6.2.9.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS on-board equipment is installed, configured, and started,
- FRMCS on-board Gateway is installed, configured, and started,

- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- FRMCS on-board Gateway is connected to 5G system,
- PIS trackside equipment is installed, configured, and started,
- FRMCS trackside Gateway is installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- FRMCS trackside Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS on-board and trackside equipment, FRMCS on-board and trackside equipment are time synchronized (date & time),
- PIS trackside application is registered in the FRMCS network,
- PIS on-board application is registered in the FRMCS network in auto_accept mode,
- PIS trackside application has opened a "Critical Data" session with the FRMCS network (i.e., session_uuid provided by the FRMCS network to PIS trackside application),
- Wireshark tool is running on PIS on-board and trackside equipment; is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.9.4 TEST PROCEDURE 1: SUCCESSFUL SESSION ESTABLISHMENT

<table>
<tr><th>Step</th><th>Action</th><th>Expected result(s)</th><th>Compliance with selected requirements</th></tr>
<tr><td>01</td><td>Execute PIS trackside software to open a session with FRMCS network in order to join PIS on-board counterpart by sending an FRMCS_GTW_SESSION_START request with data in JSON according to
Table 24. An example of data in JSON format is given in Figure 68. The command to open a "critical" session is:
<code># /frmcs/frmcsAgent.py msgTsPis start-session CData 192.168.254.130 6 2222 8</code>
<u>Note</u>: the IP address of the FRMCS trackside Gateway is defined in the file /tsPis/config.xml by the parameter <ipGateway></ipGateway>.</td><td>PIS trackside application receives an FRMCS_GTW_SESSION_START answer from the FRMCS trackside Gateway containing data in JSON format indicating the session is open with the FRMCS network. An example of data in JSON format is given in Figure 69
The data received by the PIS trackside application shall contain the parameter "session_uuid" corresponding to the identifier of this opened session in FRMCS network and the IP address of PIS on-board counterpart in the "ip_dest" parameter.
The answer is decoded by the application and logged into application's file ("/frmcs/logs.log").</td><td>D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_SESSION_START)</td></tr>
</table>

Table 24: TC_009 - Parameters and values used for FRMCS_GTW_SESSION start request to open a "Critical Data" session.

Name of the parameter	Value of the parameter
app_uuid	Defined by the FRMCS network and returned by the FRMCS trackside Gateway during registration process in the message FRMCS_GTW_REGISTER answer.
id_dest	Depending on IP plan defined for WP4
comm_profile	"Critical Data"

9.6.2.9.5 TEST PROCEDURE 2: SUCCESSFUL CONNECTION BETWEEN TRACKSIDE AND ON-BOARD APPLICATIONS

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS trackside Gateway	FRMCS resolution	FRMCS trackside Gateway sends an FRMCS_APP_SESSION_STATUS_CHANGED indicating the on-board counterpart can be joined. The data are in JSON format (see Table 20), an example is given in Figure 70.	D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_APP_SESSION_STATUS_CHANGED)
02	THALES PIS	Once the PIS trackside application receives the FRMCS_APP_SESSION_STATUS_CHANGED indicating the on-board counterpart can be joined, the connectivity between each part of the application	100% ICMP-ECHO replies received with appropriate latency. PIS trackside application logs into its log file the information that the connection with the	

		(trackside and on-board) can be checked by using ping command (ICMP-ECHO requests).
		
		To verify that PIS on-board app can be joined, execute the command
		
		`# watch cat /frmcs/apps/msgTsPis /status.xml`
		
		Wait for the “<session><status> tag value to be “Working”.
		
		Once it’s “working”, to verify the “trackside-onboard” connectivity, execute from PIS trackside server the command:
		
		`# /frmcs/frmcsAgent.py msgTsPis get-dest-ip CData | ping`
			on-board counterpart is operational (tag <session><status> in /frmcs/apps/msgTsPis/status.xml).	

9.6.2.10 PIS_TC_010: “Critical Data” session start initiated from trackside - on-board application is registered in “not_auto” mode.

9.6.2.10.1 PURPOSE

The purpose of this test is to validate the ability to establish a “Critical Data” session from PIS trackside application to PIS on-board application within the FRMCS network where FRMCS on-board Gateway will ask to PIS on-board application to accept or reject the incoming session.

9.6.2.10.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the functions is explained in D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_SESSION_START), (FRMCS_GTW_SESSION_STATUS_CHANGED) and FRMCS_APP_INCOMING SESSION_REQ.

9.6.2.10.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS on-board equipment is installed, configured, and started,
- FRMCS on-board Gateway is installed, configured, and started,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- FRMCS on-board Gateway is connected to 5G system,
- PIS trackside equipment is installed, configured, and started,
- FRMCS trackside Gateway is installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- FRMCS trackside Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS on-board and trackside equipment, FRMCS on-board and trackside equipment are time synchronized (date & time),
- PIS trackside application is registered in the FRMCS network,
- PIS on-board application is registered in the FRMCS network in not_auto mode,
- From the PIS on-board server, edit the whitelist file of the msgObPis session by executing this command:

```
# echo "msg.ts.pis" >> /frmcs/apps/msgObPis/whitelist
```

- PIS trackside application has opened a "Critical Data" session with the FRMCS network (i.e., session_uuid provided by the FRMCS network to PIS trackside application),
- Wireshark tool is running on PIS on-board and trackside equipment; is capturing in/out traffic,
- Remote connection between Thales Lab and WP4 lab is operational (i.e. all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.10.4 TEST PROCEDURE 1: SUCCESSFUL SESSION ESTABLISHMENT

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS trackside Gateway	After sending FRMCS_GTW_SESSION_START answer to PIS trackside application. The FRMCS trackside Gateway sends an FRMCS_APP_INCOMING_S	FRMCS_APP_INCOMING_SESSION received by the FRMCS on-board Gateway.	D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_

		ESSION to inform the FRMCS on-board Gateway that PIS trackside application wants to connect with its on-board counterpart. FRMCS_APP_INCOMING_SESSION request contains data in JSON format according to (an example of data in JSON format is given in Figure 71.		SESSION_START), (FRMCS_APP_SESSION_STATUS_CHANGED) and FRMCS_APP_INCOMING SESSION_REQ
02	THALES PIS on-board application	PIS on-board application receives the FRMCS_APP_INCOMING_SESSION request containing data in JSON format according to Table 25 an example of data in JSON format is given in Figure 71.	PIS on-board application accepts the incoming session and sends an FRMCS_APP_INCOMING_SESSION answer with result OK according to Table 21 PIS on-board application logs into its log file the request of incoming connection and the acceptation of the request.	
03	KONTRON/ALSTOM trackside Gateway	FRMCS trackside Gateway receives FRMCS_APP_INCOMING_SESSION answer with result OK.	FRMCS trackside Gateway sends to PIS trackside application FRMCS_APP_SESSION_STATUS_CHANGED	
04	THALES PIS	Once the PIS trackside application receives the FRMCS_APP_SESSION_STATUS_CHANGED, the connectivity between each part of the application (trackside and on-board) can be checked by using ping command (ICMP-ECHO requests). To verify that PIS on-board app can be joined, execute the command `# watch tail /frmcs/apps/msgTsPis/status.xml`	100% ICMP-ECHO replies received with appropriate latency. PIS trackside application logs into its log file the information that the connection with the on-board counterpart is operational. PIS on-board application accepts the incoming session and sends an FRMCS_APP_INCOMING_SESSION answer with result OK. The session appears in the file /frmcs/apps/msgTsPis/status.xml, in the tag	

		Wait for the "<session><status> tag value to be "Working". Once it's "working", to verify the "trackside-onboard" connectivity, execute from PIS trackside server the command: `# /frmcs/frmcsAgent.py msgTsPis get-dest-ip CData | ping`	<status><session>, under a name starting with "auto".	

Table 25: TC_010 - Parameters and values used for FRMCS_APP_INCOMING_SESSION request.

Name of the parameter	Value of the parameter
session_uuid	Session identifier for the incoming session
source	msg.ts.pis

9.6.2.10.5 TEST PROCEDURE 2: UNSUCCESSFUL CONNECTION BETWEEN TRACKSIDE AND ON-BOARD APPLICATIONS

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON/ALSTOM FRMCS trackside Gateway	After sending FRMCS_GTW_SESSION_START answer to PIS trackside application. The FRMCS trackside Gateway sends an FRMCS_APP_INCOMING_SESSION to inform the FRMCS on-board Gateway that PIS trackside application wants	FRMCS_APP_INCOMING_SESSION received by the FRMCS on-board Gateway.	D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_SESSION_START),

		to connect with its on-board counterpart.		(FRMCS_APP _SESSION_STATUS_CHANGED) and FRMCS_APP_INCOMING SESSION_REQ
02	THALES PIS on-board application	PIS on-board application receives the FRMCS_APP_INCOMING_SESSION request containing data in JSON format according to Table 21 (an example of data in JSON format is given in Figure 71).	PIS on-board application rejects the incoming session and sends an FRMCS_APP_INCOMING_SESSION answer with result NOK according to Table 23 PIS on-board application logs into its log file the request of incoming connection and the reject of the request.	
03	KONTRON/ALSTOM trackside Gateway	FRMCS trackside Gateway receives FRMCS_APP_INCOMING_SESSION answer with result NOK.	FRMCS trackside Gateway sends to PIS trackside application FRMCS_APP _SESSION_STATUS_CHANGED indicating the on-board counterpart cannot be joined	
04	THALES PIS	PIS trackside application receives FRMCS_APP _SESSION_STATUS_CHANGED indicating the on-board counterpart reject the connection.	PIS trackside application logs into its log file the information that the connection with the on-board counterpart has been rejected.	

9.6.2.11 PIS_TC_011: Close a session from trackside.

9.6.2.11.1 PURPOSE

The purpose of this test is to validate the ability to close a session from trackside.

9.6.2.11.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the function is explained in D2.1 TOBA Architecture Report – TSapp – Loose coupled interface (FRMCS_GTW Session END).

9.6.2.11.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; is capturing in/out traffic,
- "Non-Critical Data" comm_profile session is established with FRMCS network,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.11.4 TEST PROCEDURE 1: SUCCESSFUL SESSION CLOSING

Step	Action	Expected result(s)	Compliance with selected requirements
01	PIS trackside application sends an FRMCS_GTW_SESSION_END request according to Table 26. to the FRMCS trackside Gateway. Execute the following command to close a session: `#/frmcs/frmcsAgent.py msgTsPis stop-session NCData`	PIS trackside application receives an FRMCS_GTW_SESSION_END answer containing data in JSON format indicating that the session has been closed. An example of JSON data is given in Figure 72. The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").	D2.1 TOBA Architecture Report – TSapp – Loose coupled interface (FRMCS_GTW Session END)

Table 26: TC_011 - Parameters and values used for FRMCS_GTW_SESSION_END request to close successfully the FRMCS session.

Name of the parameter	Value of the parameter
app_uuid	Value given by FRMCS network during the registration process.
session_uuid	Value given by FRMSC network during the session creation

```
{"jsonrpc": "2.0",
    "result": {     }
    "id": 4}
```

Figure 72: Example of data in FRMCS_GTW_SESSION_END answer in JSON format (extract from D2.1)

9.6.2.11.5 TEST PROCEDURE 2: UNSUCCESSFUL SESSION CLOSING

Step	Action	Expected result(s)	Compliance with selected requirements

01	PIS trackside application sends an FRMCS_GTW_SESSION_END request with wrong app_uuid to the FRMCS trackside Gateway.
	
	To configure an incorrect app_uuid, edit the file /frmcs/apps/msgTsPis/status.xml and alter the tag <app_uuid> by adding a digit at the end:
	
	`<app_uuid>XXX-XXX-XXX</app_uuid>`
	
	becomes
	
	`<app_uuid>XXX-XXX-XXX0</app_uuid>`
	
	Then execute the command:
	
	`#/frmcs/frmcsAgent.py msgTsPis stop-session NCData`
		PIS trackside application receives an FRMCS_GTW_SESSION_END answer containing data in JSON format indicating that the session cannot be closed and with the root cause.
		
		The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").
			D2.1 TOBA Architecture Report – TSapp – Loose coupled interface (FRMCS_GTW Session END)

9.6.2.12 PIS_TC_012: Close a session from on-board.

9.6.2.12.1 PURPOSE

The purpose of this test is to validate the ability to close a session from on-board.

9.6.2.12.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the function is explained in D2.1 TOBA Architecture Report – TSapp – Loose coupled interface (FRMCS_GTW Session END).

9.6.2.12.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; is capturing in/out traffic,
- “Non-Critical Data” comm_profile session is established with FRMCS network,
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.12.4 TEST PROCEDURE 1: SUCCESSFUL SESSION CLOSING

Step	Action	Expected result(s)	Compliance with selected requirements
01	PIS on-board application sends an FRMCS_GTW_SESSION_END request according to Table 27 the FRMCS on-board Gateway. Execute the following command to close a session: `#/frmcs/frmcsAgent.py msgObPis stop-session NCData`	PIS on-board application receives an FRMCS_GTW_SESSION_END answer containing data in JSON format indicating that the session has been closed. An example of JSON data is given in Figure 72. The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").	D2.1 TOBA Architecture Report – TSapp – Loose coupled interface (FRMCS_GTW Session END)

Table 27: TC_012 - Parameters and values used for FRMCS_GTW_SESSION_END request to close successfully the FRMCS session.

