Deliverable D2.4

TOBA Test Report

5GRAIL

5G for future RAILway mobile communication system

D2.4 - TOBA Test Report

Due date of deliverable: 31/10/2023

Actual submission date: 30/11/2023

Leader/Responsible of this Deliverable: KONTRON / Farid BAZIZI

Reviewed: Y

Document status		
Revision	**Date**	**Description**
0.0	31/07/2022	First issue – Document skeleton
1.0	30/11/2023	Final document with lab and field test results

Project funded from the European Union's Horizon 2020 research and innovation program		
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 document *TOBA test report* is the deliverable of the work package 2 (WP2) of 5G RAIL Project. The main purpose of this document is to describe the results of the functional test case scenarios, identified in the context of the 5GRAIL, by mean of the prototype FRMCS-On Board Gateway (referred to as TOBA). The test case scenarios have been defined in the deliverable D1.1 with the aim of validating selected features and functions of FRMCS V1 specifications with respect to 5G RAIL.

Firstly, pre-integration tests have been performed for derisking in the deliverable D2.2. After derisking, the test activities have been performed in two lab environments i.e. in Budapest/Hungary (led by Nokia) and Paris/France (led by Kontron), respectively in the scope of work package 3 (WP3) and work package 4 (WP4). The field test activities have been performed in both Germany and France, in the scope of work package 5 (WP5). The 5G first reference lab in Hungary has allowed to validate the main FRMCS functionalities related to specific applications prototypes, such as ETCS, Voice, TCMS and CCTV/Video pre-integrated with the FRMCS-On Board Gateway TOBA-K (Kontron's TOBA) within WP2 scope. The 5G second reference lab in France has allowed to validate the main FRMCS functionalities related to specific application prototypes such as data, ETCS, ATO, PIS application and a minimum set for Voice pre-integrated within the TOBA. Moreover, in the lab in France, some of the data applications have been tested with both FRMCS On-Board Gateways, namely TOBA-K and TOBA-A (Alstom's TOBA). Finally, during the field tests, the prototypes already tested in the lab have been evaluated in real conditions i.e., rolling stock moving, on rail tracks with a dedicated 5G radio coverage (RMR band n39 and band n78). The TOBA-K is the FRMCS Gateway used for the field tests.

The main challenge was to address the key design paradigms for the FRMCS/5G gateways prototypes:

- Decoupling of Applications and Communication Services/Transport
- Bearer Flexibility (i.e. variety of bearers or Radio Access Technologies simultaneously)
- Resource Sharing (e.g. providing transport availability for multiple applications of any MC Service type using the same FRMCS on-board system considering the individual QoS requirements of the application and possibly priorities among applications)

Since the relevant specifications were developed in parallel with the project, the prototypes are partly based on some assumptions, that were consolidated within the 5GRAIL consortium. Besides that, additional assumptions were necessary for the description and the execution of some test cases.

On top of these assumptions, there were also technical open points that emerged naturally during the architecture elaboration. Some of the open points are in general due to FRMCS/5G specifications

gaps. All these open points have been addressed with this revision, either by considering the specification work advance, or by agreeing within the consortium assumptions. However at the end of this project, there are still some remaining open points that needs to be beared in mind, for further evolution of the prototypes (tab. 1).

Table 1: List of remaining open points

ID	D2.4 Open Point	Priority	5GRAIL status
1	**Cross border scenario** : MCX Domain management : origin, destination, migration, ...	1	Partly : Covered with a scenario using one MCx server (change of transport domain, but not service domain)
2	**TOBA Redundancy** : local, on front and back cabin, thru train "BUS", …	2	Not covered
3	**FRMCS Modem** : @900MHz with 31 dBm	1	Not covered
4	**QoS** : Dynamic 5QI, QCI	2	Partly (Static QoS)
5	**BearerFlex** : Multi-connectivity, MAMS, ATSSS, …	2	Partly
6	**OB/TS App :** Alignment with latest FFFIS	3	Partly (WebSocket vs. RESTFull)
7	**MC DATA IPConn :** alignment with latest specification (not mature), vendor interoperability	3	Partly
8	**TOBA OB and TS vendor interoperability**	3	Not covered
9	**TOBA SIP Proxying** function for Voice	1	Not resolved
10	**OBrad**	2	Not covered
11	**Train BUS : interconnection between Onboard application and Onboard FRMCS GTW**	2	Not covered
12	**FRMCS Trackside GTW architecture (in standard)**	2	Partly (TSapp, modem redundancy)
13	**Cybersecurity**	2	Partly: : TLS for local binding + TLS End2End has been done for ATO.

Abbreviations and Acronyms

Abbreviation	Description
3GPP	3rd Generation Partnership Project
5G NSA	5G Non StandAlone
5G SA	5G StandAlone
API	Application Programmable Interface
AS	Application Server
AT	ATtention
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATSSS	Access Traffic Steering, Switching and Splitting
CA	Certificate Authority
CAM	Connected and Automated Mobility
CCS	Control Command and Signalling
CCTV	Closed Circuit TeleVision
CLI	Command Line Interface
CP	Control Plane
CSCF	Call/Session Control Functions
CSFB	Circuit Switched Fall Back
DN	Domain Name
DRCS	Data Radio Communication System
DSCP	Differentiated Services Code Point
DSD	Driver Safety Device
EDOR	ETCS Data Only Radio
ETCS	European Train Control System

EU	European Union
FFFIS	Form Fit Functional Interface Specification
FIS	Functional Interface Specification
FQDN	Fully Qualified Domain Name
FRMCS	Future Railway Mobile Communication System
FRS	Functional Requirements Specification
GA	Grant Agreement
GCG	Ground Communication Gateway
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
HSS	Home Subscriber System
IMPI	IP Multimedia Private Identity
IMPU	IMS Public User Identity
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IWF	Inter Working Function
JSON	JavaScript Object Notation
MBIM	Mobile Building Information Modeling
MCG	Mobile Communication Gateway
MCx	Mission Critical
MPTCP	MultiPath Transmission Control Protocol
MNO	Mobile Network Operator

MQTT	Message Queuing Telemetry Transport
mTLS	Mutual Transport Layer Security
N3IWF	Non-3GPP Inter Working Function
NR	New Radio
NSA	Non-Stand Alone (5G Core architecture)
OB	On Board
OB_GTW	On-Board Gateway
OBA	On-Board Application (e.g. ETCS on-board, ATO on-board)
OBU	On-Board Unit
OM	Operation & Maintenance
OTA	Over The Air
OTT	Over The Top
PCB	Printed Circuit Board
PCRF	Policy and Charging Rules Function
PDN	Packet Data Network
PKI	Public Key Infrastructure
PSS	Process Safety System
QoS	Quality Of Service
RAN	Radio Access Network
RAT	Radio Access Technology
RBC	Remote Block Centre
REST	REpresentational State Transfer
RPC	Remote Procedure Call
RF	Radio Frequency
RIM	Radio Interface Management

SA	Stand Alone (5G Core architecture)
S-CSCF	Servicing-CSCF (Correspondence IMPU - @ IP)
SIP	Session Initiation Protocol
SMA	Subminiatures version A, type of coaxial RF connectors
SRS	System Requirements Specification
TCMS	Train Control Management System
TCN	Train Communication Network
TLS	Transport Layer Security
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
VPN	Virtual Private Network
WP2	Work Package 2

Abbreviation	**Description**
3GPP	3rd Generation Partnership Project
5G NSA	5G Non StandAlone
5G SA	5G StandAlone

API	Application Programmable Interface
AS	Application Server
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATSSS	Access Traffic Steering, Switching and Splitting
CA	Certificate Authority
CAM	Connected and Automated Mobility
CCS	Control Command and Signalling
CCTV	Closed Circuit TeleVision
CLI	Command Line Interface
CP	Control Plane
CSCF	Call/Session Control Functions
CSFB	Circuit Switched Fall Back
DN	Domain Name
DRCS	Data Radio Communication System
DSCP	Differentiated Services Code Point
DSD	Driver Safety Device
EDOR	ETCS Data Only Radio
ETCS	European Train Control System
EU	European Union
FFFIS	Form Fit Functional Interface Specification
FIS	Functional Interface Specification
FQDN	Fully Qualified Domain Name
FRMCS	Future Railway Mobile Communication System
FRS	Functional Requirements Specification

GA	Grant Agreement
GCG	Ground Communication Gateway
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
HSS	Home Subscriber System
IMPI	IP Multimedia Private Identity
IMPU	IMS Public User Identity
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IWF	Inter Working Function
JSON	JavaScript Object Notation
MBIM	Mobile Building Information Modeling
MCG	Mobile Communication Gateway
MCx	Mission Critical
MPTCP	MultiPath Transmission Control Protocol
MNO	Mobile Network Operator
MQTT	Message Queuing Telemetry Transport
mTLS	Mutual Transport Layer Security
N3IWF	Non-3GPP Inter Working Function
NR	New Radio
NSA	Non-Stand Alone (5G Core architecture)
OB	On Board

OB_GTW	On-Board Gateway
OBA	On-Board Application (e.g. ETCS on-board, ATO on-board)
OBU	On-Board Unit
OM	Operation & Maintenance
OTA	Over The Air
OTT	Over The Top
PCB	Printed Circuit Board
PCRF	Policy and Charging Rules Function
PDN	Packet Data Network
PKI	Public Key Infrastructure
PSS	Process Safety System
QoS	Quality Of Service
RAN	Radio Access Network
RAT	Radio Access Technology
RBC	Remote Block Centre
REST	REpresentational State Transfer
RPC	Remote Procedure Call
RF	Radio Frequency
RIM	Radio Interface Management
SA	Stand Alone (5G Core architecture)
S-CSCF	Servicing-CSCF (Correspondence IMPU - @ IP)
SIP	Session Initiation Protocol
SMA	Subminiatures version A, type of coaxial RF connectors
SRS	System Requirements Specification
TCMS	Train Control Management System

TCN	Train Communication Network
TLS	Transport Layer Security
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
VPN	Virtual Private Network
WP2	Work Package 2

Definitions

Term	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.
Loose Coupling mode	Coupling mode for an application which is not 3GPP MCx aware
Tight Coupling mode	Coupling mode for an application which is 3GPP MCx aware
Application Service	Application part responsible of the UP management
Bearer Flexibility	The FRMCS on-board system shall be capable of providing transport services using a variety of bearers (i.e. Radio Access Technologies) [FRMCS On-network communication shall support the flexible use of different radio bearers]
Channel	Specific logical or physical communication link between assets (IEC)
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.
Compliance authorities	Compliance authorities include government agencies and regulators with the legal authority to perform audits to verify compliance with governing laws and regulations (NF EN IEC 62443-4-2 Security for industrial automation and control systems - Part 4-2 : technical security requirements for IACS components, 2019-04).

Conduit	Logical grouping of communication channels that share common security requirements connecting two or more zones (IEC)
Control Plane	The control plane carries signaling traffic between the network entities.
Data communication	Exchange of information in the form of data, including video (excluding voice communication).
Domain	The highest-level group of functional entities (e.g., FRMCS is a domain, whereas PLMNs operated by different operators are administrative domains).
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.
FRMCS On-board gateway function	It is an on-board gateway function responsible for the coordination and managing of access to the FRMCS transport services offered by the FRMCS system.
FRMCS On-Board Application Client	Enables authorization of an application to the FRMCS Gateway.
FRMCS Radio Module	Modem with one or more 3GPP or/and non-3GPP radio access technologies supported by the FRMCS system.
FRMCS Service Client	Enables the use of the Communication Services and/or Complementary Services for the railway applications.
Harmonized Frequency	Harmonized communications (900 / 1900 MHz) (ETCS, ATO, Voix) Interoperability requirements
Infrastructure network	Access & core networks + MCx & IMS
Interworking	Interworking is the functionality of two networks to talk to each other enabling services to be delivered across the two networks
“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.
Network slice	A set of network functions and corresponding resources necessary to provide the required telecommunication services and network capabilities.
Non-Harmonized Frequency	Frequencies used for specific needs of infrastructure managers (telediags, data offload in stations, not for passengers). This spectrum cannot be used for interoperability

Priority service	A service that requires priority treatment based on operator policies.
Product	System, subsystem or component that is manufactured, developed or refined for use by other products (IEC 62443-4-1)
QCI (or 5QI)	A scalar that is used as a reference to a specific packet forwarding behavior (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.
Steering	Choosing the best available network based on data plan, speed, cost or latency.
Splitting	Splitting the traffic over two networks to achieve higher speeds. Networks can be combined to increase download speed, upload speed or both.
System under consideration	Defined collection of IACS assets that are needed to provide a complete automation solution, including any relevant network infrastructure assets
Switching	Moving seamlessly from one network to another. For instance, when a user leaves their home Wi-Fi network and joins the cellular network or roams from Wi-Fi hotspot to another.
Transfer interval	Time difference between two consecutive transfers of application data from an application via the service interface to 3GPP system.
Transport Service	It is a service that provides transport of user information and control signals between corresponding reference points considering the required QoS for the individual communication.

