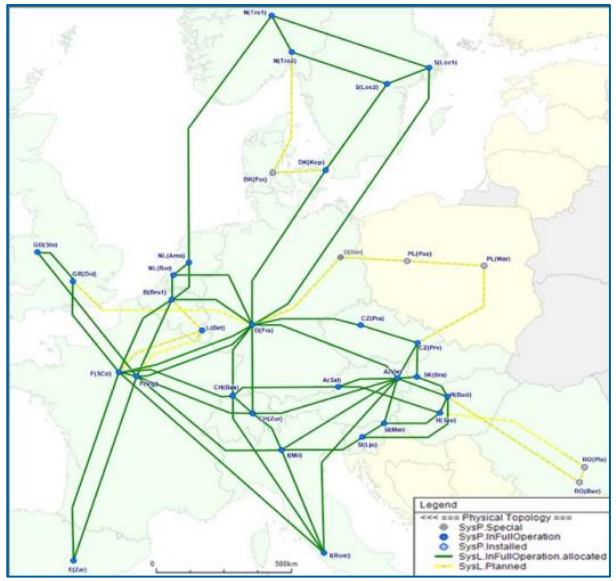
5GRAIL paves the way to the Future Railway Mobile Communication System Introduction

.

Dan Mandoc,
Head of FRMCS, UIC

IEEE Future Networks™ WORLD FORUM • 2022

Today is GSM-R…



Railways are currently using the GSM-R system for operational communication, as a key component of the European Railway Traffic Management System ERTMS.

Designed 20+ years ago and completely border-crossing interoperable, GSM-R is deployed on more than 130,000 kilometers of track in Europe and 210,000 kilometers worldwide.

GSM-R is supporting the train driver to signaller voice applications including the Railways Emergency Call and ETCS (European Train Control System), applications that requires specific functionalities and a very strong Quality of Service.

GSM-R

KEY FACTS

2G- BASED

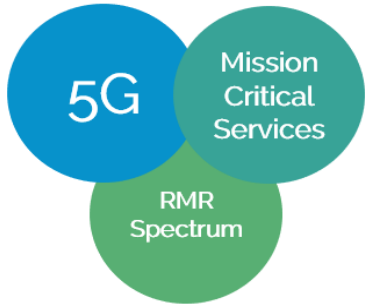
NATION-WIDE
CONNECTIVITY
INTEROPERABLE
IMPROVE SAFETY
ENABLE: REC, ETCS

–

OBSOLESCENCE
APPROACHING

…Tomorrow will be FRMCS

FRMCS
Future Railway Mobile Communication System



3GPP 5G
A GLOBAL INITIATIVE

The Future Radio Mobile Communication System (FRMCS) is the railways response for two elements of strategic importance for the future of the railways:

1. GSM-R Obsolescence
GSM-R is a 2G system. Manufacturers have announced that GSM-R equipment is due to reach the end of its life (around 2030) and will be supported until around 2035. Without a suitable and timely replacement, this will heavily impact the train system in Europe.

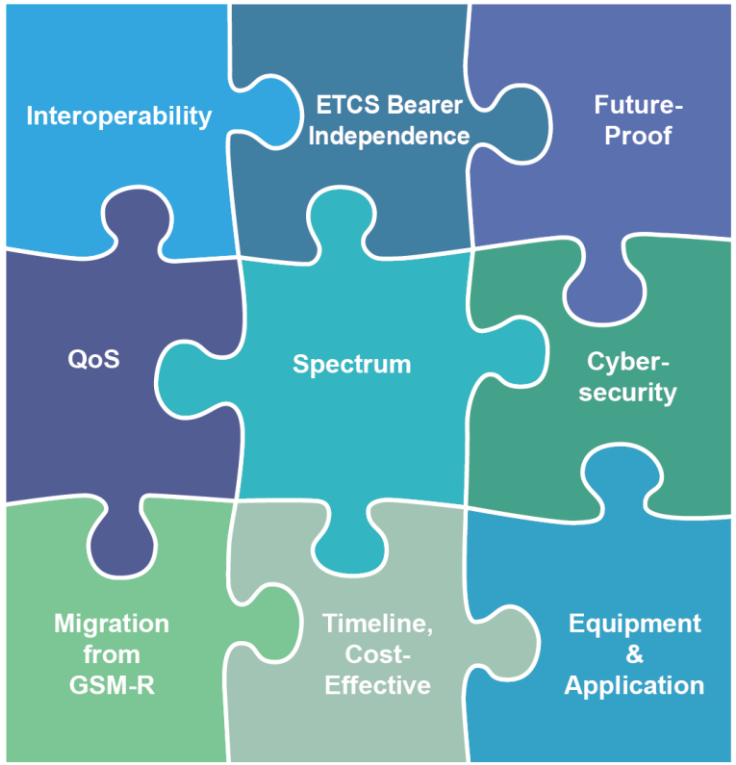
3. Digitalisation
FRMCS is also a significant opportunity - enable the Railways Digitalization - the need to transmit, receive and use increasing volumes of data, which is at the very heart of sustainable transport.

