



## 5GRAIL, the FRMCS sucesor

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# The Future Railways Mobile Communications System (FRMCS)



FRMCS is the railways answer to :

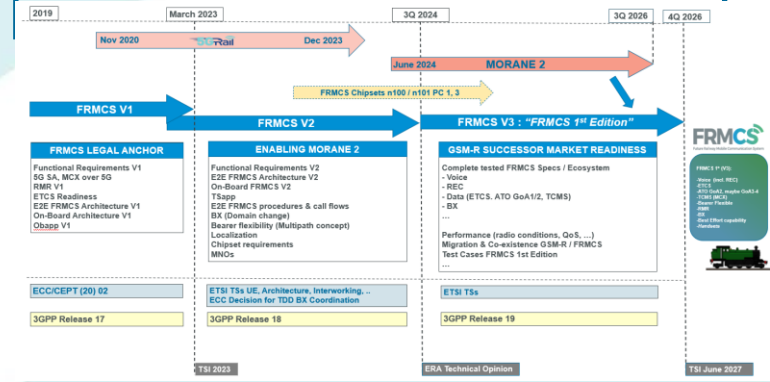


## GSM-R Obsolescence

GSM-R, is Installed on majority of European Railways tracks, and in many other countries outside Europe. GSM-R is border crossing interoperable, providing Voice calls, including the Railway Emergency Call, and supports ETCS, the European signaling system. It is a GSM / GPRS based system. GSM-R is approaching the end of life, estimated around 2035.

## Digitalisation

FRMCS will enable train performance and other business applications, to improve capacity (more trains on same track), punctuality and safety: ATO (Automatic Train Operations) TCMS (Train Control and monitoring System)

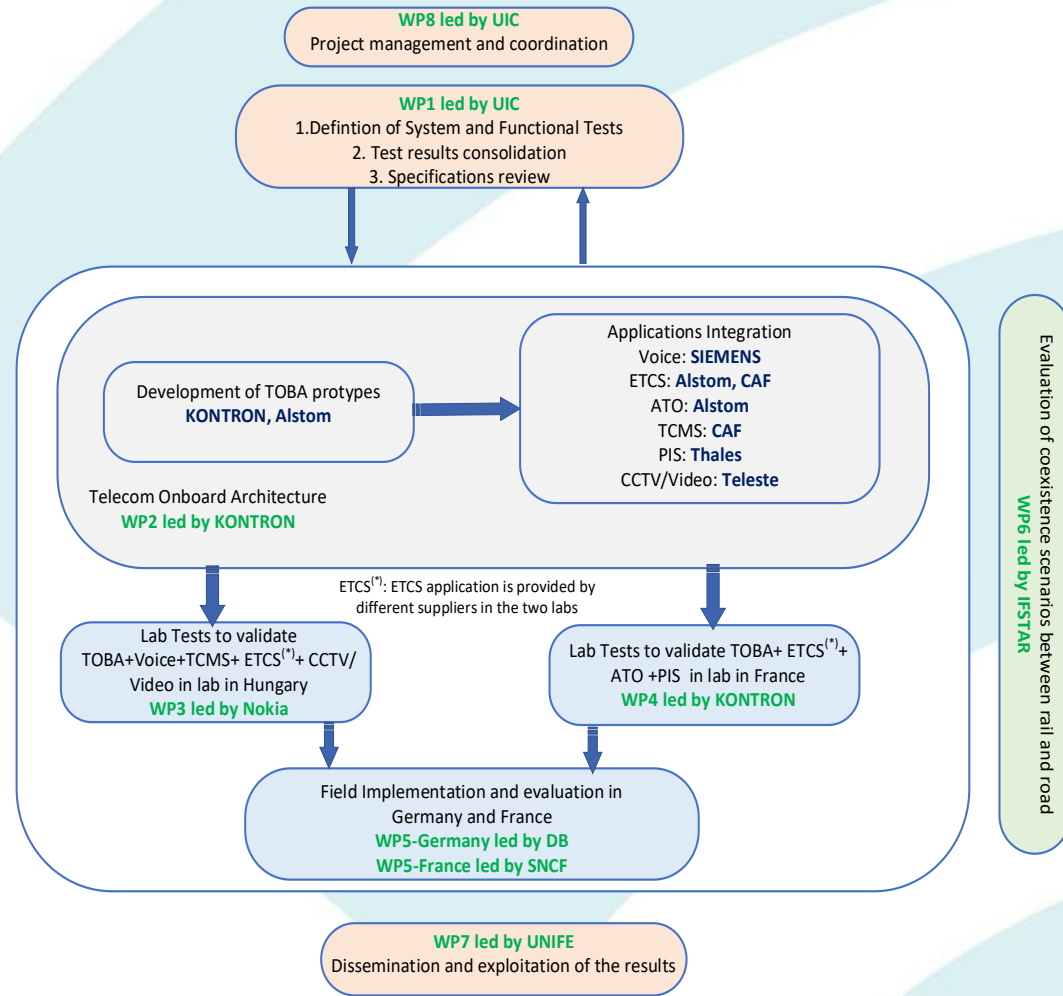


**FRMCS** is planned to be introduced mid 2027, (3GPP R18 and pre R19 features). We have obtained dedicated 5G frequencies in Europe, in 900 and 1900 MHz bands (n100 and n101). FRMCS has been introduced in the European legislation in March 2023 (CCS TSI), as the GSM-R successor, working in coexistence with GSM-R until mid of next decade. **5GRail** is a very important element for the GSM-R introduction, developing and testing the first prototypes (R17), supporting the specifications development.