User 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.
Zone	Grouping of logical or physical assets based upon risk or other criteria, such as criticality of assets, operational function, physical or logical location, required access (for example, least privilege principles) or responsible organization (IEC)

CONTENTS

Table of figures

No table of figures entries found.

List of tables

No table of figures entries found.

1 INTRODUCTION

5GRAIL aims to demonstrate prototypes of the 5G FRMCS ecosystem and to validate the FRMCS specifications, including the compliance of railway essential operational services such as railway ETCS, ATO, Voice, TCMS, video and PIS.

This document aims to capture the final outcomes of the development and integration phase of the WP2 prototypes during the FRMCS/5G pilot tests (in labs & in the field) in WP3, WP4 and WP5.

Outcomes are classified as follow:

- **Prototyping status** of the WP2 prototypes as per as D2.1 Architecture Report: prototyped functions, limitations, workarounds, non-prototyped functions, final assumptions considered.
- **Test assessment** of WP2 prototype's functions (coverage and status)
- **Learnings** from trials on the lab and the field including new functions / topics that might be considered in the future.
- **Remaining open topics** to be covered post 5GRAIL that could be specific to the prototype (GTW or Applications) or transversal / system

2 Prototyping status

2.1 Final assumption list

Assumptions raised during the architecture phase might be confirmed or evolved: revised, canceled, partially confirmed, … The final column "Final status" aims to capture this.

ID	Owner	Technical Architecture Assumptions to support WP2 execution	Final status
1	Kontron	TOBA prototype supports connection with Loose and tight Coupled applications.	Confirmed
3	Kontron	TOBA prototype (OB and TS) supports IPv4 connections, on standard ETH socket (802.3) for OBAPP and OBOM. Only IP4 is selected to minimize complexity of implementation so that OB & TS gateways prototypes can be delivered more quickly. This assumption is mainly to reduce development duration and is acceptable for prototypes. Obviously, IPv6 is considered as a future-proof technology and will be part of the final products	Confirmed
4	Kontron Siemens	For tight coupled applications OB_{APP} and TS_{APP} interface is based on MCx framework	Confirmed
5	Siemens	Voice application will be delivered using tightly coupled approach	Confirmed
6	Siemens	The voice application will be cyber security tested in accordance with Siemens PSS process.	?
7	Siemens	Principle architecture shows dual mode coordination between GSMR & FRMCS. Assumption is this will need to be developed, with minimal coordination function. It is assumed it will be either in an GSM-R environment or FRMCS environment	Confirmed
8	Siemens	QoS management within FRMCS boundary will be common between tight and loose coupling, in the sense it will both be based on MCX. QoS is statically configured and not using dynamic MCX server request to the PCF (5G CN).	Confirmed
9	Siemens	Authentication interface will be common between tight and loose coupling	Confirmed
10	Siemens	Voice arbitration will be done at the application level. Tables 5A.1.1 Call arbitration table for incoming new calls (MI) and 5A.1.2 Call arbitration table for outgoing new calls (MI) of the EIRENE SRS v16.0.0 will be used for the 5GRail project	Confirmed
11	CAF	There will be a counterpart on the trackside equivalent to wayside for Loose Coupled approach.	Confirmed
12	CAF	As there is no decision for TCMS, TCMS and ETCS will follow the same approach for resource efficiency, using both applications the same client implementation.	Confirmed
13	CAF	Bidirectional communication between trackside and wayside is allowed.	Confirmed
14	Alstom	To enable the ETCS application (loose-coupled) to receive necessary information about the link between train and trackside and the link between gateway and	Confirmed

		EVC, the Auxiliary function is used. To monitor the link between gateway and EVC, another mechanism in OBapp API shall be used	
15	Alstom	Name resolution: TOBA gateway is responsible for sending to the application the remote IP address to be used by the application for user plane. In the session establishment request, the OB ETCS application sends the FQDN of the RBC to be joined or the RBC ID, TOBA will use this information to establish the session with the relevant TS_GTW	Confirmed We do not use the real remote IP a but a virtual IP address which is NA (mechanism presented in D2.1
16	Alstom	For on-board applications: no local authentication for the 1st prototype (in other words, OBauth will not be implemented). At the end, we suppose a local authentication using TLS within OBapp API. Valid for ETCS and ATO	Confirmed
18	Alstom	The first prototype will consider FRMCS only (no switching between FRMCS and GSM-R). Valid for ETCS and ATO	Confirmed
19	Alstom	Assumption on hold waiting for clarification: Cross-border scenario not clear yet (pure roaming? Conservation of MCData-Ipconn session?). RBCs will be reachable from any FRMCS network. Thus, at border crossing between countries A and B, ETCS application will not request to FRMCS to establish a second communication service on the network of country B before terminating the communication service on the network of country A. This refers also to the second note in TOBA_FRS chapter 7.5.2, the underlying requirements become obsolete. Valid for ETCS and ATO. This assumption is based on [S9] - UIC TOBA FRS-7510 - FRMCS Telecom On-Board System – Functional Requirements Specification (FRS) – Version 0.2.0 (Draft) – 14/04/2020. Be aware, according to chapter 7.5.1 of TOBA FRS 7510 version 1.0.12 (21/05/2021 - This document is not yet published – Not present in reference document paragraph), it should be possible to be connected to RBC in country A and RBC in country B at the same time, while the transport connection only needs to be established to a single PLMN.	Confirmed
20	Alstom	ATO and ETCS are loose-coupled applications	Confirmed
21	Alstom	Name resolution: TOBA gateway is responsible for sending to the application the remote IP address to be used by the application for user plane. In the session establishment request, the ATO-OB application sends the FQDN of the ATO-TS, TOBA will use this information to establish the session with the relevant TS_GTW	Confirmed We do not use the real remote IP a but a virtual IP address which is NA (mechanism presented in D2.1
22	Alstom	Assumption on hold waiting for clarification: Cross-border scenario not clear yet (pure roaming? Conservation of MCData-Ipconn session?). ATO-TS will be reachable from any FRMCS network. Thus, at border crossing between countries A and B, ATO-OB application can request to FRMCS to establish a second communication service to a second ATO-TS even if TOBA is not attached yet on the network of country B. In other words, the application is not responsible to request to FRMCS a change of network.	Confirmed

		This refers also to the second note in TOBA_FRS chapter 7.5.2, the underlying requirements become obsolete.	
23	Alstom	OBAUTH is a local authentication between TOBA and on-board applications, it does not rely on a trackside server. We suppose a local authentication using TLS within OBAPP API	Confirmed TLS handshake is not within the API occurs before the use of the API
24	Alstom	FRMCS will need a trackside gateway in front of TOBA (at least for loose-coupled applications)	Confirmed
26	Alstom	ETCS dev will be phased that way: - 1st phase: ETCS will support flat IP approach only - 2nd phase : ETCS will implement loose couple interface (Obapp) - 3rd phase : ETCS will implement switch-over between FRMCS and GSM-R -Flat IP approach has to be considered for ETCS trackside simulator (no implementation of Tsapp for 5GRail project)	Revised 3rd phase is not implemented f 5GRAIL
27	SNCF	Remote vision app will use flat IP only interface for 5GRail project aligned with phasing approach	Confirmed
30	Thales	PIS will need a trackside auxiliary function to interop with FRMCS service function via TSAPP	Confirmed
31	Thales	PIS prototype supports connection with Loose Coupled applications	Confirmed
32	Thales	Security requirement on Obapp / Tsapp: U_p, C_p , O&M and logs data streams from applications separation on OBAPP and TSAPP interfaces. This will be prototyped by PIS application within 5GRAIL.	Revised All data streams are not separa lab testing
33	Thales	Bidirectional communication between trackside and wayside is allowed.	Confirmed
34	Thales	For on-board PIS application: local authentication will be implemented via OBAUTH (local binding)	Canceled TLS will not be implemented in scope of 5GRail. PIS is no longe cybersecurity application demonstrator
35	Thales	For trackside PIS applications: local authentication will be implemented via TSAUTH	Canceled TLS will not be implemented in scope of 5GRail. PIS is no longe cybersecurity application demonstrator
36	Thales	Bidirectional PIS data streams to be only handled by FRMCS connectivity (not via GSM-R)	Confirmed

39	Kontron	TOBA prototype QoS will be based on static QoS flow statically provisioned by network infrastructure.	Confirmed
40	Kontron	TOBA prototypes integrate 1900MHz FRMCS 5G modem - (900MHz - currently not feasible)	Confirmed
41	Kontron Thales	TOBA prototypes integrate WIFI and 4G modem to support potential fallback/bearflex Test cases	Confirmed Both available but only 4G was for fallback.
42	UIC	5GRAIL critical applications shall make use of MCX Services	Confirmed
43	UIC	FRMCS Trackside Gateway Functions should be either implemented over a dedicated product (new H/W and S/W) or part of an existing 5GC Network Elements (new S/W only)	In case of 5GRAIL, it w dedicated product (ne H/W and S/W)
44	UIC	FRMCS Trackside Gateway Functions shall be interoperable with FRMCS Onboard Gateway (i.e., TOBA). However, this is not considered with 5GRAIL prototypes.	Confirmed
45	UIC	The Auxiliary functions (i.e., accessibility of FRMCS Service via a link status) shall be within the FRMCS boundaries	Confirmed
46	UIC	ETCS and ATO shall make use of MCData IP Connectivity (IPCONN) Service type	Confirmed
47	Alstom	The OB_GTW embeds a gnss receiver or use the gnss capabilities included in Thales modem.	Confirmed
49	Alstom	For synchro: OB GTW can use the time information from GNSS receiver for its own needs (e.g. timestamping) but at this stage there is no requirement for OB GTW to distribute time to the applications through NTP	Confirmed
50	Teleste	CCTV live streaming: IP stream is provided from onboard CCTV camera, through Video Management System (VMS). VMS is interfacing with onboard FRMCS GW through OBapp. On the trackside there is another VMS, which is interfacing through Tsapp	Confirmed
51	Teleste	Transfer of CCTV archives (i.e., CCTV offload)application shall requires QoS support from Obapp	Confirmed
52	Teleste	CCTV applications (including CCTV live streaming) are Loose coupled.	Confirmed
53	Kontron	QoS is only managed for FRMCS modem (No QoS for Wi-Fi, 4G, etc.)	
54	Alstom	The OB_GTW can obtain GNSS positioning only, but it is not responsible for a consolidated positioning (i.e., location information resulting from the combination of all positioning sources available to the FRMCS system) or its distribution to the applications. The consolidated positioning and its distribution would be performed by a dedicated on-board equipment, not in the scope of the WP2 architecture report.	Confirmed
55	Nokia	Nokia will provide 3GPP standardized connectivity between dispatcher and MC Server (as defined in 3GPP SA6 TS23.280). So dispatcher will not be connected to the TS_GW and not use TSAPP. In this implementation of tight application, TSAPP=OBAPP is not assumed anymore	Confirmed

