



5GRAIL Nets4* Workshop

International Workshop on Communication Technologies for Vehicles - 16/17 November 2021

Presented by Bernd HOLFELD, WP5 Leader - 17th November 2021



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TODAY IS GSM-R...

The railways currently use the GSM-R system for operational communication, a key component of the European Railway Traffic Management System ERTMS.

Designed 20+ years ago by Railways 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 (considered to be the best method to avoid a train accident when all the other system has failed) and ETCS (European Train Control System).

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.



2G+
+
NATION-WIDE
CONNECTIVITY
INTEROPERABLE
IMPROVE SAFETY
ENABLE:
RAILWAY EMERGENCY
CALL
ETCS
-
DATA
OBsolescence
APPROACHING



...TOMORROW WILL BE FRMCS

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

Firstly, GSM-R is a 2G system, where 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.

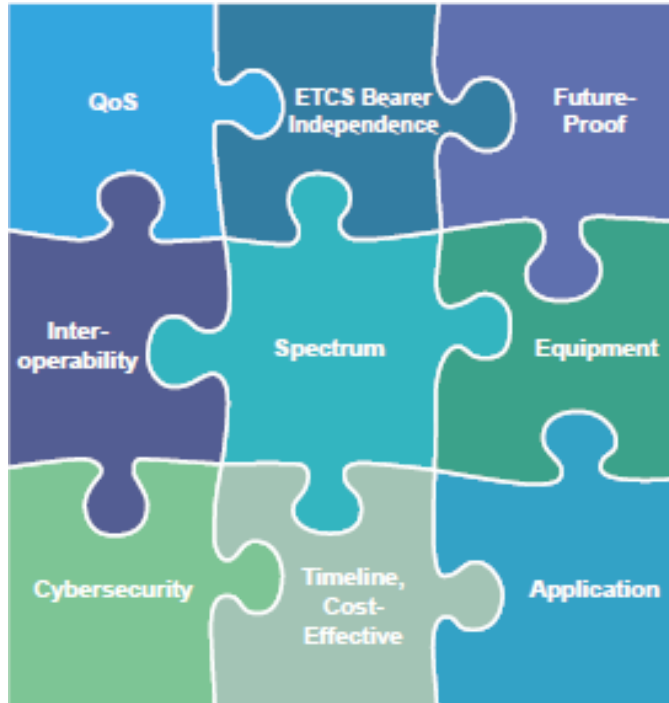
Secondly, whilst replacing GSM-R is a complex issue, due the specific railways requirements in term of Functionalities, Quality of Service, Life Cycle, Cross-Border Interoperability and European Migration Timeline, this is also a significant opportunity, which is to enable and support the Railways Digitalization - the need to transmit, receive and use increasing volumes of data, which is at the very heart of sustainable transport.

Improving the telecom service quality, the potential offered by the Internet of Things, smart maintenance, wireless connectivity instead of lineside wires, driverless trains... railways need a suitable radio system to enable these ever-increasing communication flows in an efficient way.



- 5G
- ENHANCE SAFETY
- IMPROVED RAILWAY EMERGENCY CALL
- AUTONOMOUS GOA 2 TRAINS
- ENHANCE RAIL TRAFFIC & PERFORMANCE
- DIGITALISATION





The train is a guided vehicle, that cannot steer left or right. As it weights more than 400 tons, and runs to 180km/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 capabilities must be supported by the telecom system – group calls, functional aliasing (so called functional numbering), location depending addressing, 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.

ERTMS = ETCS plus GSM-R



Trans-European Transport Network (TEN-T)

The European Railway Traffic Management System is at the core of the European concept for an interoperable railways system: when the train is crossing the border, the communications will be ensured by the same radio equipment without interruption. This will also ensure the uninterrupted signalling control.

ERTMS include today ETCS and GSM-R.

ETCS, which is a Communication-Based Train Protection System, can work in Europe only by using GSM-R, and soon also GPRS.

All new trains in Europe must be equipped with and GSM-R (and soon GPRS) and ETCS.

FRMCS is the GSM-R successor. This means that:

- FRMCS must perform at least as well as GSM-R
- FRMCS must comply with all national operational rules requirements.
- Starting the entry in force of the 2022 CCS TSI, all new trains will also be "FRMCS ready" cabled (this is a concept being finalised)
- Starting 2025/2026, all new trains will be also equipped with FRMCS. Existing GSM-R trains will start being retrofitted with FRMCS.

The European railways migration from GSM-R to FRMCS will be a process that will last some ten years (2035).