Replacing GSM-R will be complex, due the specific railways requirements in term of Functionalities, Quality of Service, Life Cycle, Cross-Border Interoperability and European Migration Timeline,

FRMCS Key Facts

- 5G, MCX based
- REC, ETCS
- ATO
- Separate communication from application
- Enhanced Railway traffic & performance
- Enable digitalisation

The specificities of railway telecommunications



FRMCS Challenges

Railway communications have very specific needs. The train is a guided vehicle, that cannot steer left or right. As it weights more than 400 tons, and runs to 180 km/h and when at high speed at 300 km/h, it breaks in more than one km. This is why:

- The Quality of Service to ensure the connectivity for the voice and signalling applications must be ensured at any moment and without errors
- Specific voice capabilities – group calls, functional aliasing (functional numbering), positioning / location depending addressing, priority, localization, etc.

To reach such a QoS, in Europe, dedicated frequencies have been allocated for Railways both for GSM-R and for FRMCS.

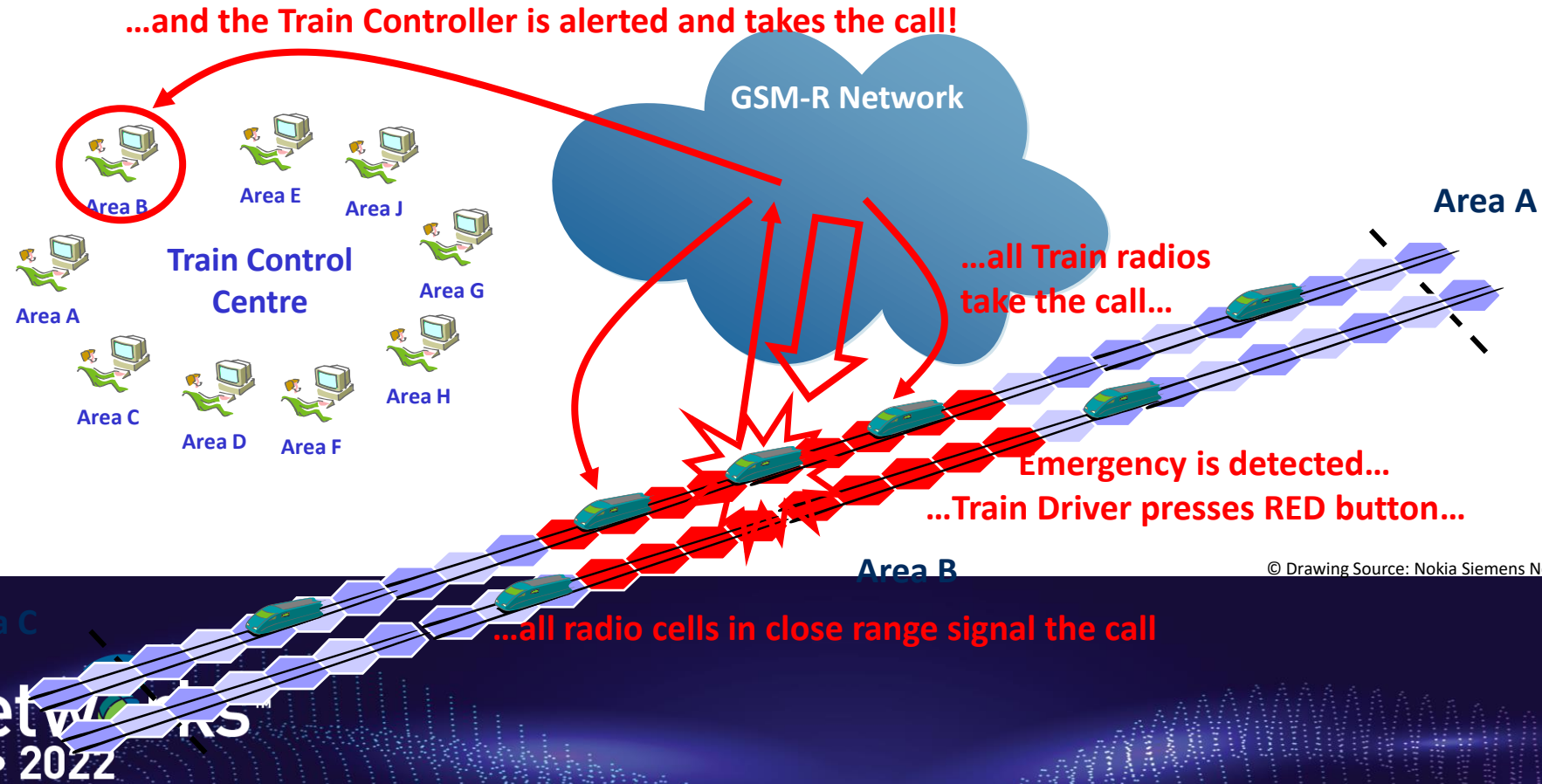
A ETCS Movement authority failure means that the train will slow down or stop. A stopped train means that all trains behind will also stop. Rail traffic restart can take hours.

A missed REC could mean that a train full of passengers could run at full speed towards e.g. another train which is derailed without knowing the danger.

You do the math.

Railway Emergency Call – the killer application

- The Railway Emergency Call (REC) is very different to 112. The Train is a guided vehicle; it cannot steer right or left, and it weights more than 800 tons. The brake distance of a train with 15 coaches from 120 kmph is some 900 metres. At higher speeds, this will be longer.
- In case of danger, the Train Driver presses the REC button on his radio. A pre-engineered Group Call Area is instantly created, and all trains in this area are notified within two seconds, and the train drivers will start braking the trains. The initiator will explain the issue (PTT); after which the Train Controller, who will also be alerted, starts organising the response and the traffic restart.