56	Kontron	In the context of 5GRAIL, it is important to notice that bearer flexibility is managed by two gateways (OB GW & TS GW) to support multi-connectivity (i.e., multiple transport domains). Thus, bearer flex is understood as multi-connectivity (i.e., multiple transport domains) in the context of 5GRAIL and not as multiple-access domains	Confirmed
57	CAF	On TCMS and ETCS, for prototype purposes "auto_accept" mode will be used	Confirmed

2.2 FRMCS GATEWAY prototyping status

2.2.1 Kontron OB GTW and TS GTW

2.2.1.1 OB_GTW-K

Functions	Reference in D2.1	Proto status	Limitation/Workaround/Justification
OBGTW_F1.1: Provide transport services - Expose an OBAPP API to the applications for decoupling application and transport	Chap. 5.2.2.4.1	OK	
OBGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.2.2.4.2	Partial	**Solution implementation on-going**
OBGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.2.2.4.3	OK	
OBGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.2.2.4.4	OK	
OBGTW_F1.5: Provide transport services - Local binding	Chap. 5.2.2.4.5	Partial	No TLS mechanism yet. To be implemented
OBGTW_F1.6: Transport user plane data toward trackside	Chap. 5.2.2.4.6	OK	
OBGTW_F1.7: Expose session supervision to the application which request it	Chap. 05.2.2.4.7	OK	

OBGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.2.2.4.8	Partial	Access to the MCX server is enabled only after Tight couple application has successfully registered and is disable once unregistered. Further solution implementation is too complex and will not be implemented within 5GRAIL
OBGTW_F2: Support multiple modems and radio technologies	Chap. 5.2.2.4.9	OK	
OBGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.2.2.4.10	OK	
OBGTW_F5.1: Ensure O&M functions - Fault management	Chap. 5.2.2.4.11	OK	
OBGTW_F5.2: Ensure O&M functions - Performance & supervision management	Chap. 5.2.2.4.11	OK	Opennms with snmp
OBGTW_F5.3: Ensure O&M functions - Configuration management	Chap. 5.2.2.4.11	Partial	Local for the moment
OBGTW_F5.4: Ensure O&M functions - Users or groups account/profile	Chap. 5.2.2.4.11	KO	
OBGTW_F5.5: Ensure O&M functions - Expose O&M interface for local client	Chap. 5.2.2.4.12	KO	
OBGTW_F5.6: Ensure O&M functions - Expose O&M interface for remote server	Chap. 5.2.2.4.13	OK	**Opennms**
OBGTW_F6: Support roaming capabilities	Chap. 5.2.2.4.14	Partial	**For the moment, only a different 5G core with the same MCx server is covered. Solution to be finalized.**
OBGTW_F7.1: Obtain positioning and time information	Chap. 5.2.2.4.15	OK	
OBGTW_F7.2: Provide positioning information to the applications	Chap. 5.2.2.4.16	KO	

2.2.1.2 TS_GTW-K

Functions	Reference in D2.1	Proto status	Limitation/Workaround/Justification
TSGTW_F1.1: Provide transport services - Expose a TS APP API to the applications for decoupling application and transport	Chap. 5.3.2.4.1	**OK**	
TSGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.3.2.4.2	**Partial**	
TSGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.3.2.4.3	**OK**	
TSGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.3.2.4.4	**OK**	
TSGTW_F1.5: Provide transport services - Local Binding	Chap. 5.3.2.4.5	**Partial**	No TLS mechanism yet. To be implemented
TSGTW_F1.6: Transport user plane data toward on-board	Chap. 5.3.2.4.6	**OK**	
TSGTW_F1.7: Expose session supervision to the application which request it	Chap. 5.3.2.4.7	**OK**	
TSGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.3.2.4.8	Partial	Access to the MCX server is enabled only after Tight couple application has successfully registered and is disable once unregistered. Further solution implementation is too complex and will not be implemented within 5GRAIL
TSGTW_F3: Connect to multiple networks	Chap. 5.3.2.4.9	**Partial**	**Based on MPTCP solution. Solution implementation ongoing**
TSGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.3.2.4.10	**OK**	

2.2.2 Alstom OB_GTW and TS_GTW

2.2.2.1 OB_GTW-A

Functions	Reference in D2.1	Proto status	Limitation/Workaround/Justification
OBGTW_F1.1: Provide transport services - Expose an OBAPP API to the applications for decoupling application and transport	Chap. 5.2.2.4.1	OK	
OBGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.2.2.4.2	OK	Multipath at service level. A LC application is allocated to several MCx clients in the OB_GTW (one per link), and several parallel sessions are established.
OBGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.2.2.4.3	OK	Several modes implemented: - application uses OBapp and session uses MCx Framework - Application uses OBapp but MCx framework is not used - Application does not use OBapp but session automatically established (flat-IP)
OBGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.2.2.4.4	OK	Using static configuration in the Core Network. No dynamic configuration through the MCX services.
OBGTW_F1.5: Provide transport services - Local binding	Chap. 5.2.2.4.5	OK	
OBGTW_F1.6: Transport user plane data toward trackside	Chap. 5.2.2.4.6	OK	
OBGTW_F1.7: Expose session supervision to the application which request it	Chap. 5.2.2.4.7	OK	
OBGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.2.2.4.8	Partial	No proxy implemented, but tight-coupled applications can reach the MCx server directly after local registration.
OBGTW_F2: Support multiple modems and radio technologies	Chap. 5.2.2.4.9	OK	
OBGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.2.2.4.10	OK	
OBGTW_F5.1: Ensure O&M functions - Fault management	Chap. 5.2.2.4.11	OK	Through internal log files
OBGTW_F5.2: Ensure O&M functions - Performance & supervision management	Chap. 5.2.2.4.11	OK	Supervision of application, sessions and links is available on the monitoring web page, but no performance data at this stage.
OBGTW_F5.3: Ensure O&M functions - Configuration management	Chap. 5.2.2.4.11	OK	Through internal configuration file

Functions	Reference in D2.1	Proto status	Limitation/Workaround/Justification
OBGTW_F5.4: Ensure O&M functions - Users or groups account/profile	Chap. 5.2.2.4.11	OK	Through internal configuration file
OBGTW_F5.5: Ensure O&M functions - Expose O&M interface for local client	Chap. 5.2.2.4.12	OK	Monitoring web page available locally for OB_GTW
OBGTW_F5.6: Ensure O&M functions - Expose O&M interface for remote server	Chap. 5.2.2.4.13	Partial	OB GTW monitoring could be accesses remotely through http monitoring web page.
OBGTW_F6: Support roaming capabilities	Chap. 5.2.2.4.14	Partial	For the moment, only between both 5G cores with the same MCx server is covered.
OBGTW_F7.1: Obtain positioning and time information	Chap. 5.2.2.4.15	OK	Supported (embedded gnss receiver).

2.2.2.2 TS_GTW-A

Functions	Reference in D2.1	Proto status	Limitation/Workaround/Justification
TSGTW_F1.1: Provide transport services - Expose a TS APP API to the applications for decoupling application and transport	Chap. 5.3.2.4.1	OK	
TSGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.3.2.4.2	OK	Multipath at service level. A LC application is allocated to several MCx clients in the OB_GTW (one per link), and several parallel sessions are established..
TSGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.3.2.4.3	OK	
TSGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.3.2.4.4	OK	

TSGTW_F1.5: Provide transport services - Local Binding	Chap. 5.3.2.4.5	**OK**	
TSGTW_F1.6: Transport user plane data toward on-board	Chap. 5.3.2.4.6	**OK**	
TSGTW_F1.7: Expose session supervision to the application which request it	Chap. 5.3.2.4.7	**OK**	
TSGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.3.2.4.8	**Partial**	No proxy implemented, but tight-coupled applications can reach the MCx server directly after local registration.
TSGTW_F3: Connect to multiple networks	Chap. 5.3.2.4.9	**OK**	
TSGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.3.2.4.10	**OK**	

2.3 APPLICATIONS prototyping status

2.3.1 ETCS (CAF)

2.3.1.1 ETCS OB

Functions	Proto status	Limitation/Workaround/Justification
OB application Identification and authentication Request	OK	No local binding over TLS supported (optional)
OB application Identification and authentication Response	OK	No local binding over TLS supported (optional)
OB Initiating a communication service request	OK	
OB Accepting a communication service request from OB application	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.

OB Rejecting a communication service request from OB application	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
OB Ending an established communication service	OK	
OB Release association	OK	
OB Communication service information on FRMCS availability	OK	
OB FRMCS Availability Request	NA	The optional FRMCS Availability Request is not expected to be implemented in the ETCS Application.
OB Providing Specific Service	NA	The optional specific service request is not expected to be implemented in the ETCS Application.
OB asking for Specific Service Request	NA	The optional specific service request is not expected to be implemented in the ETCS Application.
OB Incoming communication Request	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
OB Accepting incoming communication	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
OB Rejecting incoming communication	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.

2.3.1.2 ETCS TS

Functions	Proto status	Limitation/Workaround/Justification
TS Identification and authentication Request	OK	Implemented and tested
TS Identification and authentication Response	OK	Implemented and tested
TS Initiating a communication service request	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.

TS Accepting a communication service request from TS application	NA	No TS-TS connections are expected for ETCS, as there is only one trackside application.
TS Rejecting a communication service request from TS application	NA	No TS-TS connections are expected for ETCS, as there is only one trackside application.
TS Ending an established communication service	NA	In nominal situations it is assumed that the EVC will end the communication service.
TS Release association (power down)	NA	In nominal situations it is assumed that the RBC will not power down when communication is ended (other EVCs might need to connect).
TS Incoming communication Request	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
TS Accepting incoming communication	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
TS Rejecting incoming communication	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.

2.3.2 TCMS (CAF)

2.3.2.1 TCMS OB

Functions	Proto status	Limitation/Workaround/Justification
OB application Identification and authentication Request	OK	No local binding over TLS supported (optional)
OB application Identification and authentication Response	OK	No local binding over TLS supported (optional)
OB Initiating a communication service request	OK	

OB Accepting a communication service request from OB application	NA	No incoming sessions are expected for TCMS-OB application. Only outgoing sessions are expected.
OB Rejecting a communication service request from OB application	NA	No incoming sessions are expected for TCMS-OB application. Only outgoing sessions are expected.
OB Ending an established communication service	OK	
OB Release association	OK	
OB Communication service information on FRMCS availability	OK	
OB FRMCS Availability Request	NA	The optional FRMCS Availability Request is not expected to be implemented in the TCMS Application.
OB Providing Specific Service	NA	The optional specific service request is not expected to be implemented in the TCMS Application.
OB asking for Specific Service Request	NA	The optional specific service request is not expected to be implemented in the TMCS Application.
OB Incoming communication Request	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
OB Accepting incoming communication	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
OB Rejecting incoming communication	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.

2.3.2.2 TCMS TS

Functions	Proto status	Limitation/Workaround/Justification
TS Identification and authentication Request	OK	Implemented and tested
TS Identification and authentication Response	OK	Implemented and tested

TS Initiating a communication service request	OK	Implemented and tested
TS Accepting a communication service request from TS application	NA	No TS-TS connections are expected for ETCS, as there is only one trackside application.
TS Rejecting a communication service request from TS application	NA	No TS-TS connections are expected for ETCS, as there is only one trackside application.
TS Ending an established communication service	NA	In nominal situations it is assumed that the TCMS will end the communication service.
TS Release association (power down)	NA	In nominal situations it is assumed that the TCMS will end the communication service.
TS Incoming communication Request	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
TS Accepting incoming communication	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
TS Rejecting incoming communication	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.