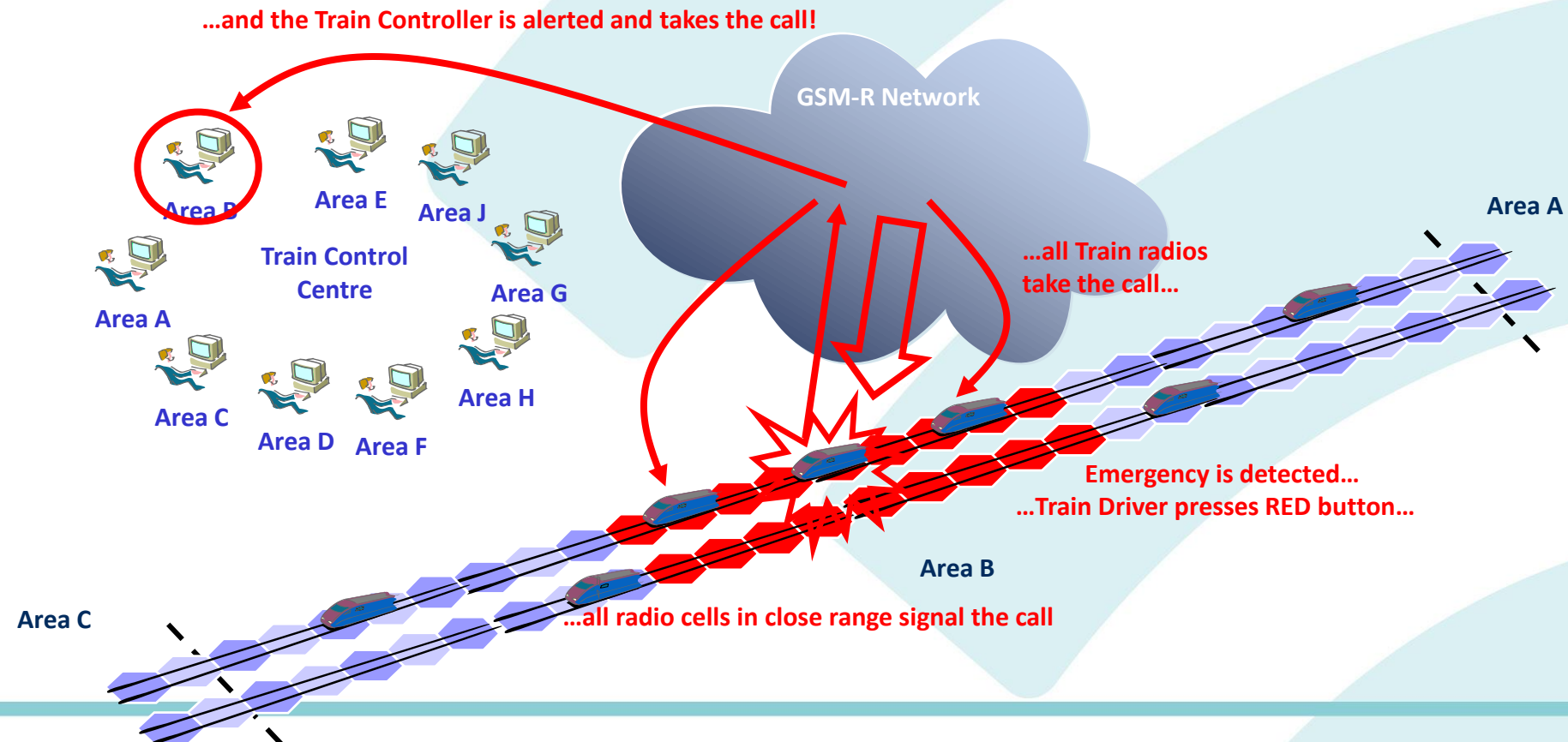


Use Case: The Railway Emergency Call



In Emergency situations a Train Driver must be able to warn all other trains running to the danger point at close range; the Train Controller for the Area must also be informed!

GSM-R REC: The Train Driver simply presses the red Railway Emergency button on his radio! All Train Driver radios at a pre-engineered range (e.g. 15 km) are notified and will automatically take the call! The Train Controller for the Area will also be alerted!



User Requirements – the foundation of FRMCS



The User Requirements Specification (URS) is the foundation of the FRMCS. The embedded image explains the scope of the URS.

All FRMCS specifications are compliant with the URS.

The URS is open for any contributor and can be downloaded from the UIC Web Site.

<https://uic.org/rail-system/frmcs/>

In addition to the critical communications e.g. voice train radio applications or signaling systems, these use cases also cover a large scale of train performance applications.

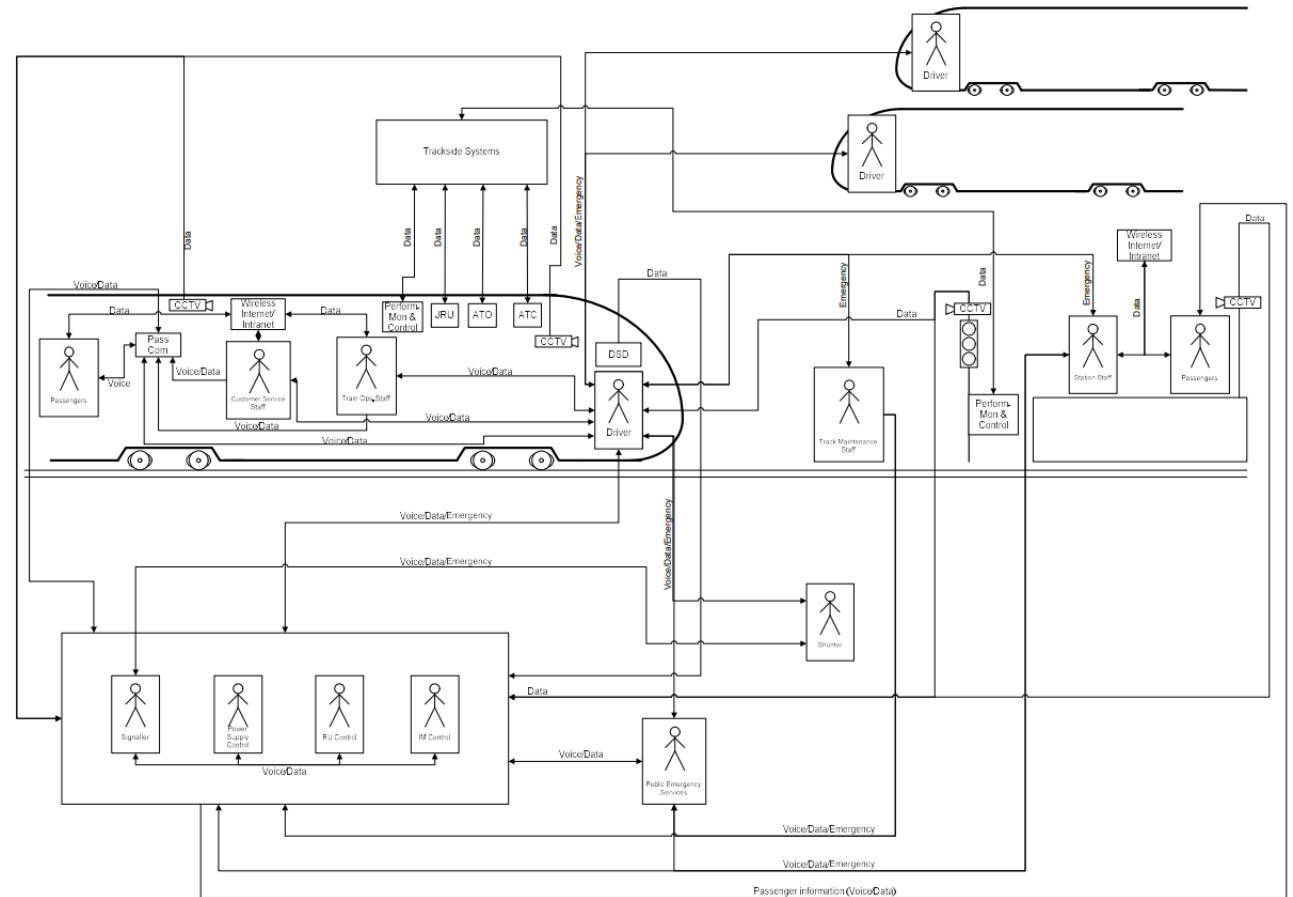


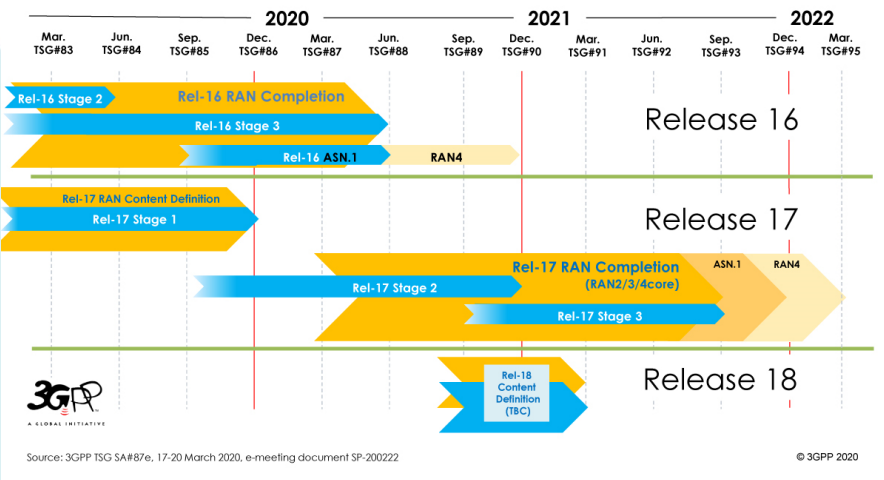
Figure 1: Application Layer Relationship Diagram



FRMCS will be based on 3GPP



- The FRMCS 1st Edition, planned to be available for early implementors in the second half of 2025, will be a 5G system based on 3GPP R17.
- UIC is currently working to ensure that the necessary 3GPP MCX (Mission Critical) services that are needed to meet the operational expectation (see embedded list) are included in the R17.
- The FRMCS system will continue to evolve with more services in R18 and beyond. We aim for the current expected improvements (Multicast, Gateway UE) to be software solutions, therefore not requiring hardware changes.