Name of the parameter	Value of the parameter
app_uuid	Value given by FRMCS network during the registration process.
session_uuid	Value given by FRMSC network during the session creation

9.6.2.12.5 TEST PROCEDURE 2: UNSUCCESSFUL SESSION CLOSING

Step	Application Prototype	Action	Expected result(s)	Compliance with selected requirements
01	THALES PIS	PIS on-board application sends an FRMCS_GTW_SESSION_END request with wrong app_uuid to the FRMCS on-board Gateway.	PIS on-board application receives an FRMCS_GTW_SESSION_END answer containing data in JSON format indicating that the session cannot be closed with the root cause.	in D2.1 TOBA Architecture Report – TSapp – Loose coupled interface (FRMCS_GTW Session END)

		To configure an incorrect app_uuid, edit the file /frmcs/apps/msgObPis/status.xml and alter the tag <app_uuid> by adding a digit at the end: <app_uuid>XXX-XXX-XXX</app_uuid> becomes <app_uuid>XXX-XXX-XXX**0**</app_uuid> Then execute the command: #/frmcs/frmcsAgent.py msgObPis stop-session NCData	The answer is decoded by the application and logged into application's log file ("/frmcs/logs.log").	


```
<-- {"jsonrpc": "2.0",
        "error": {    "code": -1,
                      "message": "OBapp API error"
                      "data": "unknown app_uuid"
        "id": 4}
.../...
```


Figure 73: Example of data in FRMCS_GTW_SESSION_END answer with failure in JSON format (extract from D2.1)

9.6.2.13 PIS_TC_013: Send text message with a normal priority to trains

9.6.2.13.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send text messages to trains.

9.6.2.13.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured and started,

- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- "Non-Critical Data" comm_profile session is established with FRMCS network, as presented in Table 12
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.13.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	From the PIS trackside HMI, the Passenger Information Controller: 1. Selects a train 2. Selects a normal priority 3. Writes the message "This is a normal priority PIS message in loose mode" 4. Presses "send" button Keep the default value of the duration proposed by the HMI.	The message "This is a normal priority PIS message in loose mode" and the priority selected by the Passenger Information Controller are displayed on the on-board display during the selected duration. **The delay between PIS trackside and on-Board display should be less than 7 seconds. (note that 6 seconds are allowed** for sub-system radio link trackside-on-Board)	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10

Note: *Due to WP4 lab configuration Figure 61, VPN additional delay needs to be measured and removed from the KPI value.*

9.6.2.14 PIS_TC_014: Send text message with a high priority to trains

9.6.2.14.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send text messages with a high priority to trains.

9.6.2.14.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- “Critical Data” comm_profile session is established with FRMCS network, as presented in the Table 12
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.14.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	From the PIS trackside HMI, the Passenger Information Controller: 1. Selects a train 2. Selects a high priority 3. Writes the message "This is a high priority PIS message in loose mode" 4. Presses "send" button Keep the default value of the duration proposed by the HMI.	The message "This is a high priority PIS message in loose mode" and the priority selected by the Passenger Information Controller are displayed on the on-board display during the selected duration. **The delay between PIS trackside and on-Board display should be less than 7 seconds.** (note that 6 seconds are allowed for sub-system radio link trackside-on-Board)	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10

Note: *Due to WP4 lab configuration Figure 61, VPN additional delay needs to be measured and removed from the KPI value.*

9.6.2.15 PIS_TC_015: Send text message with a normal priority in degraded conditions.

9.6.2.15.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send text messages to trains in degraded conditions.

5G radio link overload is considered as degraded conditions scenario.

9.6.2.15.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,

- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- “Non-Critical Data” comm_profile session is established with FRMCS network, as presented in Table 12
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.15.3 TEST PROCEDURE: 5G RADIO LINK IS OVERLOADED

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON 5GS	Generate traffic to overload the 5G radio link (e.g., simulate the transfer of CCTV archives).	Radio link is overloaded	

02	THALES PIS	From the PIS trackside HMI, the Passenger Information Controller:
		• Selects a train
		• Selects a normal priority
		• Writes the message “This is a normal priority PIS message in loose mode”
		• Presses “send” button
			The message is rejected by the FRMCS system.
			PIS trackside application logs into its log file that the message cannot be sent to the train.
			Edit the log file with the Linux command “tail”:
			`# tail -10 /tsPis/logs`
			The last lines shall be:
			`Trying to send message <message-file>.`
			`Cannot send message. Either host is down, or FRMCS reject the communication.`
				[FU- 7100 v5.0.0]:
				6.9.1.1
				8.7.1.1, 8.7.4.1, 8.7.5.1
				8.8.1.1, 8.8.4.1, 8.8.5.1
				[3GPP TR 22.889 v17.3.0]:
				12.10

9.6.2.16 PIS_TC_016: Send text message with a high priority in degraded conditions.

9.6.2.16.1 PURPOSE

The purpose of this test is to validate that the Passenger Information Controller is able to send priority text messages to trains in degraded conditions.

5G radio link overload is considered as degraded conditions scenario.

9.6.2.16.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway ,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5G Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- “Critical Data” comm_profile session is established with FRMCS network, as presented in Table 12
- FRMCS trackside and on-board Gateways internal traffic flow scheduler is configured to treat PIS messages with a high priority (i.e., corresponding to “Critical Data”),
- Remote connection between Thales lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.16.3 TEST PROCEDURE: 5G RADIO LINK IS OVERLOADED

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	Kontron 5GS	Generate traffic to overload the 5G radio link. (e.g., simulate the transfer of CCTV archives)	Radio link is overloaded	
02	THALES PIS	From the PIS trackside HMI, the Passenger Information Controller: • Selects a train • Selects a high priority • Writes the message "This is a high priority PIS message in loose mode" • Presses "send" button	The message "This is a high priority PIS message in loose mode" and the priority selected by the Passenger Information Controller are displayed on the on-board display during the selected duration. **The delay between PIS trackside and on-Board display should be less than 7 seconds.** (Note that 6 seconds are allowed for sub-system radio link trackside-on-Board)	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10

Note: *Due to WP4 lab configuration Figure 61, VPN additional delay needs to be measured and removed from the KPI value.*

9.6.2.17 PIS_TC_017 : Display train location information

9.6.2.17.1 PURPOSE

The purpose of this test is to validate the ability to synchronize the "secondary" on-board Train Mission Database with "primary" trackside database to provide accurate information to the passengers in the train about the location of the train.

9.6.2.17.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- Trackside and on-board Mission Database are operational,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5G Core Network has provided an IP address to the gateway),

- "Non-Critical Data" comm_profile session is established with FRMCS network, as presented in Table 12
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- Passenger Information Controller is authenticated to PIS trackside HMI,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- On-board display is operational,
- On-board location simulator equipment is installed, configured, and started,
- On-board location simulator provides to on-board PIS application the information about the location of the train. It is directly connected to on-board PIS equipment,
- Remote connection between Thales lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.17.3 TEST PROCEDURE

Step	Action	Expected result(s)	Compliance with selected requirements
01	From the PIS trackside equipment, the Passenger Information Controller sends from trackside the Train Mission Database to on-board using the command: `# /tsPis/transmission.sh /tsPis/rerB 192.168.254.130`	On-board and trackside files have the same size. Date and time of the on-board file correspond to the date and time of the update.	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.4.1.1, 8.4.4.1, 8.4.5.2 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10
02	Start the location simulator software: `# /obPis/obPis restart && /obPis/obPis run`	The location of the train is displayed on the on-board display.	

9.6.2.18 PIS_TC_018: On-board PIS logs downloaded on the fly in degraded conditions.

9.6.2.18.1 PURPOSE

The purpose of this test is to validate the ability to send on the fly the on-board PIS logs to trackside in degraded conditions.

5G radio link overload is considered as degraded conditions scenario.

9.6.2.18.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5G Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- on-board logs centralization in trackside is configured,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- “Non-Critical Data” comm_profile session is established with FRMCS network, as presented in Table 12
- FRMCS trackside and on-board Gateways internal traffic flow scheduler is configured to treat PIS messages with a QoS priority (i.e., corresponding to “Non-Critical Data”),
- Remote connection between Thales lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.18.3 TEST PROCEDURE: 5G RADIO LINK IS OVERLOADED

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	Kontron 5GS	Generate traffic to overload the 5G radio link (e.g., simulate the transfer of CCTV archives)	Radio link is overloaded	**[FU- 7100 v5.0.0]**: 6.9.1.1 8.4.1.1, 8.4.4.1, 8.4.5.2 8.7.1.1, 8.7.4.1, 8.7.5.1 8.8.1.1, 8.8.4.1, 8.8.5.1 **[3GPP TR 22.889 v17.3.0]:** 12.10
02	THALES PIS	On-board PIS logs are sent on the fly to trackside	On-board PIS logs ("/var/log/obPis") are received on trackside in real time. It can be verified by executing the Linux command "tail" from PIS trackside server: `# tail -f /var/log/congatec-qa3-64/obPis.log`	

9.6.2.19 PIS_TC_019: Open a "trackside to on-board" management session with a high priority.

9.6.2.19.1 PURPOSE

The purpose of this test is to validate the ability to open a "trackside to on-board" management session with a critical priority during a significant time (e.g., 15 minutes) for PIS O&M operations.

The connection shall be resilient even with non-optimal radio conditions.

9.6.2.19.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5 Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,
- NTP server is configured and operational,

- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- "Critical Data" comm_profile session, initiated from trackside PIS application, is established with FRMCS network for PIS O&M traffic flows,

```
# /frmcs/frmcsAgent.py mgtTsPis start-session remoteAccess 192.168.254.130
6 2223 8
```

- The traffic flow scheduler of the FRMCS trackside and on-board gateways is configured to manage PIS O&M flows with a high priority corresponding to "Critical Data",
- Remote connection between Thales Lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.19.3 TEST PROCEDURE

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	KONTRON	From the radio simulator, execute the scenario in order to disturb the radio conditions.	FRMCS on-board gateway is still connected to 5GS	

02	THALES PIS	From trackside PIS equipment, PIS maintainer opens an SSH connection to on-board PIS equipment using on-board PIS O&M IP address.
		`# ssh root@`/frmcs/frmcsAgent.py get-dest-ip remoteAccess``
		Execute the script KeepAliveCon.sh to maintain the SSH connection alive for 15 minutes.
		`# /home/root/KeepAliveCon.sh`
			No disconnection of the trackside to on-board SSH connection for 15 minutes.	**[FU- 7100 v5.0.0]**:
				6.9.1.1
				8.7.1.1, 8.7.4.1, 8.7.5.1
				8.8.1.1, 8.8.4.1, 8.8.5.1
				[3GPP TR 22.889 v17.3.0]:
				12.10

9.6.2.20 PIS_TC_020: Check connection to FRMCS services

9.6.2.20.1 PURPOSE

The purpose of this test is to validate the ability to verify the connection status is correct between PIS on-board application and FRMCS services.

9.6.2.20.2 REQUIREMENTS

In the scope of 5GRail, a proprietary non-specified solution is applied. The detailed description of the functions is explained in D2.1 TOBA Architecture Report– TSapp – Loose coupled interface (FRMCS_GTW_SERVICE).

9.6.2.20.3 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS on-board equipment is installed, configured, and started,
- FRMCS on-board Gateway is installed, configured, and started,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- FRMCS on-board Gateway is connected to 5G system,
- MCX client embedded into the FRMCS on-board Gateway is not registered in the MCX server,
- PIS trackside equipment is installed, configured, and started,
- FRMCS trackside Gateway is installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- FRMCS trackside Gateway is connected to 5G system,
- NTP server is configured and operational,
- NTP server, PIS on-board and trackside equipment, FRMCS on-board and trackside equipment are time synchronized (date & time),
- PIS trackside application is registered in the FRMCS network,
- PIS on-board application is registered in the FRMCS network in auto-accept mode,

```
# /frmcs/frmcsAgent.py msgObPis connect

# /frmcs/frmcsAgent.py msgObPis register msg.ob.pis 5 loose auto_accept
```

- Wireshark tool is running on PIS on-board and trackside equipment and is capturing in/out traffic.
- Remote connection between Thales Lab and Kontron lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.20.4 TEST PROCEDURE

Step	Application Prototype	Action	Expected result(s)	Compliance with selected requirements
01	THALES PIS	The PIS on-board application checks the connection status by sending FRMCS_GTW_SERVICE requests to the FRMCS on-board Gateway with data in JSON format according to Table 28 and Figure 74. `# until ``/frmcs/frmcsAgent.py msgObPis service-request``; do sleep 1; done; echo "Connected!"`	The FRMCS on-board GW receives an FRMCS_GTW_SERVICE and answers to PIS on-board application by sending an FRMCS_GTW_SERVICE answer with the status "failed" in JSON format according to Table 29.	D2.1 TOBA Architecture Report _ FRMCS_GTW_SERVICE
02	KONTRON/ALSTOM FRMCS on-board GW	MCX client registration	MCX client is registered.	
3	THALES PIS	The PIS on-board application continues to check the connection status (see action #1).	When receiving the FRMCS_GTW_SERVICE answer from the FRMCS on-board Gateway with status "connected", the PIS on-board application decodes the message and logs the information in its log file. The polling stops.	

Table 28: PIS_TC_020 - Parameters and values used for FRMCS_GTW_SERVICE request to check the connection status.

Name of the parameter	Value of the parameter
application_type	See value returned during the registration process by the FRMCS on-board Gateway
request_type	CONNECTION_STATUS


```
Example :--> {   "jsonrpc": "2.0",
        "method": "specific_services",
        "params": {     "app_uuid": "123e4567-e89b-12d3-a456-426614174000",
                        "request_type": "CONNECTION_STATUS"    }
        "id": 6}
```


Figure 74: Example of data in FRMCS_GTW_SERVICE request in JSON format (extract from D2.1)

Table 29: PIS_TC_020 - Parameters and values used for FRMCS_GTW_SERVICE answer to inform that the MCX client is not registered in the MCX server.

Name of the parameter	Value of the parameter
connexion_status	failed

9.6.2.21 PIS_TC_021: On-board PIS logs downloaded on the fly in normal conditions.

9.6.2.21.1 PURPOSE

The purpose of this test is to validate the ability to send on the fly the on-board PIS logs to trackside in normal conditions, without 5G radio link overload.