2.3.3 ATO (Alstom)

Functions	Proto status	Limitation/Workaround/Justification
(OB) Manage OBApp API (Plain websocket)	OK	
(TS) Manage TSApp API (Plain websocket)	OK	
(OB) Manage OBApp API (Websocket over TLS)	OK	**Certificate stored manually on the devices (Offline PKI)**
(TS) Manage TSApp API (Websocket over TLS)	OK	**Certificate stored manually on the devices (Offline PKI)**
(OB) Manage session establishment t**o ATO**-TS	OK	
(TS) Manage incoming sessions from ATO-OB	OK	
(OB/TS) Monitor and maintain FRMCS session	OK	
(OB/TS) Exchange applicative data through the FRMCS session	OK	
(OB/TS) Close an FRMCS session	OK	
(OB/TS) Exchange applicative data through the FRMCS session using End to End TLS	OK	**Compliant with Subset-137**

2.3.4 ETCS (Alstom)

Functions	Proto status	Limitation/Workaround/Justification
Open and monitor Websocket between ETCS application and OB_GW	OK	Plain websocket is used (no TLS)
Manage OBapp API: FRMCS_GTW_REGISTER : allow the ETCS application to register to the FRMCS OB_GTW . FRMCS_GTW_SERVICE_REQUEST: allows the application to ask for some specific FRMCS services, such as connection status **FRMCS_GTW_SESSION_START : allow the ETCS application to request a session establishment to join a trackside equipment (RBC).** **FRMCS_GTW_SESSION_END : allow the ETCS application to close an established session.** **FRMCS_APP_SESSION_STATUS_CHANGED: FRMCS OB_GTW informs the ETCS application that there are some changes on the session status (link failure, quality change, session closed from the other side, …)**	OK	
Applicative communication (ETCS-RBC) over dedicated FRMCS session	OK	
RBC handover (no cross border) : Applicative communications (ETCS-RBC) over dedicated FRMCS sessions	OK	
RBC handover (cross border) : Applicative communications (ETCS-RBC) over dedicated FRMCS sessions	OK	

2.3.5 CCTV

2.3.5.1 CCTV OB

Functions	Reference in D2.1	Proto status	Justification/Result/Comment
OB application Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	Implemented and partially tested. Handling of "already registered" response needs to be reviewed.
OB application Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	Implemented and tested
OB Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	Implemented and tested
OB Accepting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	Implemented and tested. Session answer messages were received from TOBA.
OB Rejecting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	Not tested. No reject messages were received from TOBA.
OB Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	Not tested, Lab is not ready (TOBA).
OB Release association (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	Pending	Not implemented. Application is designed for continuous operation. Needs to be reviewed.
OB Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	Implemented. Partially tested. Only "trying" status was received. No working status received.
OB FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	Implemented. Not tested as of above.
OB Providing Specific Service (FRMCS_APP_SERVICE_RESPONSE)	?	NA	N/A
OB asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	Not tested.
OB Incoming communication Request (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A
OB Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A

OB Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A

2.3.5.2 CCTV TS

Functions	Reference in D2.1	Proto status	Justification/Result/Comment
TS Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	Implemented and partially tested. Handling of "already registered" response needs to be reviewed.
TS Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	Implemented and tested
TS Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	Implemented and tested
TS Accepting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	Implemented and tested. Session answer messages were received from TOBA.
TS Rejecting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	Not tested. No reject messages were received from TOBA.
TS Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	Not tested, Lab is not ready (TOBA).
TS Release association (power down) (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	Pending	Not implemented. Application is designed for continuous operation. Needs to be reviewed.

TS Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	Implemented. Partially tested. Only "trying" status was received. No working status received.
TS FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	Implemented. Not tested as of above.
TS asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	Implemented. Not tested
TS Incoming communication Request(FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A
TS Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A
TS Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A

2.3.6 PIS

2.3.6.1 PIS OB

Functions	Reference in D2.1	Proto status	Limitation/Workaround/Justification
OB application Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	No local binding over TLS supported (optional)

OB application Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	No local binding over TLS supported (optional)
OB Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	
OB Accepting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	
OB Rejecting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	
OB Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	
OB Release association (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	OK	
OB Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	
OB FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	
OB Providing Specific Service (FRMCS_APP_SERVICE_RESPONSE)	?	NA	Not applicable to PIS application
OB asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	
OB Incoming communication Request (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	
OB Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	
OB Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	

2.3.6.2 PIS TS

Functions	Reference in D2.1	Proto status	Limitation/Workaround/Justification

TS Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	No local binding over TLS supported (optional)
TS Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	No local binding over TLS supported (optional)
TS Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	
TS Accepting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	
TS Rejecting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	
TS Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	
TS Release association (power down) (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	OK	
TS Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	
TS FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	
TS asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	
TS Incoming communication Request(FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	
TS Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	
TS Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	

2.3.7 VOICE (Siemens)

Functions	Reference to D2.1	Proto status	Limitation/Workaround/Justification
OB application identification and authentication - Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.6.3.1	OK	
OB application identification and authentication – Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.6.3.1	OK	
OB Release association (FRMCS_GTW_DEREGISTER)	Chap. 6.2.6.3.2	OK	
OB application asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.6.3.3	NA	This optional Specific Service Request is not expected to be implemented for the 5Grail project.

3 Test results

3.1 FRMCS GATEWAY

3.1.1 Kontron OB_GTW and TS_GTW

3.1.1.1 OB_GTW-K

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
OBGTW_F1.1: Provide transport services - Expose an OBAPP API to the applications for decoupling application and transport	Chap. 5.2.2.4.1	OK	OK	

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
OBGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.2.2.4.2	OK	OK LAB TBC FIELD	Tested only for TCP application flow as based on MPTCP
OBGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.2.2.4.3	OK	OK	
OBGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.2.2.4.4	OK	OK	
OBGTW_F1.5: Provide transport services - Local binding	Chap. 5.2.2.4.5	Partial	OK	Tested except for TLS in restriction
OBGTW_F1.6: Transport user plane data toward trackside	Chap. 5.2.2.4.6	OK	OK	
OBGTW_F1.7: Expose session supervision to the application which request it	Chap. 05.2.2.4.7	OK	OK	
OBGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.2.2.4.8	Partial	OK	Tested in WP3 with VOICE application
OBGTW_F2: Support multiple modems and radio technologies	Chap. 5.2.2.4.9	OK	OK	Tested with 5G (N8, N78, N39) and 4G (N38)
OBGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.2.2.4.10	OK	OK	
OBGTW_F5.1: Ensure O&M functions - Fault management	Chap. 5.2.2.4.11	OK	NA	No specific test related to it, but used during demo to visualize sessions.

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
OBGTW_F5.2: Ensure O&M functions - Performance & supervision management	Chap. 5.2.2.4.11	**Partial**	**NA**	No specific test related to it, but it is used for every test session
OBGTW_F5.3: Ensure O&M functions - Configuration management	Chap. 5.2.2.4.11	**Partial**	**NA**	No specific test related to it, but it is used for every test session
OBGTW_F5.4: Ensure O&M functions - Users or groups account/profile	Chap. 5.2.2.4.11	**Partial**	**NA**	No specific test related to it, but it is used for every test session
OBGTW_F5.5: Ensure O&M functions - Expose O&M interface for local client	Chap. 5.2.2.4.12	**OK**	**NA**	No specific test related to it, but it is used for every test session
OBGTW_F5.6: Ensure O&M functions - Expose O&M interface for remote server	Chap. 5.2.2.4.13	**OK**	**NA**	No specific test related to it, but it is used for every test session
OBGTW_F6: Support roaming capabilities	Chap. 5.2.2.4.14	**Partial**	**OK**	Tested as per as cross border scenario with 1 UE (only with 2 core)
OBGTW_F7.1: Obtain positioning and time information	Chap. 5.2.2.4.15	**OK**	**NA**	No specific test related to it, but it is used for every test session
OBGTW_F7.2: Provide positioning information to the applications	Chap. 5.2.2.4.16	**OK**	**NA**	No specific test related to it, but it is used for every test session

3.1.1.2 TS_GTW-K

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
TSGTW_F1.1: Provide transport services - Expose a TS APP API to the applications for decoupling application and transport	Chap. 5.3.2.4.1	**OK**	**OK**	
TSGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.3.2.4.2	**OK**	**OK LAB** **NOT TESTED IN FIELD**	Tested only for TCP application flow as based on MPTCP in LAB. However, we could'nt get condition to test it on field.
TSGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.3.2.4.3	**OK**	**OK**	
TSGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.3.2.4.4	**OK**	**OK**	
TSGTW_F1.5: Provide transport services - Local Binding	Chap. 5.3.2.4.5	**Partial**	**OK**	Tested except for TLS in restriction
TSGTW_F1.6: Transport user plane data toward on-board	Chap. 5.3.2.4.6	**OK**	**OK**	
TSGTW_F1.7: Expose session supervision	Chap. 5.3.2.4.7	**OK**	**OK**	

to the application which request it				
TSGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.3.2.4.8	**Partial**	**NA**	No tight coupling application on TS in 5GRAIL context (Dispatcher directly connected to MCX Server)
TSGTW_F3: Connect to multiple networks	Chap. 5.3.2.4.9	**OK**	**OK**	
TSGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.3.2.4.10	**OK**	**OK**	

3.1.2 Alstom OB_GTW and TS_GTW

3.1.2.1 OB_GTW-A

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
OBGTW_F1.1: Provide transport services - Expose an OBAPP API to the applications for decoupling application and transport	Chap. 5.2.2.4.1	**OK**	**OK**	
OBGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.2.2.4.2	**OK**	**OK**	Multipath not tested with sessions initiated by Trackside, only initiated by On-board
OBGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.2.2.4.3	**OK**	**OK**	

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
OBGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.2.2.4.4	OK	OK	
OBGTW_F1.5: Provide transport services - Local binding	Chap. 5.2.2.4.5	OK	OK	Successfully tested with Alstom ATO application. Certificates locally stored
OBGTW_F1.6: Transport user plane data toward trackside	Chap. 5.2.2.4.6	OK	OK	
OBGTW_F1.7: Expose session supervision to the application which request it	Chap. 05.2.2.4.7	OK	OK	
OBGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.2.2.4.8	Partial	NA	Not expected in WP4
OBGTW_F2: Support multiple modems and radio technologies	Chap. 5.2.2.4.9	OK	OK	Tested with 5G, 4G and Wi-Fi
OBGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.2.2.4.10	OK	OK	
OBGTW_F5.1: Ensure O&M functions - Fault management	Chap. 5.2.2.4.11	Partial	NA	No specific test related to it, since it is using an internal log file
OBGTW_F5.2: Ensure O&M functions - Performance & supervision management	Chap. 5.2.2.4.11	Partial	Partial	Not tested in WP4 lab, but tested internally.
OBGTW_F5.3: Ensure O&M functions - Configuration management	Chap. 5.2.2.4.11	OK	NA	No specific test related to it, since it is using an internal log file

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
OBGTW_F5.4: Ensure O&M functions - Users or groups account/profile	Chap. 5.2.2.4.11	Partial	NA	No specific test related to it, since it is using an internal log file
OBGTW_F5.5: Ensure O&M functions - Expose O&M interface for local client	Chap. 5.2.2.4.12	OK	Partial	Not expected to be tested in WP4 lab, but tested internally.
OBGTW_F5.6: Ensure O&M functions - Expose O&M interface for remote server	Chap. 5.2.2.4.13	Partial	NA	
OBGTW_F6: Support roaming capabilities	Chap. 5.2.2.4.14	Partial	OK	border-crossing scenario tested using 2 modems
OBGTW_F7.1: Obtain positioning and time information	Chap. 5.2.2.4.15	OK	NA	Not expected to be tested in WP4

3.1.2.2 TS_GTW-A

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
TSGTW_F1.1: Provide transport services - Expose a TS APP API to the applications for decoupling application and transport	Chap. 5.3.2.4.1	OK	OK	
TSGTW_F1.2: Provide transport services - Multipath (bearer flexibility, resilience, aggregation)	Chap. 5.3.2.4.2	OK	OK	Multipath not tested with sessions initiated by Trackside, only initiated by On-board

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
TSGTW_F1.3: Provide transport services - Session management for loose-coupled applications	Chap. 5.3.2.4.3	**OK**	**OK**	
TSGTW_F1.4: Provide transport services - Provide to the application the required communication attributes	Chap. 5.3.2.4.4	**OK**	**OK**	
TSGTW_F1.5: Provide transport services - Local Binding	Chap. 5.3.2.4.5	**OK**	**OK**	Tested with ATO application. Certificates locally stored
TSGTW_F1.6: Transport user plane data toward on-board	Chap. 5.3.2.4.6	**OK**	**OK**	
TSGTW_F1.7: Expose session supervision to the application which request it	Chap. 5.3.2.4.7	**OK**	**OK**	
TSGTW_F1.8: Session proxying for tight-coupled applications	Chap. 5.3.2.4.8	**Partial**	**NA**	
TSGTW_F3: Connect to multiple networks	Chap. 5.3.2.4.9	**OK**	**OK**	
TSGTW_F4: Authenticate/authorize access to the FRMCS service level.	Chap. 5.3.2.4.10	**OK**	**OK**	

3.2 APPLICATIONS

3.2.1 ETCS (CAF)

3.2.1.1 ETCS OB

Functions	Proto status	Test status	Limitation/Workaround/Justification
OB application Identification and authentication Request	OK	OK	No local binding over TLS supported (optional)
OB application Identification and authentication Response	OK	OK	No local binding over TLS supported (optional)
OB Initiating a communication service request	OK	OK	If communication service request was performed right after the FRMCS_GTW_REGISTER answer, the FRMCS GW failed in the communication establishment. (See chapter 4.2.1 for more information)
OB Accepting a communication service request from OB application	NA	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
OB Rejecting a communication service request from OB application	NA	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
OB Ending an established communication service	OK	OK	
OB Release association	OK	OK	
OB Communication service information on FRMCS availability	OK	OK	
OB FRMCS Availability Request	NA	NA	The optional FRMCS Availability Request is not expected to be implemented in the ETCS Application.
OB Providing Specific Service	NA	NA	The optional FRMCS Availability Request is not expected to be implemented in the ETCS Application.