© Drawing Source: Nokia Siemens Networks

5GRAIL is an essential part of the FRMCS introduction plan

2Q'201 — 4Q'2022 — 4Q'2023 — 2025-2026 — 2026 — 2040

FRMCS V1 Specs

STARTING POINT

- URS 4.0
- Use Cases for 3GPP (60%)

PLAN

- FRS, SRS 1.0
- ➢ On-Board FRS, SRS 1.0
- ➢ FIS, FFFIS 1.0
- ➢ FRMCS Principle Architecture
- ➢ ETCS over FRMCS Principle Architecture
- ➢ Preparation for EC TSI inclusion (→ ERA)
- ➢ CEPT Reports on Railway Frequencies & ECC Decision
- ➢ Validation of Uses Cases V1 in 3GPP R16
- ➢ Use Cases V2 to 3GPP R17 (95%)
- Use Cases Gaps vs. 3GPP => ETSI TS

FRMCS Demonstrator

STARTING POINT

- Stabilized FRMCS Specification
- R16 Products : MCX 5G (→ Industry)

PLAN

- FRMCS prototypes (→ H2020 5GRail)
- FRS, SRS 2.0
- On Board FRS, SRS 2.0
- FIS & FFFIS 2.0
- ➢ Validation of Use Cases V1 in 3GPP R17
- Use Cases V3 in 3GPP R18
- TSI inclusion 1 (→ ERA)
- Additional elements for TSI
- Technical Migration Scenarios
- European Interconnection Study
- Signalling Impacts

FRMCS European Trial ⇒ Readiness

STARTING POINT

- Operational FRMCS Specs
- R17 Products : FRMCS 5G (→ Industry)

PLAN

- FRMCS European Trials (→ EU Rail, H2020: 5GRAIL-2?)
- FRS & SRS 3.0
- On-board FRS 3.0
- FIS & FFFIS 3.0
- Validation of Use Cases V3 in 3GPP R18
- Use Cases V4 in 3GPP R19 (evolution)
- TSI inclusion 2 (→ ERA)
- Cross-borders
- Interconnection hubs development (→ EU-Rail, H2020 ?)
- Guidelines for Migration

National Deployments

STARTING POINT

- FRMCS 1st Edition
- R17-R18 Products

PLAN

- Corridors (→ CEF 2 ?)
- National Plans
- MNOs Synergies
- Tenders preparation: 2023 – 2024

(FRMCS evolutions:

2nd Edition, …)

The plan is to make available a FRMCS 1st Edition, end 2025, to start the national trials. It will be based on 5G, MCX, 3GPP R17 &18 products.

To reach that the embedded plan is followed.

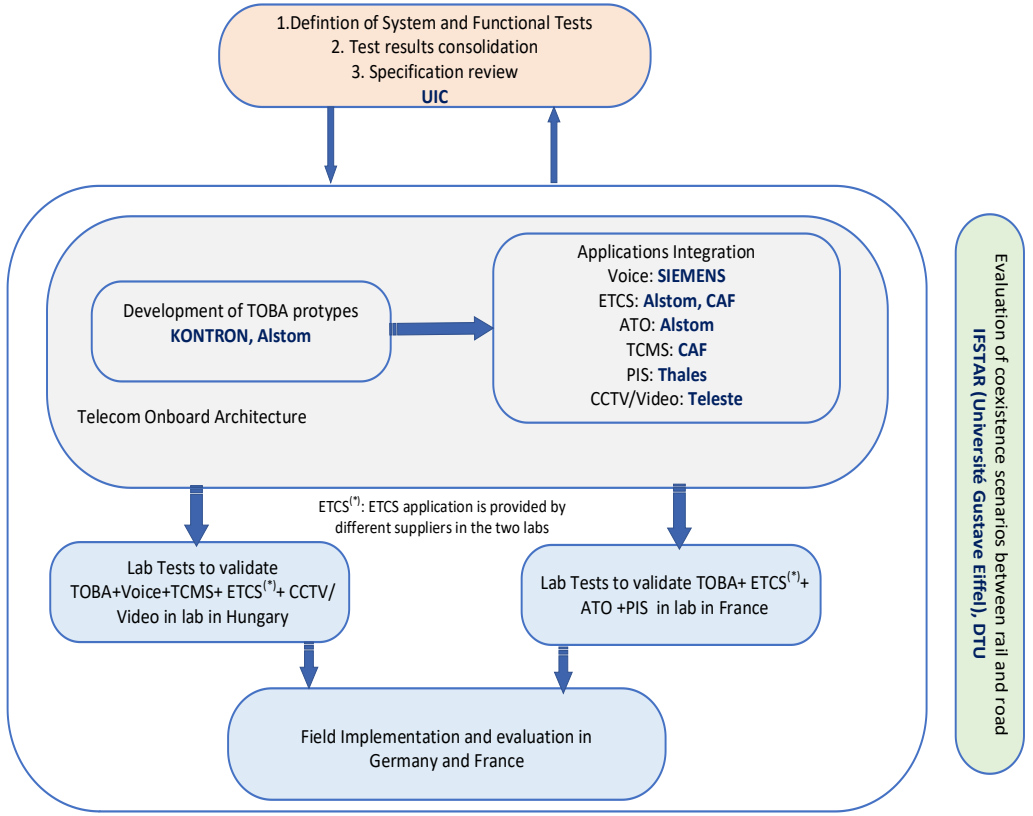
A very important step of this plan is building and testing the first FRMCS Demonstrator.