9.6.2.21.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

The initial state covers the following steps:

- PIS trackside and on-board equipment are installed, configured, and started,
- PIS trackside and on-board software are configured and are running,
- FRMCS trackside and onboard Gateways are installed, configured, and started,
- PIS trackside equipment is connected to the FRMCS trackside Gateway,
- PIS on-board equipment is connected to the FRMCS on-board Gateway,
- 5G system (Radio Access Network & Core Network) is operational,
- FRMCS on-board Gateway is connected to 5G Core Network (i.e., 5G Core Network has provided an IP address to the gateway).
- GRE tunnels between FRMCS trackside & on-board are operational and FRMCS gateways can communicate with each other,

- on-board logs centralization in trackside is configured,
- NTP server is configured and operational,
- NTP server, PIS trackside equipment, FRMCS trackside equipment, 5G system, FRMCS on-board equipment and PIS on-board equipment are time synchronized (date & time),
- Wireshark tool is running on PIS trackside and on-board equipment; it is capturing in/out traffic,
- "Non harmonized Data" comm_profile session is established with FRMCS network, as presented in Table 12
- FRMCS trackside and on-board Gateways internal traffic flow scheduler is configured to treat PIS messages with QoS priority (i.e., corresponding to "Non harmonized Data"),
- Remote connection between Thales lab and WP4 lab is operational (i.e., all PIS IP flows are authorized in the firewalls according to the flow matrix).

9.6.2.21.3 TEST PROCEDURE

Step	Prototype	Action	Expected result(s)	Compliance with selected requirements
01	THALES PIS	On-board PIS logs are sent on the fly to trackside	On-board PIS logs ("/var/log/obPis") are received on trackside in real time. It can be verified by executing the Linux command "tail" from PIS trackside server: `# tail -f /var/log/congatec-qa3-64/obPis.log`	

10 WP4-Optional voice test cases

As presented in Table 8 and mentioned in the GA, in the scope of WP4 a minimum set of voice test cases can be performed in the scope of WP4. The description of these test cases and the associated network configuration is presented in the following.

10.1 Voice-WP4_001: Private MCPTT call without floor management.

10.1.1 Purpose

The purpose of this test case is to describe the MCPTT implementation of a train driver to controller voice communication.

10.1.2 Description of initial state/configuration

The initial state is composed of 2 smartphones where the voice application is installed connected to the 5G network with the corresponding network set-up, presented in §5.9

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch MCX application client on Smartphone A	Client A is registered on IMS/MCX network	3GPP TS 23.379 and 3GPP TS 24.380
02	Launch MCX application client on Smartphone B	Client B is registered on IMS/MCX network	
03	Initiate a point-to-point call from MCPTT client A to MCPTT client B	Call is established with bi-directional voice path.	
04	MCPTT client A releases the call.	Call is terminated on both sides.	

10.2 Voice-WP4_002: MCPTT group call with floor management

10.2.1 Purpose

The purpose of this test case is to describe the MCPTT implementation of the multi-train voice communication.

10.2.2 Description of initial state/configuration

The initial state is composed of 3 smartphones where the voice application is installed. 2 of them are connected to the 5G network (A and B) and the third smartphone C is connected to the Wi-Fi. The associated network set-up is presented in §5.9

An important QoS requirement of this group call test case is the session set-up time qualified as **normal**, to be measured and compared for the smartphones connected to the 5G and 4G network. Also, another KPI might be the moment between the floor request up to the time the floor is granted to be measured for the different bearers.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch MCX application client on Smartphone A	Client A is registered on IMS/MCX network	3GPP TS 23.379 and 3GPP TS 24.380
02	Launch MCX application client on Smartphone B	Client B is registered on IMS/MCX network	
03	Launch MCX application client on Smartphone C	Client C is registered on IMS/MCX network	
04	Initiate a MCPTT group call from MCPTT client A. MCPTT clients B and C, which belong to the group, join the GC	Call is established with bi-directional voice path.	
05	MCPTT client B takes the floor, talks then releases the floor	Voice can be heard by other MCPTT clients	
06	MCPTT client C takes the floor, talks then releases the floor	Voice can be heard by other MCPTT clients	
07	MCPTT client A releases the group call.	Call is terminated for all members of the GC.	

10.3 Voice-WP4_003: MCPTT emergency group call

10.3.1 Purpose

The purpose of this test case is to describe the MCPTT implementation of the multi-train voice communication.

10.3.2 Description of initial state/configuration

The initial state is composed of 3 smartphones where the voice application is installed. 1 of them is connected to the 5G network, the 2nd one is connected to the 4G network, and the third smartphone C is connected to the Wi-Fi. The associated network set-up is presented in §5.9

An important QoS requirement of this group call test case is the session set-up time qualified as **immediate**, to be measured and compared for the smartphones connected to the 5G, 4G and Wi-Fi network. Also, the difference between the normal session set-up time of a group call or a point-to-point call has to be compared with the immediate session set-up time of the emergency call.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch MCX application client on Smartphone A	Client A is registered on IMS/MCX network	3GPP TS 23.379 and 3GPP TS 24.380
02	Launch MCX application client on Smartphone B	Client B is registered on IMS/MCX network	
03	Launch MCX application client on Smartphone C	Client C is registered on IMS/MCX network	
04	Initiate a MCPTT emergency call from MCPTT client A. MCPTT clients B and C, which belong to the group, join the GC automatically	Call is established and voice can be heard by other MCPTT clients	
05	MCPTT client A releases the group call.	Call is terminated for all members of the EGC.	
05	Initiate a MCPTT emergency call from MCPTT client B. MCPTT clients A and C,	Call is established and voice can be heard by other MCPTT clients	

	which belong to the group, join the GC automatically		
06	MCPTT client B releases the group call.	Call is terminated for all members of the EGC.	
08	Initiate a MCPTT emergency call from MCPTT client C. MCPTT clients A and B, which belong to the group, join the GC automatically	Call is established and voice can be heard by other MCPTT clients	
09	MCPTT client B releases the group call.	Call is terminated for all members of the EGC.	
10	From the recorded pcap traces, measure the emergency group call setup time (time elapsed between the INVITE message sent by the EGC initiator and the first RTP message it can send)		

10.4 Voice-WP4_004: Private MCPTT call is ongoing, and MCPTT emergency group call is launched.

10.4.1 Purpose

The purpose of this test case is to validate the MCX arbitration between a private MCPTT call and the MCPTT emergency group call.

10.4.2 Description of initial state/configuration

The initial state is composed of 3 smartphones where the voice application is installed. 2 of them (client A and B) is connected to the Wi-Fi, the 3rd one is connected to the 5G network (n78 band), as presented in Figure 50.

Step	Action	Expected result(s)	Compliance with selected requirements
01	Launch MCX application client on Smartphone A	Client A is registered on IMS/MCX network	3GPP TS 23.379 and 3GPP TS 24.380
02	Launch MCX application client on Smartphone B	Client B is registered on IMS/MCX network	
03	Initiate a point-to-point call (MCPTT private call) from MCPTT client A to MCPTT client B	Call is established with bi-directional voice path.	
04	Initiate a MCPTT emergency call from MCPTT client C. MCPTT clients A and B, which belong to the group, join the GC automatically	Emergency call is established and voice can be heard by other MCPTT clients	
05	MCPTT client C terminates the emergency call and client A and B switch to the MCPTT private point - to call	Voice can be exchanged between MCPTT clients A and B, as initially	

11 Remote vision test cases for derisking in WP4

These are test cases that will be performed in labs, prior to be tested in the field, but are not considered in the scope of the labs, based on the GA, are characterized as derisking test cases. Remote control of engines in a PC (light version) will be tested in lab in nominal and degraded conditions using a static On-board and trackside gateway configuration with specific IP addresses and com_profile.

11.1 RV_WP4-TC_001: Nominal conditions in lab: streaming of video from moving stock to trackside.

11.1.1 Purpose

The purpose of this test case is to test the remote vision in nominal/perfect network conditions.

11.1.2 Description of initial state/configuration

- Onboard VMS is installed.
- Onboard VMS has at least one camera installed.
- Onboard camera is connected to the onboard VMS, is integrated with FRMCS onboard GW through OBapp interface.
- Track side VMS system is installed.
- Onboard VMS is integrated with the trackside VMS.
- Track side VMS is integrated with FRCMS trackside GW through TSapp interface.

11.1.3 Test procedure

These tests will be performed with TOBA-K in band n39 because this is the field configuration.

Note: *Detailed description of Remote vision application testing will be provided in §13.3.3*

Step	Action	Expected result(s)	Compliance with selected requirements
01	Power-up FRMCS GWs (Onboard and Trackside)	GWs are initialized	**FU-7100 v5.0.0:** §6.13 **3GPP TR22.889 V17.4.0:** [R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003] [R-7.1.3-001] [R-7.1.4-001]
02	Power-up train camera, onboard and trackside VMS	Camera Terminal is indicated as available in trackside VMS	
03	Verify established connections from Trackside/onboard VMS with the FRMCS GWs through TSapp/OBapp interfaces	Trackside/onboard VMS connections are established	

04	The train Operator requests video from the onboard camera	The operator can see live camera stream at trackside VMS	[R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7
05	Check the Performance report	No losses are observed.	

11.2 RV_ETCS_WP4-TC_002: Remote control of engines in parallel with ETCS application in lab nominal conditions

11.2.1 Purpose

The purpose of this test is to demonstrate that the performances of both applications are preserved as for separate applications in nominal conditions.

Initial conditions/configurations of both applications are considered as in nominal conditions.

The test will be performed with TOBA-K in n39 band because it is mainly field-testing application.

11.2.2 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
01	Power-up FRMCS GWs (Onboard and Trackside)	GWs are initialized	**FU-7100 v5.0.0:** §513 MG-7900 §18 **3GPP TR22.889 V17.4.0:**
02	Power-up train camera, onboard and trackside VMS	Camera Terminal is indicated as available in trackside VMS	

03	Verify established connections from Trackside/onboard VMS with the FRMCS GWs through TSapp/OBapp interfaces.	Trackside/onboard VMS connections are established	[R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003] [R-7.1.3-001] [R-7.1.4-001] [R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7 **3GPP TR22.889** §6.11.2.5 D2.1 TOBA Architecture Report– OBapp – Loose coupled interface – GTW_SESSION_STATUS
04	The train Operator requests video from the onboard camera.	The operator can see live camera stream at trackside VMS	
05	While remote vision application is on-going, ETCS application is launched	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP	
06	Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is "Working"	The content of the session status "working" message is correct	
07	Check that the user plane communication is established for ETCS, and parallel video transmission is still ongoing.	The data transfer is performed using the RBC IP	
08	Terminate the user plane communication and the remote video transmission.	No error returned	
09	Terminate the user plane communication for the ETCS application.	No error returned	
10	Check the logs of both applications and compare the KPIs with the nominal separate functioning of each application	Observed performances have to be identical, as for each application separately	

11.3 RV_ETCS_WP4-TC_003: Remote control of engines in parallel with ETCS application in degraded radio conditions using Vertex emulator.

11.3.1 Purpose

The purpose of this test is to demonstrate the radio resource management based on QoS in degraded conditions, when using in parallel two applications ETCS and Remote Vision, ETCS being the most critical one and configured as GBR. The degraded conditions were created by using Vertex emulator.

Initial conditions/configurations of both applications are considered as per nominal conditions.

The test will be performed with TOBA-K in n39 band because the application is only foreseen for the field testing.

11.3.2 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
01	Power-up FRMCS GWs (Onboard and Trackside)	GWs are initialized	**FU-7100 v5.0.0:** §513 MG-7900 §18 **3GPP TR22.889 V17.4.0:** [R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003] [R-7.1.3-001] [R-7.1.4-001] [R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7 **3GPP TR22.889** §6.11.2.5 D2.1 TOBA Architecture Report v2– OBapp – Loose coupled interface – GTW_SESSION_STATUS
02	Power-up train camera, onboard and trackside VMS	Camera Terminal is indicated as available in trackside VMS	
03	Verify established connections from Trackside/onboard VMS with the FRMCS GWs through TSapp/OBapp interfaces	Trackside/onboard VMS connections are established	
04	The train Operator requests video from the onboard camera	The operator can see live camera stream at trackside VMS	
05	While remote vision application is on-going, ETCS application is launched	The FRMCS GTW is correctly answering OK with the expected session ID and RBC @IP	
06	Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”	The content of the session status “working” message is correct	
07	Check that the user plane communication is established, and parallel video transmission is on-going.	The data transfer is performed using the RBC IP	
08	Degraded radio conditions are created by using the Vertex emulator to add fading, varying speed and multipath, as per field conditions.	Both applications are still on going, even in the degraded conditions	

09	Terminate the user plane communication for the remote video transmission	No error returned	
10	Terminate the user plane communication for the ETCS application	No error returned	
11	Check the logs of both applications and compare the KPIs with the nominal separate functioning of each application	ETCS performances have to be preserved, even though some degradation can be expected in Remote Vision	

11.4 RV_WP4-TC_004 OPTIONAL: Remote Vision in cross-border scenario using 1UE.

11.4.1 Purpose

Remote Vision is a ‘flat IP’ application. A specific configuration is set-up by creating a GRE tunnel between the On-board and Trackside GTW with fixed QoS value, thanks to DSCP method, based on associated com_profile. This configuration is loaded to the gateway when powered on. The application only needs to know the IP addresses of On-board and Trackside gateway. For that reason, this application has certain advantages for testing and also as Video application is a challenging one for field conditions.

The purpose of this test is to demonstrate that the performance of the Remote Vision application is not impacted in border crossing conditions, meaning when changing transport network and moreover that OB_GTW is able to maintain transport service, when crossing the border (e.g., between two countries simulated by two independent 5Gcores).

This test will be performed with TOBA-K in n39 band, as per field configuration.

11.4.2 Description of initial state/configuration

- The RF configuration set-up is presented in Figure 38
- 5G cell (gNodeB of 1st 5Gcore) is on and 5G cell (gNodeB of the 2nd 5Gcore) is off.