OB asking for Specific Service Request	NA	NA	The optional specific service request is not expected to be implemented in the ETCS Application.
OB Incoming communication Request	NA	NA	The optional specific service request is not expected to be implemented in the ETCS Application.
OB Accepting incoming communication	NA	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
OB Rejecting incoming communication	NA	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
			No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.

3.2.1.2 ETCS TS

Functions	Proto status	Test status	Limitation/Workaround/Justification
TS Identification and authentication Request	OK	OK	No local binding over TLS supported (optional)
TS Identification and authentication Response	OK	OK	No local binding over TLS supported (optional)
TS Initiating a communication service request	NA	NA	No incoming sessions are expected for ETCS-OB application. According to Subset-026 3.6.0, only outgoing sessions are expected.
TS Accepting a communication service request from TS application	NA	NA	No TS-TS connections are expected for ETCS, as there is only one trackside application.
TS Rejecting a communication service request from TS application	NA	NA	No TS-TS connections are expected for ETCS, as there is only one trackside application.
TS Ending an established communication service	OK	NA	In nominal situations it is assumed that the EVC will end the communication service.
TS Release association (power down)	OK	NA	In nominal situations it is assumed that the RBC will not power down when communication is ended (other EVCs might need to connect).

TS Incoming communication Request	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
TS Accepting incoming communication	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
TS Rejecting incoming communication	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.

3.2.2 TCMS (CAF)

3.2.2.1 TCMS OB

Functions	Proto status	Test status	Limitation/Workaround/Justification
OB application Identification and authentication Request	OK	OK	No local binding over TLS supported (optional)
OB application Identification and authentication Response	OK	OK	No local binding over TLS supported (optional)
OB Initiating a communication service request	OK	OK	
OB Accepting a communication service request from OB application	NA	NA	No incoming sessions are expected for TCMS-OB application. Only outgoing sessions are expected.
OB Rejecting a communication service request from OB application	NA	NA	No incoming sessions are expected for TCMS-OB application. Only outgoing sessions are expected.
OB Ending an established communication service	OK	Pending	Implemented. Not tested.
OB Release association	OK	Pending	Implemented. Not tested.
OB Communication service information on FRMCS availability	OK	OK	
OB FRMCS Availability Request	NA	NA	The optional FRMCS Availability Request is not expected to be implemented in the TCMS Application.
OB Providing Specific Service	NA	NA	The optional FRMCS Availability Request is not expected to be implemented in the TCMS Application.

OB asking for Specific Service Request	NA	NA	The optional specific service request is not expected to be implemented in the TCMS Application.
OB Incoming communication Request	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
OB Accepting incoming communication	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
OB Rejecting incoming communication	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.

3.2.2.2 TCMS TS

Functions	Proto status	Test status	Limitation/Workaround/Justification
TS Identification and authentication Request	OK	OK	No local binding over TLS supported (optional)
TS Identification and authentication Response	OK	OK	No local binding over TLS supported (optional)
TS Initiating a communication service request	OK	OK	
TS Accepting a communication service request from TS application	NA	NA	No TS-TS connections are expected for TCMS, as there is only one trackside application.
TS Rejecting a communication service request from TS application	NA	NA	No TS-TS connections are expected for TCMS, as there is only one trackside application.
TS Ending an established communication service	OK	Partial	Implemented. Not tested.
TS Release association (power down)	OK	Partial	Implemented. Not tested.
TS Incoming communication Request	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.
TS Accepting incoming communication	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.

TS Rejecting incoming communication	NA	NA	Not applicable as “auto_accept” is used. The acceptance or refusal of the connection will be done at application level.

3.2.3 ATO (Alstom)

Functions	Proto status	Test status	Justification/Result/Comment
(OB) Manage OBApp API (Plain websocket)	OK	OK	
(TS) Manage TSApp API (Plain websocket)	OK	OK	
(OB) Manage OBApp API (Websocket over TLS)	OK	OK	
(TS) Manage TSApp API (Websocket over TLS)	**OK**	OK	
(OB) Manage session establishment to ATO-TS	OK	OK	
(TS) Manage incoming sessions from ATO-OB	OK	OK	
(OB/TS) Monitor and maintain FRMCS session	OK	OK	
(OB/TS) Exchange applicative data through the FRMCS session	OK	OK	
(OB/TS) Close an FRMCS session	OK	OK	
(OB/TS) Exchange applicative data through the FRMCS session using End to End TLS	OK	OK	

3.2.4 ETCS (Alstom)

Functions	Proto status	Test status	Limitation/Workaround/Justification
Open and monitor Websocket between ETCS application and OB_GW	OK	OK	Plain websocket has been tested.
Manage OBapp API:	OK	OK	

FRMCS_GTW_REGISTER : allow the ETCS application to register to the FRMCS OB_GTW . FRMCS_GTW_SERVICE_REQUEST: allows the application to ask for some specific FRMCS services, such as connection status FRMCS_GTW_SESSION_START : allow the ETCS application to request a session establishment to join a trackside equipment (RBC). FRMCS_GTW_SESSION_END : allow the ETCS application to close an established session. FRMCS_APP_SESSION_STATUS_CHANGED: FRMCS OB_GTW informs the ETCS application that there are some changes on the session status (link failure, quality change, session closed from the other side, …)			
Applicative communication (ETCS-RBC) over dedicated FRMCS session	OK	OK	
RBC handover (no cross boarder) : Applicative communications (ETCS-RBC) over dedicated FRMCS sessions	OK	OK	
RBC handover (cross boarder) : Applicative communications (ETCS-RBC) over dedicated FRMCS sessions	OK	OK	OK with TOBA-A NOK with TOBA-K (partially working)

3.2.5 CCTV

TOBA setup requires 2x MCx clients for CCTV.

3.2.5.1 CCTV OB

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment

OB application Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	OK	Implemented and tested
OB application Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	OK	Implemented and tested
OB Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	OK	Implemented and tested
OB Accepting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	OK	Implemented and tested.
OB Rejecting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	Not tested	Not tested.
OB Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	N/A	Not tested. Application is designed for continuous operation.
OB Release association (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	Pending	Not tested	Not tested. Application is designed for continuous operation.
OB Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	OK	
OB FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	OK	
OB Providing Specific Service (FRMCS_APP_SERVICE_RESPONSE)	?	NA	N/A	N/A
OB asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	Not tested	Not tested.
OB Incoming communication Request (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A	N/A
OB Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A	N/A
OB Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	NA	N/A

3.2.5.2. CCTV TS

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
TS Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	OK	Implemented and tested
TS Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	OK	Implemented and tested
TS Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	OK	Implemented and tested
TS Accepting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	OK	Implemented and tested.
TS Rejecting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	Not tested	Not tested.
TS Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	Not tested	Not tested. Application is designed for continuous operation.
TS Release association (power down) (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	Pending	Not tested	Not tested. Application is designed for continuous operation.
TS Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	OK	Implemented and tested.
TS FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	OK	Implemented and tested.
TS asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	Not tested	Not tested
TS Incoming communication Request (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A	N/A
TS Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A	N/A
TS Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	N/A	N/A	N/A

3.2.6 PIS

3.2.6.1 PIS OB

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
OB application Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	Partial	No local binding over TLS supported (optional) Register in “not_auto” mode not tested
OB application Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	OK	No local binding over TLS supported (optional)
OB Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	OK	
OB Accepting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	OK	
OB Rejecting a communication service request from OB application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	OK	
OB Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	NA	Not applicable because OB offloading logs is continuous
OB Release association (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	OK	OK	
OB Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	OK	
OB FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	OK	
OB Providing Specific Service (FRMCS_APP_SERVICE_RESPONSE)	?	NA	NA	Not applicable to PIS application
OB asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	OK	
OB Incoming communication Request (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	NA	Not tested

OB Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	NA	Not tested
OB Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	NA	Not tested

3.2.6.2 PIS TS

Functions	Reference in D2.1	Proto status	Test status	Justification/Result/Comment
TS Identification and authentication Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.5.4.1	OK	OK	No local binding over TLS supported (optional)
TS Identification and authentication Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.5.4.1	OK	OK	No local binding over TLS supported (optional)
TS Initiating a communication service request (FRMCS_GTW_SESSION_START Request)	Chap. 6.2.5.4.3	OK	OK	
TS Accepting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	OK	
TS Rejecting a communication service request from TS application (FRMCS_GTW_SESSION_START Answer)	Chap. 6.2.5.4.3	OK	NA	Not tested
TS Ending an established communication service (FRMCS_GTW_SESSION_END)	Chap. 6.2.5.4.4	OK	OK	
TS Release association (power down) (FRMCS_GTW_DEREGISTER)	Chap. 6.2.5.4.2	OK	OK	
TS Communication service information on FRMCS availability (FRMCS_APP_SESSION_STATUS_CHANGED)	Chap. 6.2.5.4.9	OK	Partial	Delete session from TOBA-GW is not working.
TS FRMCS Availability Request (FRMCS_GTW_SESSION_STATUS)	Chap. 6.2.5.4.5	OK	OK	
TS asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.5.4.6	OK	OK	

TS Incoming communication Request(FRMCS_APP_INCOMING_SESSION_ REQ)	Chap. 6.2.5.4.7	OK	OK	
TS Accepting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	OK	
TS Rejecting incoming communication (FRMCS_APP_INCOMING_SESSION_REQ)	Chap. 6.2.5.4.7	OK	NA	

3.2.7 VOICE (Siemens)

Functions	Reference to D2.1	Proto status	Test status	Limitation/Workaround/Justification
OB application identification and authentication - Request (FRMCS_GTW_REGISTER Request)	Chap. 6.2.6.3.1	OK	OK	
OB application identification and authentication – Response (FRMCS_GTW_REGISTER Response)	Chap. 6.2.6.3.1	OK	OK	
OB Release association (FRMCS_GTW_DEREGISTER)	Chap. 6.2.6.3.2	OK	OK	
OB application asking for Specific Service Request (FRMCS_GTW_SERVICE_REQUEST)	Chap. 6.2.6.3.3	NA	NA	This optional Specific Service Request is not implemented.

4 Learnings

4.1 FRMCS GATEWAY

4.1.1 API naming and symmetry between OB and TS

There is no reason to differentiate OBapp and TSapp API (same service, same parameters exchanged…).

Hence the specification of the API shall be common for both OBapp and TSapp and must not contain any parameter or function name that reflects “On-board” or “Trackside” context. Then, the API software could be used for both On-board or trackside gateway, or for both on-board or trackside application.