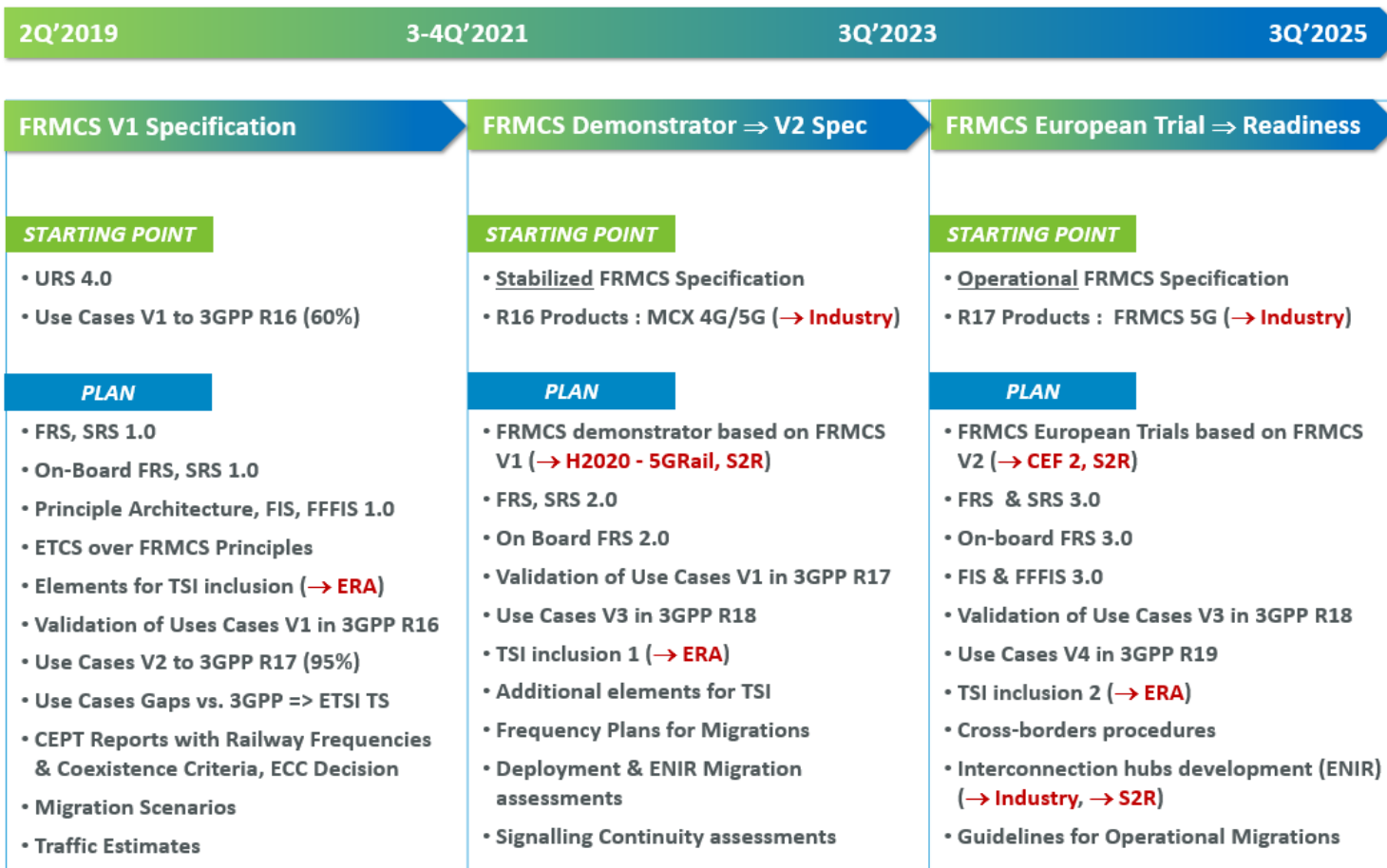


URS Ref.	Application	Use	Type	applications to be considered for the migration phase
5.1	On-train outgoing voice communication from the train driver towards the controller(s) of the train	Critical	Comms	Y
5.2	On-train incoming voice communication from the controller towards a train driver	Critical	Comms	Y
5.3	Multi-Train voice communication for drivers including ground user(s)	Critical	Comms	Y
5.4	Banking voice communication	Critical	Comms	Y
5.5	Trackside Maintenance Voice communication	Critical	Comms	Y
5.7	Public emergency call	Critical	Comms	Y
5.8	Ground to ground voice communication	Critical	Comms	Y
5.9	Automatic Train Protection communication	Critical	Comms	Y
5.10	Automatic Train Operation communication	Critical	Comms	Y
5.11	Data communication for Possession Management	Critical	Comms	Y
5.12	Trackside Maintenance Warning System communication	Critical	Comms	Y
5.13	Remote control of Engines	Critical	Comms	Y
5.14	Monitoring and control of critical infrastructure	Critical	Comms	Y
5.15	Railway Emergency Communication	Critical	Comms	Y
5.16	On-train safety device to ground communication	Critical	Comms	Y
5.19	Voice recording and access	Critical	Comms	Y
5.20	Data recording and Access	Critical	Comms	Y

URS Ref.	Application	Use	Type	applications to be considered for the migration phase
10.1	Billing information	Business	Support	Y
5.24	On-train outgoing voice communication from train staff towards a ground user	Critical	Comms	Y
5.25	On-train incoming voice communication from a ground user towards train staff	Critical	Comms	Y
5.27	Critical real time video	Critical	Comms	Y
5.27	Critical real time video in case of ATO GoA3/GoA4 operation	Critical	Comms	Y
8.1	Assured voice communication	Critical	Support	Y
8.2	Multi user talker control	Critical	Support	Y
8.3	Role management and presence	Critical	Support	Y
8.4	Location services	Critical	Support	Y
8.5	Authorisation of communication	Critical	Support	Y
8.7	Authorisation of application	Critical	Support	Y
8.8	QoS class negotiation	Critical	Support	Y
8.9	Safety application key management communication	Critical	Support	Y
8.10	Assured data communication	Critical	Support	Y
8.11	Inviting-a-user messaging	Critical	Comms	Y
8.12	Arbitration	Critical	Comms	Y



FRMCS Introduction High Level Plan



Railways goal is to make available together with partner Industry and Authorities a FRMCS 1st Edition to Railways , to start the national trials. This will be based on 5G, 3GPP R17 MCX products.

