5GRAIL – first FRMCS demonstrator

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 951725.

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FRMCS is the 5G GSM-R successor and the Railways Digitalization enabler

GSM-R

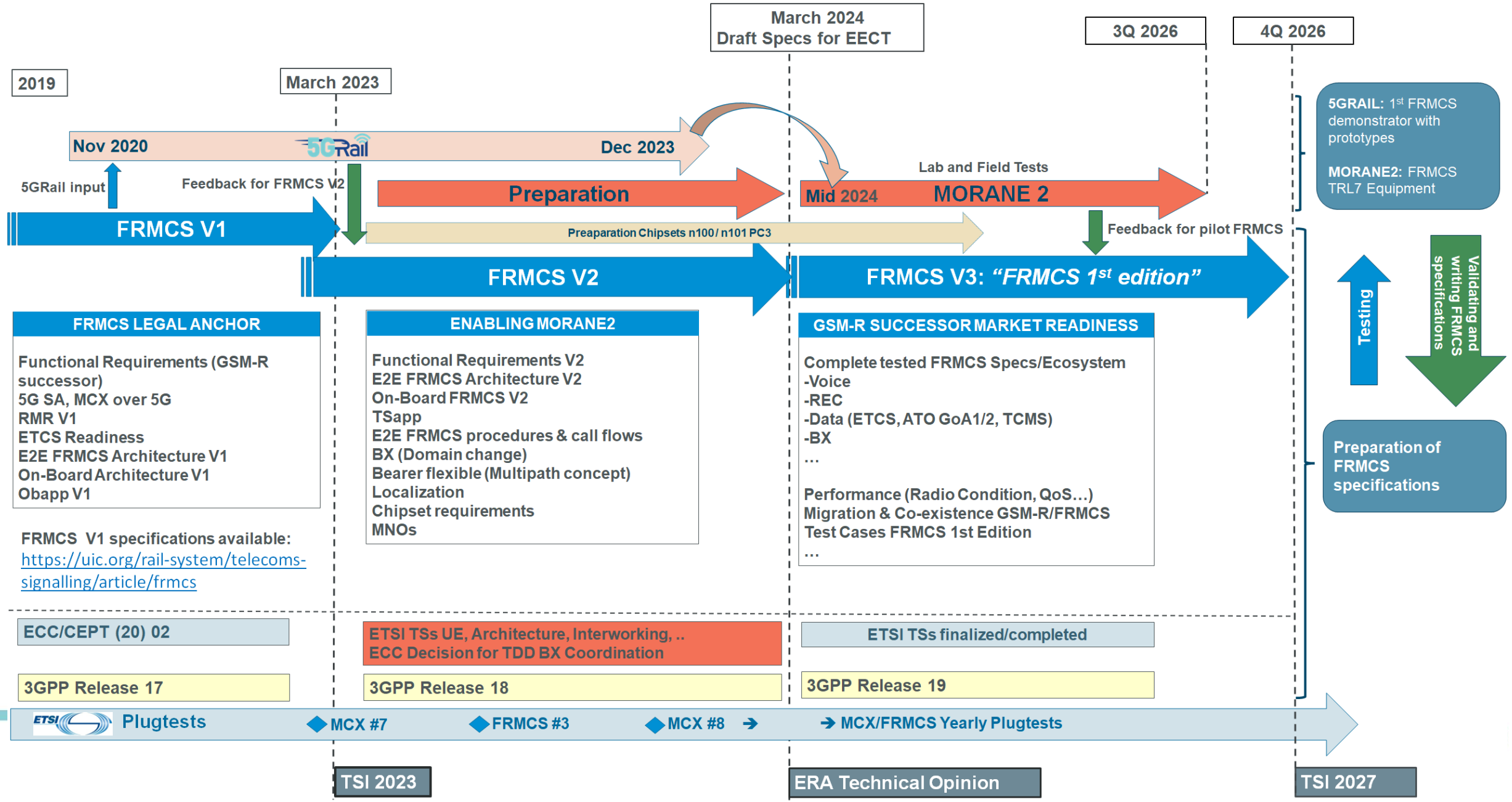
-BASED ON 2G+
-NATION-WIDE CONNECTIVITY
-BORDER CROSSING INTEROPERABLE
-IMPROVE SAFETY
-ENABLE:
- RAILWAY VOICE
- RAILWAY EMERGENCY CALL
- ETCS
-
OBSOLESCENCE IS FAST APPROACHING

- **GSM-R is a success story**: deployed on more than 130,000 kilometers of track in Europe (with 90.000 activated On Board Cab Radio's), and some 210,000 kilometers worldwide, completely border-crossing interoperable.
- The European railways currently use the GSM-R system for operational communication, a key component of the European Railway Traffic Management System (ERTMS).
- GSM-R is supporting the train driver to controller operational communications but also the Group calls, the Railways Emergency Call and the European Train Control System (ETCS)
- Even if with a limited data capability, GSM-R is supporting also other railway applications, e.g., track side phones, passenger information screens on platform, etc.
- But…GSM-R is 2G based technology, obsolete soon.
- Future Railway Mobile Communication System (FRMCS) should perform at least as good as GSM-R for the ERTMCS voice and data applications.
- Moreover, FRMCS is a major trigger for the wide-ranging digitalization of the rail sector satisfying the increasing demand of data while keeping the high quality of service for critical railways applications, in an interoperability context.