This will be performed through the EU co-funded H2020 ICT-053 5GRAIL project.

We currently are in full execution of this plan, with dedicated frequencies being allocated by EC, Version 1 FRMCS Specifications being finalized for the 2022 CCS TSI, and first prototypes starting being tested.

5GRail scope, structure and partners

- **5GRAIL scope is to:**
- **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.** Consider emulated cross-border conditions.
- **Prepare a performance measurements methodology, based on field activities,** to apply on further 5G FRMCS operational deployment; define and emulate coexistence scenarios between railway and roads;
- **Analyze the outcomes of these tests to loop back on FRMCS V1 specification, to amend or modify those**, and then obtain a finalized version of FRMCS V2 specification for sector regulation.



ALSTOM · mobility by nature · — France
CAF — Spain
DB NETZE — Germany
DTU — Denmark
Infraestruturas de Portugal — Portugal
kontron S&T Group — Germany
NOKIA — Finland
ÖBB INFRA — Austria
SBB CFF FFS — Switzerland
SIEMENS — Germany
SNCF RÉSEAU — France
TELESTE — Finland
THALES Building a future we can all trust — France
100 YEARS ANNIVERSARY uic INTERNATIONAL UNION OF RAILWAYS — Association
unife — Association
Université Gustave Eiffel — France

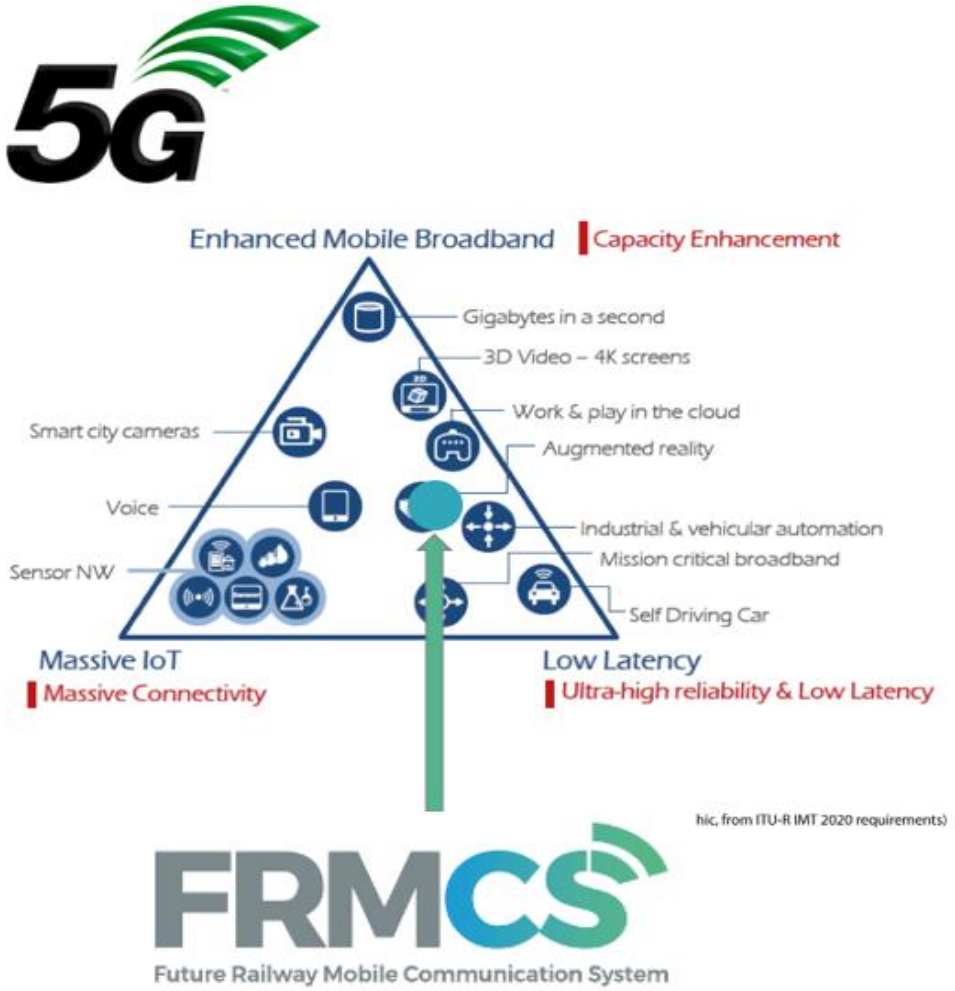
FRMCS is a 5G MCX technology

5G is depicted with three principal dimensions for performance as a platform for Verticals ready to use it:

- eMBB (enhanced Mobile Broadband)
- mMTC (massive Machine Type Communications)
- URLLC (Ultra-Reliable and Low Latency Communications)

FRMCS apart being planned as a 5G technology, is also considered as Critical Communications/Mission Critical, with additional specificities