It is the case in 5GRAIL OBapp/TSapp definition (see D2.1), but it is not the case in UIC FFFIS (see [S10]), which defines OBapp API. For example:

- One of the API message is named “FRMCS_EVENT_STREAM_OPENING_ON-BOARD_FRMCS_ANSWER” (see 9.3.2 of FFFIS). This could be named instead: “FRMCS_EVENT_STREAM_OPENING_GTW_FRMCS_ANSWER”, and then would be valid for both OB and TS. There are several other similar examples.
- One of the API parameters is named “Application On-board identifier” (see 9.4 in FFFIS), and written “appOBId” in the ASN.1 description. Again, there is no reason to have a distinction between On-Board and Trackside.

To sum up, the API definition in the FFFIS should be thought to be applied for both OB_GTW and TS_GTW.

Additionally, the name of the API itself should be valid for both OB and TS, with a common name such as “FRapp API” (FRMCS applications API), “RCSapp API” (Railways Communication System applications API) or “GWapp” API (Gateway – applications API), instead of OBapp API or TSapp API.

4.1.2 Multipath (Alstom)

Alstom implemented a multipath at service layer (several MCdata-IPconn sessions established on the different links), as explained in D2.1 (chapter related to the Alstom multipath implementation).

Several ways have been tested, but they also depend on what is supported by the MCX server/SIP core.

A first idea was to use SIP forking, which allows a SIP UA to be registered with different IP addresses; and when a call is directed to this UA, all the registered IP addresses receives the SIP INVITE message. The underlying mechanism is represented in the below diagrams: registration phase using two links and expected behavior for a session establishment.

Registration phase

- Notion of « link »: the OB_GTW shall register a client through several links

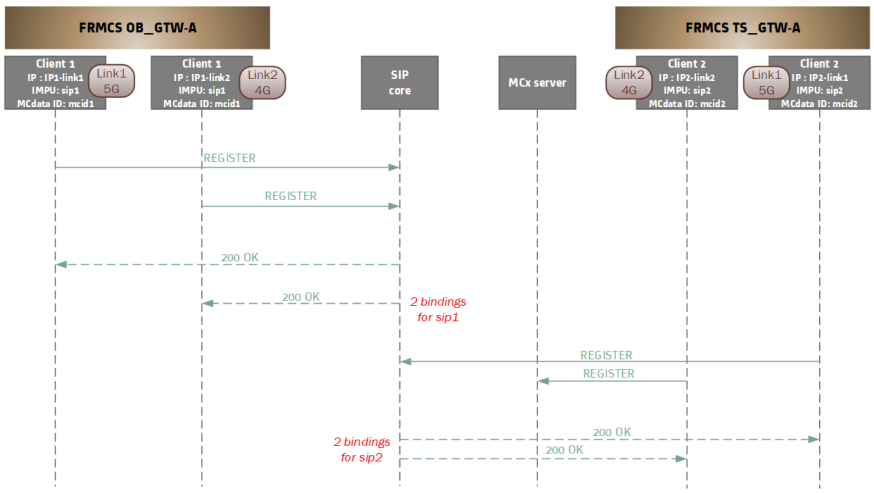

Figure 1: Registration phase - solution using SIP forking

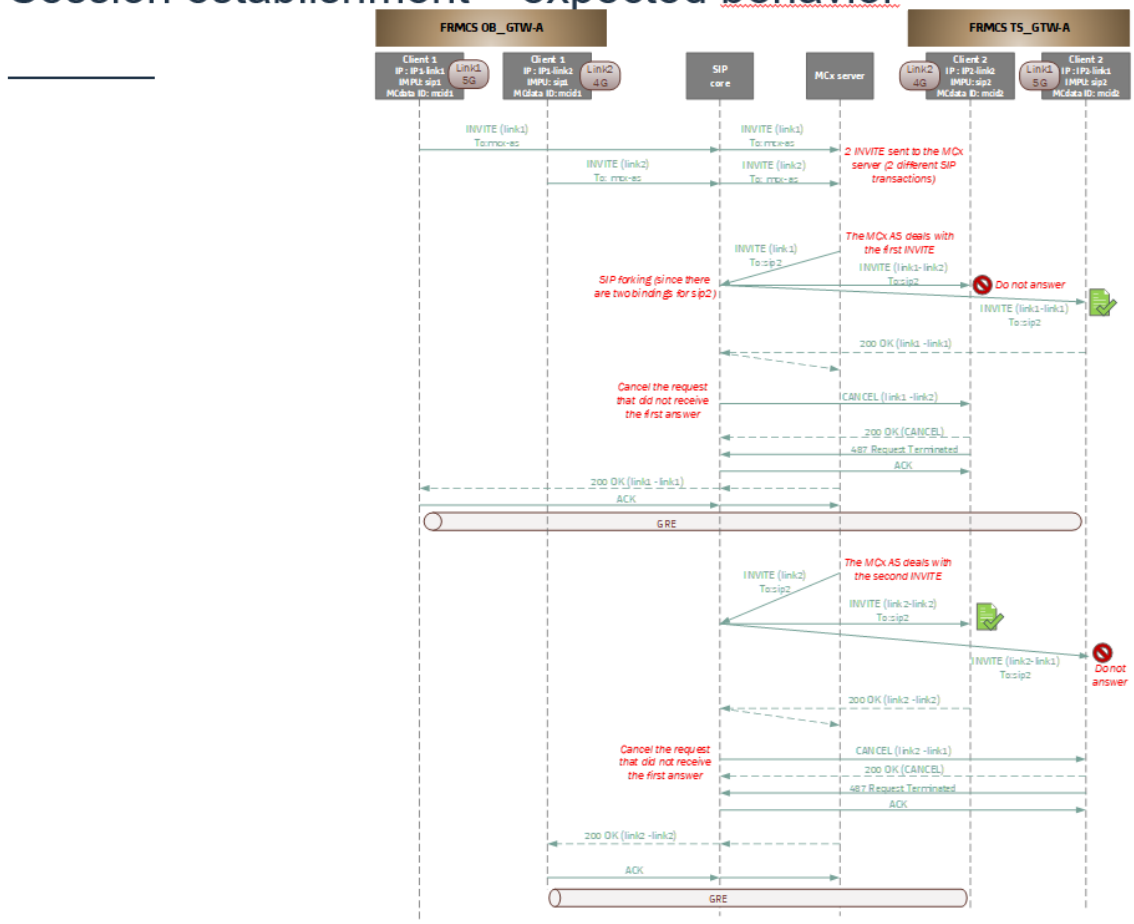

Figure 2: Session establishment - solution using SIP forking

The issue is that the MCX server used in WP4 does not support two parallel sessions between the same pair of MCdata clients. Then, the second 200 OK answer is never received on the initiator side (OB_GTW), because not sent by the MCX server.

Consequently, a second solution making use of two different pairs of MC and SIP identities were used (one pair for each link). Hence, the two parallel sessions are allowed by the MCX server because they involve two different pairs of MCx clients. This solution works, the only drawback compared with the SIP forking solution is more complexity to configure SIP and MCX identities (more identities to be used).

Hence, depending on the solution choice for an interoperable multipath usage, the underlying constraints on the MCX server/SIP core shall be well defined. For example, with the first solution

above, support of SIP forking by SIP core and support of several sessions between the same pair of MCx clients by the MCX server are required.

4.1.3 Multipath (Kontron)

The Kontron's multipath solution, in the scope of 5GRail project, is based on the MPTCP protocol.

To be able to open the two links needed to manage the multipath, and taking into account the MCx server limitations of not being able to manage two sessions for the same pair of MCx clients, it has been decided to duplicate the MCx Client for a given application.

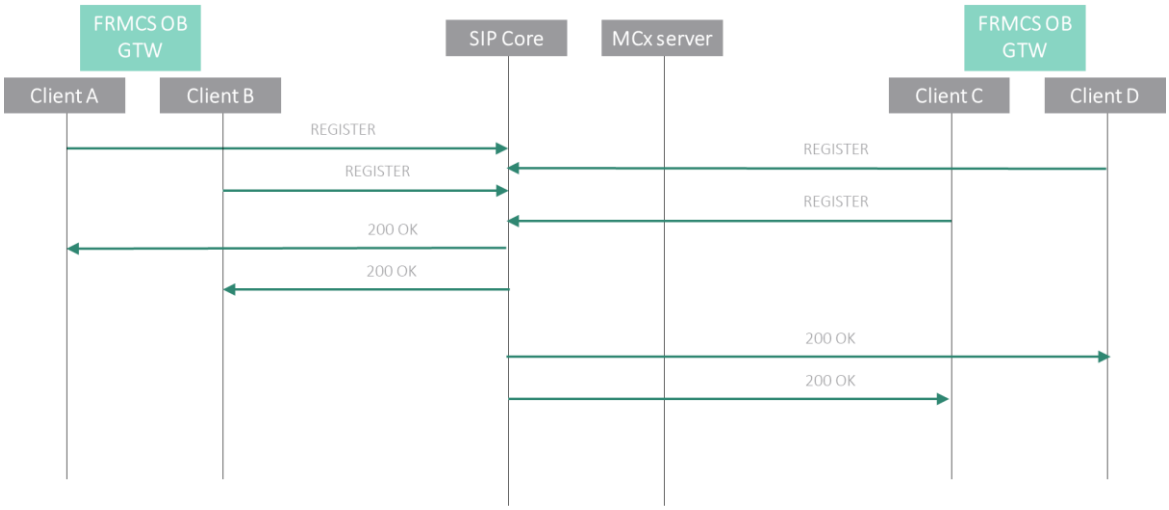

Figure 3: Multipath registration

At the reception of a start sessions, one SIP Invite and one GRE Tunnel are managed per MCx client as shown on the figure below.

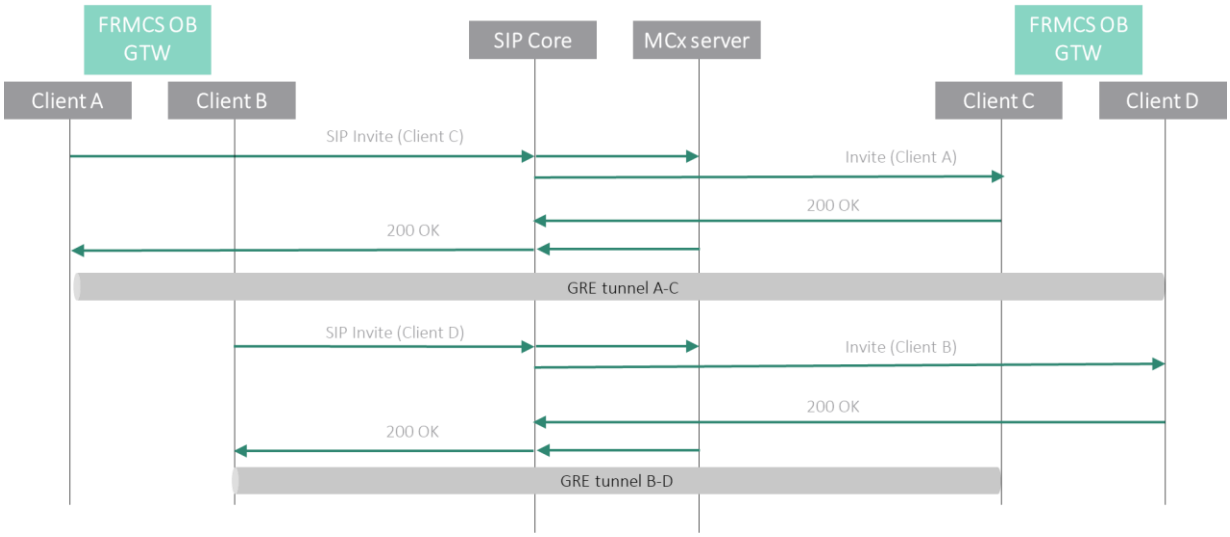

Figure 4: Multipath session opening

As stated by Alstom in chapter **Error! Reference source not found.**, to avoid duplication of the MCx Clients for the same application, it would be necessary to update the MCx server and the SIP core so that they will support multi session for a given pair of MCx Clients.

