Successful Transition to FRMCS

UNIFE Position Paper on the Key Success Factors for the transition to FRMCS

28 September 2021

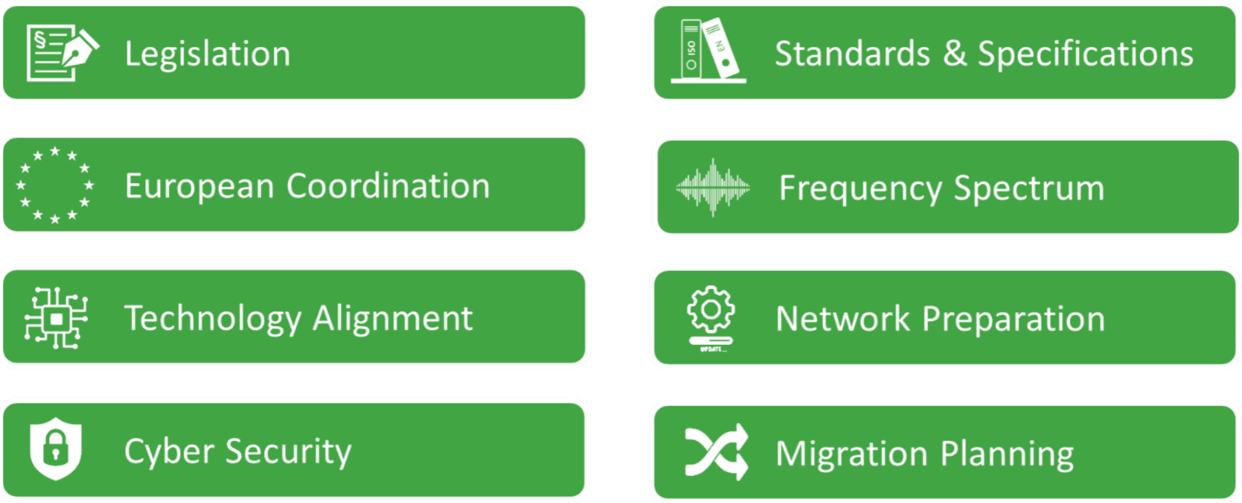
About UNIFE

Based in Brussels since 1992, UNIFE is the association representing Europe's rail supply industry at the European Union (EU) and international levels. UNIFE's members include more than 100 companies – from SMEs to major industrial champions – active in the design, engineering and manufacture of rolling stock (i.e. trains, metros, trams, freight wagons) as well as rail signalling and infrastructure equipment. UNIFE also brings together the national rail industry associations of 11 European countries.

The UNITEL Committee of UNIFE, set up in 2018, brings together UNIFE members with significant telecommunications experience with a focus on building consensus for the development and implementation of the future interoperable railway communication system (FRMCS/Next Generation), the inherent successor of GSM-R, as part of the future ERTMS.

Overview

In this position paper UNIFE presents the European railway telecommunications supply industry's view on the most important aspects, challenges and measures to guarantee the expected timelines for a successful introduction and migration towards the Future Railway Mobile Communication System (FRMCS). The paper will address the following eight topics seen by UNIFE and its UNITEL Committee as the 'Key Success Factors' for the transition to FRMCS. Finally, we propose a balanced timeline for the introduction of products and solutions to meet the market requirements for the introduction of FRMCS.



Introduction – Market Environment

Since 2012 when the UIC FRMCS project was established, railway industry members of UNIFE were in active cooperation with the UIC, the European Union Agency for Railways and other railway stakeholders across Europe in defining and specifying FRMCS as the next generation railway operational communications as well as the migration from Global System for Mobile Communications – Railway (GSM-R) towards it. The specification work will result in an update of the EU legal framework to guarantee and maintain technical interoperability across Europe. The railway sector is working closely together in the definition, standardization and piloting and later implementation phase of FRMCS in various standardization groups at European Telecommunications Standards Institute (ETSI), 3rd Generation Partnership Project (3GPP) and The Electronic Communications Committee of The European Conference of Postal and Telecommunications Administrations (ECC CEPT).