To reach that the embedded plan is followed.

A crucial step of this plan is building and testing the FRMCS Demonstrator, especially On-Board, based on the FRMCS specifications. This will be performed through the EU co-funded H2020 ICT-053 5GRAIL project.

The migration from GSM-R to FRMCS will be complex, and is estimated to last some ten years. It will be done for whole Europe.

Today, a train driver could refuse the start of journey if GSM-R does not work, because there will no easy link with the Signaller, and especially because there will no REC available. Such situations happened in few limit cases, e.g. during a national GSM-R outage.

Reaching this target (FRMCS 1st Edition in 2025), which is a European level issue, is extremely important for the European Railway community.

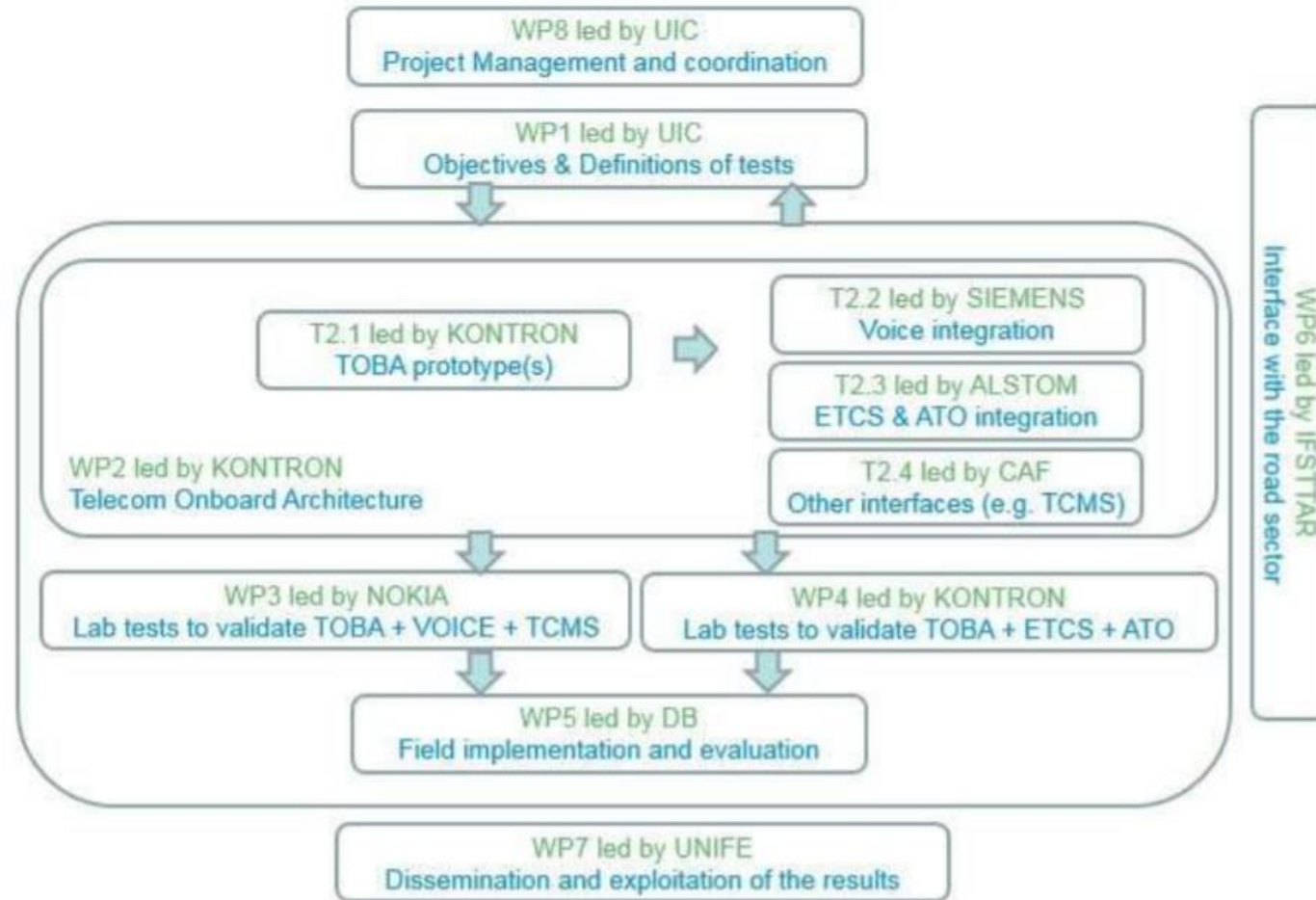


Project acronym	5G RAIL
Project title	5G for future RAILway mobile communication system
Starting date	01/11/2020
Duration in months	30
Call (part) identifier	H2020-ICT-2019-3
Topic	ICT-53-2020 5G PPP – 5G for Connected and Automated Mobility (CAM)

The 5GRail Project scope is:

- Elaborate FRMCS prototypes based on the FRMCS Version 1 specifications, including telecom 5G infrastructure compliant with FRMCS 3GPP specific standardization elements, and the new on-board equipment (FRMCS On-Board Gateway and additionally prototypes of adapted ETCS and ATO elements);
- Define all the relevant technical and functional tests to be achieved to verify the compliance of the prototypes with the FRMCS V1 specification, maximizing the scope of applications to be tested or simulated (particularly operational voice services, ETCS, ATO, TCMS, video and interaction with automotive) and including some measurements of performance;
- Execute these tests in lab environment firstly, and then in railway environment with train runs, considering cross-borders conditions; define 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 V1 specification for sector regulation.