# 5G RAIL Scope

- Define the relevant functional end-to-end tests required to verify the compliance of the prototypes with the FRMCS V1 specifications, including in BX mode
- Elaborate FRMCS prototypes, based on the FRMCS V1 specifications. Includes the new On-Board FRMCS equipment (TOBA) and the prototypes of the critical applications Voice, ETCS, ATO and performance applications TCMS, Video, PIS, Remote Vision
- Test these prototypes lab environment firstly, and then in field, in railway environment with train real runs. Consider cross-border scenarios within the existing architectures
- Define and emulate coexistence scenarios between railway and roads
- Analyze the outcomes of these tests to loop back on FRMCS specification, to amend or modify them. Work on performance test methodology.



# FRMCS Use Cases tested in 5GRAIL



## 5G features:

- 5G SA
- 5G QoS
- 5G User Equipment supporting the 5G frequency bands n8, n78, and pre-n101\* (FRMCS 1900 MHz)

## MCx services:

- Mission Critical Push-to-Talk (MCPTT) Service
- Functional alias
- Multi-talker control
- Mission Critical Data (MCData) Service
- Mission Critical Services

(\*): RMR (Railway Mobile Radio) Band: Defined in ECC (20) 02: 1900 - 1910 TDD, and 2\*5.6 MHz in 900 MHz Band. Includes GSM-R: 4MHz in 900 MHz

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 controller	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 Call	X	O	X	
Data applications				
Automatic Train Protection communication (ETCS)	X	X	X	X
Automatic Train Operation communication (ATO, GoA2)		X		X
TCMS (Train Control and Monitoring System) : <input type="checkbox"/> On-Train Telemetry communications <input type="checkbox"/> On-Train Remote Equipment Control	X		X	
Non-critical real time video (BX, HU, DE)	X		X	
Transfer of CCTV archives	X		X	
PIS (Passenger Information System)		X		
Remote control of engines (Remote Vision application)		O		X

X – Mandatory Test Case    O – Optional Test Case



Grant agreement  
No 951725



# FRMCS High Level Architecture

FRMCS is a 5G SA Mission Critical (MCX) based system.

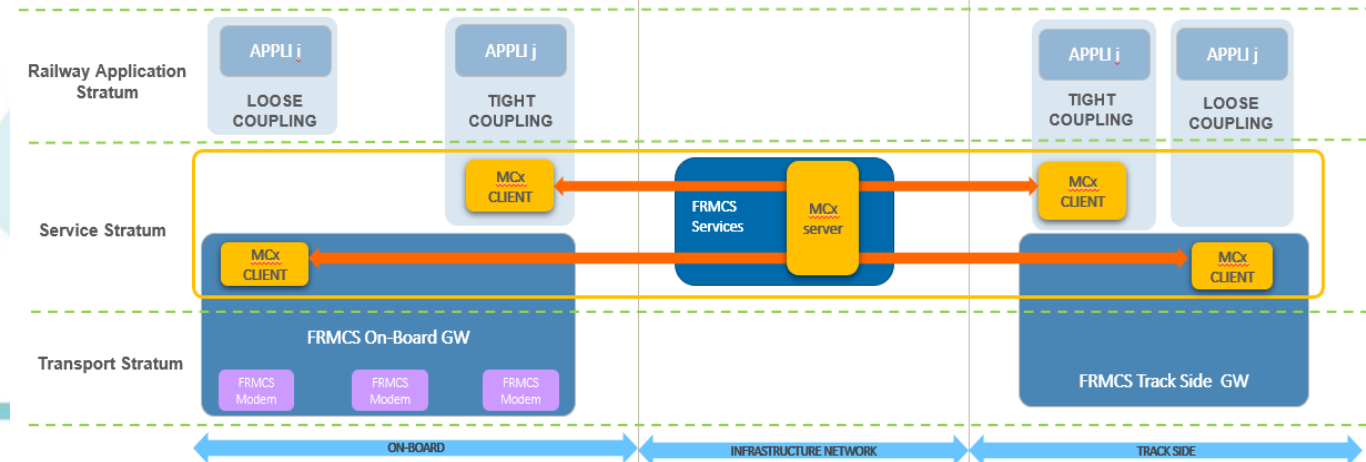
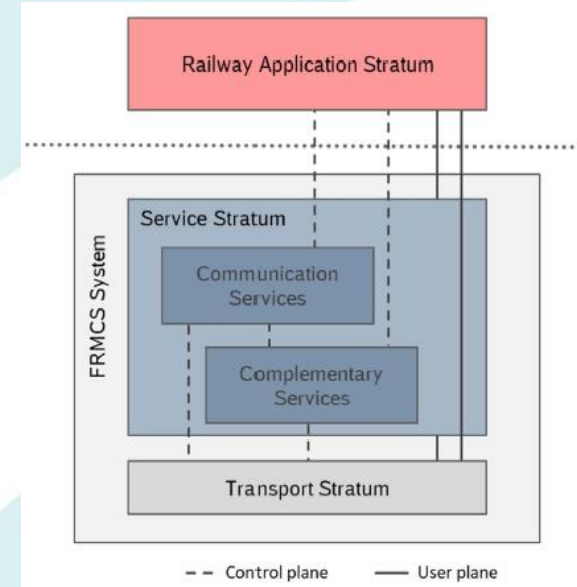
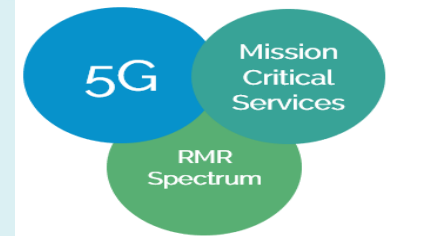
The Mission Critical Control Layer is part of the Communication Layer, together with the Transport Layer. The Communications layer is separated from the User Layer.