- eMBB: higher user mobility (moving trains, some running at 300 km/h), improved coverage and diverse deployment (e.g., satellite usage both as relay or as a gNB).
- mMTC: CCTV, IoT sensors
- URLCC: automation (network slicing and edge computing are FFS), ultrareliable, low latency



FRMCS use cases to be 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 (voice and data application)	X	O	X	
Data applications				
Automatic Train Protection communication	X	X	X	X
Automatic Train Operation communication (limited to GoA2 ATO)		X		X
TCMS (**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	X		X	
Transfer of CCTV archives	X		X	
PIS (**P**assenger **I**nformation **S**ystem)		X		
Remote control of engines (Remote vision application)		O		X

Advanced 5G features:

- ❑ **5G QoS characteristics and optimized signalling relevant for mission-critical communications**
- ❑ **5G unicast IP based PDU (Protocol Data Unit) session**
- ❑ **5G User Equipment supporting 5G NR bands, relevant for the FRMCS**

MCx services:

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

X – Mandatory Test Case

O – Optional Test Case

5GRAIL achievements (1st period)

- The TOBA (Telecom On-Board Architecture – acronym used for the On-Board FRMCS) equipment is available for Lab Testing.
- Elaboration of Test plan with more than a hundred test cases, based on FRMCS use cases, validating selected 5G and MCX features

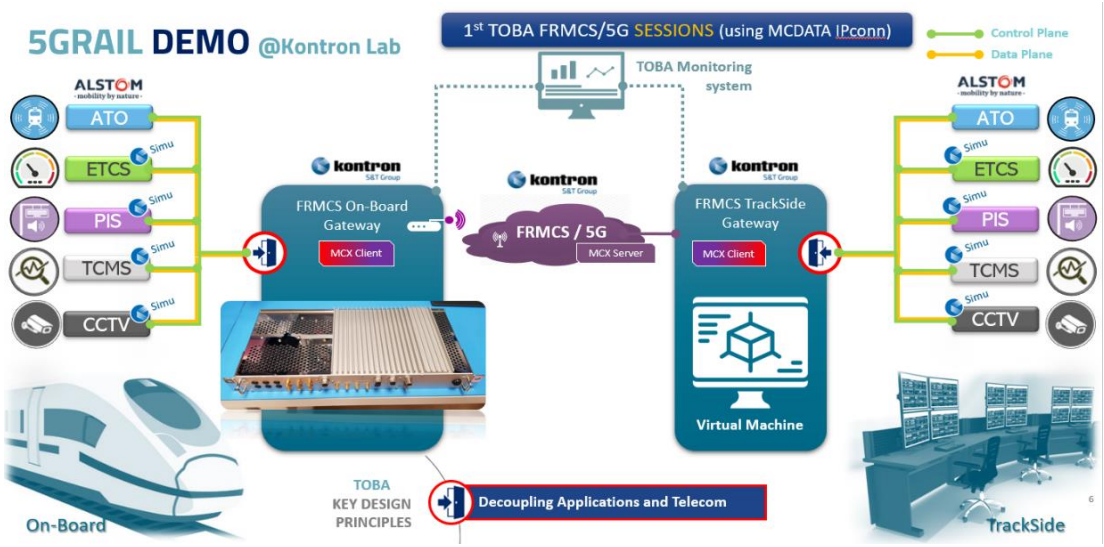
- Labs in Hungary and France have successfully integrated partners' equipment and applications and provided remote access to them.
- Integration testing has been performed, and the Lab tests have started.

- The first FRMCS data call, aligned with TSI 2022, was achieved in WP4 Lab
- FRMCS 1900 MHz, 31 dB chipset was made available, and is now successfully integrated in the TOBA.
- MCX Voice calls are under testing in WP3 Lab.
- 5G frequencies to be used in the Lab and Field tests are agreed. These are n8, n78 and n39.

- List of field test cases is agreed. Field testbed preparation is progressing.

- Emulation of selected Road and Rail coexistence scenarios is progressing

- 5GRail mid-term Conference have been held in Q1 2022 with some 100 attendants
- Dissemination activities with participation to conferences, publications in scientific magazines, social media



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

7.2.1.1 Purpose

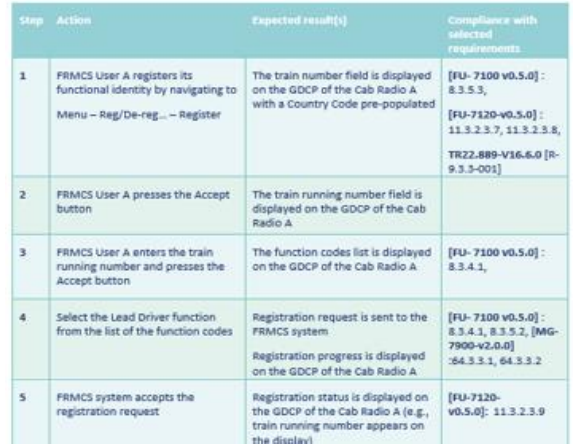
The purpose of this test is to demonstrate that an FRMCS User can register a functional identity (train running number and function code) on the FRMCS system. Once the registration is completed the FRMCS User can be reached by its FRMCS functional identity.