5G Rail FRMCS
Future Railway Mobile Communication System

-5G SA,3GPP MCX
- DEDICATED FREQUENCIES IN 1900 MHz TDD AND 900 MHz FDD
- COEXISTENCE WITH GSM-R
- BORDER CROSSING INTEROPERABLE
-ENABLE ATO, TCMS
-AND IN GENERAL - DIGITALISATION
- FUTURE PROOF
-WILL IMPROVE OPERATIONS, AND TRAIN PERFORMANCE
-
INTRODUCED IN 2023 EC CCS TSI

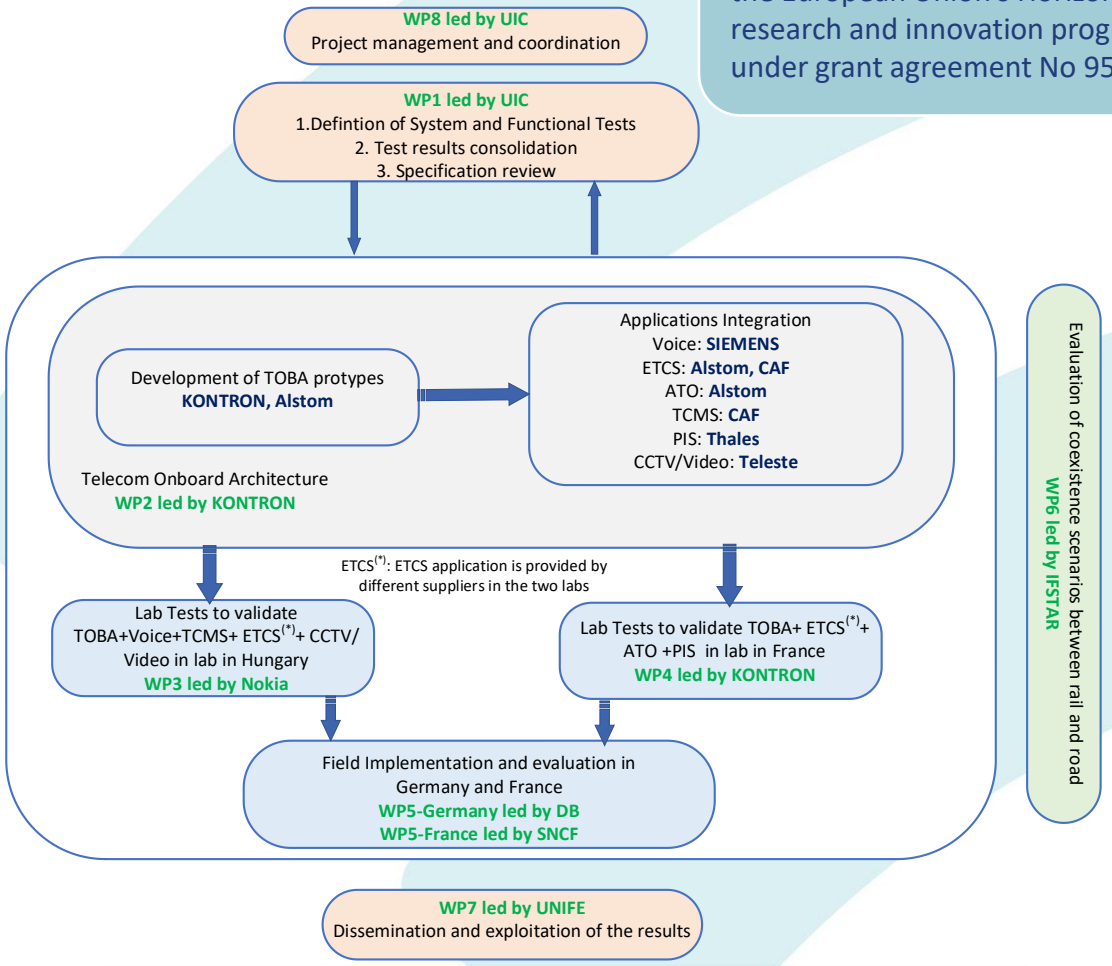
The way towards FRMCS 1st edition



5GRAIL scope, structure and partners

5GRAIL is an EU funded project. This project has received funding from the European Union's Horizon 2020 research and innovation program, under grant agreement No 951725.

- **Elaborate FRMCS prototypes** based on the FRMCS V1 specifications, including the new on-board equipment (TOBA) additionally prototypes of the critical applications Voice, ETCS, ATO and performance applications TCMS, CCTV/Video;
- **Define the relevant functional end-to-end tests** required to verify the compliance of the prototypes with the FRMCS V1 specifications;
- **Execute these tests in lab environment firstly, and then in railway environment with train runs;**
- **Validate prototypes in lab and field conditions, considering border crossing use cases, as well;**
- **Prepare a performance measurements methodology,** to apply on further 5G FRMCS operational deployment;
- Define and emulate **coexistence scenarios between railway and roads;**
- **Analyze the outcomes of the tests campaigns to loop back on FRMCS specification, to amend or modify them.**



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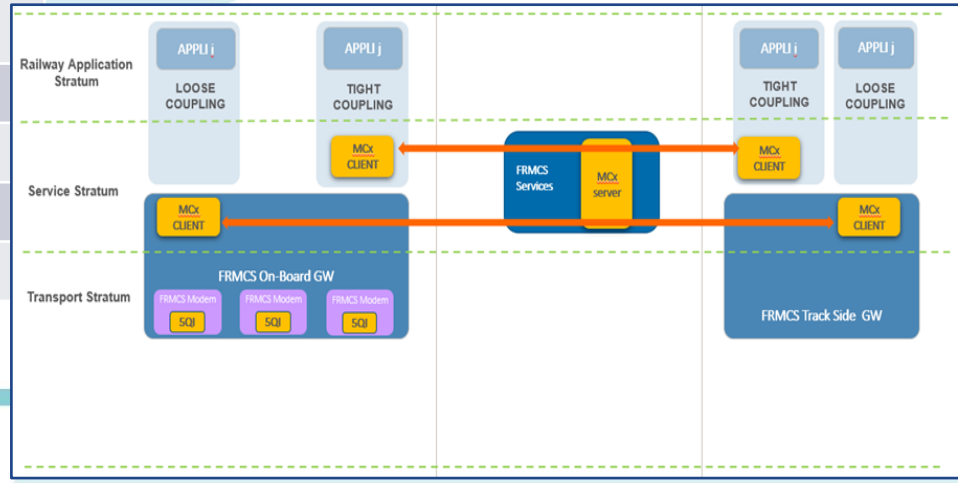
FRMCS Use cases tested in 5GRAIL