This means that the application will communicate with a MCX Client (that can be placed with it, outside TOBA (Voice, Tight Coupling) or in the TOBA (Data, Loose Coupling)).

The MCX layer will record the application type and the connectivity needs, and consequently will perform the connection with track side (within MCX domain).

With this, we will have a secure link, that has a controlled QoS, and deliver the required functionalities.

Moreover, this will achieve the separation of the Communication Layer from the User Layer; this will guarantee a future proof FRMCS.



# 5GRAIL FRMCS Prototypes



Based on the FRMCS available specifications (which are 3GPP based) and considering the Use Cases requirements as well as the test cases constraints, we have built the following prototypes:

**Equipments:**

On-Board Gateway (TOBA) (two prototypes (TOBA-A and TOBA-K))

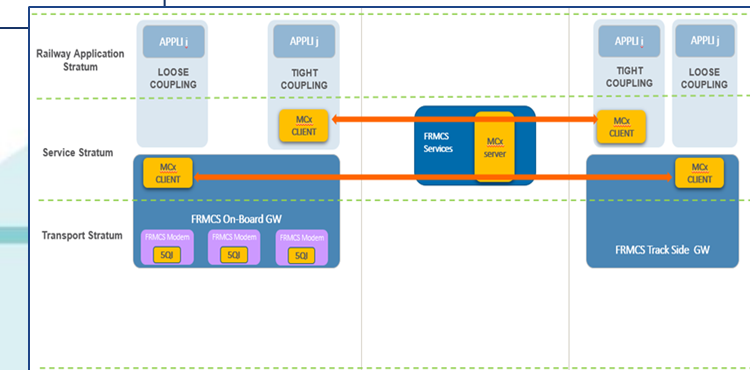
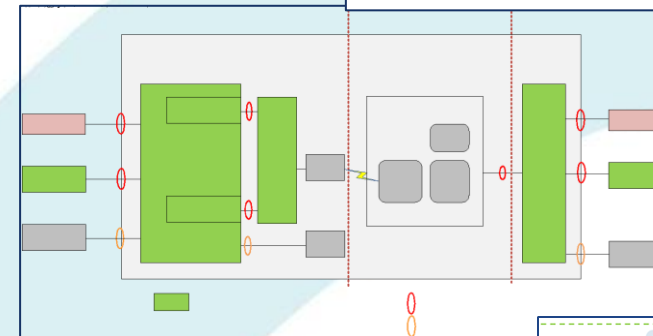
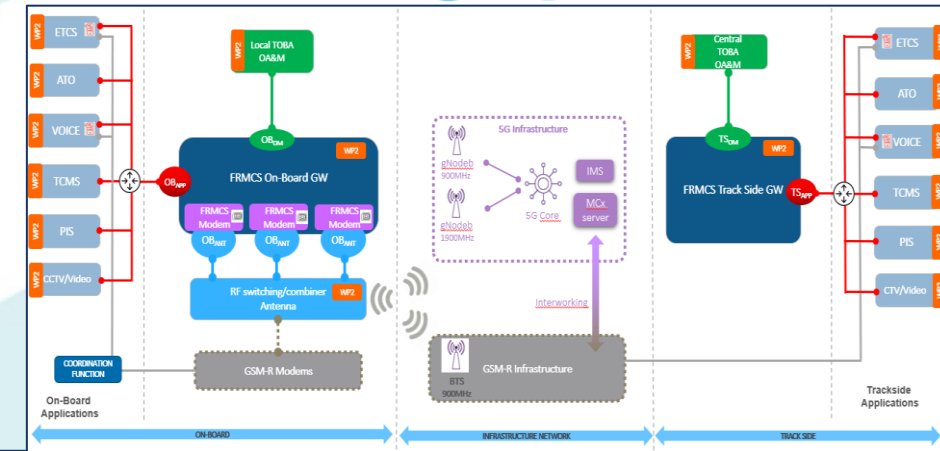
Track Side Gateway