5G RAIL Overall Framework



Lab Test Applications and Scenarios



	Applications	Test cases	Nominal radio conditions	Degradated radio conditions	Cross-border	Bearer-flex	Combined applications (critical, non-critical)
LAB WP3	Voice - Siemens	REC alert with automatic voice initiation by driver	X	X	X		
		REC alert with automatic voice initiation by controller	X	X	X		
		New entry to the Railway emergency alert (user regrouping feature)	X	X			
		Leaving of Railway emergency alert by a driver	X	X			
		Termination of the Railway emergency alert by the controller	X	X			
		Initiation of driver to controller voice communication	X	X	X		
		Initiation of controller to driver voice communication	X	X	X		
		Initiation of multi-train voice communication for drivers including ground user(s) communication	X	X	X		
		Initiation of multi-train voice communication for drivers including ground user(s) communication with interworking services	X	X	X		
		Join a multi-train voice communication for drivers including ground user(s) communication	X				
		Terminate a multi-train voice communication for drivers including ground user(s) communication (driver termination)	X				
		Terminate a multi-train voice communication for drivers including ground user(s) communication (controller termination)	X				
	ETCS - CAF	EVC to RBC communication	X	X			1. ETCS (critical)/TCMS(non-critical) 2. ETCS (critical)/driver to dispatcher(non-critical)
	TCMS - CAF	Telemetry	X	X			
		On-train remote equipment control	X				
LAB WP4	CCTV - Teleste	Transfer of CCTV archives	X	X		X	
	Video - Teleste	Transfer of data	X	X			
	ETCS - Alstom	EVC to RBC communication	X	X			
		RBC handover on the same 5G network	X				
		RBC and BTS handovers on the same 5G Network		X			
		RBC Handover on two different 5G Network			X		
		EVC to RBC communication with MT bearer switch 5G to 4G/WiFi				X	
	ATO - Alstom		X	X		x	
	PIS - Thales						



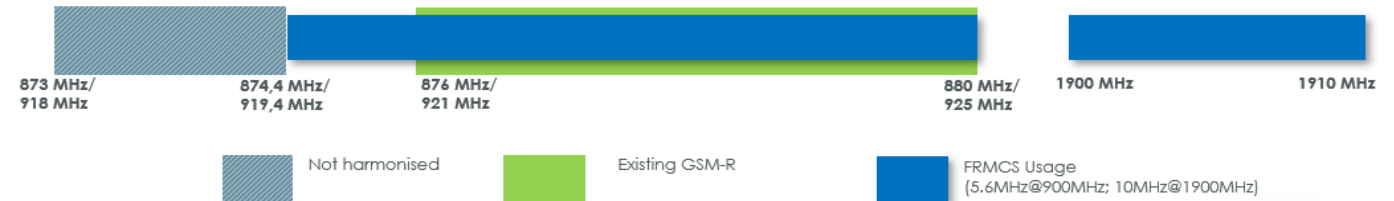
5GRail Frequencies



After a work of some four years, ECC has granted dedicated frequencies to FRMCS in Europe via ECC Decision (20) 02 “Harmonised use of the paired frequency bands 874.4- 880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR)” (<https://docdb.cept.org/download/1446>)

We have created a work item within 3GPP which is ongoing to standardize these frequencies.

Dedicated frequencies: allocated RMR (FRMCS) Spectrum in Europe
(post-migration)



One of 5GRail main targets is to provide a FRMCS demonstrator that works within this range of frequencies.

For the 900 MHz allocated bandwidth, there are no such modems existing. We have therefore agreed within the Consortium to utilize 5G N8 modems (880- 925 MHz / 915 – 960 MHz, FDD), which is very close to target bandwidth, is relevant for the radio measurements. The Modems are already available.

We have also agreed with Nokia proposal (agreed with DB and the rest of the Consortium) to utilize n78 (3300 – 3800 MHz TDD) in Lab 1 (Budapest) and Germany Field testing. This a 5G band already used for industrial application, and which could be interesting for railways for e.g. Train Performance applications, and it is a TDD band. The Modems are already available, they are being integrated in the On Board Gateway.

For 1900 Mhz, we had an initial promise for 5G n39 (1880 – 1920 MHz, TDD) modems, which finally was dropped, due to Qualcomm roadmap. In coordination with Thales, UIC have contacted Qualcomm Europe and sensibilized on the Railways case, and the 5GRail context. This was successful, and we are happy to report that we currently have an agreement for an upgraded MODEM (QCX315), which is dealt with through Thales. The modems capabilities are being evaluated, we will come back in few weeks with the assessment result.



Work Packages and Consortium members



WP Number	WP Title	Lead
WP1	FRMCS tests definition, tests results consolidation and specification review	UIC
WP2	TOBA prototypes development	KONTRON
WP3	Validation of ETCS, Voice, TCMS and CCTV/Video within TOBA – Laboratory tests	NOKIA
WP4	Validation of Data, ETCS, ATO and Cybersecurity within TOBA – Laboratory tests	KONTRON
WP5	Field Implementation and Evaluation	DB Netz
WP6	Rail and Road communication systems coexistence	UNI.EIFFEL
WP7	Dissemination, Communication and Exploitation	UNIFE
WP8	Project Management & Coordination	UIC

5GRAIL started on 1st of November 2020, for a 30 months duration.

The project is advancing, with a very good experts engagement, and with the On-Board Gateway Architecture report first version delivered, and the Test Plan and the first prototypes will be available end October 2021.

1	UIC	France
2	Nokia-DE	Germany
3	KONTRON	Austria
4	Alstom	France
5	DB Netz	Germany
6	SNCF Reseau	France
7	THALES	France
8	SBB	Switzerland
9	UNIFE	Belgium
10	CAF	Spain
11	OBB	Austria
12	SIEMENS	UK
13	IP	Portugal
14	UNIVERSITE GUSTAVE EIFFEL	France
15	TELESTE	Finland
16	DTU	Denmark
17	NOKIA-IT	Italy
18	NOKIA-HU	Hungary



Conclusion



5GRail is advancing well. October is a important period, where the first prototypes and Test Cases will be made available.

The Consortium members are actively participating; the work rhythm is very good.

To date the deliverables that were planned, for WPs 2, 3, 4, 6 and 7, are uploaded, few of them e.g. D2.1 following a phased approach.

During these activities we have met issues and risks, which are inherent for such complex activities. We have mitigated as explained with assumptions, and for some specifications e.g. the On Board gateway Architecture Report we have released the documents in a phased approach.

For frequencies we are set for the n8 (900 Mhz) and n78 (3.7 Mhz), and currently assessing the Qualcomm n39 mobiles capabilities.

The project is on a good path, and will deliver the prototypes and tests as per the plans.

As said, we aim for a minimized delta to the FRMCS specifications as possible; the precise delta will be known around end October of this year.



