FRMCS supplier perspectives, insights from the EU-Rail Deployment Group

An overview of supply industry players

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ABBREVIATIONS AND ACRONYMS

3GPP	3rd Generation Partnership Project
5GRail	Project financed by DG Connect for FRMCS prototyping and testing under the programme H2020 ICT-53 (Grant Agreement #951725)
ACS	Adaptable Communication System
ATO	Automatic Train Operation
CCS TSI	Control Conmmand and Signaling Technical Specifications for Interoperability
CEPT	Conférence Européenne des administrations des Postes et Télécommunications
DG Connect	Directorate-General for Communications Networks
DG Move	Directorate-General for Mobility and Transport
EC	European Commission
ECC	European Communications Committee
ENISA	European Union Agency for Cybersecurity
ERA	European Union Agency for Railway
EU-RAIL JU	Europe's Rail Joint Undertaking
ERTMS	European Railway Traffic Management System
ETCS	European Traffic Control System
ETSI TC-RT	ETSI Technical Committee - Railway Telecom
FRMCS	Future Railway Mobile Communication System
GSM-R	Gobal System for Mobile Railway Communications
KMS	Key Management System
MCX	Mission Critical Services
MNO	Mobile Network Operator
R2DATO	Rail to Digital Automated up to autonomous Train Operation
RAT	Radio Access Technology
RMR	Railway Mobile Radio
TCMS	Train Control and Monitoring System
UIC	Union Internationale des Chemins de Fer
FRMCS V1, V2, V3	UIC FRMCS Specifications version 1, 2 or 3

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An overview of industry players shaping the FRMCS ecosystem

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Introduction

This article, initiated by the FRMCS sub-group of the EU-RAIL European Deployment Group, presents elements for the development of FRMCS, gathered through a series of bilateral meetings with leading companies in the railway telecommunications sector. The article gives an overview of FRMCS suppliers insights and perspectives.

For this article EU-Rail approached industry players for interviews. This article gives an overview of concepts exchanged with the companies that participated in the interviews and that agreed to be part of this publication. The information provided here reflects therefore only a limited part of the sector and actors' capabilities and it is not comprehensive.

EU-Rail is the European Public Private Partnership initiating and coordinating new railway innovations and development of target architecture to achieve the Single European Railway Area (SERA). To facilitate better, faster and cost-efficient deployment of these initiatives EU-Rail has set up an open Deployment Group to rail stakeholders. It comprise today representative from Supply Industry, Operators, Infrastructure managers, Leasing companies and the European Commission and ERA. FRMCS deployment is the first topic to be considered.

FRMCS was born as the successor to GSM-R to support the full range of railway operational communications, overcoming the bandwidth, latency, and lifecycle limitations of 2G technology.

In this context, the UIC is responsible for coordinating the definition of requirements, while ERA and ETSI provide the regulatory foundation by publishing artifacts ranging

from System Requirement Specifications (SRS) to Technical Specifications for Interoperability (TSI's) and technical glossaries.

On the spectrum side, the European framework has allocated paired bands at 874.4–880 MHz and 919.4–925 MHz, as well as the unpaired 1900–1910 MHz block dedicated to TDD services—a turning point for the design of antennas and RAN solutions, enabling efficient beamforming in band n101.

From a functional perspective, FRMCS integrates and standardizes 3GPP MCX services, enriched with specific extensions for the railway domain, ensuring that safety and automation applications have native access to mission-critical primitives. Finally, on the radio network side, integration with Mobile Network Operators (MNOs) is steadily advancing, although it is considered a complementary approach rather than the core deployment strategy.

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1. FRMCS technology, standards, migration, security, mobile operators and business models

The European and global railway sector is undergoing a radical transformation in communication technologies. After decades of using the GSM-R system—now nearing the end of its lifecycle—the railway industry has decided to converge toward a new technological paradigm known as the **Future Railway Mobile Communication System (FRMCS)**. This system is not merely the natural evolution of the telecommunications technology used by trains and railway infrastructures, but a true conceptual revolution that integrates the railway ecosystem with next-generation mobile network architectures, particularly currently those based on 5G standards. The evolution will be continued by introducing future mobile network generations and including potential new MNO integrations.

FRMCS arises from the need to ensure superior performance, safety, cybersecurity, reliability, and the ability to support future applications that GSM-R can no longer sustain. The needs of the railway sector have changed significantly over the past twenty years. The increasing demand for automation, the progressive adoption of next-generation railway traffic control and management systems, applications linked to the concept of smart mobility, and integration with multimodal transport require a communication platform that is scalable, resilient, cybersecure (refer to paragraph 1.4) and above all, capable of ensuring interoperability at the European level. In this context, FRMCS positions itself as a European solution for mission-critical communications in the railway domain. It is not merely a technological replacement, but a common strategy involving equipment manufacturers, railway operators, Infrastructure managers, lessors, telecom industry, software solution providers, European and standardization bodies. Its implementation will have not only technical but also economic and strategic impacts, reshaping the competitive balance among the key players in the sector.