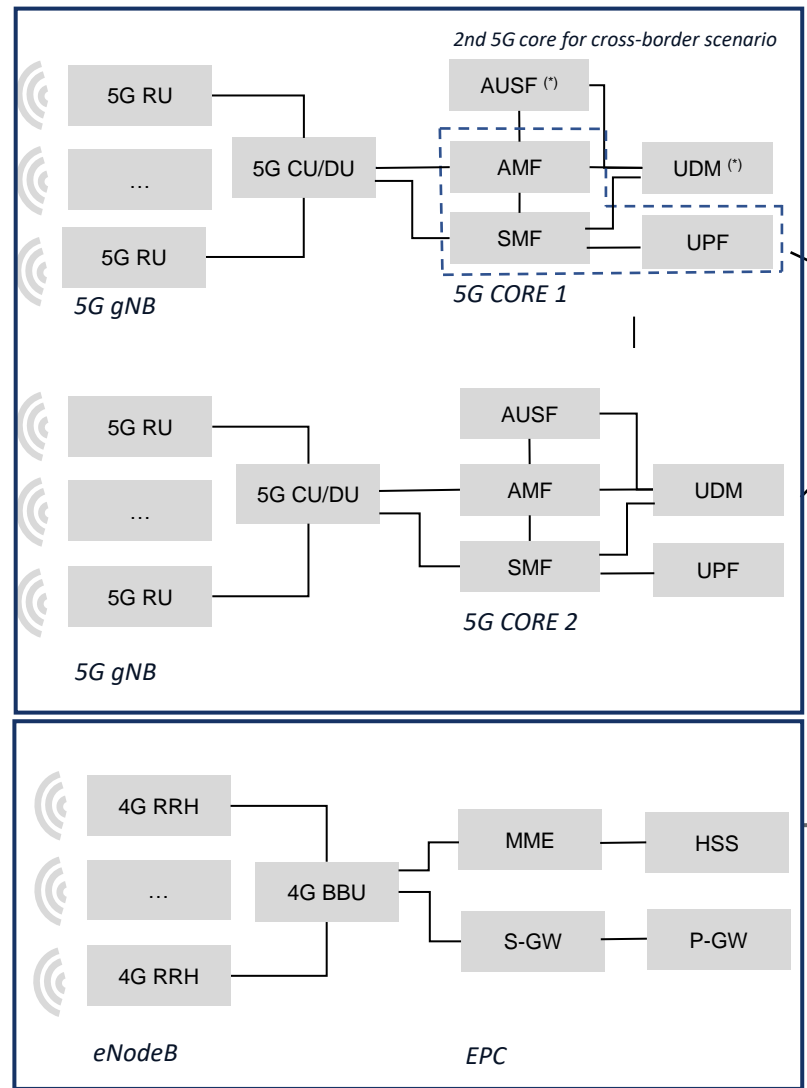
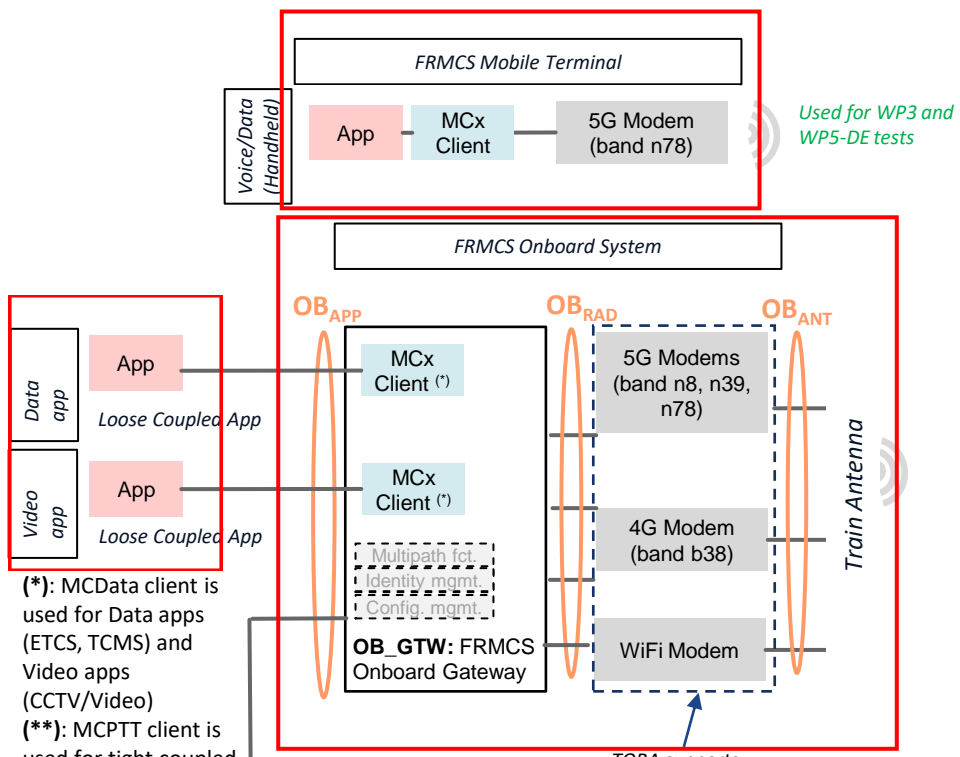
FRMCS 1900 MHz PC3 Radio Module

**Applications:**

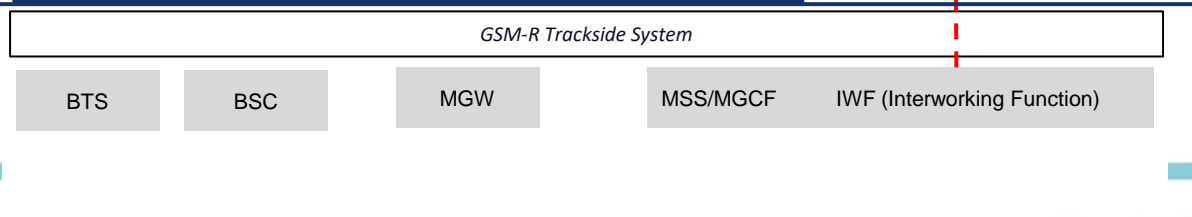
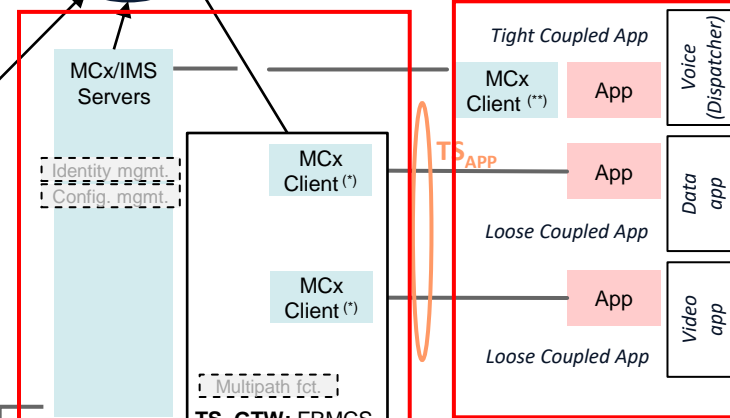
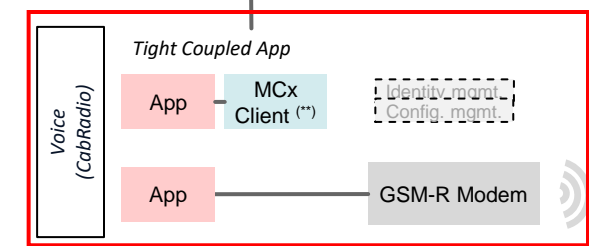
- Voice
  - REC
  - FRMCS – GSM-R Interworking
- ETCS
- ATO
- TCMS – telemetry
- Video
- Remote Vision (Remote train Driving)
- PIS