Voice applications	WP3 Lab Nokia Hungary	WP4 Lab Kontron France	WP5 Field DB	WP5 Field SNCF
On-train outgoing voice communication from the train driver towards the controller(s) of the train	X	O	X	
On-train incoming voice communication from the controller towards a train driver	X	O	X	
Multi-Train voice communication for drivers including ground user(s)	X	O	X	
Railway Emergency Communication	X	O	X	
Data applications				
Automatic Train Protection communication (ETCS) (BC, F)	X	X	X	X
Automatic Train Operation communication (limited to GoA2 ATO)		X		X
TCMS (**T**rain **C**ontrol and **M**anagement **S**ystem) : ❑ On-Train Telemetry communications ❑ On-Train remote Equipment control	X		X	
Non-critical real time video (BC, HU, DE)	X		X	
Transfer of CCTV archives	X		X	
PIS (**P**assenger **I**nformation **S**ystem)		X		
Remote control of engines (Remote vision application)(BC, F)		O		X

X - Mandatory Test Case, O – Optional Test Case, BC - Border-crossing conditions

Demonstrate FRMCS principles



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Test Plan executed to lab and field testbeds

To WP3 lab

NOKIA

Radio, Core , Terminals

SIEMENS

Cab Radio

kontron S&T Group

Gateways

TELESTE

Video Camera and Servers

CAF

Onboard and Trackside

To WP4 lab

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

7.2.1.1 Purpose

The purpose of this test is to demonstrate that an FRMCS User can register a functional identity (train running number and function code) on the FRMCS system. Once the registration is completed the FRMCS User can be reached by its FRMCS functional identity.

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7.2.1.2 Description of initial state/configuration

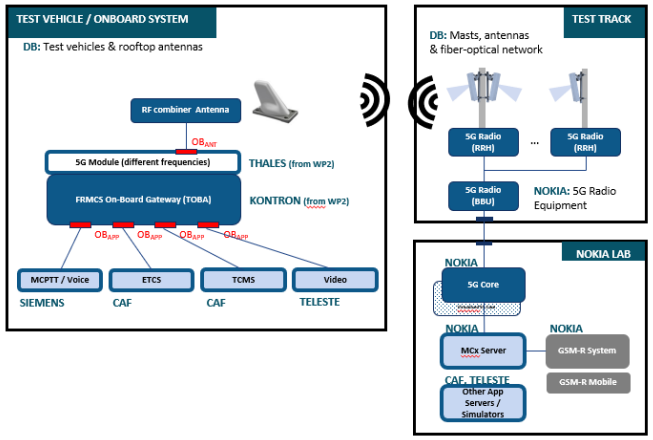
1. The Cab Radio A equipment type is recognised by the FRMCS system. This is handled by a predefined configuration file embedded within the Voice application software.
2. FRMCS User A is logged in into the FRMCS system. The user credentials (username and password) are predefined in a configuration file within the Voice application software.
3. The Cab Radio A is powered on, and the Idle screen is displayed on the GDCP.
4. The FRMCS User A has not been previously registered to a functional identity.
5. An FRMCS handheld device or another FRMCS subscriber registered on the same network is available.

7.2.1.3 Test procedure

Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A registers its functional identity by navigating to Menu – Reg/De-reg… – Register	The train number field is displayed on the GDCP of the Cab Radio A with a Country Code pre-populated	[FU- 7100 v0.5.0] : 8.3.5.3, [FU-7120-v0.5.0] : 11.3.2.3.7, 11.3.2.3.8, TR22.889-V16.6.0 [R-9.3.3-001]
2	FRMCS User A presses the Accept button	Th… running number field is di… the GDCP of the Cab R…	
3	FRMCS User A enters the train running number and presses the Accept button	Th… codes list is displayed on… of the Cab Radio A	[FU- 7100 v0.5.0] : 8.3.4.1,
4	Select the Lead Driver function from the list of the function codes	Re… request is sent to the FR… em Re… progress is displayed on… of the Cab Radio A	[FU- 7100 v0.5.0] : 8.3.4.1, 8.3.5.2, [MG-7900-v2.0.0] :64.3.3.1, 64.3.3.2
5	FRMCS system accepts the registration request	…tatus is displayed on th… the Cab Radio A (e.g., train… number appears on the display)	[FU-7120-v0.5.0]: 11.3.2.3.9

Testing

To WP5-DE



To WP5-FR

- OBapp/TSapp compatibility for data "loose coupled" applications (ETCS, ATO, TCMS, PIS, CCTV, Video) and tight coupled (train driver to controller voice applications, group calls including REC)
- Cross-border scenarios
- Bearer flex with CCTV, ETCS
- QoS negotiation through combined MCServices use cases in degraded radio conditions
- GSM-R Interworking (with 5G FRMCS)