5GRail

7.2.1.2 Description of initial state/configuration

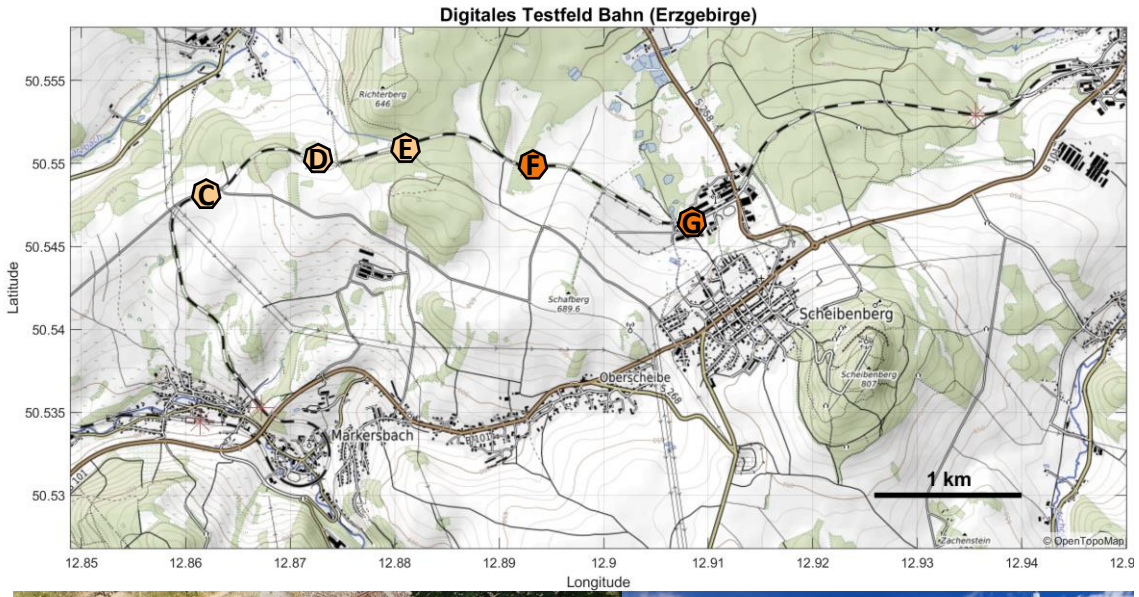
1. The Cab Radio A equipment type is recognised by the FRMCS system. This is handled by a predefined configuration file embedded within the Voice application software.
2. FRMCS User A is logged in into the FRMCS system. The user credentials (username and password) are predefined in a configuration file 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



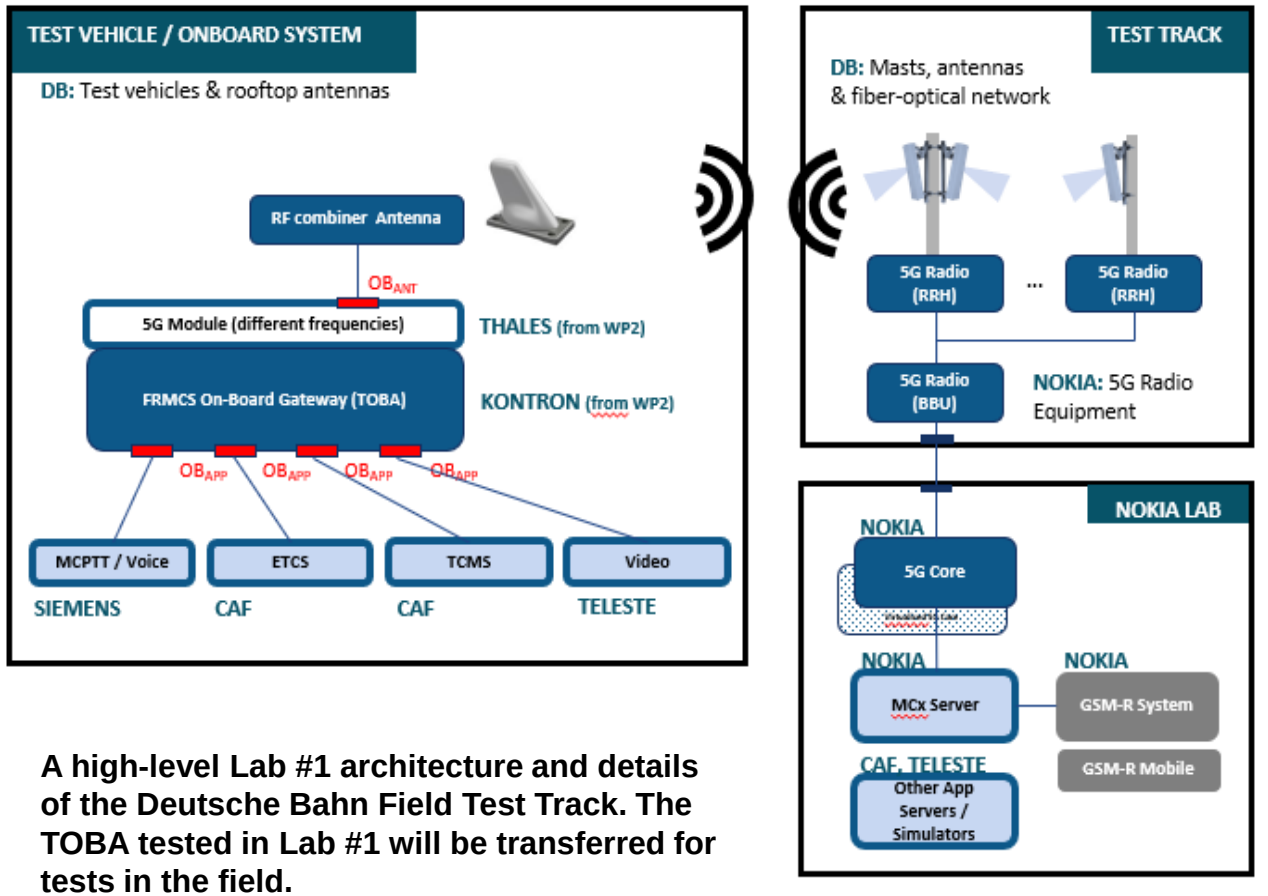
Step	Action	Expected result(s)	Compliance with selected requirements
1	FRMCS User A registers its functional identity by navigating to Menu – Reg/De-reg… – Register	The train number field is displayed on the GDCP of the Cab Radio A with a Country Code pre-populated	[FU- 7100 v0.5.0] : 8.3.5.3, [FU-7120-v0.5.0] : 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	The train running number field is displayed on the GDCP of the Cab Radio A	
3	FRMCS User A enters the train running number and presses the Accept button	The function codes list is displayed on the GDCP 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	Registration request is sent to the FRMCS system Registration progress is displayed on the GDCP 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	Registration status is displayed on the GDCP of the Cab Radio A (e.g., train running number appears on the display)	[FU-7120-v0.5.0]: 11.3.2.3.9