These prototypes have respected the FRMCS architecture, including the MCX and FRMCS edge interfaces (Obapp and TSapp) specific architectures

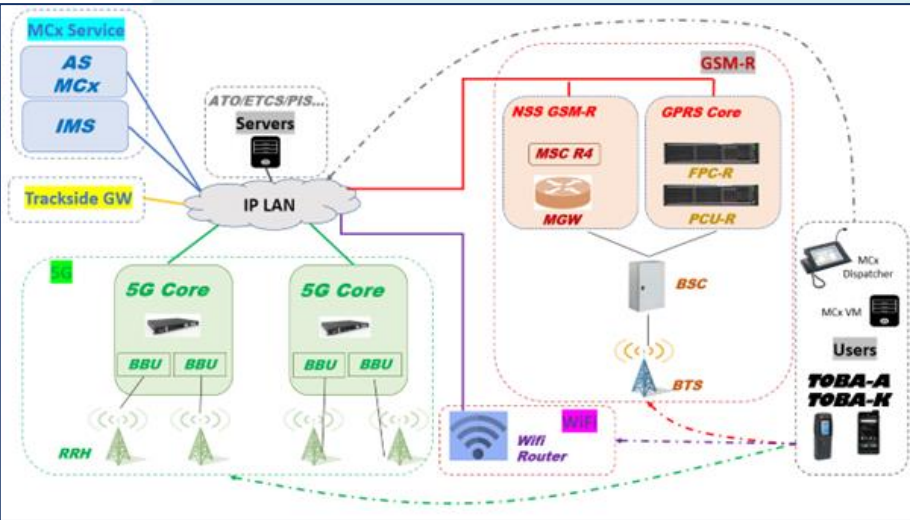
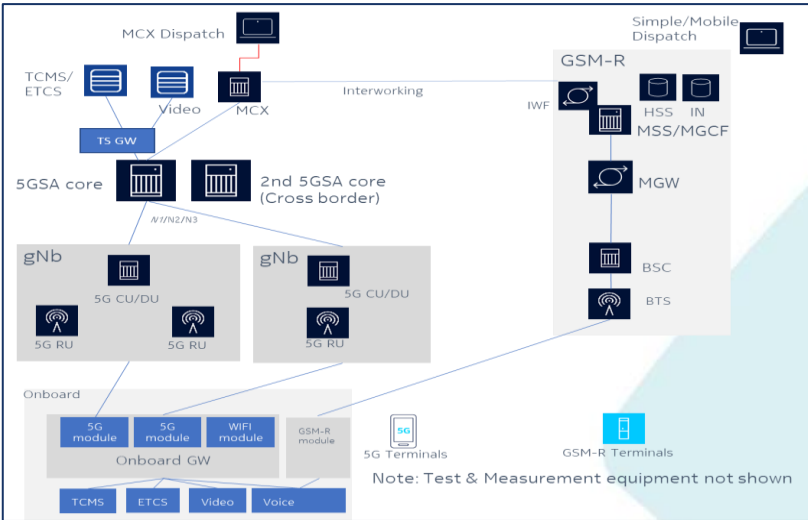




(\*): AUSF and UDM are only used in WP4



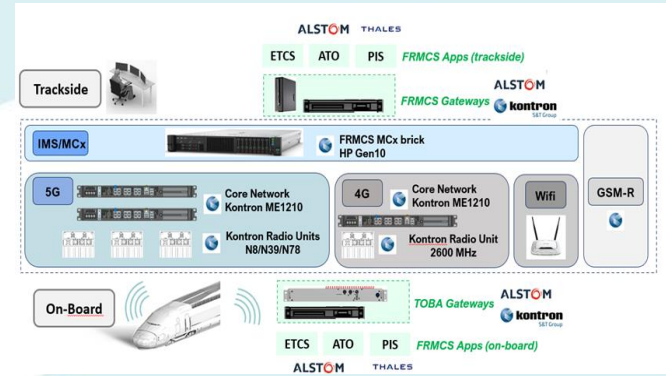
# Lab Tests achievements



We have tested the FRMCS prototypes in two labs : Nokia (Hungary) (WP3) and Kontron (France) (WP4).

The Lab Integration, Functional and Performance tests have been finalised. We have achieved the following results:

- ETCS, ATO, TCMS and Video MCDData successfully tested
- Voice , including REC and interworking with GSM-R MCPTT successfully tested
- PIS (Passenger Information System) successfully tested (lab only)
- Remote Vision have been successfully tested both as stand alone and as combined applications scenarios with ETCS,
- Cross-border solutions are being developed and tested: 1) using 2 UEs , and 2) Inter PLMN handover over AMF (details in next slides)





# Field Tests achievements



Field tests have been done in France and Germany, on two different (real) tracks.