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ALSTOM THALES

ETCS ATO PIS *FRMCS Apps (trackside)*

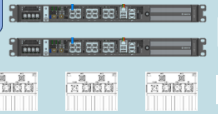
Trackside

FRMCS Gateways ALSTOM kontron S&T Group

IMS/MCx

FRMCS MCx brick HP Gen10

5G



Core Network Kontron ME1210

Kontron Radio Units N8/N39/N78

4G

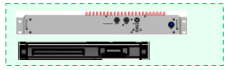
Core Network Kontron ME1210

Kontron Radio Unit 2600 MHz

Wifi

GSM-R

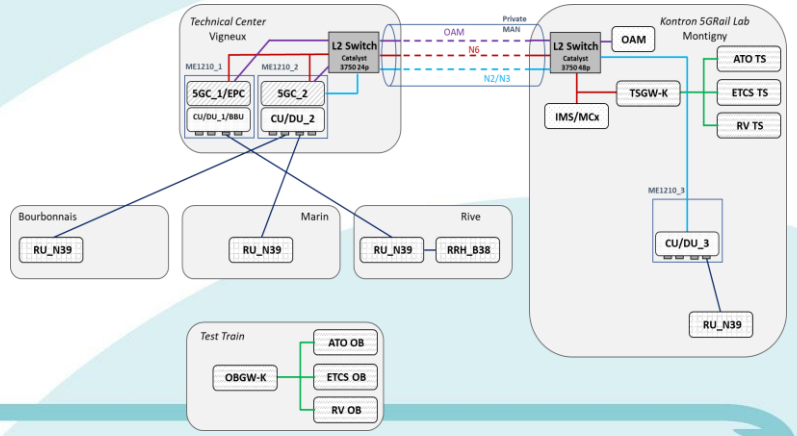
On-Board



TOBA Gateways ALSTOM kontron S&T Group

ETCS ATO PIS *FRMCS Apps (on-board)*

ALSTOM THALES



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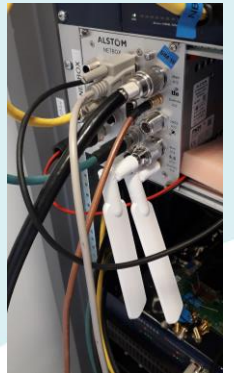
5GRAIL Lab tests achievements