4.1.4 API improvements

Few minor improvements could be performed in the API definition, such as:

- In the REGISTER method, the parameter application_type should be a string (ETCS, ATO, ..) instead of an integer, for a better readability.
- In the REGISTER method, we could add a parameter to say if the originator_id is absolute or relative, depending on the ability of the application to have a globally unique originator_id or if the OB_GTW has to add a part to make it unique.. An absolute originator_id could be used directly by the OB_GTW to build the FRMCS identifiers (e.g. MCX/SIP identities); whereas relative originator_id could be completed with a suffix (such as identification of the train) before building FRMCS identifiers (e.g. MCX/SIP identities) NOTE: this point depends on the addressing requirements which are FFS in the UIC SRS specification.

WebSocket protocol is well adapted to the OBapp API and the use of notifications.

4.1.5 Registration dependencies on MCX services/Bearer availability

In the current implementation of the FRMCS_GTW_REGISTER message is used to guarantee a local registration of the application. This means that the answer of this FRMCS_GTW_REGISTER is instantaneous and does not reflect neither the status of the corresponding MCx client registration nor the bearer availability.

The consequence of this implementation is that the application has to implement a periodic FRMCS_GTW_SERVICE_STATUS request to be sure that it is connected before starting a session, as described in figure 3.

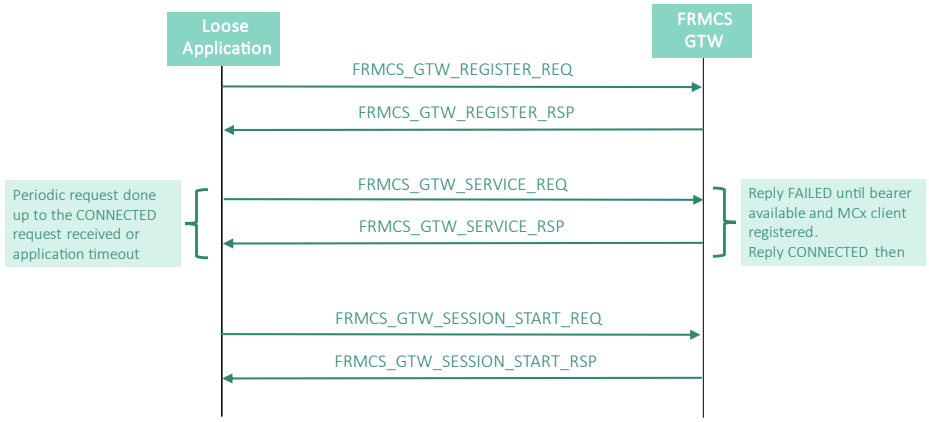

Figure 5: Current application registration

Lesson learned:

In order to avoid having a specific mechanism at application level it should have been better to ask the FRMCS OB GTW to manage the different step of the synchronization between the Application requests and the MCX/bearer status. The behavior in this case is highlighted in figure 4.

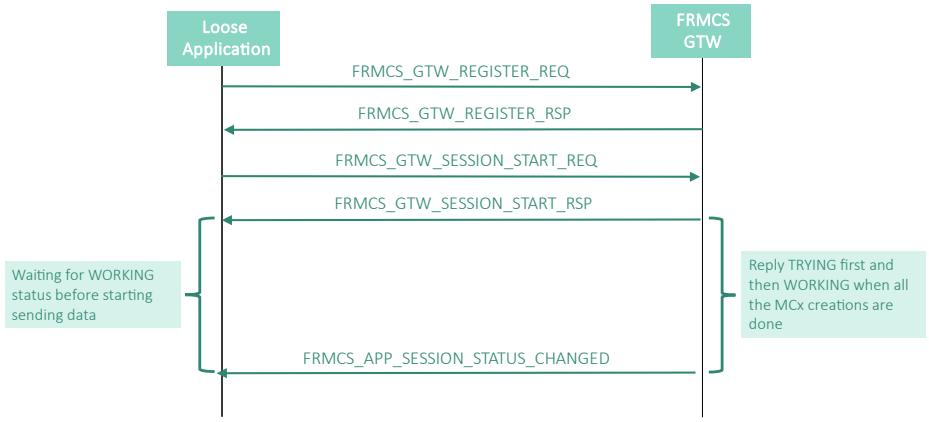

Figure 6: Improved application registration

Knowing that the FRMCS_GTW_SESSION_START_REQ message could be received by the FRMCS GTW before the end of the MCx Register procedure.

In such a case the FRMCS_GTW_SESSION_START_RSP returns Trying status, and once the MCx register and the SIP Invite successful, the FRMCS_APP_SESSION_STATUS_CHANGED message is sent to the application with CONNECTED status.

In case of MCx issue (during registration or SIP Invite procedure), then the FRMCS_APP_SESSION_STATUS_CHANGED message contains the FAILED status.

4.1.6 FRMCS Modem instabilities

In the context of the 5Grail, the modem ES3, a prototype developed specifically for this project was used. During the different test phases (lab and field), it was noticed that the ES3 modems were not too stable in terms of hooking to the network. Those instabilities were more important in field conditions (wireless network connection) than in lab (wired network connection).

One of the difficulties we came across being to adapt the RIM (software part in charge of managing the different modems) for the management of the ES3 modems

As prototypes, ES3 modems are not yet supported by the Modem Manager package we use for controlling modems. Hence, information regarding ES3 modems are not properly set, especially information related to modem status (i.e. connected/disconnected) and signal quality required for the decision to change radio coverage areas (i.e. cells). Each modem camps in a cell. So, we need to poll the ES3 modem periodically to check its status and signal quality using MBIMCLI and AT commands respectively.

Our main concern is to be able to switch radio coverage areas as quickly as possible to ensure traffic continuity when the modem is no longer operational (i.e. failure, disconnected or bad signal quality).

The polling period is set to 4 seconds based on our lab tests in wired conditions.

An inconsistency was observed between the results reported by MBIMCLI and AT commands: very often the AT command reports “ERROR” (i.e. no network service) whereas the MBIMCLI command reports that the ES3 modem is still connected and takes quite a long time (more than 1 minute) to confirm modem disconnection.

This delay in status reporting from MBIMCLI commands impacts the detection time of modem disconnection to switch to another coverage area. To minimize the disconnection detection time, instead of relying on the modem status, we consider that it is disconnected as soon as its status is disconnected, or there is no or bad signal quality.

Another observation is that when the modem recovers from a loss of signal quality, it used to take a while to scan all the frequency bands. To reduce this scanning time, the list of preferred bands is reduced to the wanted ones by using the specific Thales AT command: at^band_pref_ext.

As mentioned earlier, the instabilities appeared to be more important on field i.e. in wireless conditions.

Another point, linked to the data transfer has been met during lab tests. Indeed when performing Iperf transfers, we faced a sort of congestion of the ES3 modem, as shown in figure 5.

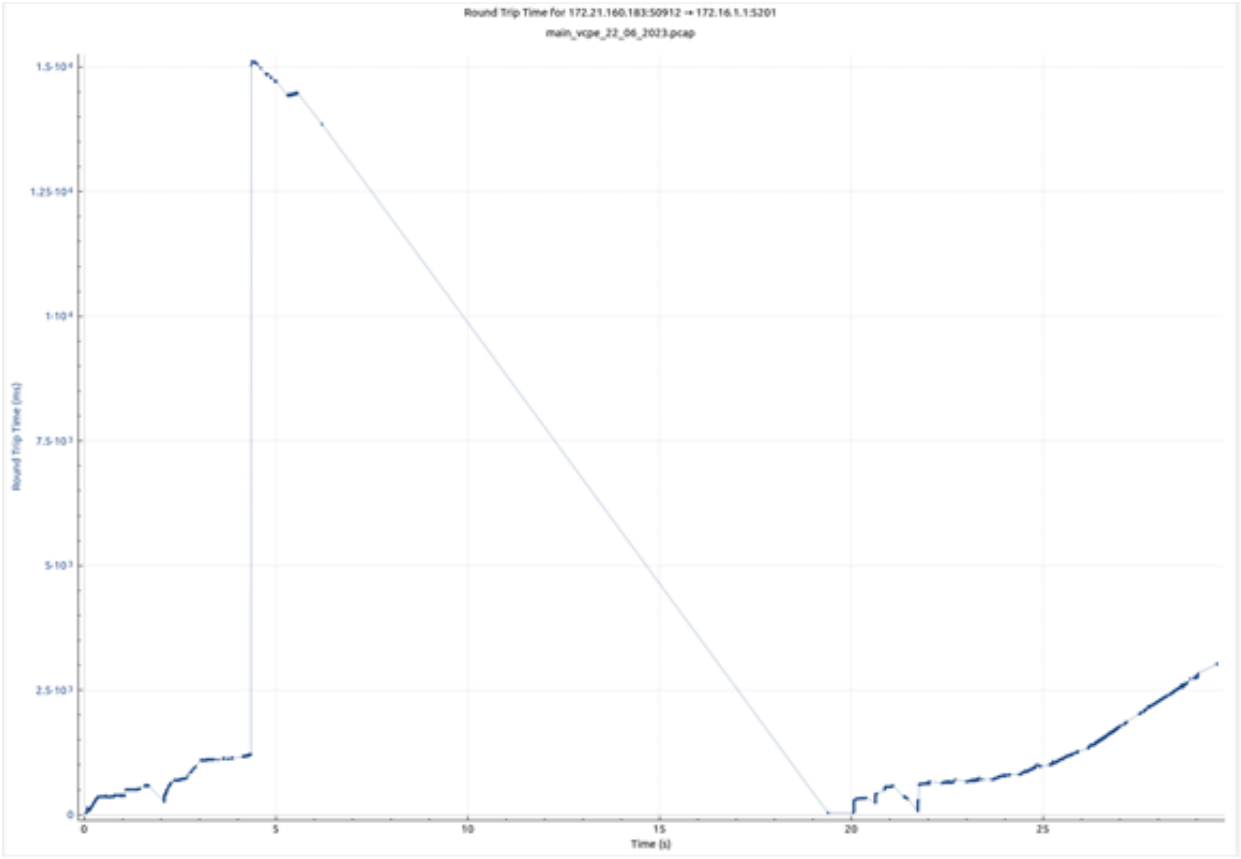

Figure 7: Modem's delay in data transmission

Figure 5 shows a big spike where the RTT jumps to 15 seconds.

An explanation of this could be that we have buffer bloat on the radio link. In that case, the radio would accept a large amount of data, much faster than what it could actually transfer. TCP would then keep sending at that inadequate rate until the buffer of the radio is full, then all additional packages sent afterwards are discarded. This point have not been investigated any further in the context of WP4/WP5 tests as this issue was not met with ATO or ETCS data transfers.

Lesson learned:

- When integrating a new modem, either a final product or a prototype, it is important to plan a integration phase where it is possible to tests, in lab conditions, all the modem functions and to debug them in details, with only the modem and the modem manager without any upper layer software.
- Moreover, when working with modem prototype it should be useful to have a phase to perform field tests only with the OB GTW to debug as much as possible the modem in real conditions. This will give the possibility to fully adapt the RIM accordingly

4.1.7 Testing condition Radio coverage lapse time form network A and B

During the field tests, we faced different kind of issues:

- A short coverage because of the need to turn off the BBU in order to avoid the interferences, as shown on the figure 6.

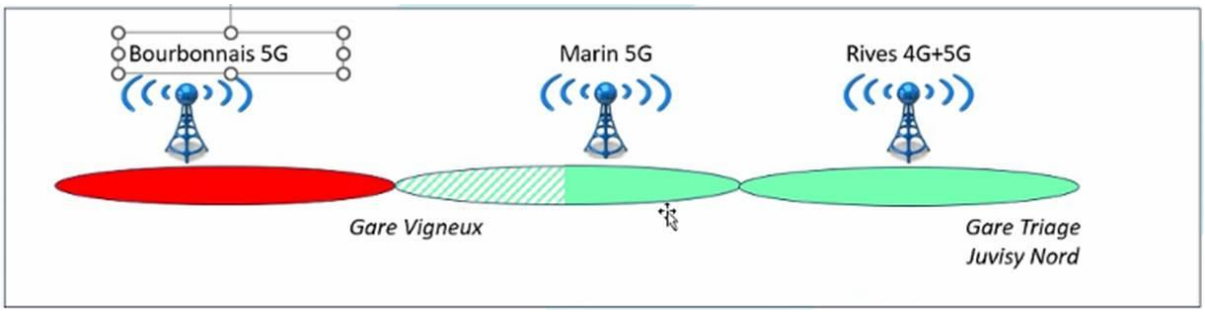

Figure 8: real coverage for WP5 France tests

What we can see is that the effective coverage area was far less then what was expected as Bourbonnais BBU was turned off and half of Marin's network coverage was also inoperable.