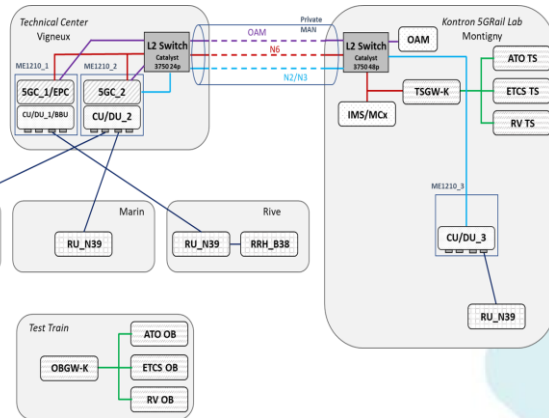
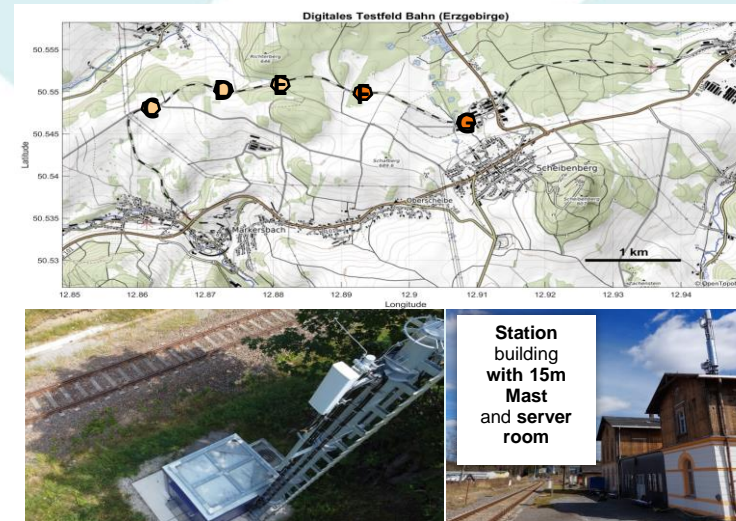
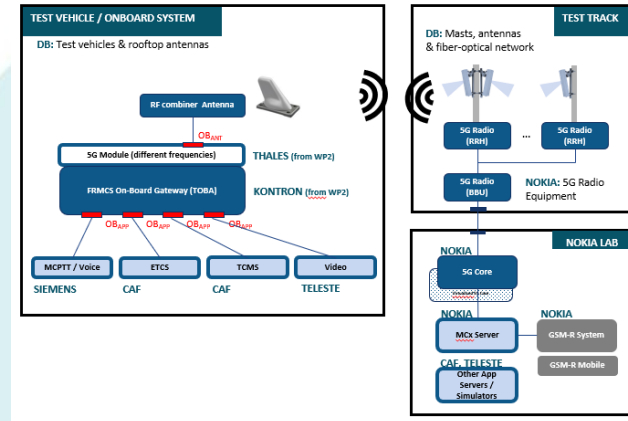
For this, we transferred the prototypes from labs. The field tests are a subset of the lab tests (slide 4).

The track in France is on a in-use Paris local train (RER) line in Paris Area, that is also used by SNCF for experimental tests. The track is linked with the Lab situated in France.

The track in Germany is a DB test track. The track is linked with the Lab situated in Hungary.

We have tested successfully:  
 Voice,  
 REC,  
 ETCS,  
 ATO,  
 TCMS,  
 Video,  
 Remote Vision.

We have organized a successful Demo in September 2023.



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



We have implemented and tested the interworking between FRMCS and GSM-R, including for the railway Emergency Call, which is a very different application compared with 112.

You can see below some particularities of this test:

## Implementation:

- Pre-standard FRMCS Railway Emergency Call using initiator's location criterion, processed by the MCX server
- Pre-standard GSM-R Interworking Function implemented in Nokia's MSC