The target for the commercial availability and first deployments is for Q2 2025, with the first inclusion of FRMCS related definitions in the European Technical Specifications for Interoperability (TSIs) planned for 2022. The baseline for the introduction of FRMCS was the prognosed end of support for

GSM-R in 2030, with extension on a project basis (see the separate available 'GSM-R Long-term Support Statement - Statement from the members of the UNITEL Committee on the railway telecommunications supply industry's long-term support of GSM-R, July 2021'). However, for increased competitiveness of the railway sector and its contribution to a greener European transport system, the digitalization and automation of railways has become a must. UNIFE considers digitalization as an important market driver for the installation of a broadband-capable FRMCS.

The GSM-R market will still increase its maturity level in the coming years. As of today, significant rollouts and extensions of new lines are ongoing as well as some modernisation in projects to guarantee support for the time being until GSM-R reaches obsolescence. In contrast, projects not even tendered yet, and with a longer timeline than the expected lifetime of GSM-R, may potentially not consider the introduction of GSM-R, but may even consider relying solely on FRMCS. In parallel, maintaining the existing GSM-R networks alongside FRMCS leads to higher costs.

Considering the market situation outside Europe and in some countries in East Europe where the step from analogue radio systems to a digital GSM-R network was not done yet or only partially, a demand for introducing FRMCS in the short-term is vital. Already today deployments or at least plans for early deployment in countries like Korea, Australia, India and Russia before 2025 are under consideration. This results in risk of segmentation of the market as well as the technology because such early adopters will most likely go for 4G rather than 5G technology as a basis for their railway communication networks. A discrepancy to FRMCS, which is targeted for 5G technology, will therefore arise.

For these reasons a timely introduction and deployment of FRMCS is essential to ensure a stable and healthy business environment for all involved partners. To allow successful introduction it is important to focus and prioritise functionality. The introduction of FRMCS needs, in addition to all mandatory functionality comparable with GSM-R, a capability for enhanced broadband functionality that will also drive the introduction by attracting the railways on their way towards digitalisation.

Legislation

A successful introduction of the interoperable critical communication for FRMCS requires the legal framework to be established to foster any investments. Starting with the introduction of FRMCS, and during the whole migration phase, the rolling stock will have to be compatible with both GSM-R and FRMCS. It is therefore important to define the GSM-R/FRMCS on-board solution as soon as possible in order to include these requirements in the ongoing development of new vehicle platforms and to be included in the upcoming EU TSI 2022, with a focus set on ETCS. This is particularly important since tendering processes typically take a long time for definition and budget planning before any deployment and need to rely on a stable legal framework.

However, suitable trackside deployments will need further enhancements of the TSI to achieve the expected introduction of FRMCS in 2025, with Proof of Concept and trials before this date.

European Coordination

During the introduction period of GSM-R in the late 1990s the involved stakeholders successfully created a framework to translate the technical requirements into commercial products and solutions with a dedicated project to focus on first market applications, trials and pilot rollouts within real-life railway operational environments. This project was named MORANE and it facilitated close cooperation between railway users, regulatory bodies and the supply industry.

The challenges with the introduction of FRMCS and network rollout are certainly comparable due to the fact that technologies which are new for the railway operational environment are to be used (e.g. 4G, 5G, 3GPP Mission Critical Services).

Beside the coordination and funding on standardisation and specifications of the FRMCS, the support for coordinated European trials is seen as very important. UNIFE already formulated the benefits shown below of a framework for a funded European trial activity in a separate position paper. Coordinated activities for a European first market application and piloting represent an essential step to successfully introduce the new communication system into the railway networks. The 5GRail project under Horizon 2020 is an important step by evaluating first specifications with prototypes in lab and field trial environments. Further verification trials focusing on cross border deployment concepts of FRMCS for the European TEN-T network should follow.