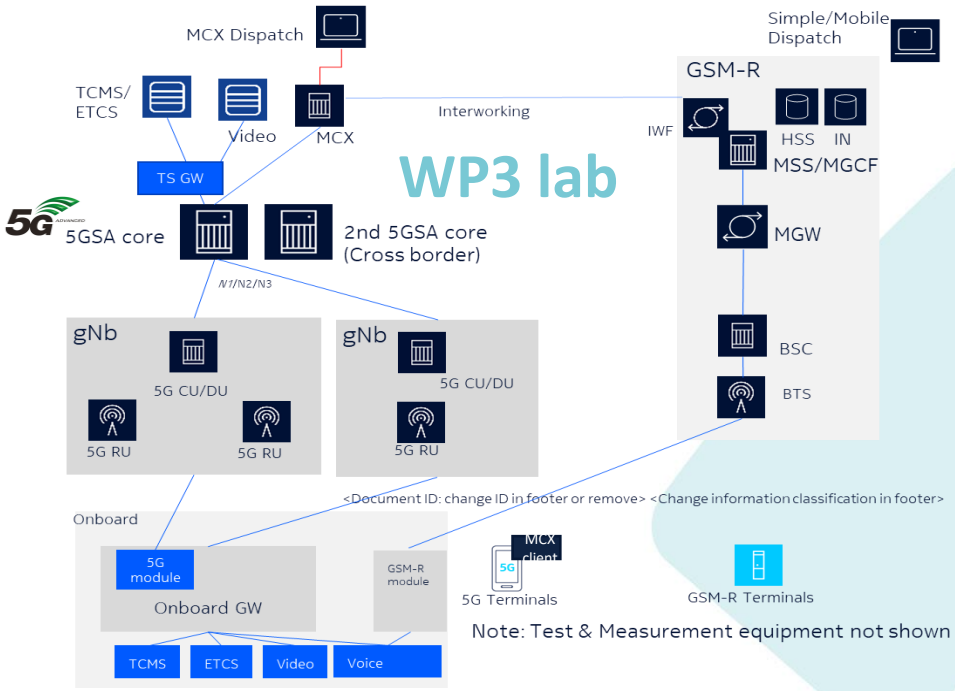


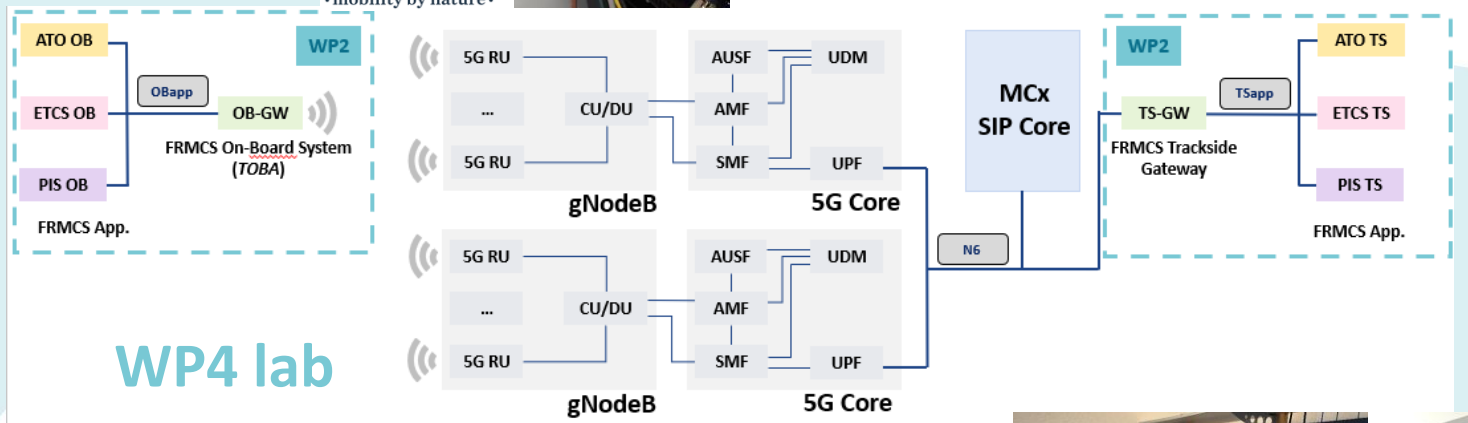
kontron

THALES

ALSTOM
· mobility by nature ·

5GRail

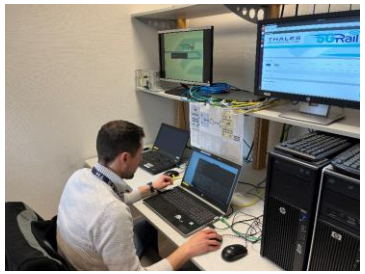




CAF
Onboard and Trackside

TELESTE
SIEMENS
Video Camera and Servers
Cab Radio

- MCData testing : successful ETCS, ATO (critical applications), and also TCMS and Video data tests;
- MCPTT testing (Voice): successful pre-standard REC, interworking with GSM-R, network transition FRMCS GSM-R, combined scenarios with Video application;
- PIS (Passenger Information System): successfully tested in lab;
- Remote Vision have been successfully tested both as stand alone and as combined applications scenarios with ETCS;
- Cross-border solutions are developed and tested: 1) using 2 UEs , and 2) Inter PLMN handover;
- Cybersecurity: Local binding (OBapp) and e2e TLS with ATO successfully tested.



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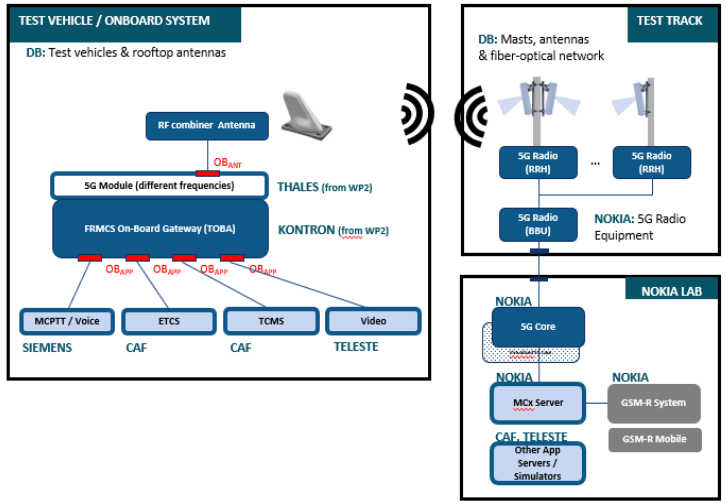
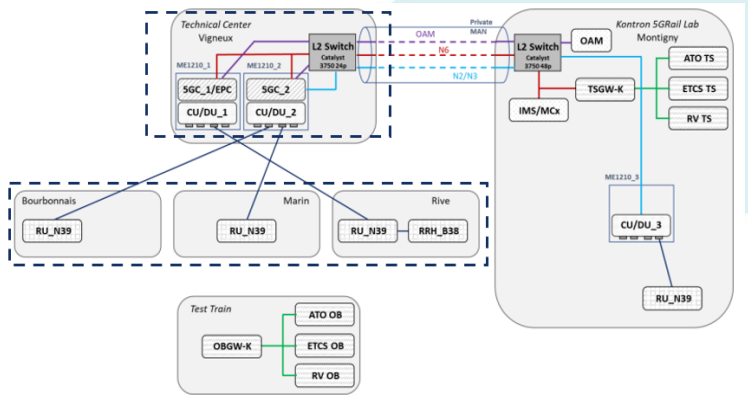
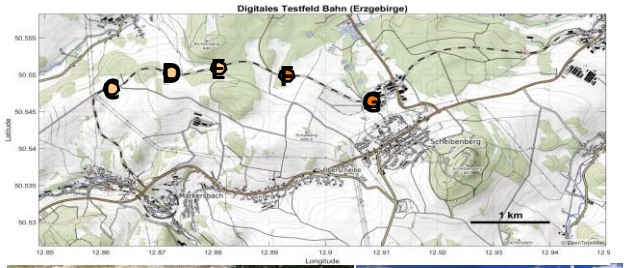
5GRAIL Field Testbed achievements







Lab Germany

German Testbed at Erzgebirge:

- TOBA-K in field conditions in n78 (3.7 GHz TDD band)
- Successful MCPTT testing (Voice): pre-standard REC, interworking with GSM-R, multi-user talker control, arbitration, combined scenarios with Video application;
- Successful MCData testing with ETCS (CAF), TCMS and Video using bearer-flex feature realized as 5G inter-frequency handover (bearer change on two 5G subbands)

French Testbed at Vigneux-sur-Seine:

- TOBA-K in field conditions in n39 (1.9 GHz TDD band)
- Successful MCData testing with ETCS (Alstom), ATO, Remote Vision (as for remote driving configuration), combined scenarios with ETCS and remote Vision, ETCS and ATO, ETCS, ATO using bearer-flex multiconnectivity feature.

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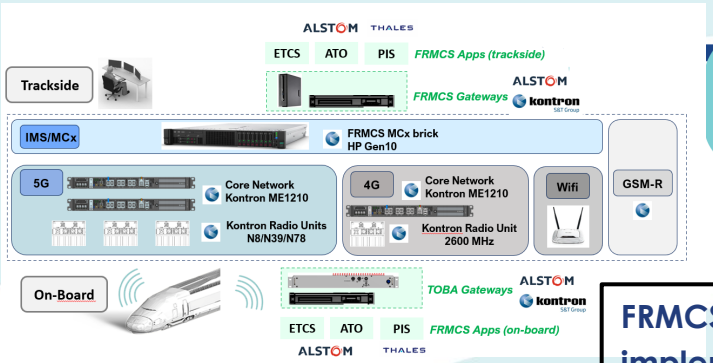
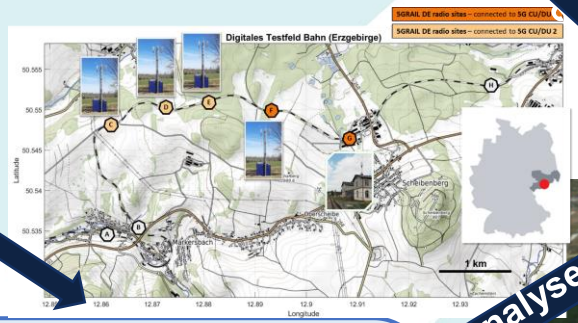
Analysis of observations from labs and field tests and feedback to the specifications