11.4.3 Test procedure

<table>
<tr><th>Step</th><th>Action</th><th>Expected result(s)</th><th>Compliance with selected requirements</th></tr>
<tr><td>01</td><td>Power-up FRMCS GWs (Onboard and Trackside)</td><td>GWs are initialized</td><td rowspan="7">FU-7100 v5.0.0: §513
MG-7900 §18
3GPP TR22.889 V17.4.0:
[R-7.1.2-001]
[R-7.1.2-002]
[R-7.1.2-003]
[R-7.1.3-001]
[R-7.1.4-001]
[R-7.1.4-002]
[R-7.1.4-003]
[R-7.1.5-001]
[R-7.1.5-002]
[R-7.1.5-003]
[R-7.1.6-001]
3GPP TSTS22.261 V18.2.0:
§7
3GPP TR22.889 §6.11.2.5
D2.1 TOBA Architecture Report v2– OBapp – Loose coupled interface – GTW_SESSION_STATUS</td></tr>
<tr><td>02</td><td>Power-up train camera, onboard and trackside VMS</td><td>Camera Terminal is indicated as available in trackside VMS</td></tr>
<tr><td>03</td><td>Verify established connections from Trackside/onboard VMS with the FRMCS GWs through TSapp/OBapp interfaces</td><td>Trackside/onboard VMS connections are established</td></tr>
<tr><td>04</td><td>The train Operator requests video from the onboard camera</td><td>The operator can see live camera stream at trackside VMS</td></tr>
<tr><td>05</td><td>Switch on the 5G cell of the 2nd 5Gcore and progressively attenuate the 5G cell (gNodeB of the 1st 5Gcore), in order to simulate the border crossing conditions</td><td>No impact has to be observed on the on-going Remote Vision session.</td></tr>
<tr><td>09</td><td>Terminate the user plane communication for the remote video transmission</td><td>No error returned</td></tr>
<tr><td>10</td><td>Compare the logs between nominal and the cross-border scenario</td><td>Check that there is no impact on the application KPIs due to the cross-border conditions.</td></tr>
</table>

12 Cybersecurity

12.1 Introduction

Cybersecurity local binding and end-to-end will be tested with ATO application in the scope of WP4

To test local binding TLS is activated for ATO and in the gateway part.

The following set-up will be used for ATO testing as per §15 [29]:

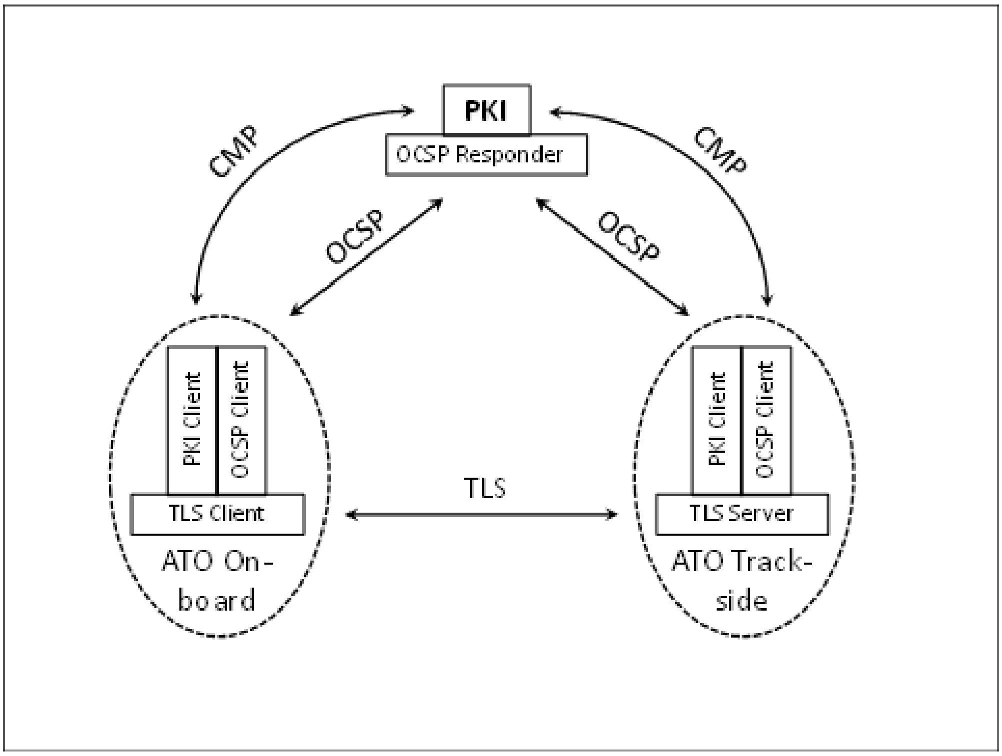


Figure 75: Testing set-up for ATO with TLS

12.1.1 ATO OBapp/TSapp compatibility test cases – With TLS activated.

12.1.1.1 ATO-TLS_001: Check the health of the link between ATO and the TOBA

12.1.1.1.1 PURPOSE

The purpose of this test is to check that the **TLS** link between ATO and TOBA is correctly set-up and working properly.

12.1.1.1.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.

- With TLS local binding activated
- FRMCS Gateway is connected and configured to ATO equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
    - With TLS local binding activated
- The ATO-onboard equipment is connected and power on in nominal state.

12.1.1.1.3 TEST PROCEDURE 1: THE WEBSOCKET STATUS IS CORRECT

See 8.3.1.1.3

12.1.1.1.4 TEST PROCEDURE 2: THE WEBSOCKET IS NOT RESPONDING

See 8.3.1.1.4

12.1.1.2 ATO-TLS_002: Check the registration and the connection status.

12.1.1.2.1 PURPOSE

The purpose of this test is to check if the registration and the connection status is correct between the ATO application and the FRMCS OB_{APP} **when the TLS is used**.

12.1.1.2.2 DESCRIPTION OF INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
    - With TLS local binding activated
- FRMCS Gateway is connected and configured to ATO equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
    - With TLS local binding activated
- The ATO-onboard equipment is connected and power on in nominal state.

12.1.1.2.3 TEST PROCEDURE 1: REGISTRATION

See 8.3.1.2.3

12.1.1.2.4 TEST PROCEDURE 2: LOSS OF THE WEBSOCKET ONCE THE REGISTRATION IS COMPLETED:

See.8.3.1.2.6

12.1.1.2.5 TEST PROCEDURE 3: CHECK THE CONNECTION STATUS

See 8.3.1.2.7.

12.1.1.3 ATO-TLS_003: Communication between the ATO-onboard and ATO-Trackside application

12.1.1.3.1 PURPOSE

The purpose of this test is to check that the communication between the ATO-OB and the ATO-TS is provided by the 5G network during the test **when the TLS local binding is used**.

12.1.1.3.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
    - With TLS local binding activated
- FRMCS Gateway is connected and configured to ATO equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
    - With TLS local binding activated
- The ATO-onboard equipment is connected and power on in nominal state.

12.1.1.3.3 TEST PROCEDURE: NOMINAL COMMUNICATION

See 8.3.1.3.3.

12.1.1.4 ATO-TLS_004: Test cases in degraded mode

12.1.1.4.1 PURPOSE

The purpose of this test is to check that the failures that may occur on the TLS handshake are correctly managed by the system.

12.1.1.4.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
    - With TLS local binding activated
- FRMCS Gateway is connected and configured to ETCS equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
    - With TLS local binding activated
- The ATO-onboard equipment is connected and power on in nominal state.

12.1.1.4.3 TEST PROCEDURE 1: WRONG ROOT CA CERTIFICATE

Step	Action	Expected result(s)	Compliance with selected requirements
01	Configure a wrong Root CA certificate on OB side	The SS126 shall log an error message saying the certificate doesn't exist	
02	Configure a wrong Root CA certificate on TS side	The ATO-TS shall log an error message saying the certificate doesn't exist	

12.1.1.4.4 TEST PROCEDURE 2: WRONG CLIENT CERTIFICATE

Step	Action	Expected result(s)	Compliance with selected requirements
01	Configure a wrong client certificate on OB side	The SS126 shall log an error message saying the certificate doesn't exist	
02	Configure a wrong client certificate on TS side	The ATO-TS shall log an error message saying the certificate doesn't exist	

12.1.1.5 ATO-TLS_005: ATO in nominal and perfect lab conditions

12.1.1.5.1 PURPOSE

Same as 8.3.2.1 but with E2E TLS.

12.1.1.5.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

Same as 8.3.2.2but with E2E TLS.

12.1.1.5.3 TEST PROCEDURE

See.8.3.2.3

12.1.1.6 ATO-TLS_006: Degraded conditions for E2E TLS handshake

12.1.1.6.1 PURPOSE

The purpose of this test is to check that the failures that may occur are correctly managed by the system.

12.1.1.6.2 DESCRIPTION OF THE INITIAL STATE/CONFIGURATION

- The ATO equipment are installed and configured.
  - With E2E TLS activated
- FRMCS Gateway is connected and configured to ETCS equipment and to the 5G network.
- The ATO-Trackside equipment is connected and configured.
  - With E2E TLS activated
- The ATO-onboard equipment is connected and power on in nominal state.

12.1.1.6.3 TEST PROCEDURE 1: PKI SERVER IS NOT REACHABLE

Step	Action	Expected result(s)	Compliance with selected requirements
01	Stop the PKI server	The PKI server is stopped	
02	Start the TLS handshake between the ATO-OB and ATO-TS	1. The handshake fails 2. The ATO-OB log an error message 3. The ATO-OB try to reconnect 4. See 1.	

13 Field Test cases

As explained in the previous chapters, a subset of lab tests will be performed in the field. The choice is based on two criteria: a) the importance of verification of the feature or FRMCS principle in the field context and b) if the field configuration allows the implementation of this test.

The list of field tests is presented in chapter §6 and in Table 10. In the column 'Field' (Test environment) is mentioned whether these tests will be performed in German or in French testbed.

All field tests will be executed following the steps description as for lab, that is why there is no dedicated description for field tests, except for Remote vision application. This application is purely field one, to be tested only in French testbed but derisked priorly in WP4 lab. For that reason, only the tests related to Remote vision are explicitly described in this field tests chapter.

The main difference in the execution of field tests concerns the mandatory preliminary tests to ensure that the required radio conditions are fulfilled and that the connectivity prerequisites are satisfied per test case.

13.1 Evaluation of the modem performances in the field

To evaluate the infrastructure characteristics and validate the n39 modem performances in field conditions, a campaign is organized, priorly to the field tests. The AT command to be executed for that purpose is **AT^DEBUG?** An example of information provided by this command is presented below:

RAT: NR5G_SA

mcc :001, **mnc**:04

nr_cell_id:19088135

nr_tac (Type Allocation Code):100

nr_band: n39

nr_band_width:10.0MHz

nr_channel:380910

nr_pci (Physical CellID):7

nr_rsrp (Reference Signal Received Power): -73.0dBm

nr_rsrq (Reference Signal Received Quality): -11.0dB

nr_snr (Signal to Noise Ratio):40.0dB

The AT commands are executed via the AT port of the modem device, using a session emulator (e.g., putty)

13.2 End-to-end connectivity validation

This preliminary test is important to validate the end-to-end connectivity between the On-Board and TS application. During this test, round trip delay and pathloss need to be measured and compared with values observed in labs, in order to apply adjustments for the tests with the track moving.

In the following, the procedure to apply for this end-to-end ping is described:

- Connect the test PC on the OB side at the OBapp interface.
- Launch the OB and TS applications.
- On the On-Board part, execute the command **'nft list ruleset'** to retrieve the IP assigned locally (@IP local).
- On the test PC, execute the command **'ip ro add @IP locale via @IP OBapp dev interface.'**
- On the Trackside part, execute the command **'nft list ruleset'** to retrieve the IP assigned locally (@IP local)
- On the test PC, execute the command **'ip ro add @IP locale via @IP TSapp dev interface.'**
- Launch the ping command to this IP address between On-Board and TS, to check if the end-to-end connectivity.

Moreover, to measure the latency, the codecs and 5QI values to be supported in field, the iPerf tool will be used and the configuration will be based on the Wireshark traces.

13.3 Prerequisites per application tests

In the following, the steps of test execution needing specific conditions or preliminary verifications will be listed per application, to be tested in the French field testbed. Regarding the applications to be tested in the German field testbed, the prerequisites will be covered by the WP5-DE deliverables but also in the D1.4.

13.3.1 ATP (ETCS) test cases

Application _TC_ID	Test Description	Steps	OB Requirements	TS Requirements	Test Duration
ETCS_WP4-WP5_OBapp-TC_001:	Test Procedure 1: The Web-socket status is correct	2-Check the status	ETCS equipment are installed and configured. FRMCS Gateway is connected and configured to ETCS equipment	Ensure good 5G coverage conditions	10s

			and to 5G network. ETCS Trackside equipment are connected and configured. ETCS onboard and trackside equipment are connected and power on in nominal state		
ETCS_WP4-WP5_OBapp-TC_002	Test Procedure 1: Registration	2-Register ETCS Application	Same OB requirements as per ETCS_WP4-WP5_OBapp-TC_001, Test procedure 1	Ensure good 5G coverage conditions	10s
ETCS_WP4-WP5_OBapp-TC_002	Test Procedure 6: Check the connection status	1- Open the WebSocket Check the status 2-Register ETCS Application 3-Check the connection status (polling)	Same OB requirements as per ETCS_WP4-WP5_OBapp-TC_001, Test procedure 1	Ensure good 5G coverage conditions	30s
ETCS_WP4-WP5_TC_003	Test Procedure 1: Communication in level 2 between ETCS onboard application and RBC	1-Establishment of a new session for communication with RBC1 (session start message)	The moving stock must be under 5G coverage.		30s
ETCS_WP4-WP5_TC_003	Test Procedure 1: Communication in level 2 between ETCS onboard	2-Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”	Same requirements as in step 1. A permanent communication between the test team onboard	Ensure good 5G coverage conditions	

	application and RBC		and the train driver must be established.		
ETCS_WP4-WP5_TC_003	Test Procedure 1: Communication in level 2 between ETCS onboard application and RBC	3-Check that the user plane communication is established.	Same requirements as in step 2		
ETCS_WP4-WP5_TC_003	Test Procedure 1: Communication in level 2 between ETCS onboard application and RBC	4-Terminate the user plane communication	ETCS equipment are installed and configured. FRMCS Gateway is connected and configured to ETCS equipment and to 5G network. ETCS Trackside equipment are connected and configured. ETCS onboard and trackside equipment are connected and power on in nominal state. The connection status is OK. The configuration A, ETCS end to end FRMCS call in nominal conditions, with the corresponding radio set-up		
ETCS_WP4-WP5_TC_003	Test Procedure 1: Communication in level 2 between ETCS onboard application and RBC	5-Terminate the session			
ETCS_WP4-WP5_TC_003	Test Procedure 1: Communication in level 2 between ETCS onboard application and RBC	6-Check that the FRMCS GTW is responding to the connection status request			

ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	1- Establishment of a new session for communication with RBC1 (session start message)			
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	2-Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”	The moving stock must be under 5G coverage. A permanent communication between the test team onboard and the train driver must be established.	Ensure good 5G coverage conditions	
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	3- Check that the user plane communication is established.	A permanent communication between the test team onboard and the train driver must be established	The application server needs to be accessible from the same network	>1min
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	4-Establishment of a new session for communication with RBC2 (session start message)	ETCS equipment are installed and configured. FRMCS Gateway is connected and configured to ETCS equipment and to 5G network. ETCS Trackside equipment are connected and configured. ETCS onboard and trackside equipment are connected and		
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	5-Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”			
ETCS_WP4-WP5_TC_003	Test procedure 2:	6-Check that the user plane			

	RBC handover on the same 5G network	communication is established.	power on in nominal state. The connection status is OK. The configuration A, ETCS end to end FRMCS call in nominal conditions, with the corresponding radio set-up.		
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	7 - Terminate the user plane communication with the RBC1			
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	8-Terminate the session1			
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	9-Check that the user plane communication is still established with the RBC2.			
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	10-Terminate the user plane communication with the RBC2			
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on the same 5G network	11-Terminate the session2			
ETCS_WP4-WP5_TC_003	Test procedure 2: RBC handover on	12-Check that the FRMCS GTW is responding to the connection status request			

	the same 5G network				
ETCS_WP4-WP5_TC_003	Test procedure 3: RBC handover on a different 5G network	1- Establishment of a new session for communication with RBC1 (session start message)	The moving stock must be under 5G coverage.		
ETCS_WP4-WP5_TC_003	Test procedure 3: RBC handover on a different 5G network	2- Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is "Working"	The moving stock must be under 5G coverage. A permanent communication between the test team onboard and the train driver must be established.	Ensure good 5G coverage conditions	
ETCS_WP4-WP5_TC_003	Test procedure 3: RBC handover on a different 5G network	3- Check that the user plane communication is established.	Same requirements as in the previous step.	Application server needs to be accessible by the same network	
ETCS_WP4-WP5_TC_003	Test procedure 3: RBC handover on a different 5G network	4- Establishment of a new session for communication with RBC2 (session start message) RBC2 is on a different network		Manual trigger is needed (e.g. based on a certain location, KP)	
ETCS_WP4-WP5_TC_003	Test procedure 3: RBC handover on a different 5G network	5- Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is "Working"		A trigger is also required to notify the end of the run	

ETCS_WP4-WP5_TC_003	Test procedure 4: RBC&BTS handover on the same 5G network (intra-gNodeB HO)	1- Perform multiple RBCs handover (using a balise scenario) during several hours (approximately 6 or 8h). There are only hundred meters between the beacons to perform handover every 3 minutes (approximately) At the same time perform multiple BTS handover, while ETCS application is on-going, multiple intra-gNodeB handover are performed where the 2nd 5G cell is switched on and progressively the radio power of the 1st 5G cell is manually decreased. The frequencies of BTS handovers and RBC handovers are different. 2- Compare the log with the logs of the nominal conditions test case	Same requirements as per previous test procedure		
ETCS_WP4-WP5_TC_003	Test procedure 5: Bearer flexibility: Redundancy use case: OB GW going from 4G to	1 - Establishment of a new session for communication with RBC (session start message) on 5G network. 2 - Check that the FRMCS GTW is still	Same requirements as per previous test procedure		

	5G coverage with on-going ETCS call continuation and vice-versa	responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”. 3 - Check that the user plane communication is established.			
ETCS_WP4-WP5_TC_003	Test procedure 5: Bearer flexibility: Aggregation use case: OB-GW is moving from 5G only coverage to a 4G+5G coverage, ETCS is using simultaneously both bearers and vice versa	1 - Establishment of a new session for communication with RBC (session start message) on 5G network. 2 - Check that the FRMCS GTW is still responding to the connection status request until the session status (sent by the FRMCS GTW) is “Working”. 3 - Check that the user plane communication is established.			

13.3.2 ATO test cases

Application_ TC_ID	Test Description	Steps	OB Requirements	TS Requirements	Test Duration
ATO_ OBapp-TC_001	Check the health of the link between ATO and the TOBA Test Procedure 1: The Web-socket status is correct	See 8.3.1.1.3	The ATO equipment are installed and configured. FRMCS Gateway is connected and configured to ATO equipment. The ATO-onboard equipment is connected and power on in nominal state	The ATO-Trackside equipment is connected and configured	10s
ATO_ OBapp-TC_002	Check the registration and the connection status: Procedure 1: Registration	See 8.3.1.2.3	Same requirements as in previous procedure	Same requirements as in previous procedure	10s
ATO_ OBapp-TC_002	Check the registration and the connection status: Procedure 5: Check the connection status	See 8.3.1.2.7	Same requirements as in previous procedure	FRMCS Gateway is connected and configured to ATO equipment and to the 5G network. The ATO-Trackside equipment is connected and configured	
ATO-TC_003	Communication between ATO On-board and ATO trackside - Nominal communication (check of the	See 8.3.1.3.3	Same requirements as in previous procedure	Same requirements as in previous procedure	

	API) in field conditions				
ATO-TC_005	HO intra gNodeB with ATO in field testbed	1- Launch all softs: by opening the cmd files Start_5Grail_OB and Start_5Grail_TE	A permanent communication between the test team onboard and the train driver must be established. Journal profile (step 3.1) must be sent before segment profile (step 3.2).	The moving stock must be under 5G coverage.	
ATO-TC_005	HO intra gNodeB with ATO in field testbed	2- In the scenario, an establishment of a new session is performed by sending a 'session start' message. Go to the application ATO_REPLAY and load the scenario TEST_5G. STrm then launch it			
ATO-TC_005	HO intra gNodeB with ATO in field testbed	3.1 Transfer of journal profile before the train starts its journey. 3.2 Transfer of segment profile once the train starts its journey. 3.3 the train starts its mission until handover is performed. The 2nd 5G cell is switched on and progressively the radio power of the 1st cell decreases as the train moves away from the 1st antenna.			
ATO-TC_005	HO intra gNodeB with ATO in field testbed	4- Compare the log with the logs of the nominal conditions test case	Log tools are running.		
ATO-TC_005	HO intra gNodeB with ATO in field testbed	5- Once the train leaves the 2nd cell, 5G coverage is lost.			

ATO-ETCS-TC_009	ETCS onboard combined with ATO application	See 8.3.7	The ATO equipment are installed and configured The ATO-onboard equipment is connected and power on in nominal state ETCS equipment are installed and configured. FRMCS Gateway is connected and configured to ETCS equipment and to 5G network. ETCS Trackside equipment are connected and configured. ETCS onboard and trackside equipment are connected and power on in nominal state	FRMCS Gateway is connected and configured to ATO equipment and to the 5G network The ATO-Trackside equipment is connected and configured Ensure good 5G coverage.	

13.3.3 RV_WP5-TC_001: Remote control of Engines in field conditions: streaming of video from moving stock to trackside.

13.3.3.1 Introduction

Remote vision is the name of the SNCF application to be performed only in field with connection to WP4 lab trackside equipment.

The purpose of the tests in this section, is to assess the live streaming of video out of a frontal camera installed on the moving stock. Video flows shall go through the onboard video management system (**VMS**) interconnected to the onboard gateway (**GW**) and then transported through the 5G/FRMCS infrastructure to reach the trackside VMS via the trackside GW. The remote vision application enables the remote vision of the environment in front of the moving stock using a video stream envisioned to be very important in railway operation. Testing remote vision application in real field conditions is mandatory for WP5. This is why the remote vision test case will be performed in prior, in WP4-lab, as an optional test case for derisking purposes.

Since remote vision is a bandwidth demanding application, our proposal is to also perform a combined test case with remote vision and ETCS application, ETCS considered as a critical application. The rationale behind is to observe the radio resource management and the impact on the KPIs of both applications, assuming that ETCS is a critical application, not to be impacted at all. The combined remote vision and ETCS application is optional for WP5 and WP4.

All the test cases involving remote vision application will be performed with TOBA-K in band n39.

It is worth mentioning that real time video is considered as an enabler of the digitalisation and modernization of the operation of a train and could positively affect the safety of the railway ecosystem. In this context, multiple applications could leverage it. Through this facility, we imagine the supervision of passengers, and the different railway assets in addition to tracks status regular monitoring.

The customised configuration of TOBA-K to consider remote vision as a super loose application is explained in §16.7

13.3.3.2 Purpose

The purpose of this test case is to test the remote vision in realistic/degraded network conditions.

The test will be performed with TOBA-K in n39 band.

13.3.3.3 Description of initial state/configuration

- Onboard VMS is installed.
- Onboard VMS has at least one camera installed, the camera view pointing to moving pictures/objects (no static picture view)
- Onboard camera is connected to the onboard VMS, is integrated with FRMCS onboard GW through OBapp interface.
- Trackside VMS system is installed.
- Onboard VMS is integrated with the trackside VMS.
- Trackside VMS is integrated with FRCMS trackside GW through TSapp interface.
- Degraded network condition could occur.

13.3.3.4 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
01	Power-up FRMCS GWs (Onboard and Trackside)	GWs are initialized	**FU-7100 v5.0.0:** §513 MG-7900 §18 **3GPP TR22.889 V17.4.0:** [R-7.1.2-001] [R-7.1.2-002] [R-7.1.2-003] [R-7.1.3-001] [R-7.1.4-001] [R-7.1.4-002] [R-7.1.4-003] [R-7.1.5-001] [R-7.1.5-002] [R-7.1.5-003] [R-7.1.6-001] **3GPP TSTS22.261 V18.2.0:** §7 **3GPP TR22.889** §6.11.2.5
02	Power-up train camera, onboard and trackside VMS	Camera Terminal is indicated as available in trackside VMS	
03	Verify established connections from Trackside/onboard VMS with the FRMCS GWs through TSapp/OBapp interfaces	Trackside/onboard VMS connections are established	
04	The train Operator requests video from the onboard camera	The operator can see live camera stream at trackside VMS	
05	**While the train is on the move**, from 5G site 1 to 5G site 2, or under the coverage of gNodeB of site 3 radio transition to a destination cell takes place due to mobility, received signal level or coverage. (cf. Figure 22). The train operator keeps remotely observing the view through the onboard camera	Trackside VMS decodes the incoming video stream. Potentially, some lost packets, lost frames, visual effects on the video could be observed. On-board (HD) and ground (adaptive) video recordings (to compare videos).	
06	Performance report is generated. Remote vision apps generate different levels of logs that are used to consolidate relevant data for KPIs and compile the information via CSV files generally. There are counters collected on network, such as:	The presented figures are JUST an indication, since there is no previous experience in remote vision in 5G rail context. The values are measurements in a car on the road near a 5G test antenna. (a) **Video packet losses** (real loss) ~ 10^{-5}. This	

	(a) Video packet losses (real loss) **(b) Video packet losses** on time-out (late arrival due to the jitter over the network). These packets are lost. **(c) Instantaneous bitrate** is calculated from the size of the packets and the successive arrival times. **(d) Network losses** are packet lost that persists after a pre-defined window that is a threshold on the number of packets. The considered threshold is ~¼ sec but can be adjusted based on lab testing. **(e) The end-to-end latency** could be processed based on GPS time embedded in the videos as metadata and compared with the ground decoder GPS time (2 GPS sensors required or synchronised NTP servers). This measurement could be completed by an intermediate ground latency in Vigneux if the Train-Vigneux-Montigny solution is validated (optional feature under development) .	is often the goal for a compressed video, and this value was reported in the 5G car. (b) **Video packet losses** on time-out (late arrival due to the jitter over the network): almost constant; around 10^{-4} but depends on vehicle speed and other factors. (c) **Instantaneous bitrate** (1 log every second): more than 30Mb/s effective (which we cannot reach, limited by the on-board CPU constraints) (d) **Network losses (+ duration)**: close to zero with a single antenna without considering handovers. It will be most probably different for 5G-Rail where there would be a moving stock.	

13.3.4 RV_ETCS_WP5-TC_002: Combined Remote Vision and ETCS in field conditions.

See §11.2. The same steps are to be applied to the field environment.

13.3.5 RV_ETCS_WP5-TC_003: Cross-border with remote vision application in field conditions.

See §11.4. The same steps are to be applied to the field environment.

14 CONCLUSIONS

This document describes the most representative test cases for each selected use case to be performed in labs hosting a complete FRMCS ecosystem, composed by protypes.

The main objective of each test case is to validate functions defined in 3GPP Release 16 and some pre-defined for 3GPP Release 17 (at least from 3GPP stage 1 and stage 2) but also some specific interworking elements defined at the level of ETSI TC-RT, that are key features for the FRMCS specifications and mainly for the migration period.

The document applied a phased approach, v1 which is mainly focused to the lab test plan and v2 which had addressed the open points of v1, intending to provide more information about the field tests. Currently, amendments referring to applications KPIs are added to the lab test cases, the list of field test cases is agreed, and some additional or optional test cases are provided for labs.

The final version of D1.1is essentially driven by the testbed architecture progress which impact the field test description, the lab tests progress but also the finalization of the cybersecurity set-up in the lab.

The D1.1 will be followed by the D1.2 Test report conclusion from simulated/lab environments, expected to be the outcome of observations of lab tests in the scope of WP3 and WP4. It will summarize all the observations that may raise amendments or lack of specifications or even implementation technical issues.