Thank you for your attention

www.5GRail.eu

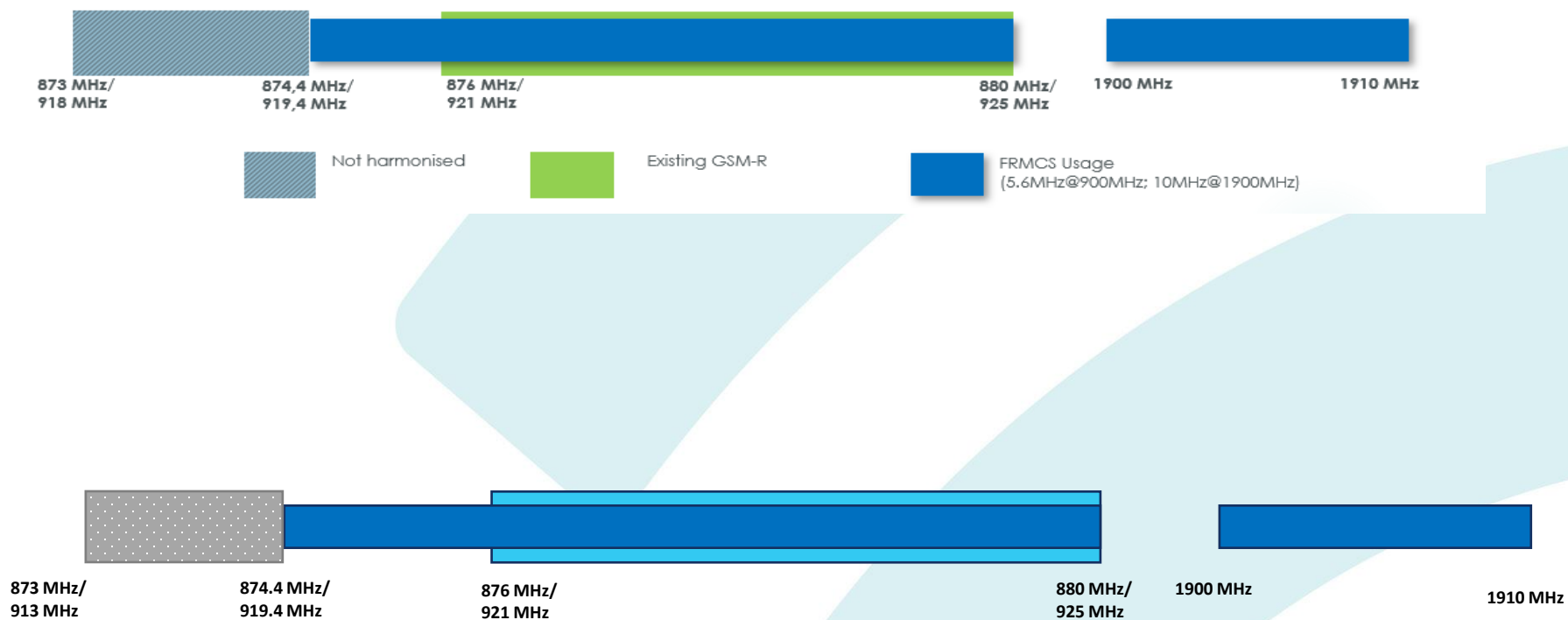


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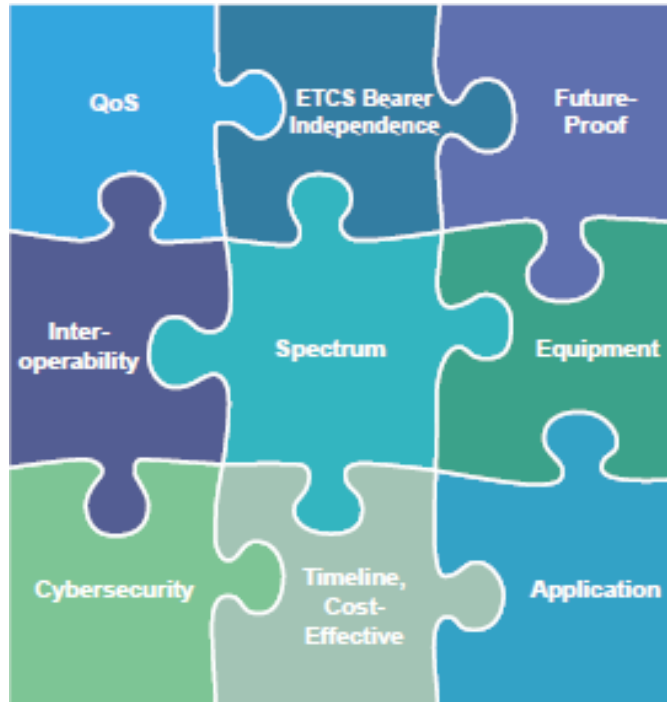
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Dedicated frequencies: allocated RMR (FRMCS) Spectrum in Europe (post-migration)



THE FRMCS CHALLENGES



The train is a guided vehicle, that cannot steer right or left. As it weights more than 400 tons, and runs to 180km/h and when at high speed at 300 km/h, it breaks in more than 1 km. This is why:

- The Quality of Service to ensure the connectivity for the voice and signalling applications must be without errors and at any moment
- Specific capabilities must be supported by the telecom system – group calls, functional aliasing (so called functional numbering), location depending addressing, etc.

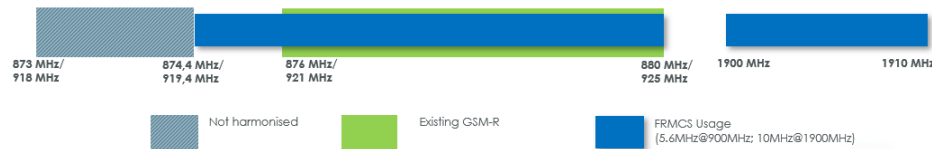
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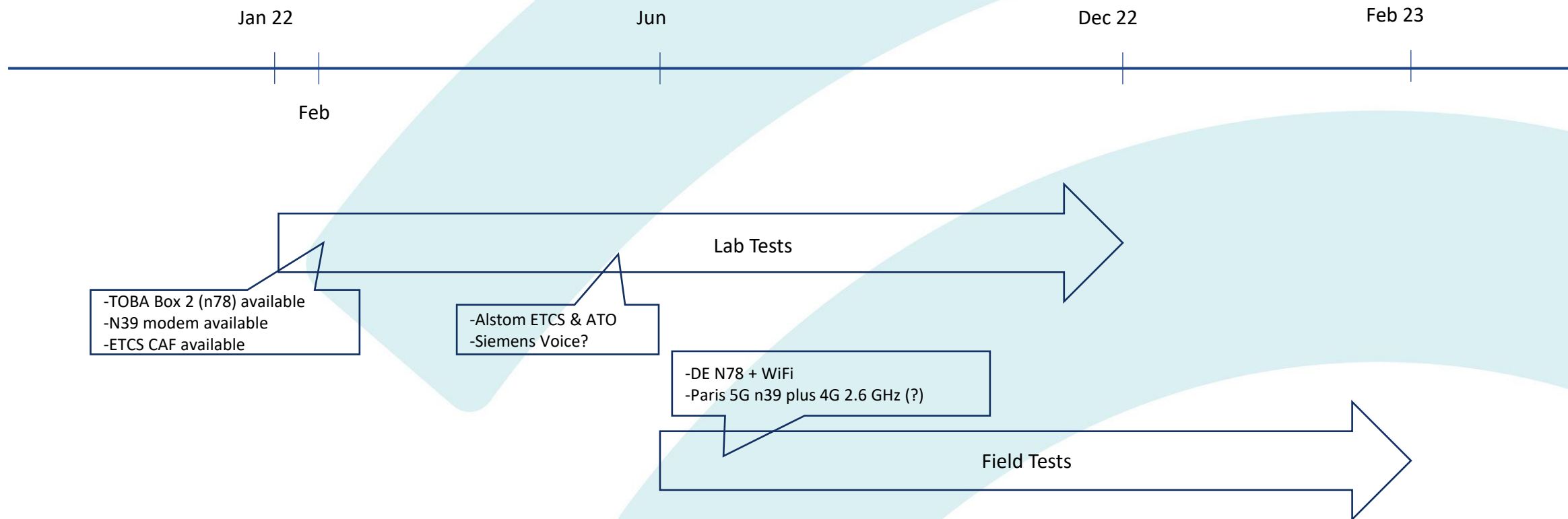
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You do the math.