WP3&WP4
Lab Tests
(France & Hungary)

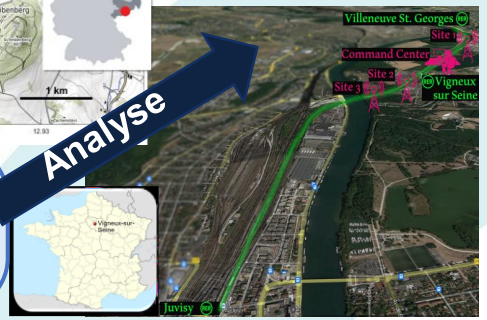
Analyse

WP1
Defintion of System and Functional Tests



Analyse

Analysis of Results
(Validation, Modification, Mesures)



WP5
Field Tests/Train Runs
(France & Germany)

FRMCS V1 Specifications (UIC)
5G FRMCS Standard (3GPP/ETSI)

Feedback to the specifications

Lab & Field Observations

FRMCS specific 5GRAIL implementation

- ❑ 5G SA
- ❑ OBapp and API improvements
- ❑ MCX credentials
- ❑ Data and Voice applications migration to MCX architecture
- ❑ IP end-to-end routing
- ❑ Session establishment interoperability (e.g., client-server from different providers)
- ❑ Bearer Flex
- ❑ Cross Border:
  - ❑ usage of 2xUEs
  - ❑ inter-PLMN handover
- ❑ Performance measurements
- ❑ MCPTT voice tests, including REC, GSM-R interworking

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REC call as FRMCS - GSM-R Transition (Border Crossing use case)

Implementation:

- Pre-standard FRMCS Railway Emergency Call using initiator's location criterion, processed by the MCX server