1.1 Extended Technological Framework and Architectural Implications

The evolution of railway communications toward FRMCS is not a simple replacement of equipment, but rather a redefinition of the system architecture that encompasses the entire operational lifecycle of the railway. The enabling features of 5G—such as high reliability of the radio link, reduced latency for critical interfaces, the ability to prioritize specific data flows along deterministic paths, and logical isolation through slicing—become concrete tools to support operational scenarios ranging from full remote execution of on-board functions to advanced real-time diagnostics of traction and signaling components.

In its fully mature and target form, serving as the reference architecture for all vendors, the FRMCS network is expected to be used for mission-critical controls with best-effort domains for non–safety-related services, while ensuring a clear separation of responsibilities and security domains.

As FRMCS evolves toward a more modular and service-oriented architecture, the design approach moves from traditional monolithic implementations to a platform-based model. In this model , MCX services, quality-of-service orchestration, network API exposure, and end-to-end observability become integral elements of both system design and daily operations.

The frequency issue holds strategic importance. At European level, the 1900–1910 MHz band constitutes the cornerstone of dedicated spectrum availability for the railway domain.

However, national implementation plans and longer-term prospects for global harmonisation will influence the overall network architecture. In this context, Europe's approach may serve as a reference, while the final morphology of networks will depend on how spectrum portions reserved for railways are balanced with controlled sharing models, where these are economically and technically viable.

The architecture must therefore include devices and radio components capable of supporting multi-band and multi-regime operations, enabling progressive migration even in heterogeneous operational contexts such as high-speed lines, regional routes, metropolitan nodes, and freight connections.

1.2 Standards, Maturity Roadmap and Interoperability

The convergence between ETSI, 3GPP and UIC marks the transition from a vertical railway network to an ecosystem based on horizontal standards aligned with specific railway requirements. This process is further supervised by the European Commission and supported by UNITEL, which, while not directly involved in the drafting of technical specifications, play a key role in facilitating their ratification, regulatory acceptance and widespread adoption.

MCPTT, MCData, and MCVideo profiles are interpreted in light of railway safety needs, operational procedures, and chains of responsibility. The maturity curve will follow a path of pilot phases, pre-production, and rollout on commercial networks, with long-term coexistence with GSM-R and interworking solutions designed to reduce risks and service disruptions.

Interoperability certification in the railway domain cannot be confined to the protocol level but must also encompass dispatching processes, human-machine interfaces, and the management of events under degraded conditions, since true interoperability is, above all, operational. At the same time, interoperability and the harmonisation of mission-critical services represent key challenges in the deployment and operation of mobile broadband communication systems, particularly for raiways.

The FRMCS Plugtests events are designed to validate the implementation of FRMCS standards and to assess interoperability across diverse solutions, through a wide range of test scenarios based on the 3GPP Mission Critical Services framework with a clear focus on railway-specific features. These events foster a collaborative

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environment where vendors, operators, inframanagers and other railway organizations can jointly ensure that equipment from different manufacturers works seamlessly together. This work is further supported within the framework of the EU-Rail Joint Undertaking, notably through the FP2-MORANE2 project, which contributes to the validation, maturation, and operational assessment of FRMCS by providing large-scale tests, trials, system integration activities, and feedback to standardisation and certification processes.

Achieving this level of interoperability and standard alignment is crucial for the effective rollout of FRMCS, as reliable communication underpins the safety, efficiency, and coordination of railway operations. The FRMCS Plugtests are an integral part of the broader MCX Plugtests programme.

1.3 Migration from GSM-R and Continuity Strategies

Migration is a systems engineering endeavor requiring discipline, long-term vision, and careful risk management. The dual-mode philosophy is the most practical choice in many contexts, as it allows the gradual introduction of FRMCS services while maintaining GSM-R reliability until the new ecosystem reaches full maturity. The replacement schedule of assets, the planned substitution of cab radios, the upgrade of control centers, and the adaptation of ETCS operational and data flows (i.e., the processes and information exchanges governing train control and signaling under the European Train Control System) form a mosaic of activities where suppliers compete not only on products but also on integration capabilities and project management.

Migration is also an opportunity to rethink operational models: the introduction of extended telemetry, intelligent line monitoring, predictive radio resource management, and the integration of field systems with data lakes and analytical environments open up productivity gains that extend beyond communications alone.

1.4 Security, Cybersecurity, and Operational Reliability

With the introduction of 5G and FRMCS, the number of digital entry points exposed to cyber threats (the attack surface) increases, which in turn requires a zero-trust cybersecurity approach—where no device, user, or network segment is automatically trusted and every access is continuously verified—adapted to railway-specific operational and safety constraints. Control plane protection, strong authentication of on-board terminals, segregation of safety-related flows, and formal validation of critical paths fall within a taxonomy of controls that must be conceived as an integral part of the architecture, not as a subsequent overlay. Geographic redundancy, protections against common-mode failures, recovery plans, and resilience of the mission-critical core become minimum requirements to ensure continuity of essential services. Certification and compliance with functional safety standards, where applicable, are

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complemented by cybersecurity best practices to deliver a security posture consistent with the criticality of the domain.