The following table is a demonstration that all the mandatory MCX or FRMCS features are at least tested once in a lab by at least one application, which mainly one of the objectives of WP1:

Application	Functional Alias	Arbitration	Interworking (FRMCS/GSM-R)	IPConn	QoS		Bearer flex		Cybersecurity Local binding/e2e TLS	Cross-border with 1UE	Cross border with 2UEs	
					TOBA-K	TOBA-A (lab)	TOBA-K	TOBA-A (lab)		TOBA-K	TOBA-A (lab) 2x5GUE	TOBA-K 1x5GUE& 1x4GUE
ETCS - WP4				✓	✓	✓	✓	✓		✓	✓	✓
ATO				✓	✓	✓		✓	✓		✓	
RV				✓	✓					✓ (field derisking)		
RV combined with ETCS					✓							
PIS				✓		✓		✓				
Voice/REC	✓	✓	✓		✓							
ETCS – WP3				✓	✓							
TCMS				✓	✓					✓		
CCTV				✓			✓					
Video				✓	✓					✓		

Table 30 Features tested by application.

15 REFERENCES

id	DOCUMENT TITLE	REFERENCE, VERSIONS
[1]	FRMCS User Requirements Specification,	FU-7100
[2]	FRMCS Use cases	MG-7900
[3]	FRMCS Functional Requirement Specification (FRMCS FRS)	FU- 7120
[4]	System Requirements Specification (FRMCS SRS)	AT- 7800
[5]	Study on Future Railway Mobile Communication System, Stage 1 (Release 16 & Release 17)	3GPP TR22.889 V17.4.0 3GPP TR22.889 V16.6.0
[6]	Technical Specification Group Services and System Aspects, Mission Critical Services over 5G System, Stage 2 (Release 17)	3GPP TS 23.289 V1.0.0
[7]	Technical Specification Group Services and System Mission Critical Services Common Requirements (MCCoRe) Stage 1 (Release 17)	3GPP TS 22.280 V17.4.0
[8]	Technical Specification Group Services and System Aspects Mission Critical Push to Talk (MCPTT) Stage 1(Release 17)	3GPP TS 22.179 V17.0.0
[9]	Technical Specification Group Services and System Aspects Mission Critical Data services Release 16	3GPP TS22.282 V16.4.0
[10]	Group Services and System Aspects Security of the Mission Critical (MC) service (Release 17)	3GPP TS 33.180 V17.2.0
[11]	Technical Specification Group Services and System Aspects System architecture for the 5G System (5GS) Stage 2(Release 17)	3GPP TS 23.501 V17.0.0
[12]	Technical Specification Group Services and System Aspects. Mobile Communication System for Railways Stage 1(Release 17)	3GPP TS22.289 V17.0.0

[13]	Technical Specification Group Services and System Service requirements for the 5G system Stage 1 (Release 18)	3GPP TSTS22.261 V18.2.0
[14]	ETSI- Study on FRMCS System Architecture	ETSI TR 103 459 V1.2.1 (2020-08)
[15]	ETSI-GSM-R/FRMCS Interworking	ETSI TR 103 768 V0.0.4 (2021-062)
[16]	D2.1 TOBA Architecture report	REV3 – 31/01/2023
[17]	D3.1 First Lab Integration and Architecture Description	13/09/2021 – v1 31/03/2022 – v2
[18]	D4.1 Second Lab Integration and Architecture Report	14/09/2021 – v1 25/03/2022 – v2
[19]	Grant Agreement number: 951725 — 5GRAIL — H2020-ICT-2018-20 / H2020-ICT-2019-3	
[20]	D3.2 First Lab Setup Report	28/02/2022 - v1 30/06/2022 – v2
[21]	D4.2 Second Lab Setup Report	25/02/2022 – v1
[22]	Functional Interface Specification	FIS – 7970
[23]	Form Fit Functional Interface Specification	FFFIS-7950
[24]	ERTMS/ETCS GSM-R Bearer Service Requirements	Subset 093 – v4.0.0
[25]	Radio Transmission FFFIS for EuroRadio	V13.0.0
[26]	Subset-037	v3.2.0
[27]	Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2 - (Release 17)	3GPP TS 23.379 v17.8.0

[28]	Mission Critical Push To Talk (MCPTT) media plane control; Protocol specification	3GPP TS 24.380 v17.6.0
[29]	Subset 126 – Appendix A	Issue: 0.0.10

16 APPENDICES

16.1 5G FRMCS System Principles

The following tables present the 5G FRMCS principles and MCX features that will be validated through the proposed test cases.

							Relevant Communication Applications								Relevant Support Applications											
							5.9	5.10	5.19	5.20	5.27	6.19	6.20	6.23	8.1	8.2	8.3	8.4	8.5	8.7	8.8	8.9	8.10	8.11	8.12	10.1
		5GRAIL	LAB WP3	LAB WP4	FIELD DB WP5	FIELD SNCF WP5	Automatic Train Protection communication	Automatic Train Operation communication	Voice recording and access	Data recording and Access	Critical real time video	Messaging Services	Transfer of data	Real time video call	Assured voice communication	Multi user talker control	Role management and presence	Location services	Authorisation of communication	Authorisation of application	QoS class	Safety application key management communication	Assured data communication	Inviting-a-user messaging	Arbitration	Billing information
URS Ref.	Applications																									
5	Critical Communication Applications																									
5.1	On-train outgoing voice communication from the train driver towards the controller(s) of the train*	X	X	O	X	O										X	X	X	X	X	X			X	X	
5.2	On-train incoming voice communication from the controller towards a train driver*	X	X	O	X	O										X	X	X	X	X	X			X	X	
5.3	Multi-Train voice communication for drivers including ground user(s)	X	X	O	X	O										X	X	X	X	X	X			X	X	
5.9	Automatic Train Protection communication*	X	X	X	X	X		X					X				X	X	X	X	X				X	
5.10	Automatic Train Operation communication (limited to GoA2 ATO)*	X		X		X	X						X				X	X	X	X	X				X	
5.13	Remote control of Engines	O		O		O							X				X	X	X	X	X		O		X	
5.15	Railway Emergency Communication*	X	X	O	X	O							X			X	X	X	X	X	X				X	
6	Performance Communication Applications																									
6.9	On-Train Telemetry communications (TCMS includes 6.9 + 6.11 + 6.20), including PIS	X	X	X	X	X							X				X	X	X	X	X				X	
6.11	On-train remote equipment control (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X								X				X	X	X	X	X				X	
6.13	Non-critical real time video (see clause 5.27) - MCVideo, MCData related?	X	X	X	X	X							X				X	X	X	X	X				X	
6.20	Transfer of data (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X												X		X	X	X				X	
6.22	Transfer of CCTV archives (Wi-Fi related?)	X	X	O	TBC												X		X	X	X				X	

Table 31: TC_020 – 5G FRMCS features to be tested per use case (1/2)

							FRMCS System principles related use cases (source: TR 22.889)																					
							12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.2	12.2	12.2	12.2
		5GRAIL	LAB WP3	LAB WP4	FIELD DB WP5	FIELD SNCF WP5	Area Broadcast Group Communication interworking between GSM-R and FRMCS	Location Service interworking between GSM-R and FRMCS Users	Presence interworking between GSM-R and FRMCS	Point to Point communication between GSM-R and FRMCS Users	Interworking with legacy systems including LMR	Builds stable positioning framework for FRMCS services and devices including trainborne and handheld devices	Interworking between GSM-R and FRMCS	Bearer flexibility	QoS in a railway environment	Provide broadband and mission critical services with seamless connectivity	Offer railway services high-quality control functions with real-time train status monitoring	Provide call priority during interworking with LMR	FRMCS Positioning Accuracy	FRMCS System security framework	Interworking to external networks	FRMCS On-network/Off-network communication	Call restriction service	Allocation and isolation of FRMCS communication resources	FRMCS Equipment capabilities for multiple FRMCS Users	FRMCS System/FRMCS User roaming capabilities	Availability – increasing measures	Flexible use of available contiguous spectrum blocks(s) and related bandwidth(s)
							Yes	Yes	N/A	TBC	N/A	Option	Yes	Yes	Yes	N/A	N/A	N/A	Yes	TBC	N/A	N/A	Option	Yes	Yes	Yes	Option	N/A
URS Ref.	Applications																											
5	Critical Communication Applications																											
5.1	On-train outgoing voice communication from the train driver towards the controller(s) of the train*	X	X	O	X	O		O		X			X	X	X					O			O	O	X	X		
5.2	On-train incoming voice communication from the controller towards a train driver*	X	X	O	X	O		O		X		O	X	X	X					O			O	O	O	X		
5.3	Multi-Train voice communication for drivers including ground user(s)	X	X	O	X	O	X	X					X	X	X					X				O	O	X		
5.9	Automatic Train Protection communication*	X	X	X	X	X						O	X	X	X					X				X	X	X	O	
5.10	Automatic Train Operation communication (limited to GoA2 ATO)*	X		X		X						O		X	X					X				X	O	O		
5.13	Remote control of Engines	O		O		O									O				O	X					X			
5.15	Railway Emergency Communication*	X	X	O	X	O	X	X				O	X	X	X				O	O				X	X	X		
6	Performance Communication Applications																											
6.9	On-Train Telemetry communications (TCMS includes 6.9 + 6.11 + 6.20), including PIS	X	X	X	X	X								O	X					X								
6.11	On-train remote equipment control (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X									O	X					X								
6.13	Non-critical real time video (see clause 5.27) - MCVideo, MCData related?	X	X	X	X	X						O		X	X				O	X				X	X	O		
6.20	Transfer of data (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X							O		O	X					O								
6.22	Transfer of CCTV archives (Wi-Fi related?)	X	X	O	TBC									X	X													

Table 32: TC_020 – 5G FRMCS features to be tested per use case (2/2)

16.2 – MCX configuration in WP3 and WP4

The following tables present the OB_{APP}/TS_{APP} clients needed per each application, and the underlying SIP ID and MCX ID that must be configured in the infrastructure.

This is the outcome of coordination meetings between Work packages 2, 3 and 4, and is a specific 5GR solution, not necessarily aligned with the standard addressing mechanism which will be included in the future version of FRMCS FIS. Especially, only one static domain part is used in each WP, and domain parts for SIP and MC IDs are the same.

16.2.1 IDs used in WP3

ETCS (CAF):

Application			MCx client in the OB_GTW			
On-Board or Trackside	Name	originator_id (Obapp REGISTER)	SIP URI private	SIP URI public	MC ID	MCData ID
OB	EVC / ETCS	00100100010	+820100000031@mcptt.nokia.com	+820100000031@mcptt.nokia.com	00100100010	00100100010@mcptt.nokia.com
TS	RBC / ETCS	00100100011	+820100000032@mcptt.nokia.com	+820100000032@mcptt.nokia.com	00100100011	00100100011@mcptt.nokia.com

TCMS (CAF):

Application			MCx client in the OB_GTW			
On-Board or Trackside	Name	originator_id (Obapp REGISTER)	SIP URI private	SIP URI public	MC ID	MCPTT ID
OB	MCG / TCMS	00100100012	+820100000033@mcptt.nokia.com	+820100000033@mcptt.nokia.com	00100100012	00100100012@mcptt.nokia.com
TS	GCG / TCMS	00100100013	+820100000034@mcptt.nokia.com	+820100000034@mcptt.nokia.com	00100100013	00100100013@mcptt.nokia.com

Voice (Siemens):

Application			MCx client in the application (Tight)				
On-Board or Trackside	Name	originator_id (Obapp REGISTER)	SIP URI private	SIP URI public	MC ID	MCPTT ID	Functional Alias
	Smartphone1	00100100005	+820100000006@mcptt.nokia.com	+820100000006@mcptt.nokia.com	00100100005	00100100005@mcptt.nokia.com	dispatcher-111.voice@mcptt.nokia.com
	Smartphone2	00100100006	+820100000007@mcptt.nokia.com	+820100000007@mcptt.nokia.com	00100100006	00100100006@mcptt.nokia.com	dispatcher-222.voice@mcptt.nokia.com
TS	Controller (Nokia dispatcher)	00100100003	+820100000001@mcptt.nokia.com	+820100000001@mcptt.nokia.com	00100100003	00100100003@mcptt.nokia.com	not supported
OB	CAB1 / voice	00100100008	+820100000025@mcptt.nokia.com	+820100000025@mcptt.nokia.com	00100100008	00100100008@mcptt.nokia.com	driver-111.voice@mcptt.nokia.com
OB	CAB2 / voice	00100100009	+820100000041@mcptt.nokia.com	+820100000041@mcptt.nokia.com	00100100009	00100100009@mcptt.nokia.com	driver-222.voice@mcptt.nokia.com

Note: *Currently, functional alias cannot be displayed on the dispatcher's terminal, MCID can be displayed instead. However, if smartphones are used as it will happen during the field tests, functional alias can be displayed.*

CCTV/Video (Teleste):

Application			MCx client in the OB_GTW			
On-Board or Trackside	Name	originator_id (Obapp REGISTER)	SIP URI private	SIP URI public	MC ID	MCPTT ID
OB	NVR / Video	00100100014	+820100000035@mcptt.nokia.com	+820100000035@mcptt.nokia.com	00100100014	00100100014@mcptt.nokia.com
TS	WCG / video	00100100015	+820100000036@mcptt.nokia.com	+820100000036@mcptt.nokia.com	00100100015	00100100015@mcptt.nokia.com
TS	WCG2 / video	00100100016	+820100000042@mcptt.nokia.com	+820100000042@mcptt.nokia.com	00100100016	00100100016@mcptt.nokia.com

SIP core and MCX server related information:

SIP core	
Name or IP address	87.254.196.110

MCx server	
SIP IMPU	to be completed
Name or IP address of IdMS	87.254.196.110

16.2.2 IDs used in WP4:

Application			MCx client in the OB_GTW			
On-Board or Trackside	Name	originator_id (Obapp REGISTER)	SIP URI private IMPI	SIP URI public IMPU	MC ID	Mcdata ID (= MC service ID)
ETCS						
OB	EVC	id000005.ty02.etcs	id000005.ty02.etcs@sv-lab.net	id000005.ty02.etcs@sv-lab.net	id000005.ty02.etcs	id000005.ty02.etcs@sv-lab.net
TS	RBC1	id500033.ty01.etcs	id500033.ty01.etcs@sv-lab.net	id500033.ty01.etcs@sv-lab.net	id500033.ty01.etcs	id500033.ty01.etcs@sv-lab.net
TS	RBC2	id500034.ty01.etcs	id500034.ty01.etcs@sv-lab.net	id500034.ty01.etcs@sv-lab.net	id500034.ty01.etcs	id500034.ty01.etcs@sv-lab.net
TS	RBC3	id500035.ty01.etcs	id500035.ty01.etcs@sv-lab.net	id500035.ty01.etcs@sv-lab.net	id500035.ty01.etcs	id500035.ty01.etcs@sv-lab.net
TS	RBC4	id500036.ty01.etcs	id500036.ty01.etcs@sv-lab.net	id500036.ty01.etcs@sv-lab.net	id500036.ty01.etcs	id500036.ty01.etcs@sv-lab.net
ATO						
OB	ATO-OB	ato-ob.ato	ato-ob.ato@sv-lab.net	ato-ob.ato@sv-lab.net	ato-ob.ato	ato-ob.ato@sv-lab.net
TS	ATO-TS	ato-ts.ato	ato-ts.ato@sv-lab.net	ato-ts.ato@sv-lab.net	ato-ts.ato	ato-ts.ato@sv-lab.net
PIS						
OB	PIS-OB	msg.ob.pis	msg.ob.pis@sv-lab.net	msg.ob.pis@sv-lab.net	msg.ob.pis	msg.ob.pis@sv-lab.net
OB	PIS-OB	mgt.ob.pis	mgt.ob.pis@sv-lab.net	mgt.ob.pis@sv-lab.net	mgt.ob.pis	mgt.ob.pis@sv-lab.net
OB	PIS-OB	log.ob.pis	log.ob.pis@sv-lab.net	log.ob.pis@sv-lab.net	log.ob.pis	log.ob.pis@sv-lab.net
TS	PIS-TS	msg.ts.pis	msg.ts.pis@sv-lab.net	msg.ts.pis@sv-lab.net	msg.ts.pis	msg.ts.pis@sv-lab.net
TS	PIS-TS	mgt.ts.pis	mgt.ts.pis@sv-lab.net	mgt.ts.pis@sv-lab.net	mgt.ts.pis	mgt.ts.pis@sv-lab.net
TS	PIS-TS	log.ts.pis	log.ts.pis@sv-lab.net	log.ts.pis@sv-lab.net	log.ts.pis	log.ts.pis@sv-lab.net

SIP core and MCX server related information:

SIP core	
Name or IP address of the proxy CSCF	172.21.160.68:5060

MCx server	
SIP IMPU	sdp01@sv-lab.net
Name or IP address of IdMS	172.21.160.69:8450

Domain part of SIP URI	
domain part for SIP IMPU	sv-lab.net
domain part for MC service ID	sv-lab.net

16.3 Priority QoS in WP3

The following table presents the mapping between 5QI and DSCP marking in the scope of WP3:

For data, the chosen mapping is configured in 5G network. The application profile and DSCP, needs to be known.

Note for voice (*):

- For voice 5QI2 is considered. It is assumed no difference between REC and normal voice because the DSCP value needs to be configured and is fixed in the cab radio.
- Priority between REC and normal voice is handled by MCX arbitration at the application level, not related to 5QI values.

Applications	OB_GTW		Infrastructure static configuration
comm_profile transmitted by the application	DSCP value (bit)	DSCP value (decimal)	QoS parameters used for WP3
1- Voice (*)	101 101	43	5QI: 2, ARP 7, GBR
2- Operational Voice	101 010	42	Not used
3- Emergency voice (*)	101 001	41	5QI: 2, ARP 1, GBR
4- Video	100 001	33	5QI : 7, non-GBR
5- Low latency Video	100 000	32	Not used
6- Non harmonized Data (TCMS)	001 000	8	5QI:9, non-GBR
7- Operational Data	010 011	19	Not used
8- Emergency Data	010 111	23	Not used

9- Low latency Data	010 110	22	Not used
10 - ETCS	010 101	21	5QI 5, non-GBR

Table 33 QoS and DSCP Marking

16.4 Priority QoS in WP4

There are static QoS rules configured in the 5G network for the “internet apn”. The following QoS flows are configured for the “internet apn”, in the scope of WP4:

- QoS flow #1 = default one
- QoS flow #2 :
  - 5QI 3 (gBR)
  - gBR UL/DL = 100kbit/s
  - max BR UL/DL = 1Mbits/s
  - TFT filtering: for DSCP value 110 000 (CS6)
- QoS flow #3:
  - 5QI 5 (non gBR)
  - TFT filtering: for DSCP value 101 000 (CS5)

The following static QoS configuration is used per application in WP4:

Remote Vision:

- Comm_profile:5
- **5QI 7**
- Non-GBR
- Packet Delay Budget 100ms
- Error Rate 10-3

ATO:

- Comm_profile:11
- **5QI 2**
- GBR
- Packet Delay Budget 150ms
- Error Rate 10-3
- Guaranteed Bit Rate 100 kb/s
- Maximum Bit Rate 1 Mb/s

ETCS:

- Comm_profile:10
- **5QI 3**
- GBR
- Packet Delay Budget 50ms
- Error Rate 10-3
- Guaranteed Bit Rate 100 kb/s.
- Maximum Bit Rate 1 Mb/s

16.5 MCPTT KPIs

Based on D3.2v2 and § 15[8], the following figure summarizes the KPIs for the MCPTT service, to be used for the voice test cases:

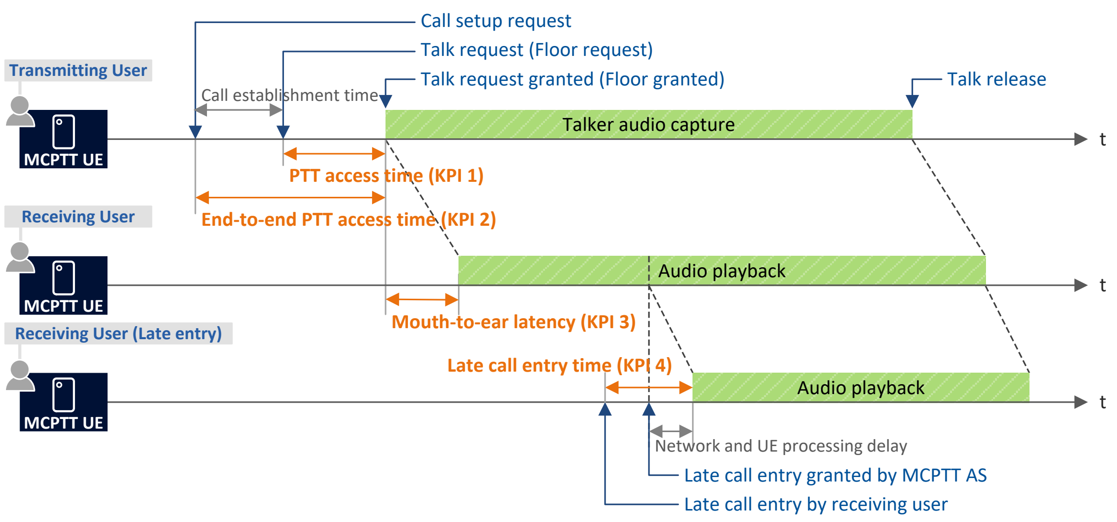


Figure 76 MCX KPI Overview

In 5G Rail : the following KPI will be measured depending on the test case:

MCPTT Access time (KPI 1)

- The time between when an MCPTT User request to speak (normally by pressing the PTT butt on) and when this user gets a signal to start speaking. This time does not include confirmatio ns from receiving users.
- MCPTT Access time (KPI 1) is less than 300ms for 95% of all MCPTT requests, for MCPTT Eme rgency Group Calls and Imminent Peril Calls, the KPI 1 is less than 300ms for 99% of all MCPT T requests

End-to-end MCPTT Access time (KPI 2)

- The time between when an MCPTT User requests to speak and when this user gets a signal t o start speaking, including MCPTT call establishment (if applicable) and acknowledgement (if used) from first receiving user before voice can be transmitted. A typical case for the End-to-end MCPTT Access time including acknowledgement is an MCPTT Private Call (with Floor con trol) request where the receiving user's client accepts the call automatically.

- The MCPTT Service shall provide an End-to-end MCPTT Access time (KPI 2) less than 1000 ms for users under coverage of the same network when the MCPTT Group call has not been est ablished prior to the initiation of the MCPTT Request.

Mouth-to-ear latency (KPI 3) will not be measured in detail but will be qualified and assessed by the person performing the test.

Late call entry performance (KPI 4) measurement depends on the WP1 definition for Railway Emergency Call and might be skipped.

For the measurement logging of SIP messages in the UE and Server will be used alternatively the dedicated Wireshark monitoring PC attached to Onboard and Trackside (cf. Figure 12)

Both CAB Radio as well as Nokia UE will support detailed logging capabilities. In the following the measurement task are described based on Nokia UE for KPI 1:

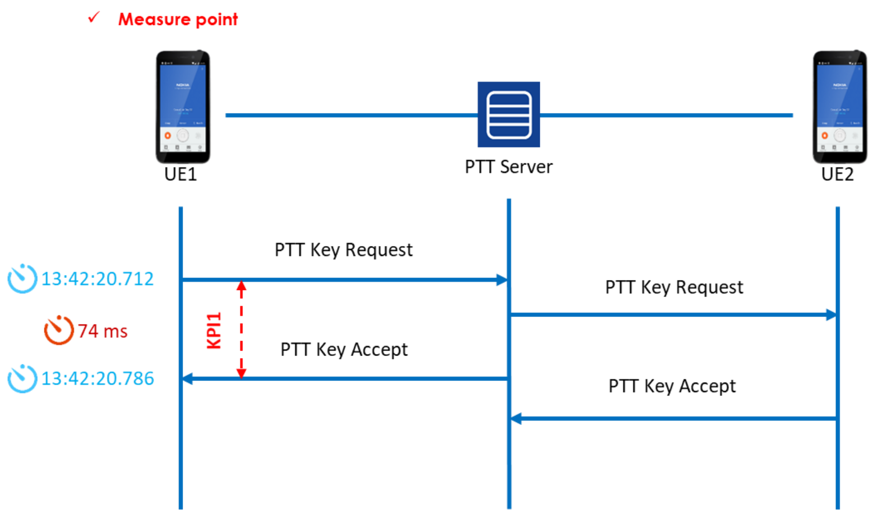


Figure 77: MCX KPI 1 Measurement Configuration

The procedure will log the RTCP messages for Key Request and Accept by timestamps allowing to derive KPI 1.

A similar setup is installed for KPI 2 measurement:

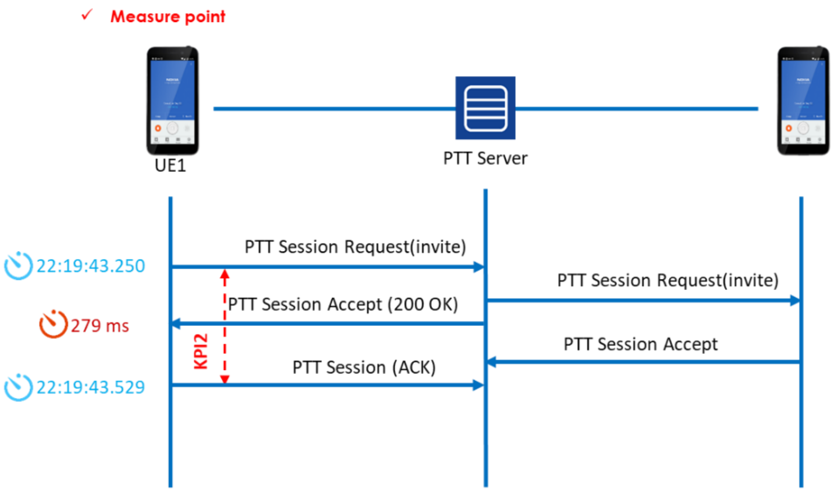


Figure 78: MCX KPI 2 Measurement Configuration

The procedure will log the SIP Invite and acknowledgement messages by timestamps allowing to derive KPI 1.