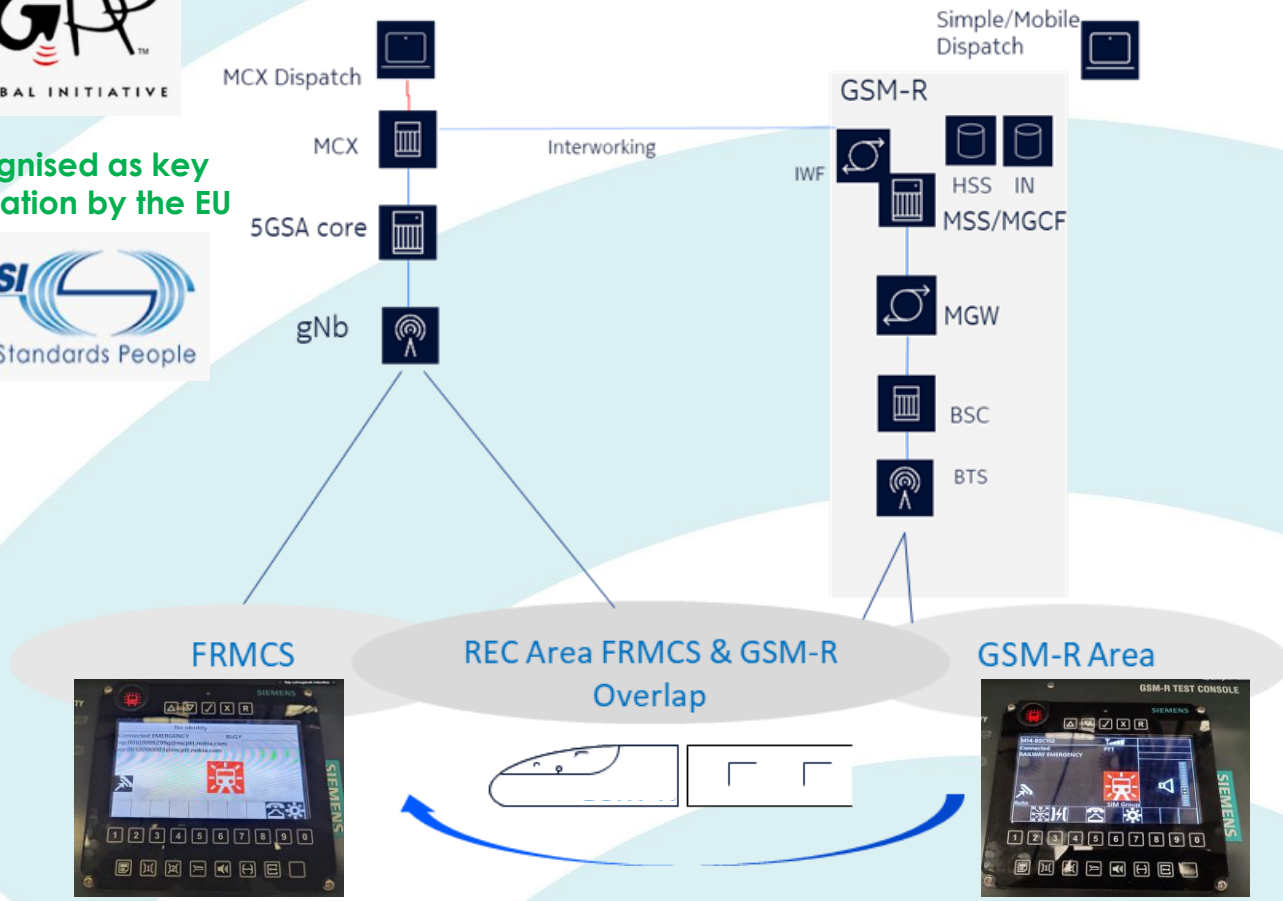
Innovation/Amendment of specifications

- Pre-standard GSM-R Interworking Function implemented in Nokia's MSS/MSC

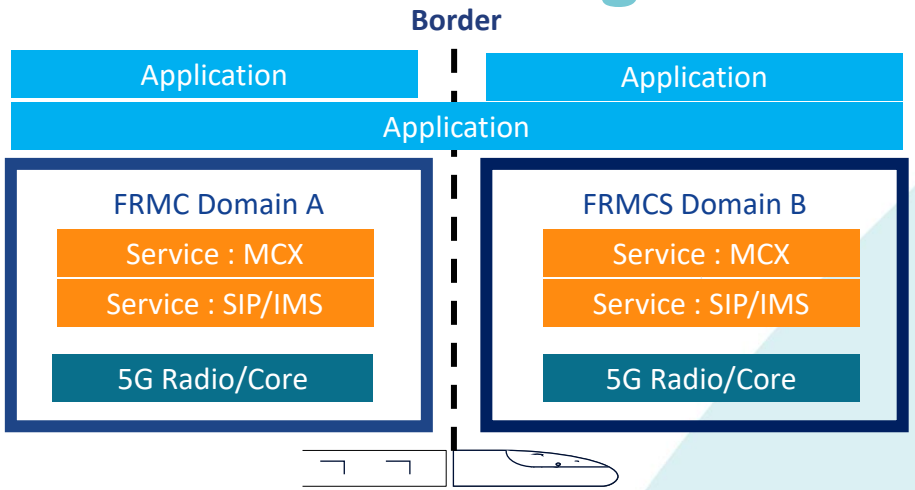
Recognised as key innovation by the EU

Call flow:

- Establishment of FRMCS Railway Emergency Call triggers automatically GSM-R REC setup
- CAB Radio participates in REC call on GSM-R (using IWF)
- Moving from GSM-R to FRMCS as a Border Crossing Scenario:
  - ✓ CAB radio changes from GSM-R attached to FRMCS
  - ✓ CAB radio joins ongoing REC call on FRMCS



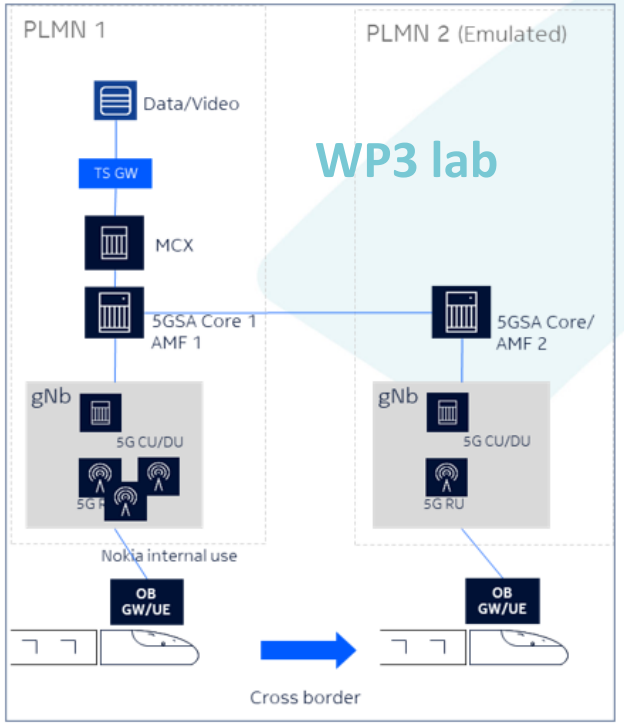
5G Border Crossing



Application
Home or visited control

MCX: Interconnect and Migration
SIP:Roaming

5G: Roaming, Mobility, Handover



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To fulfil service continuity requirements in border crossing 2 solutions were tested in 5GRAIL :

Inter-gNode HO over AMF

2UEs: used simultaneously (TOBA-K) or based on link priority (TOBA-A)

2UEs is the solution in FRMCS v2 specifications until inter-PLMN HO features completion

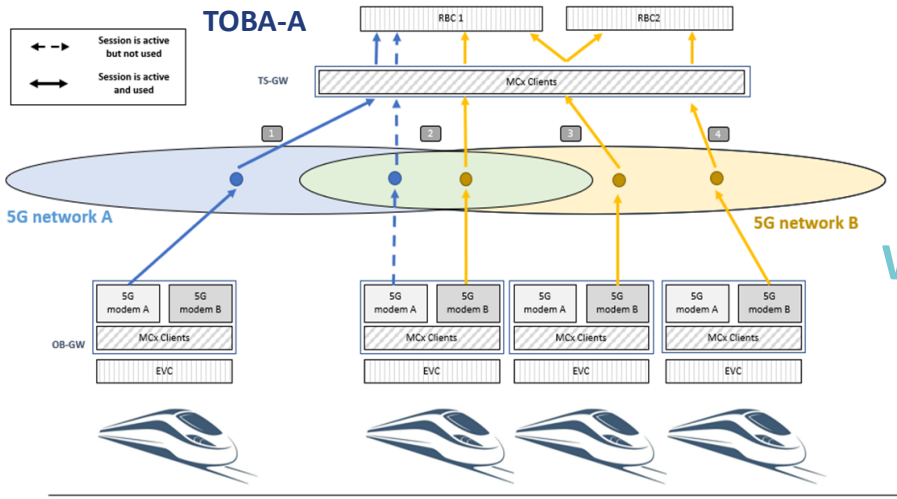
5GRail Border Crossing (BC) scenarios:

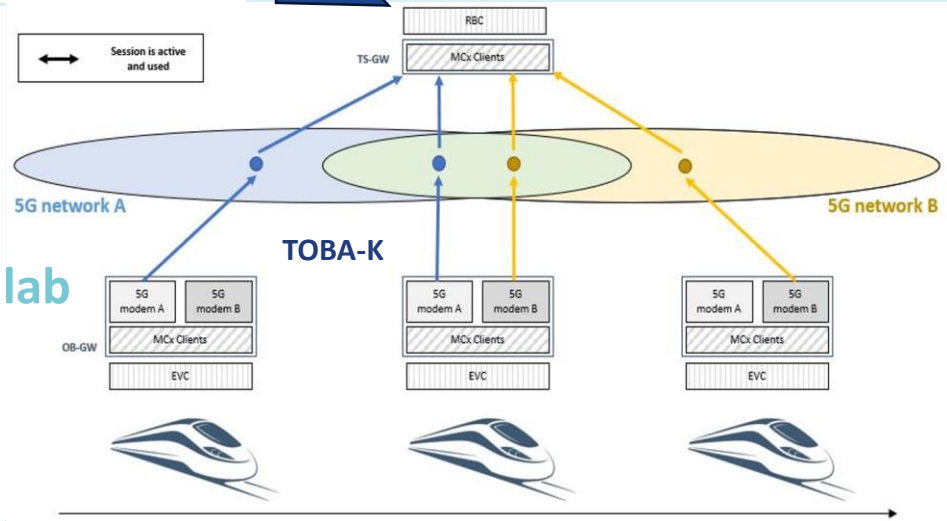
We have considered two scenario's:

- we have considered "application level'' 2 UE's BC. This model will be used in early FRMCS releases, for ETCS and ATO, until we will solve the MCX level BC interconnection and migration, at 3GPP level.

This model was successfully tested in WP4.

- We have also tested elements of inter-PLMN Handover in WP3. These ensure a fast transition (around150 ms), meaning service continuity for ETCS which is a data application.





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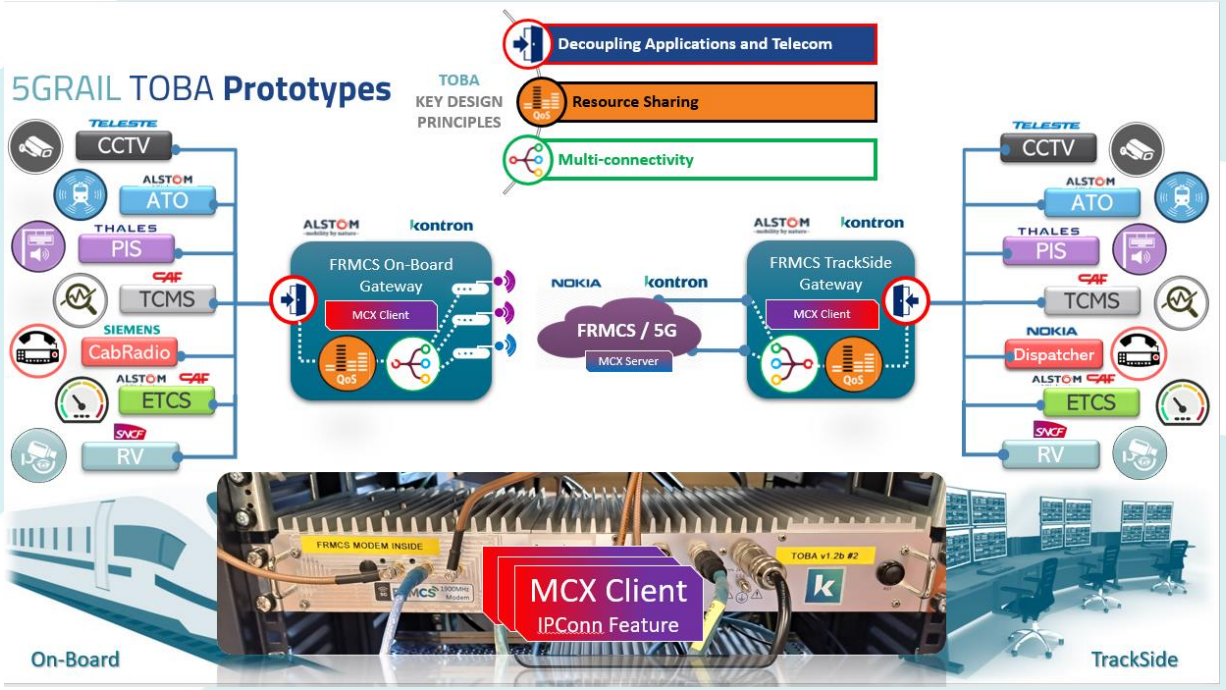
5GRAIL reached its target

- **Future proofness:** TOBA designed with decoupling of applications and telecom, as per FRMCS v1 specifications
- **5G NR Spectrum (FRMCS 1900MHz TDD, 900MHz FDD, 3.7GHz TDD)**
- **MCX features:** validated, with current products and mechanisms
- **QoS:** tested for both MCPTT and MCData, with current available products and mechanisms
- **Combined Applications over same TOBA:** successfully tested (in GSM-R we use different radio's for Voice and ETCS)
- **Cybersecurity:** Local binding (OBapp) and e2e TLS (TOBA and applications)
- **Cross-border:** Two solutions considered, the 2x5GUEs implementation will be included in FRMCS v2 specifications.
- **Bearer flexibility** tested both as multiconnectivity and multi-access
- **FRMCS v1** and **3GPP/ETSI** specifications have ben influenced by 5GRAIL



5G Rail received innovation recognition from the EC, for following items:

- **FRMCS tailor-made 5G Module (1900 – 1910 MHz TDD)**
- **5G FRMCS – GSM-R interworking**
- **Cyber Security architecture for the MC over 5G ATO application**

We invite you to our final conference, planned for the 7th of December 2023!
https://5grail.eu/2023/07/03/experimental-trials-for-the-future-railway-mobile-communication-system-in-5grail-project-registrations-open-for-5grail-final-conference-on-07-12-2023/

Our demo at German Testbed very appreciated!

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5GRail Demo Team

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Thank you for your kind attention