The European Control-Command & Signalling system is interoperable in Europe: when the train is crossing the border there will be communications will be ensured by the same radio equipment without interruption. This also means that FRMCS must comply with all national operational rules.

Dedicated frequencies: allocated RMR (FRMCS) Spectrum in Europe
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15 JUNE 2021

15 JULY

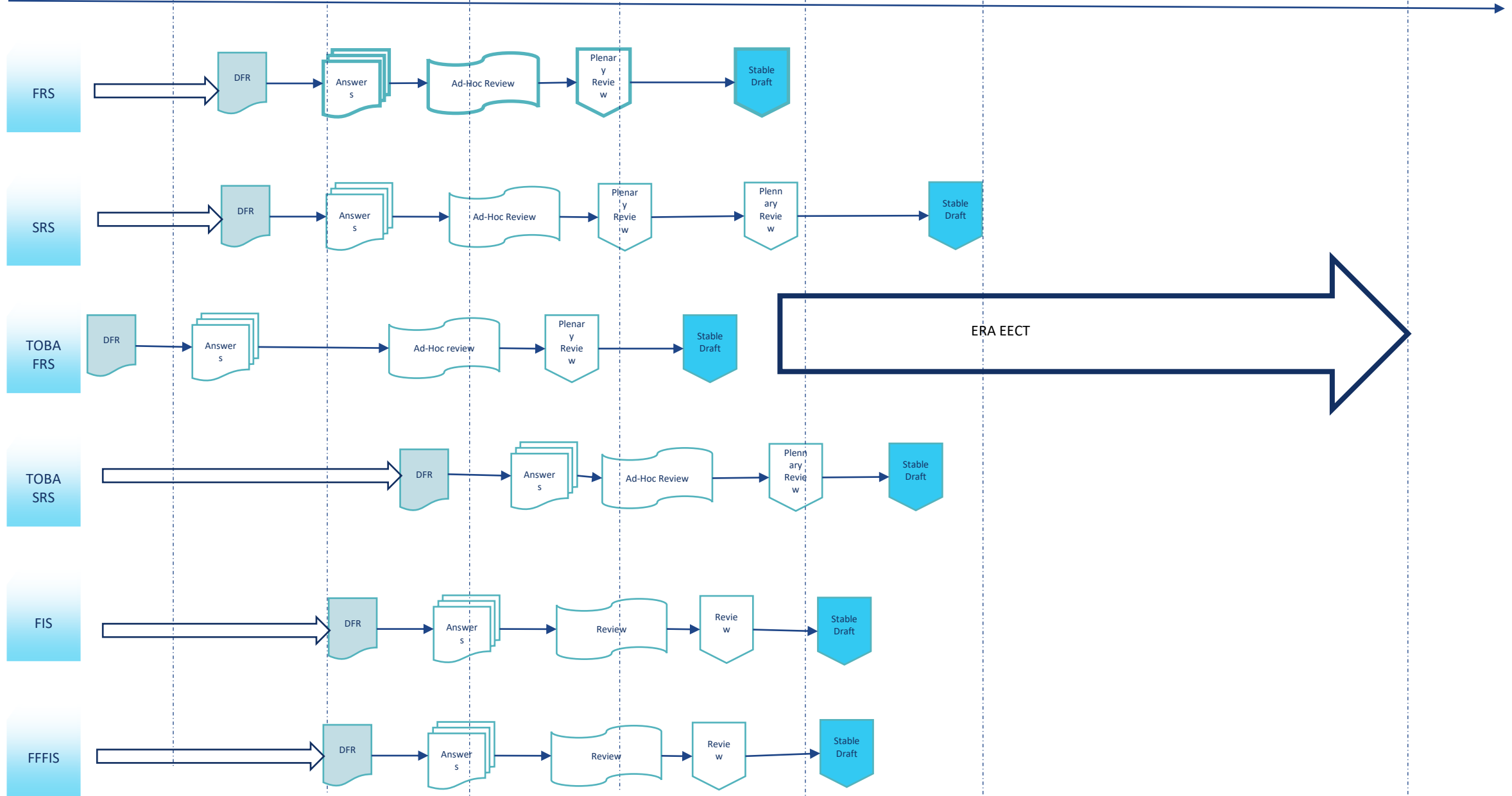
15 August

15 September

15 October

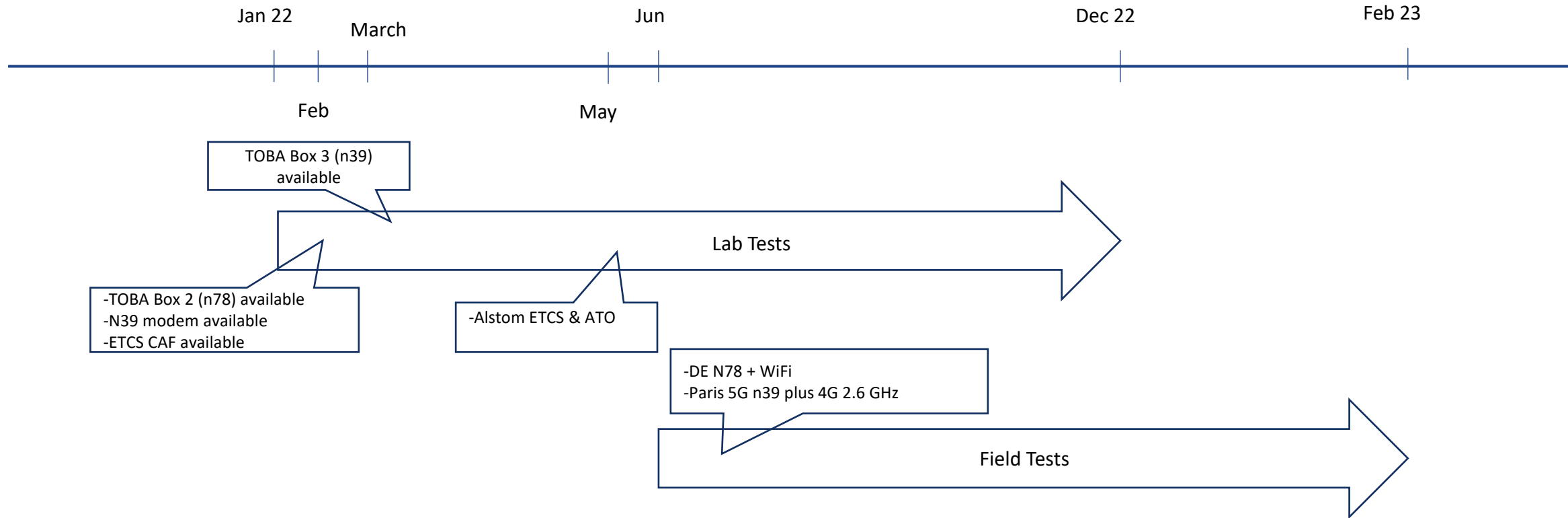
15 November

31 March



DFR = Draft for Review

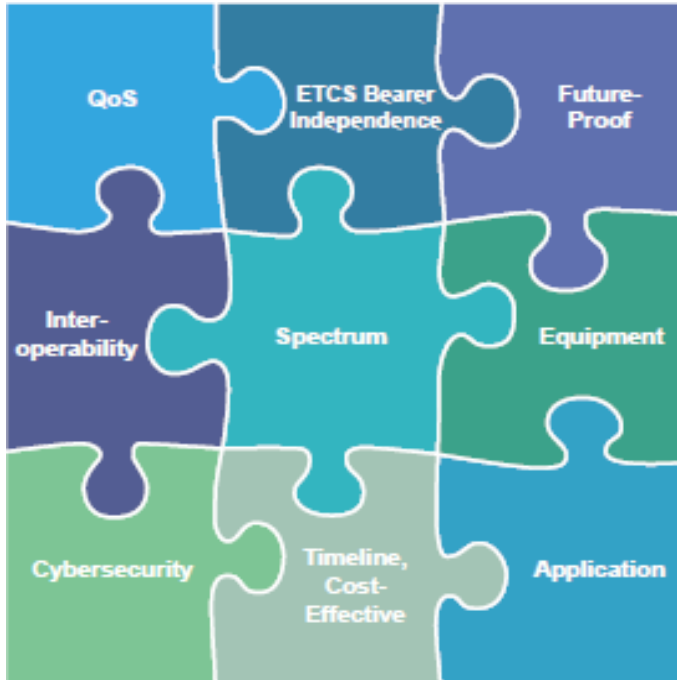
Stable Draft – Agreed by Consortium, for ERA EECT review



Risks:

- 1 REC over the Thales MODEM
2. Voice applications availability
3. ETCS from Alstom availability

FRMCS CHALLENGES – considered within 5GRAIL



FRMCS main challenges are listed in the embedded picture.

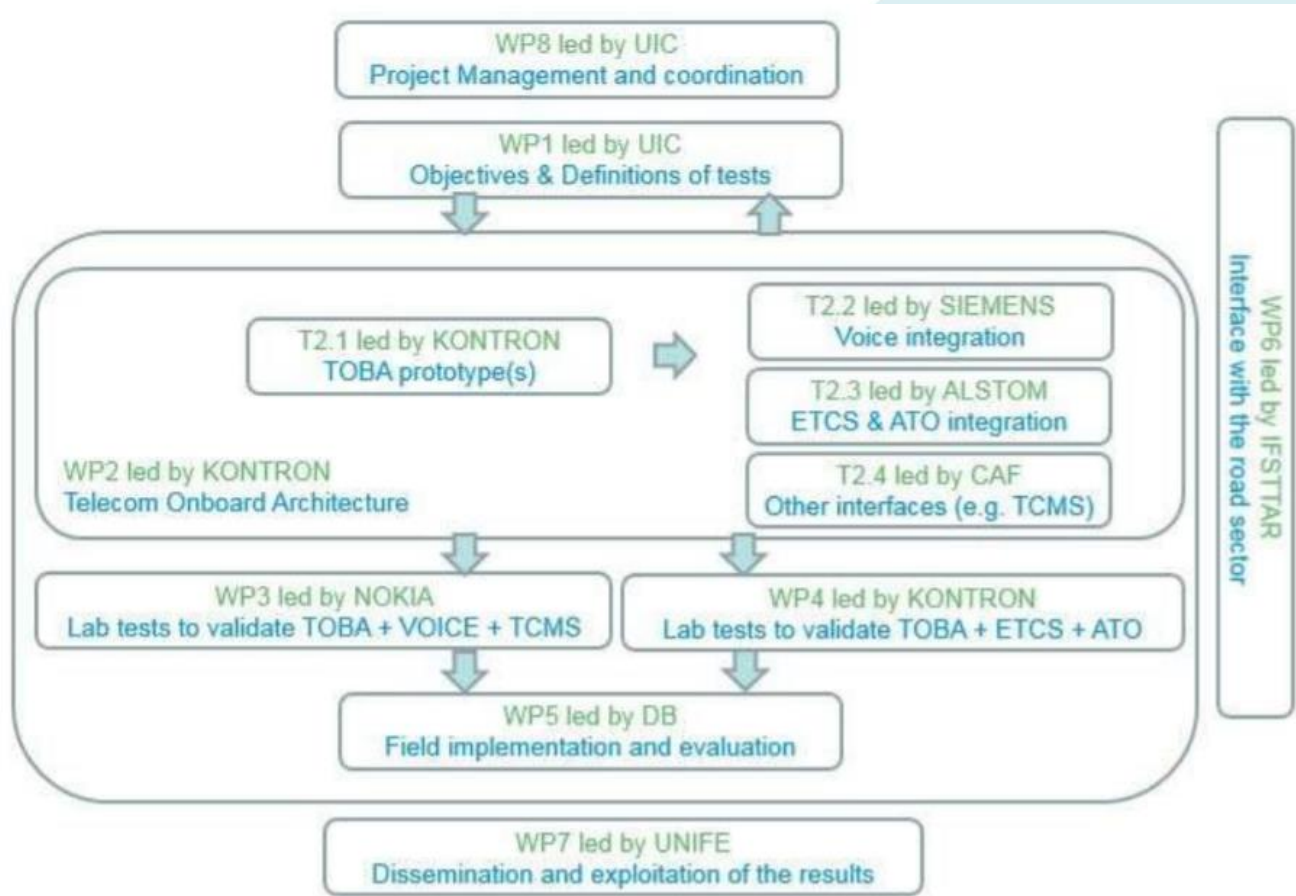
They are considered within 5GRail:

- Interworking with GSM-R;
- Railway Emergency Call demonstrator;
- ETCS and ATO signalling systems demonstrators;
- Train Performance applications;
- Cross Border scenarios;
- Quality of Service Scenarios (in lab and real-track conditions);
- Radio modules in the FRMCS frequency range;
 - as per the ECC draft decision (20)02 – which allocated dedicated frequencies for FRMCS in 900 and 1900 MHz

5GRAIL is on its scheduled path. It is a crucial step for the FRMCS introduction. It is a project followed with great interest by the European Railway community, which have started already planning the migration to FRMCS.



5G RAIL scope and overall framework



Elaborate FRMCS prototypes based on the FRMCS V1 specifications, including telecom 5G infrastructure compliant with FRMCS 3GPP specific standardization elements, and the new on-board equipment (FRMCS On-Board Gateway and additionally prototypes of adapted ETCS and ATO elements);

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