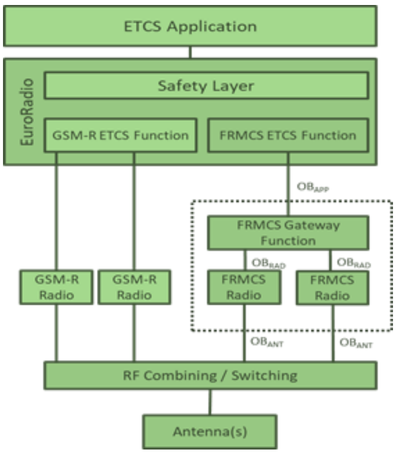
Standards and Specifications

From the outset, the FRMCS programme paid particular attention to the mission critical communication system as standardised in 3GPP. This activity was initially driven by the Public Protection and Disaster Relief (PPDR) community to define a broadband-capable successor system for their TETRA systems or analogue systems. In the meantime, several domains with critical communication needs have enhanced the standards with their specific needs. This started in 3GPP Rel.15 with railway requirements added into the specifications. Most benefits arise when synergies in products, markets and standardisation with other industries can be utilised – 3GPP 5G with the dedicated support for railway industry requirements as well as for mission critical communication provides this framework.

Special Situation: The Onboard System

Trains need to interact with different kinds of trackside infrastructure and it needs to be assured that this interaction works flawless and smoothly. The European Rail Traffic Management System (ERTMS) with GSM-R was a major step to achieve this interoperability but FRMCS will go beyond GSM-R as it will give more flexibility to the train operators with its modular approach. The decoupling of applications and the train-to-ground communication system will allow an independent evolution of on-board components and systems while retaining the compatibility on a sub-system level. This key objective is essential for the success of FRMCS and must not only be reflected in the technical (standardisation) domain but also in the legal framework. It should provide the necessary means for an iterative and flexible upgrade with regards to component certifications and vehicle authorisations.

FRMCS will coexist together with the well-established and proven GSM-R systems for quite a long time and trains must support both technologies during this migration period. This duality is the most challenging part for the on-board communications system especially when it comes to the retrofitting of existing fleets in terms of available space for internal and external (RF equipment) installations. The evolution of existing GSM-R communication equipment, like Voice Cab-Radio and EDOR, towards FRMCS should be managed through the addition of an FRMCS on-board gateway, instead of evolving the current legacy products (i.e. Voice Cab-Radio and EDOR). Such an additional FRMCS gateway will also be able to support the communication of other applications. Once the GSM-R infrastructure is decommissioned, the legacy GSM-R Voice Cab Radio and EDOR can also be decommissioned.



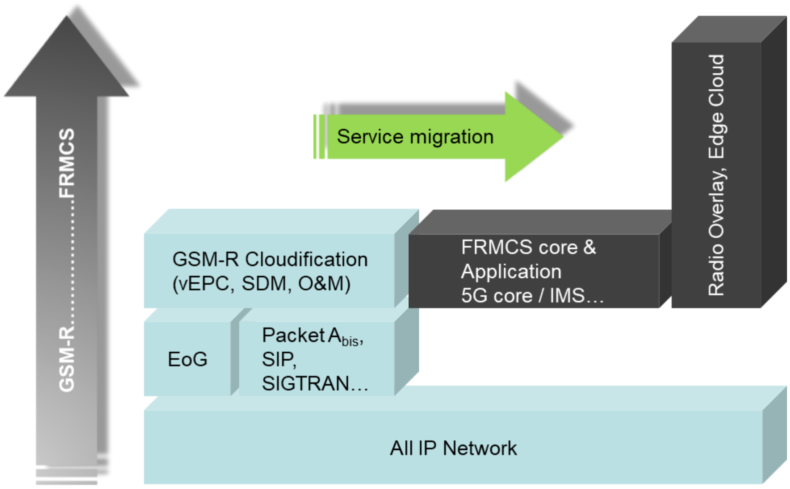
Furthermore, FRMCS will not be the only game changer affecting the rolling stock. The expected modularity, along with an extended interconnectivity of on-board systems, will also lead to new communication networks on the train itself. This evolution of these communication networks is not defined yet and must not jeopardize the current FRMCS definition and implementation. The communication networks' evolution will have to ensure the proper cybersecurity implementation allowing the FRMCS system to be used as defined currently.

Technology Alignment and Network Preparation

Even if FRMCS introduction is still some time ahead, railway operators can already start preparing and aligning today's GSM-R systems with upcoming FRMCS, e.g. by introducing IP, cloud and virtualization in GSM-R, in order to allow smooth migration from GSM-R to FRMCS.