- The radio coverage instability are mainly due to some interferences. Some investigations have carried to identify the root cause of those interference highlighted that some non-identified installations were emitting signal too close to the FRMCS frequency bands in the testing area. It was shared with SNCF the need to investigate on the origin of those disturbances, but no improvements were noticed so far during the field tests period. Indeed, during the different runs, it appeared that the different radio signals (4G and 5G) were not always received with the same strength and at the same place. This impacts hugely the success of our cross-border, bearer flex tests.
- The train line used for the field tests was a commercial line, so it was not possible to decrease the train speed in the good coverage zones. The consequence of this constraint

being that the time available in the different coverage areas when travelling during a tests was too short.
Due to the small coverage area length, the time spent in good coverage area was too short (5 minutes maximum). Therefore, it would have been useful to be able to decrease the train speed in those coverage areas when testing complex features such as cross-border and bearerflex.

- The ES3 modem, which took longer to connect to the network after entering to the coverage area. During the different runs some manual commands have been found in order to speed up the ES3 network hookup.
  Unfortunately, to send a command manually to the modem required to stop the TOBA software that was also using the AT command port. Hence, once the modem is connected to the network, by the time to restart the FRMCS OB GTW and the applications, the train was out of the coverage area.

The table below characterizes the timing issue met during the different crossborder runs:

Run	First Radio coverage duration	double coverage (4G+5G) duratrion	Time needed by modem to attach	Time needed by the TOBA to restart	Time needed by ETCS to restart	Impact
JUV->VIL	(4G) more than 5 minutes	2 minutes	30 to 40s if done manually	1 minute	1 minute	The train went out of the double coverage area before the application was fully connected (no 4G+5G->5G transition)
VIL->JUV	(5G) 2 minutes	2 minutes	30 to 40s if done manually	1 minute	1 minute	The train entered the double coverage area before the application was fully connected (no 5G->4G+5G transition)

Table 2: Crossborder timing

Lesson learned:

During this field tests we faced lots of issues because of the field testing conditions. Some of those issues could have been avoided or lessened with these following actions:

- The FRMCS network coverage should have been assessed properly before the beginning of the WP5 tests in order to be able to detect any anomaly within the network such as those interferences we have come across.
- Regarding the ES3 behavior, as stated in chapter 4.1.6, it would have been useful to have specific tests for the ES3 before starting the WP5 tests. This would allow us to have enough time to derisk the modem in both hardware and software wise.

- Last but not least, this kind of tests, with limited radio coverage and time constraints, need a dedicated trial line where the train can slow down or stop when needed in order to give time to the modem to connect to the network. For information, this configuration was used in the DB WP5 part and no issue had been seen either with radio coverage or with modems.

4.2 APPLICATIONS

4.2.1 ETCS (CAF)

4.2.1.1 Communication initiation pre-conditions

If communication service request was performed right after the FRMCS_GTW_REGISTER answer, the FRMCS GW failed in the communication establishment.

4.2.1.1.1 Problem description

The FRMCS_GTW_REGISTER function is not linked with the MCX registration. It is used only for local binding. Therefore, if the communication service request is requested before the FRMCS GW has performed the MCX registration, the status of the communication gets stucked in “Trying”.

4.2.1.1.2 Solution proposal

The FRMCS GW could implement a logic to perform the MCX registration and the communication service request sequentially, being transparent to the application.

4.2.2 ETCS (Alstom)

4.2.2.1 WebSocket monitoring mechanism

WebSocket implements a Ping-Pong mechanism which enables the application to monitor the status of the WebSocket connection.

The OB_GTW shall answer to the Ping request independently of the OBapp API request.

Some issues have been encountered when the GTW takes too long time to answer to a ping mechanism, because the GTW was waiting to answer to a parallel OBapp API request. Then, the application decides to close the WebSocket connection, considered as failed.

4.2.2.2 Maximum delay to answer to an API request

The maximum delay to answer to an API request should be defined:

- For the OB_GTW/TS_GTW: maximum delay between an API request (REGISTER, SESSION_START, SERVICE_REQUEST, SESSION_END, DEREGISTER) and the sending of the corresponding answer. Knowing that the OB_GTW/TS_GTW does not need to wait for any result from the radio network/service domain, since the event coming from the radio network/service domains are managed by API notifications.
- For the application: maximum delay to answer to an INCOMING_SESSION_REQ request.

Some issues have been encountered when the GTW takes too much time to answer to a request, and the ETCS application decides then to close the WebSocket connection, or eventually cancels the request.

4.2.2.3 Session_end processing

Following a nominal session_end request, an application receives firstly a session_status_changed notification (with session_status=deleted), then a positive answer to the request.

The application was expecting to receive firstly the answer, and secondly the notification with session_status deleted.

The dynamic for a session_end should be clarified.

4.3 Parameters shared by the FRMCS GTW and the applications

There are several kinds of parameters which need to be shared between the FRMCS GTW and the applications for a correct usage of OBAPP/TSAPP interfaces:

- The parameters to be defined in the OBAPP/TSAPP specifications (hence, no liberty to configure the value of these parameters). For 5GRAIL implementation, such parameters are defined in D2.1 document.
- The “project parameters”: it would be not relevant to impose them in the specification because they have to fit to the project implementation (e.g.: Gateway IP address). Nevertheless, these parameters are to be agreed between applications and FRMCS to ensure a proper GTW operation. For 5GRAIL implementation, such parameters are defined in this chapter.

- The parameters that do not require to be previously agreed between applications and GTW, but are exchanged between them (e.g. using OB_{APP}/TS_{APP} fonctions).

"Project parameters" which have to be used for 5GRAIL implementation (especially for WP3-4-5) are the following:

Parameters	Value to be used	Comments
Listening port for OB_{APP}/TS_{APP} API, without TLS – Kontron Gateway	8765	
Listening port for OB_{APP}/TS_{APP} API, without TLS – Alstom Gateway	8765	
Listening port for OB_{APP}/TS_{APP} API, with TLS – Kontron Gateway	8443	
Listening port for OB_{APP}/TS_{APP} API, with TLS – Alstom Gateway	8443	
IP address of TS_GTW-K listening for TS_{APP} API	See WP3-4-5 IP addressing plan	
IP address of OB_GTW-K listening for OB_{APP} API	See WP3-4-5 IP addressing plan	
IP address of TS_GTW-A listening for TS_{APP} API	See WP3-4-5 IP addressing plan	
IP address of OB_GTW-A listening for OB_{APP} API	See WP3-4-5 IP addressing plan	
Pool of virtual IP addresses – OB_GTW-K	172.16.1.0/24	To be validated by WP3 and WP4, according to their IP addressing plan.
Pool of virtual IP addresses – TS_GTW-K	172.16.2.0/24	To be validated by WP3 and WP4, according to their IP addressing plan.
Pool of virtual IP addresses – OB_GTW-A	192.168.2.0/24	To be validated by WP3 and WP4, according to their IP addressing plan.

Pool of virtual IP addresses – TS_GTW-A	192.168.3.0/24	To be validated by WP3 and WP4, according to their IP addressing plan.
Originator ID	Compliant with the WP3 and WP4 naming rules	

5 CONCLUSION

This document describes the main achievements of the prototyping work carried out in the context of 5GRAIL. The achievements have been quantified through a set of tests run in both lab and in field conditions with a complete FRMCS ecosystem, composed by protypes.

This work has allowed to achieved key functions of the FRMCS specifications. In practical terms good achievements regarding the key design principles have been met, such as:

- Implementation of OBapp Tsapp API which decouples application and transport

- carry various kinds of application data (ETCS, ATO, PIS, CCTV, voice), often simultaneously over the same FRMCS OB-GTW

- End-to- end local binding procedure tested with ATO application

- a common agreement on the definition of the key parameters that have to be shared between FRMCS GTW and applications for a correct usage of OBapp/TSapp interfaces

A table summarizing open points to be addressed for further technical improvements has been shared. This table can serve as a starting point to design future strategies at the productization stage of the FRMCS GTW and applications.

In terms of project organization we have come across some learnings that need to be considered for future consortium projects:

- ***very short radio double coverage zone:*** we end up having 1/3rd of the planned operational zone working. This due to some interference detected in the testing zone that required to turn off some of the BBUs. The consequence of this being to have too short double coverage zone in order to achieve a successful border crossing test,

- ***testing zone traffic constraints:*** the testing zone was a commercial line, hence a lot of constraints linked to the train speed, the stopping time in coverage areas (during tests and for preparation) and testing timeslots. These constraints hinder a lot the success of the testing of complex future such as bearerflex and crossfield in the field.

- the modem used for the 5G was a prototype from Thales: therefore not too stable, added to the poor testing conditions mentioned earlier. Most of the time the modem was struggling to connect to the network. We used to = fully reset it to be able to connect to the network with some manual commands in live. With the constraint of the short coverage zone, by the time that the modem connects to the network we were already out of the testing zone. In the context of future projects, it worth hardening the ES3 modem beforehand either by Thales or by a third party.

6 STANDARDS DOCUMENTS

[R1] Document Title	**[R2]** Reference, version
[S1] Radio-frequency connectors –Part 16: Sectional specification – RF coaxial connectors with inner diameter of outer conductor 7 mm (0,276 in) with screw coupling – Characteristics impedance 50 Ω (75 Ω) (type N)	IEC 61169-16
[S2] Management Information Base for Network Management of TCP/IP-based internet: MIB-II	RFC 1213
[S3] MC Services Security aspects (useful to understand MCx authentication and authorization)	3GPP TS 33.180
[S4] Mission Critical Data (MCData) signalling control; Protocol specification	3GPP TS 24.282
[S5] Mission Critical Data (MCData) media plane control; Protocol specification	3GPP TS 24.582
[S6] UIC - FRMCS Use cases	UIC MG-7900, Version 2.0.0
[S7] 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on Future Railway Mobile Communication System	3GPP TR 22.889
[S8] UIC - FRMCS Principle Architecture	UIC MG-7904 Version 0.3.0 (Draft)

[S9] UIC – FRMCS – Telecom On-board system – Functional Requirement Specification	UIC TOBA FRS-7510 Version 0.2.0 New version 1.0.12
[S10] UIC FFFIS – Form Fit Functional Interface Specification	FRMCS FFFIS-7950 Version 0.10.0
[S11] Common functional architecture and information flows to support mission critical communication services	3GPP TS 23.280 Stage 2
[S12] 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Functional architecture and information flows to support Mission Critical Data (MCData)	3GPP TS 23.282 V17.6.0, Stage 2 (Release 17) - 04/2021
[S13] Rail Telecommunications (RT); Future Rail Mobile Communication System (FRMCS); Study on system architecture	ETSI TR 103.459 V1.2.1, 08/2020

7 REFERENCES DOCUMENTS

[R3] Document Title	**[R4]** Reference, version
UIC FRMCS – User Requirements Specification	FU-7100 Version 5.0.0
ETSI Future Rail Mobile Communication System (FRMCS) – Study on system architecture	ETSI TR 103 459 Version 0.2.2
UIC FRMCS – Functional Requirements Specification	FU-7120 Version 0.3.0
UIC FRMCS On-Board System Requirements Specification (TOBA SRS)	TOBA-7530
UIC FRMCS Functional Interface Specification (FRMCS FIS)	
UIC FRMCS Form-Fit Functional Interfaces (FRMCS FFFIS)	
UIC FRMCS System Requirements Specification (FRMCS SRS)	FW-AT-3404