Interconnection of testbed in Germany with Nokia's lab in Hungary for field testing activities



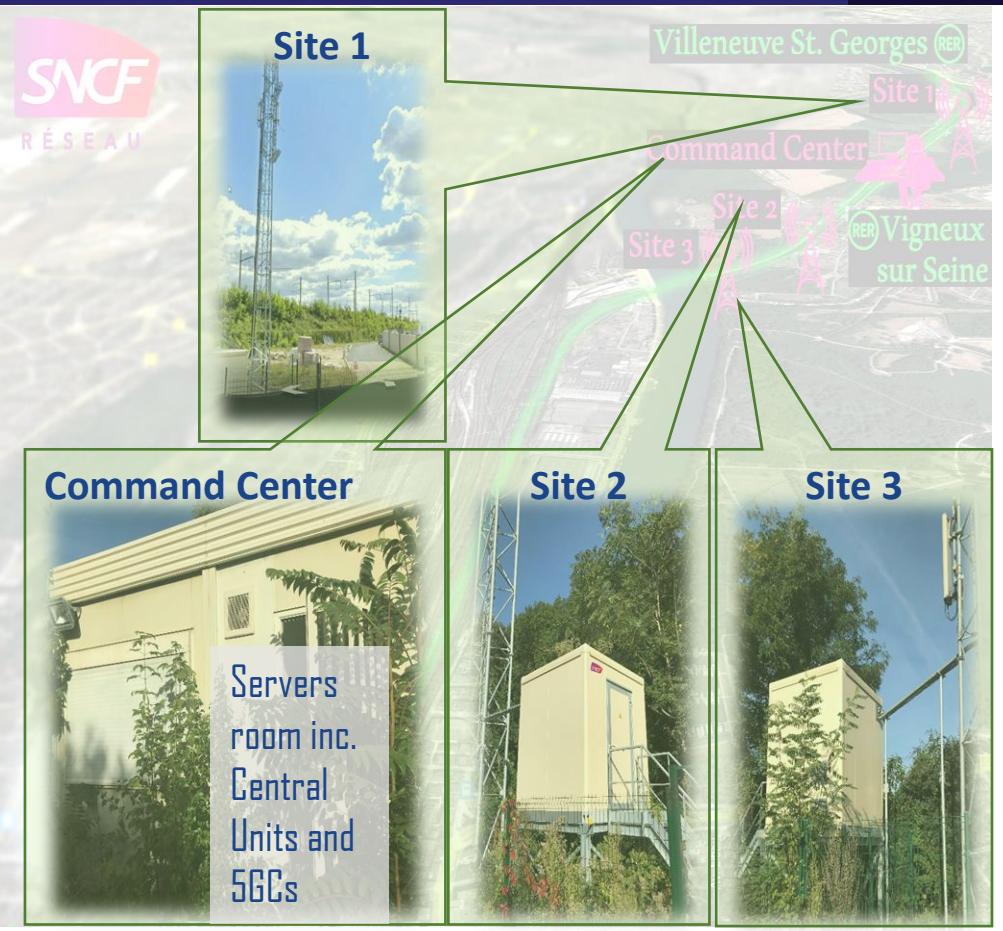
Infrastructure **Cabinets and Masts**

Station building **with 15m Mast** and **server room**



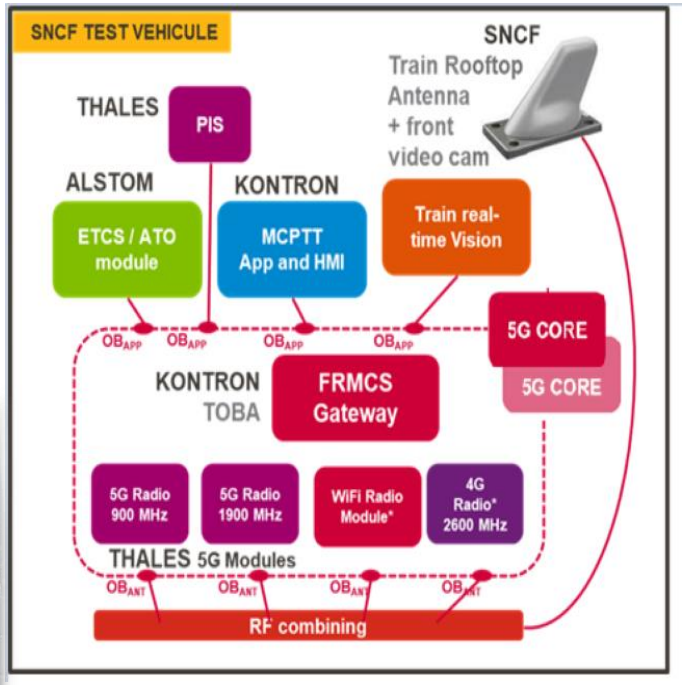
A high-level Lab #1 architecture and details of the Deutsche Bahn Field Test Track. The TOBA tested in Lab #1 will be transferred for tests in the field.

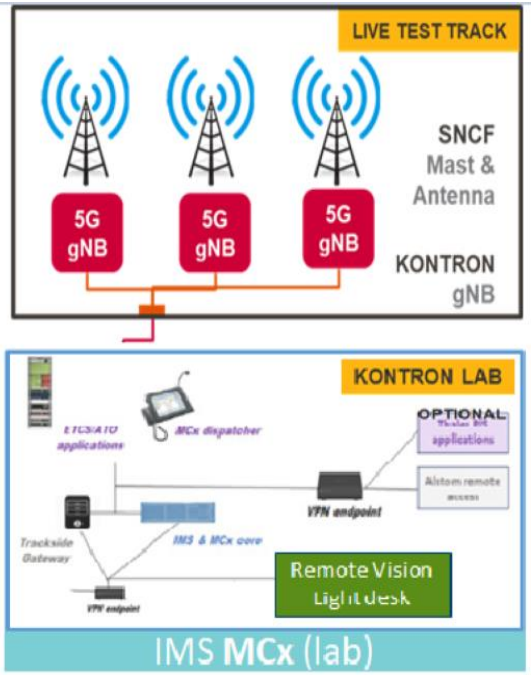
Interconnection of testbed in France with Kontron's lab for field testing activities



Power Distribution Frame

Command Center Servers Rack (19")





A high-level Lab #2 (France) architecture and details of the SNCF Field Test Track, which is an operational RER line. The TOBA tested in Lab #2 will be transferred for tests in the field.

Conclusions and Way Forward

5GRail is a very important step for the introduction of the 5G FRMCS radio system for European Railways, delivering the first FRMCS prototypes, in term of equipment and applications.