Innovation/Amendment of specifications

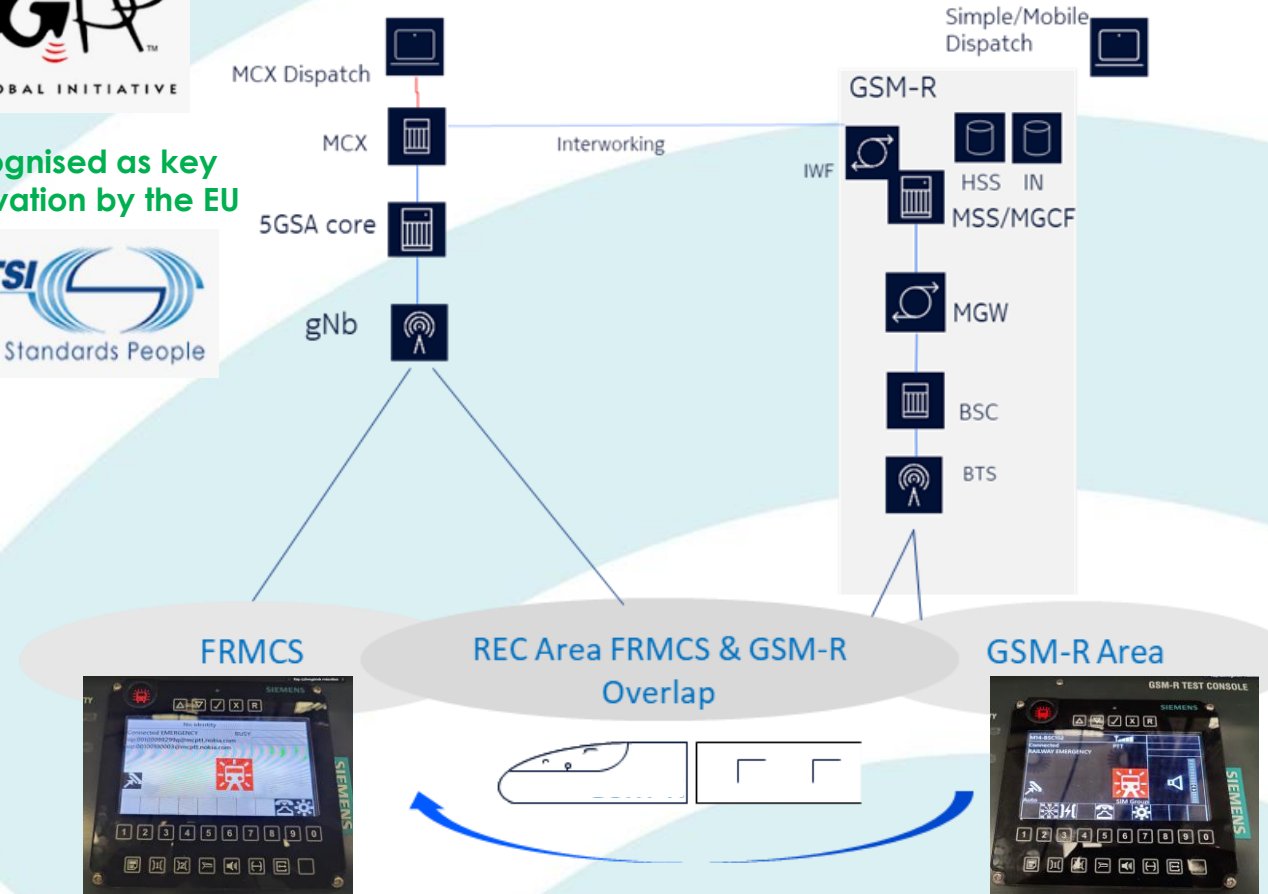


Recognised as key innovation by the EU



## Call flow:

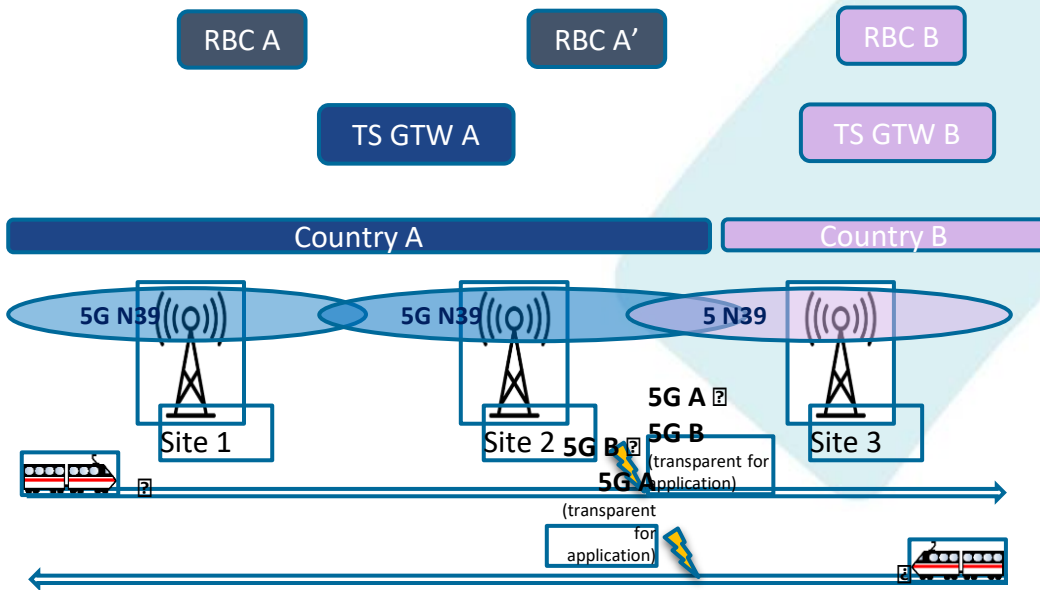
- Establishment of FRMCS Railway Emergency Call triggers automatically GSM-R REC setup;
- CAB Radio participates in REC call on GSM-R (using IWF);
- Moving from GSM-R to FRMCS as a Border Crossing Scenario:
  - ✓ CAB radio changes from GSM-R attached to FRMCS
  - ✓ CAB radio joins ongoing REC call on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