The following aspects are of importance:

- Modernisation of the transmission network
- Optimisation of spectrum usage and frequency plans
- GSM-R core cloudification
- Dispatcher modernisation towards full IP based architecture



Modernisation of the transmission network

Already today, GSM-R infrastructure supports IP-based transport networks, Packet Abis in Radio Access, SIP and SIGTRAN in the core network. FRMCS will be IP-native and will require an IP-based transport network supporting the high bandwidth throughput. Low latency and high reliability are also evolving to support the efficient delivery of the FRMCS (5G) cloud-enabled services. IP-based transport offers a way to converge all mobile traffic and to extend its transport capabilities to full convergence of fixed and mobile networks in order to address new service opportunities for optimised railway operation.

Optimisation of spectrum usage

Spectrum in a band usable for railways (considering the speed and the coverage requirements of railways) is a limited resource. Options for optimisation of spectrum usage are available in GSM-R, for example in the form of ETCS over GPRS. Even more efficient use of GSM-R spectrum can be achieved by ATO (GoA 1 and 2) leveraging GSM-R/GPRS. ETCS/ATO over GPRS not only allows optimisation of spectrum usage, it is also a first step in the direction to full IP networks. Already a preparing/optimising GSM-R frequency plan can be considered depending on the targeted spectrum.

GSM-R core cloudification and virtualisation

Most of today's GSM-R networks are based on bare metal deployment. FRMCS will not only need to support a much wider range of services but also bearer independency, ultra-low latency and slicing. To meet all these requirements, the network architecture must change and this is being led by the evolution to a cloud-native core network as defined for 5G. An intermediate step in this journey will be the cloudification of the GSM-R core network, not only to gain experience in cloud but also to allow a smooth migration by using some of the elements in both of the networks in parallel during the migration phase e.g. subscriber data management and packet core functionality.

Preparing dispatcher systems and benefits for control rooms

Fixed line dispatchers and control room users will benefit from the introduction of FRMCS as will maintenance users and system administrators. The split of systems as implemented today, between a "mobile radio system" (GSM-R) and a "fixed terminal system" will vanish, resulting in one single unified and simplified railway communication system. FRMCS will implement various application servers in a cloud-based deployment. Such application servers will provide standardised functionality like mission critical communication services and will implement control room specific operational features like enhanced role management. Application servers will be accessible for any type of user (mobile and fixed), providing features in a bearer independent manner.

Consequently, any type of service and application, in particular the ones related to broadband communication, will be provided to dispatchers and control room users, resulting in increased operational efficiency, safety and security. Starting with the cloudification of GSM-R, the benefits of the introduction of FRMCS like modernisation to IP Multi-Protocol Label Switching (MPLS)/optical networks and access to cloud-based applications become available within the control rooms as well.

Frequency Spectrum

GSM-R has thrived in railways thanks to the use of interoperable standards and, where possible, the use of a harmonized 2 x 4 MHz frequency band (876-880 MHz uplink / 921-925 MHz downlink). Following the 54th ECC meeting, CEPT has adopted and published in November 2020 ECC Decision (20)02 harmonising two frequency bands for railways: 2 x 5.6 MHz FDD in the 900 MHz range (874.4-880 MHz uplink / 919.4-925 MHz downlink) and 1 x 10 MHz TDD in the 1900 MHz range (1900-1910 MHz). This spectrum harmonisation, associated to operating conditions adequate to railway deployments, constitutes a major milestone towards FRMCS especially for critical services requiring interoperability.

Future milestones notably include the definition and adoption within the 3GPP specifications of the two frequency bands, including potentially the support of up to 31 dBm High Power UE (HPUE). The acquisition of an official 3GPP band is expected to be more conducive to foster a sustainable ecosystem of chipsets, notably for terminals. The question of whether to specify the band for 5G NR only or to make provisions for both LTE and 5G NR has to be balanced with the timeline for introduction of FRMCS (naturally more aligned with 5G), the lack of terminals supporting the smallest LTE carriers (LTE 1.4 MHz) and the available standardisation bandwidth in the relevant 3GPP working groups.