The TOBA prototypes – that include radio modules compatible with FRMCS 1900 MHz conditions are available for testing. Most of the application prototypes are available. They have been worked out to reach compatibility with the FRMCS architecture.

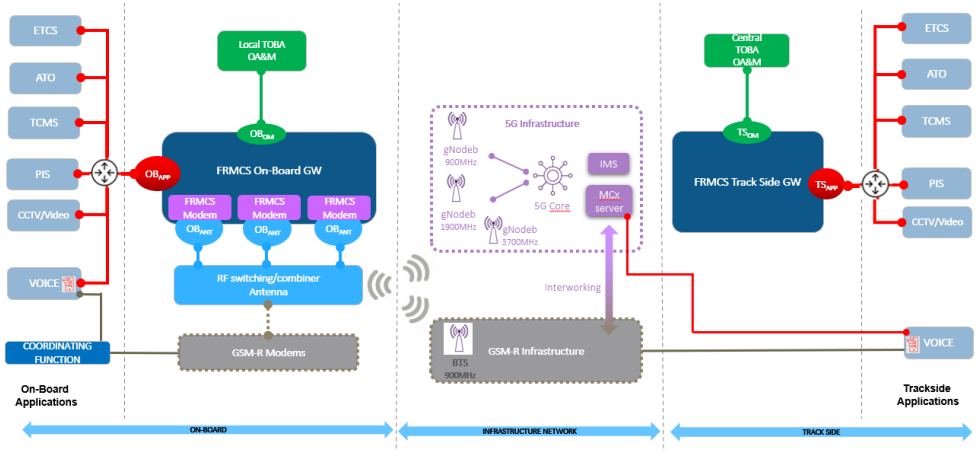
The test plan, that covers the lab functional and performance tests is available.

Lab test have started, with first data call successfully performed. Preparation for Field Tests have started.

Rail and Road coexistence scenarios is well progressing.

5G SA Border Crossing set-up tests to reach a working scenario in FRMCS conditions is ongoing.

The project is already delivering on the sense of interaction with V1 specifications, and the first achieved calls. It is on a good path; we will continue the activities as planned to reach the expected results!



IEEE Future Networks™ WORLD FORUM • 2022

Horizon 2020 European Union Funding for Research & Innovation
Contract No. 951725

5GRail

Thank you for your kind attention