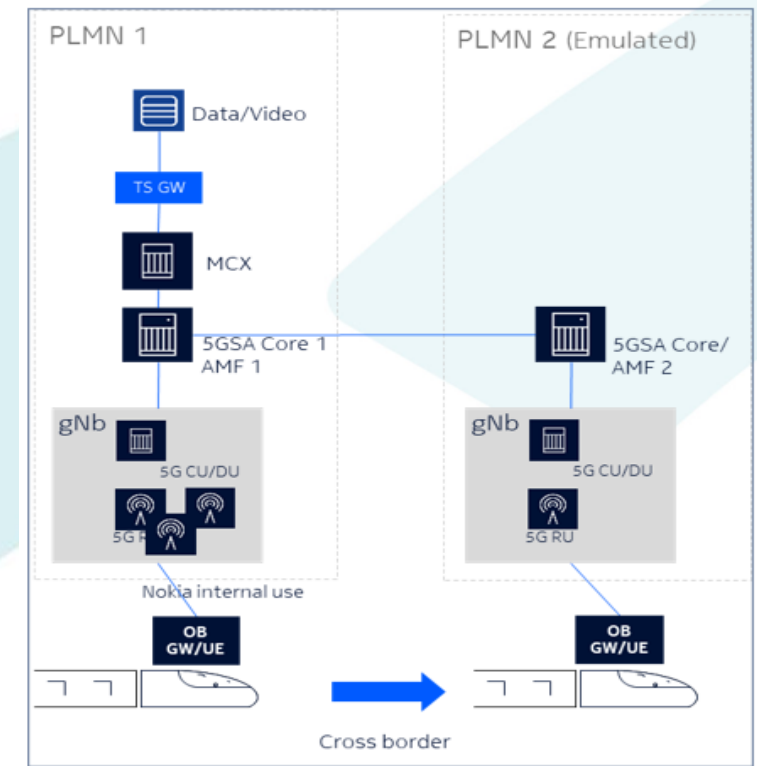
# Cross-border scenario's in 5G RAIL



## Scenario #1: 2 UE's in On Board FRMCS (ETCS application)



Scenario #2 (WP3): We have tested successfully tested in Nokia Lab two of the three necessary steps for the inter-PLMN handover, over AMF.



FRMCS is a 5G SA MCX system. 5G SA roaming schemes are not yet mature in Europe. Also, and mainly, the MCX "Domain Change" (interconnection and interworking) is being standardized, with solution expected for R18 or 19. To cope with the need for service continuity, required in Europe for ETCS, we are considering two UEs for MORANE 2. Of course, in future, we will have to reach one UE BX service continuity.

We have tested both Scenario's – 2UE's, WP3, Kontron Lab and also in WP3, Nokia Lab two of three steps of an 5G SA InterPLMN Handover over AMF (N14) (one UE).



# 5GRail Achievements

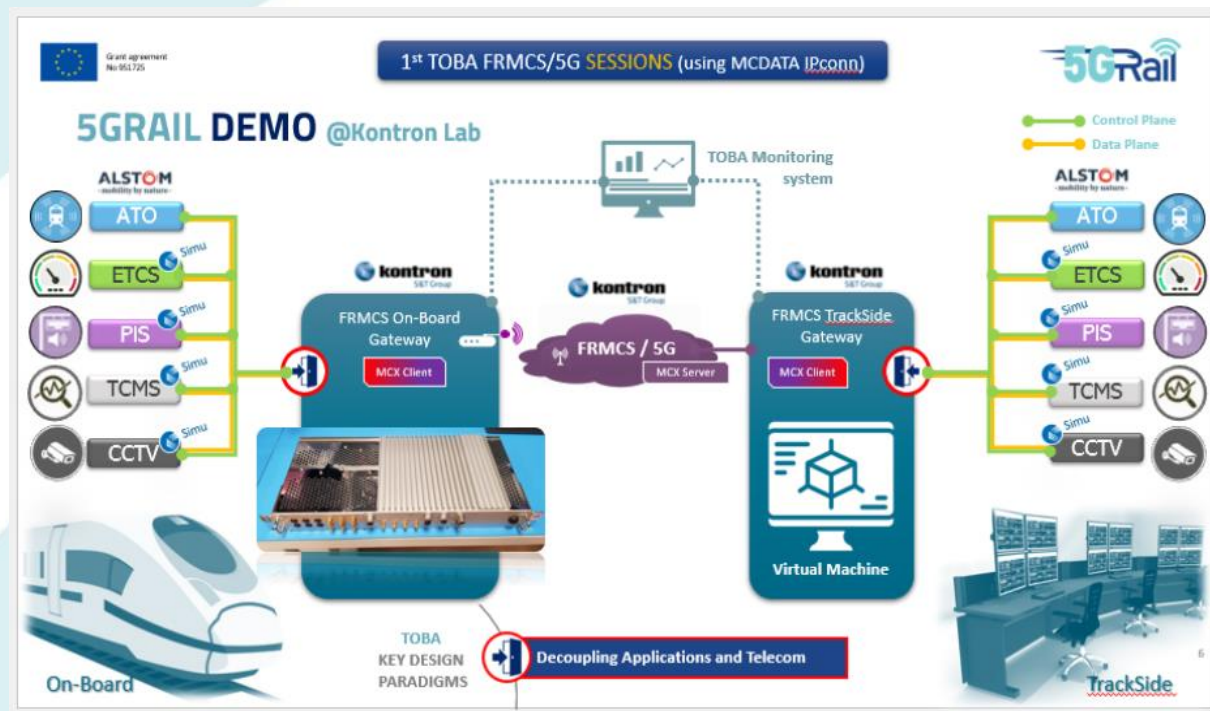


- Following FRMCS issues have been tackled in 5GRail:
- **Future proofness:** TOBA designed with decoupling of applications and telecom, as per FRMCS v1 specifications
- **5G NR Spectrum (FRMCS 1900 MHz, n8, n78)**
- **MCX features:** validated, with current products and mechanisms
- **QoS:** tested through 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 tested in Lab
- **Support to specifications:** 5GRail have offered valuable input to FRMCS specifications, and will help MORANE 2, the FRMCS European Pilot, planned to start in June 2024.

## 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

5GRail will be finalised in December 2023.



## **Attend our Final Event, in Brussels, 7 of December 2023!**

<https://5grail.eu/2023/10/03/experimental-trials-for-the-future-railway-mobile-communication-system-in-5grail-project-registrations-open-for-5grail-final-conference-on-07-12-2023/>



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