Although a key instrument for railways critical operations and an enabler of interoperability between countries, the harmonised spectrum available to railways remains relatively small and may not be sufficient on its own for all the operational and business applications envisioned by railways in the FRMCS User Requirements Specifications. As such, understanding the constraints and implications (notably on the on-board system and its associated rooftop antenna setup) will be key to properly addressing the strategic planning of the migration to FRMCS. As of today, within the GSM-R world, the FRMCS system will enable the support of a hybrid model for Railways making use of Public MNO resources for non-critical and non-interoperable services as a complementary solution thanks to bearer flexibility.

Migration Planning

One of the key challenges for railway operators is the smooth migration towards FRMCS, especially for those in Europe with a large installed GSM-R base who will have to carefully plan the migration of their network and fleet. However, where limited digital or analogue systems are deployed, the introduction of FRMCS could be realised in a faster way as a greenfield deployment and even more easily if no interoperability between different networks needed to be considered. This can be applied e.g. for networks outside Europe, or in areas with no GSM-R covered tracks. If sufficient spectrum is available, the introduction of FRMCS can be even faster. The use of satellite or public mobile networks could also be considered based on the requirements of a particular railway.

When we are considering Europe where GSM-R networks are deployed and are in operation, careful planning of the migration is needed. The following challenges need to be addressed:

- Continued interoperability at all the times during the migration phase
- Avoiding service interruption during migration

To achieve this, several migration aspects need to be analysed jointly by infrastructure managers and industry. These must consider current deployments in the network and the specific situation of European corridors and cross border situations:

- Separate Migration Phases (onboard, transmission, network, …)
- Migration Strategy (introducing the onboard system first)
- Spectrum availability for migration
- Coexistence of FRMCS and GSM-R
- Phasing out of GSM R e.g. use of free spectrum
- Service migration scenarios

Cybersecurity

Moving from GSM-R to FRMCS is a huge leap in terms of benefits but is also a challenge for Cybersecurity.

The introduction of Network Function Virtualization (NFV), particularly distributed Software Defined equipment, will bring flexibility and agility but with the cost of a much more difficult and complex implementation of the Cybersecurity.

Let's first split the following:

- The infrastructure (relays, antennas & access points …)
- Sovereignty of the manufacturers, and highly increased hackable parts (NFV, SDN, SDR) into the system will lower the cyber confidence in those equipment
- The 5G Protocol itself (slices, bandwidth allocations, resiliency …)
- If you control the equipment, you control the slices and all the protocol features
- The data that is being carried (that we intend to use for the rail industry)

Let's simplify the equation admitting that the infrastructure itself and the 5G protocol will contain flaws and cannot be blindly trusted, then apply cyber principles to our rail data:

- Confidentiality (low risk) - Encryption and/or encapsulation of our data
- Integrity (medium risk) - Most of encryption methods also come with integrity features in order to avoid tampering/injection
- Availability (high risk) - 5G will enable such bandwidth that we will have to shield the endpoints against DDoS risks (multiplications of possible sources such as IoTs)

Assuming the carrier or the protocol cannot be trusted, let's focus on the data we have to transfer and apply the proven best practices:

- Sort/classify the data in terms of sensitivity (from a safety and security point of view)
- Set the priority of the data group (operational view)
- Choose between native encryption and/or network encapsulation (VPNs technologies)
- Identification/authentication of each source/destination (adding integrity check)

In short, we recommend not trusting the carrier, but instead, protecting the data in motion and our Rail Infrastructure leveraging on:

- The gateways to safeguard the Rail Infrastructure from the 5G Infrastructure and the On-board system end to end
- Those gateways will only accept source(s) that are able to prove their identity
- The encryption and/or encapsulation to secure our data

The European Union Agency for Cybersecurity (ENISA) performed a complete risk assessment on all the components of a 5G Network. The deployment of measures against cybersecurity threats are a continuous process and effective means to follow the vulnerabilities and threats are needed. Best practices and recommendations, e.g. on a European level from ENISA and European Rail Information Sharing and Analysis Centre (ER-ISAC), should be followed.