In case KPI 4 will be measured, depending on REC implementation, the following call flow is to be considered:

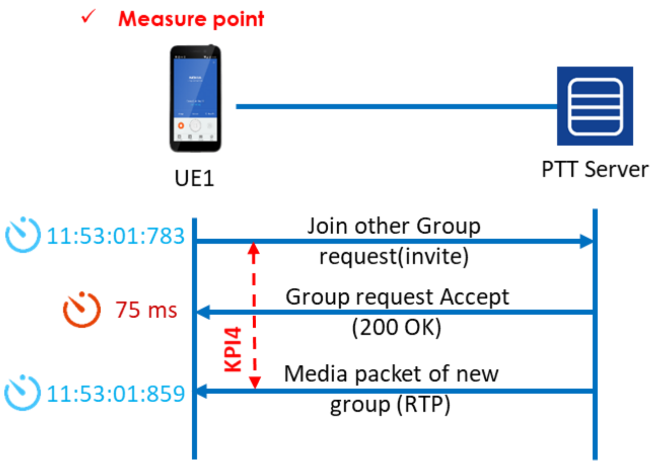


Figure 79: MCX KPI 4 Measurement Configuration

16.6 Applicability of MCX building blocks to the test cases of WP3

Application_TC_ID	Test case	3GPP stage 2 MCX Features
Voice_001	Registration of a functional identity related to the user	Rel. 16, 3GPP TS 23.280: 7.4.2.2.12 Functional alias management client 7.4.2.2.13 Functional alias management server 7.4.2.3.2 MC service server 8.1.5 Functional Alias 10.13 Functional alias management (on-network) 10.13.2.3 Functional alias activation request 10.13.2.4 Functional alias activation response
Voice_002	Deregistration of a functional identity	Rel. 16, 3GPP TS 23.280: 7.4.2.2.12 Functional alias management client 7.4.2.2.13 Functional alias management server 7.4.2.3.2 MC service server 8.1.5 Functional Alias 10.13 Functional alias management (on-network) 10.13.2.5 Functional alias de-activation request 10.13.2.6 Functional alias de-activation response
Voice_003	Authorisation of communication	Rel. 16, 3GPP TS 23.379 annex A.3: MC PTT ID (not Functional Alias based) [R-5.6.5-003] of 3GPP TS 22.179 [2] [R-6.7.3-007] of 3GPP TS 22.280 [17]
Voice_004	Authorisation of application	Rel. 16, 3GPP TS 33.180. 5.1 User authentication and authorization 5.1.3.2.2 Using SIP REGISTER Figure 5.1.1-1: Sequence of method option: MCX authentication and authorisation steps selected: 1. IDMS management 2. SIP register
Voice_005	Multi - user talker control	Rel. 16, 3GPP TS 23.379: 7.4.2.3.5 Media distribution function 7.4.2.3.6 Media mixer 10.9.1.2.9a multi-talker floor release 10.9.1.2.10a multi-talker floor taken. [R-6.2.3.7.2-001] of 3GPP TS 22.179 [2]
Voice_006	Arbitration	Rel.16, 3GPP TS 23.379 7.4.2 Application plane of MCPTT service 10.9.1.3.2 Floor Override
Voice_008	Initiation of a voice communication from a train driver towards a train controller responsible for the train movement area	Rel. 16, 3GPP TS 23.379: 10.7 Private call 10.7.2.1.1 MCPTT private call request (MCPTT client to MCPTT server) 10.7.2.1.4 MCPTT private call response Functional Alias for called party not supported in Rel. 16 (MC Service User ID used. Location Parameter in Private call not defined on Stage 3: SIP Any Ext field used

Voice_009	Initiation of a voice communication from a train controller towards a train driver	Rel. 16, 3GPP TS 23.379: 10.7 Private call 10.7.2.1.1 MCPTT private call request (MCPTT client to MCPTT server) 10.7.2.1.4 MCPTT private call response Functional Alias for called party not supported in Rel. 16 (MC Service User ID used). Selection of client based on Dispatcher configuration
Voice_010	Initiation of a multi-train voice communication from a train driver towards train drivers and ground users	Rel. 16, 3GPP TS 23.379, Group Call 10.6.2.2 Information flows for group call in on-network. And related Group Call message chapter
Voice_21	Initiation of a multi-train voice communication from a train driver towards train drivers and ground users, using IWF	Rel. 16, 3GPP TS 23.379 7.5.2.11 Reference point IWF-1 (between the MCPTT server and the interworking function to legacy systems) TS 23.283 Mission Critical Communication Interworking with Land Mobile Radio Systems 7.4.1 Reference point IWF-1 (between the IWF and the MCPTT server 7.4.3 Reference point IWF-3 (between the IWF and the group management server)
Voice_011	Railway Emergency Call initiated by a train controller	Rel. 16, 3GPP TS 23.280 10.9 Location management (on-network) 10.9.2.1 Location reporting configuration 10.9.2.2 Location information report And all other MCX features of REC, as per Voice_22

Voice_22	Railway Emergency Call initiated by a train driver without interworking	Rel. 16, 3GPP TS 23.379 Emergency Call 10.6.2.2 Information flows for group call in on-network. 10.6.2.2.1 MCPTT emergency group call request 10.6.2.2.1a MCPTT emergency group call response And Terminate Note: Emergency Alert is also tested Client determination can use internal server rules which triggers the notification (3GPP TS 24.379 Rel. 17 Section 6.3.2.4.2 procedure which triggers 3GPP TS 24.379 Rel. 17 Section 12.1.1.4 procedure) and subsequent trigger the client-based affiliation procedure. 10.6.2.3.1.1 pre-arranged group call
Voice_012	Railway Emergency Call initiated by a train driver including interworking	REC MCX and IWF features are applied
Voice_013	Joining an ongoing Railway Emergency Call	Preconfigured group call and REC MCX features
Voice_014	Leaving an ongoing Railway Emergency Call	Preconfigured group call and REC MCX features
Voice_015	GSM-R to FRMCS system transition with service continuation	Rel. 16 3GPP TS 23.379 7.5.2.11 Reference point IWF-1 (between the MCPTT server and the interworking function to legacy systems) TS 23.283 Mission Critical Communication Interworking with Land Mobile Radio Systems 7.4.1 Reference point IWF-1 (between the IWF and the MCPTT server 7.4.3 Reference point IWF-3 (between the IWF and the group management server) and REC MCX features.

ETCS_WP3-WP5_TC_001	Nominal communication between ETCS on board application and RBC	Rel. 16 3GPP TS 23.282 5.11 IP connectivity (IPcon) capability 7.14 IP connectivity 7.14.2.1.1 MCData IPcon point-to-point request 7.14.2.1.2 MCData IPcon point-to-point response Only point to point (no group call). 5.1 Transmission and 5.2 Reception Control is not used (GRE Tunnel between clients directly)
ETCS_WP3-WP5_TC_005	Nominal communication between ETCS on board application and RBC, including BTS handover (same 5G network)	Rel. 16, 3GPP TS 23.282: 5.11 IP connectivity (IPcon) capability 7.14 IP connectivity 7.14.2.1.1 MCData IPcon point-to-point request 7.14.2.1.2 MCData IPcon point-to-point response
ETCS_WP3-WP5_TC_002	Communication between ETCS on board application and RBC (same 5G network) in degraded radio conditions	
ETCS_WP3-WP5_TC_003	Increase data transferred in the ETCS communication	
ETCS_WP3-WP5_TC_004	ETCS onboard combined with other data application	
TCMS_TC_001 (Telemetry)	Nominal communication between MCG on board application and GCG	
TCMS_TC_004 (Telemetry)	Nominal communication between MCG on board application and GCG, including BTS handover (same 5G network)	

TCMS_TC_002 (Telemetry)	Evaluate FRMCS On-Board System and impact on application with degrading radio conditions	
TCMS_TC_003 (Telemetry)	Cross border scenario with TCMS (Telemetry) or other MCData application	Depending on the implementation scenario
TCMS_RC_TC_001 (On-train remote equipment control)	Nominal communication between GCG trackside application and onboard MCG (same 5G network)	Rel. 16, 3GPP TS 23.282: 5.11 IP connectivity (IPcon) capability 7.14 IP connectivity 7.14.2.1.1 MCData IPcon point-to-point request 7.14.2.1.2 MCData IPcon point-to-point response
Video_TC_001	Streaming of video from train to trackside	
Video_TC_003	Streaming of video from train to trackside including BTS handover (same 5G network)	
Video_TC_002	Degraded communication: streaming of video from train to trackside	
CCTV_TC_001	CCTV offload from train to trackside	
CCTV_TC_002	CCTV offload from train to trackside with bearer-flex	

Table 34: Liste of 3GPP 'building blocks' per test case of WP3

16.7 Remote vision implemented as a ‘Super loose’ application in the On-board gateway.

The aim is to have in TOBA configuration file info about Remote Vision app (IPs OB and TS, Comm profile), to handle Remote Vision as an OBapp compatible application. Then at start-up, the TOBA box will:

- Establish a user plane (GRE tunnel between 2 OB and TS GTW based on IPConn) with the right DSCP value (based on com profile)
- Route the flows (IN/OUT) between Remote Vision app and TOBA GTWs both on OB and TS thru the associated GRE tunnel

In this case, the Remote Vision application would just need to know the GTW IPs. We could say that in this way, we implemented a kind of “Super loose GTW” that is embedded in the TOBA box.

16.8 Overview of French field Testbed

The following figure is a complementary view of the French testbed interconnection to WP4 lab, as presented in §2.4.7:

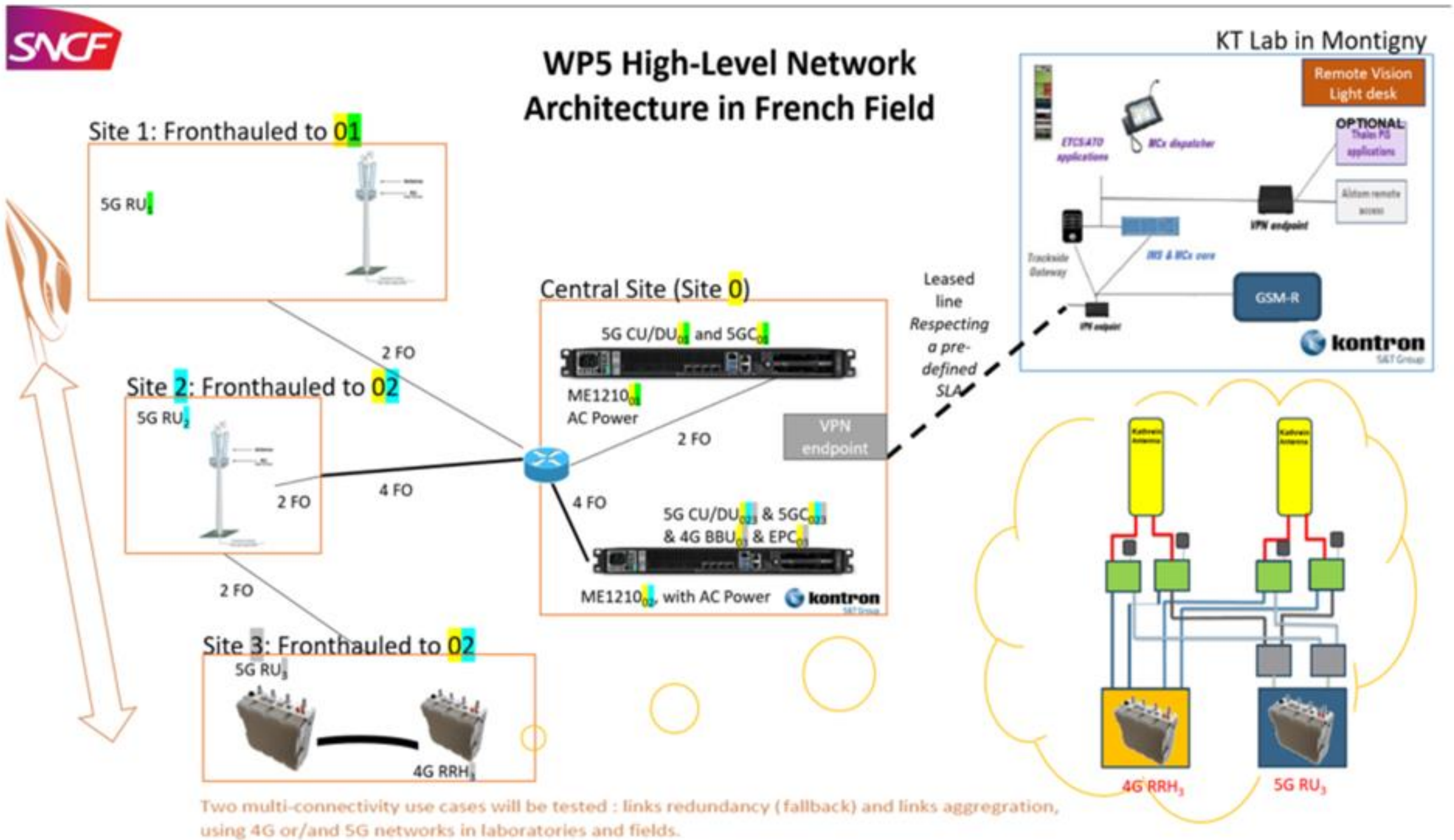


Figure 80: Overview of French field testbed

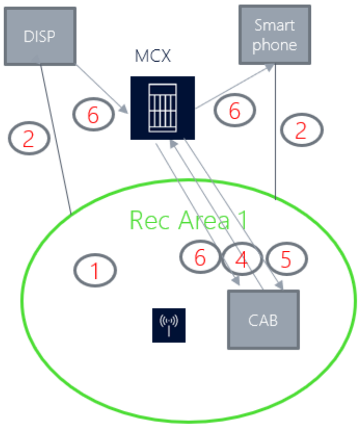
16.9 REC initiated by the controller.

REC Lab (II)
Controller initiated (LAB Only, no movement needed)

1 CAB Radio, 1 Smartphone, 1 Dispatcher.

1. Emergency Group defined related to Area 1 -> GPS Coordinates define the Area 1
2. Fixed configuration for Smartphone and Dispatcher for Group Area 1 . They do affiliation on their own
3. CAB radio with GPS Fake for Area 1
4. CAB radio sends location report in the Area 1
5. Dynamic group affiliation for CAB Radio
6. Dispatcher: Setup of MCX Emergency Call for Group Area 1 -> MCX invites also CAB radio , Smartphone

- Termination by Dispatcher



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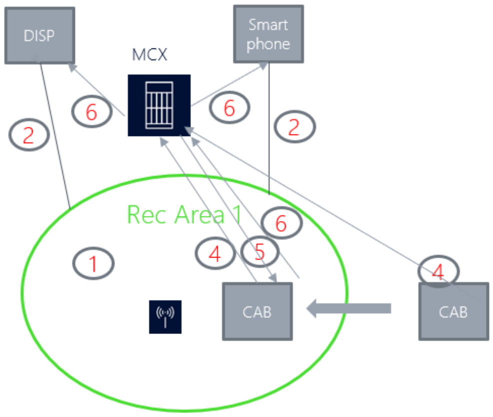
16.10 REC initiated by the cab radio.

REC Lab & Field (I)
Cab Initiated

1 CAB Radio, 1 Smartphone, 1 Dispatcher.

1. Emergency Group defined in MCX Server related to Area 1 -> GPS Coordinates define the Area 1
2. Fixed configuration for Smartphone and Dispatcher for Group Area 1 . They do affiliation on their own
3. CAB radio with GPS Fake for Area 1
4. CAB radio sends continuous location report : first out of Area, second in Area
5. Dynamic group affiliation for CAB Radio when in Area 1
6. CAB Radio : Setup of MCX Emergency Call for Group Area 1 -> MCX invites also Dispatcher, Smartphone

- Termination by Dispatcher ?



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