Timeline and Phased Approach

A balanced approach of products and solutions is required to meet the market requirement for FRMCS. It is important to have a joined-up view of industry and railway operators on the introduction and migration plan of the networks.

As input for discussion, UNIFE sees the following timeline and phased approach to achieve the expected deployment of FRMCS starting in 2025:

	Phase 1 2021-2023	**Phase 2** 2023-2025	**Phase 3** 2025-2028	**Phase 4** 2028+
	5GRail, Demos and PoC	European Trial, Customer PoC	Initial Pilots and commercial operations	General deployment, coexistance and migration projects
Functionality Focus	Limited	Reduced	Basic Use case: Critical voice, ETCS, ATO, TCMS, Broadband data application, GSM-R Interworking	Aligned with requirements and use cases defined in URS: IoT, Virtual Coupling, Shunting ATO GoA3/4 depending on ATO specification
3GPP	3GPP Rel. 15/16 MCPTT, MCData (IPconn)	3GPP Rel. 16/17 MCPTT, MCData (IPconn)	3GPP Rel. 17 MCX over 5GS MCVideo for rail	3GPP Rel. 18+ MCX Interconnect, Gateway UE MCX, 5G Off Net
System Architecture	5G and MCX, TOBA	5G and MCX/FRMCS, TOBA Cross Boarder support	5G, FRMCS	Satellite, WiFi, Enhanced wireline, Off Net, Multi Cast
Deployment options	5G SA FRMCS prototype	5G SA FRMCS Precommercial	Reliability, 5NR functionality for coverage	Enhanced reliability and coverage functionality

Summary

This paper has provided the European railway telecommunications supply industry's view regarding the key success factors to be addressed to make the transition to FRMCS a success – as it was when introducing GSM-R - and on a first timeline and phased approach to achieve the expected deployment from 2025 onwards.

We expect the introduction of digitalisation and automation in rail will become a dominant driver for the introduction of FRMCS and future broadband applications far beyond today's GSM-R. Our findings on the key success factors can be summarised as follows:

- **Legislation**: without the legal framework, no introduction and no investment can be expected in infrastructure and onboard. Especially for the latter, early definition needs to be included. UNIFE also sees the need for continuous enhancements aligned with the progress in specification and standardisation.

- **European Coordination**: the involvement of different specification and standardisation groups for the impacted telecommunication and signalling technologies requires a coordinated approach. A coordinated, funded trial activity is important for first evaluation of the defined concepts.

- **Standards and Specifications**: Railways can greatly benefit from synergies with other domains with respect to mission critical networks. Following 3GPP defined Mission Critical Communication standards will allow for synergies in product and solutions based on solid standards. A special focus has been placed on the Onboard Gateway standardisation as they allow for early preparation of the rolling stock.

- **Technology Alignment and Network Preparation**: With FRMCS as an Internet Protocol (IP) based technology the preparation of the today's transmission network is an important step. As the latest GSM-R products already support smooth IP evolution, operators can benefit from an aligned technology evolution. When it comes to virtualisation and cloudification – as key concepts for 5G – some of the GSM-R products can support such an evolution path while benefitting from IT-based technology and migration of products which are already capable of supporting GSM-R and 5G. By introducing the European Train Control System (ETCS) over General Packet Radio Service (GPRS), spectrum usage can be optimised in case the GSM-R band will be used for migration.

- **Frequency and Spectrum**: The harmonised frequency bands for FRMCS are now under standardisation in 3GPP as 5G bands, which is a base to foster a sustainable eco-system of chipsets, notably for mobile devices. However, with the capability of bearer flexibility, different bands such as satellite or Mobile Network Operator (MNO) sharing models can be considered as options to help e.g. for flexible FRMCS introduction.

- **Migration Planning**: due to the complexity of a migration phase in parallel to an operational GSM-R system, detailed planning by railway operators is proposed to define preparation and execution phases in advance. For greenfield projects the introduction is expected to be easier and faster.

- **Cybersecurity**: Introducing IP and IT / Cloud technology with 5G mandates is required to ensure adequate Cybersecurity. Beside standardised mechanisms in 5G technology additional measures are needed. It is strongly recommended to follow best practices and recommendations established e.g. on European level by ENISA and ER-ISAC.

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