1.5 Mobile Network Operator (MNO)

The specifications defined by ETSI and aligned with 3GPP already allow FRMCS to operate both on dedicated railway spectrum and over public cellular infrastructure, primarily through mechanisms such as Multi Operator Core Networks (MOCN) sharing and multipath support. These capabilities enable initial and controlled forms of integration with Mobile Network Operators (MNOs), allowing trains to rely on dedicated, highly controlled frequency bands for mission-critical communications, while also exploiting MNO coverage to improve resilience, cost efficiency and service availability.

In practice, adoption remains cautious not because of an operator preference against FRMCS, but due to the stringent reliability, latency, availability, and security requirements imposed by the FRMCS specifications themselves, which are difficult to fully guarantee over public networks..

As a result, most railway operators currently prioritize the development of dedicated communication networks—particularly in the 900 and 1900 MHz railway bands—as the most straightforward way to comply with these requirements.

Nevertheless, hybrid approaches are increasingly being tested, combining dedicated infrastructure with MNO-provided coverage to fill coverage gaps or extend services into less accessible regions. These hybrid models are widely viewed as a pragmatic transitional solution, especially during the early phases of FRMCS roll-out

Challenges remain significant, particularly in guaranteeing end-to-end quality of service when traffic traverses public networks. Issues such as domain handovers, regulatory alignment, contractual service guarantees and strict isolation of safety-critical flows from general commercial traffic are still being addressed. At the same time, multipath and network slicing capabilities are evolving to provide more deterministic performance over shared infrastructure.

Looking forward, this integration is expected to become fully standardized and operationally mature with the introduction of FRMCS V3 currently targeted for around the end of 2026. FRMCS V3 is expected to strengthen support for large-scale MNO involvement by addressing remaining gaps in cross-border interoperability, hybrid operation governance, and advanced, railway-grade Quality of Service (QoS) mechanisms.

1.6 Market, Supply Chain, and Business Models

The FRMCS market is inherently hybrid, blending railway DNA with the pace of mobile telecommunications innovation. Architectural choices regarding private 5G, hybrid networks with shared portions, and measurable service-level agreements will shape

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investments and returns. Value is shifting toward managed services, data analytics, predictive maintenance, and end-to-end performance assurance. In this context, major network providers and traditional railway players seek alliances to present coherent, comprehensive proposals, while software and hardware specialists find significant opportunities as enabling technologies. The supply chain, also driven by geopolitical and regulatory considerations, will increasingly favor European components and transparent sourcing, particularly in the critical portions of the network core and railway terminals.

Looking further ahead, the emergence of 6G—expected to be deployed first by Mobile Network Operators as part of their public network evolution—will introduce new capabilities in terms of latency, reliability, sensing, and other native integration. While 6G will not be immediately adopted for mission-critical railway communications, its early deployment by MNOs will progressively influence FRMCS roadmaps, especially for non-safety-critical services, advanced data applications, and future hybrid architectures. This reinforces the importance of forward-compatible designs and close alignment between the railway ecosystem and the mobile telecommunications industry.

2. A cross section of European Industries capabilities and approaches

Building on the FRMCS cornerstones—namely technology, standards, migration, security, the role of mobile network operators, and business models—, a series of bilateral meetings were organized in collaboration with EU-Rail and   active players currently engaged in the development of the future railway telecommunications system. For this article EU-Rail approached industry players for interviews. Below is an overview of the key concepts exchanged with the companies that participated in the interviews and that agreed to be part of this publication. **The information provided here reflects therefore only a limited part of the sector and actors' capabilities and it is not comprehensive**.

2.1 Alstom: Convergence of Signaling, Automation, and On-Board Communication

Alstom approaches FRMCS with the perspective of a railway system house that integrates rolling stock, signaling, and digital ecosystems. Communication is not an end in itself but a means to elevate automation, particularly through convergence with ETCS and increasingly advanced levels of ATO.

The company invests in on-board components integrated with FRMCS terminals, gateways orchestrating flows toward the network core, and validation solutions

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certifying the robustness of the communication chain throughout the operational lifecycle. Its competitive strength lies in offering integrated turnkey project packages, where adherence to railway specifications avoids the frictions typical of multi-vendor integrations.

In the long term, Alstom aims to transform FRMCS into an enabler of energy management strategies, predictive train diagnostics, and customer-facing services, while maintaining a clear distinction between safety-critical and service domains, supported by appropriate technical and procedural safeguards.

2.2 Ericsson: 5G Platform, Slicing, and Security for Dedicated Railway Networks

Ericsson interprets FRMCS through the lens of a mature and industrialized 5G platform, emphasizing the construction of dedicated railway networks with strict Mission Critical quality-of-service controls. Its commercial proposition includes dedicated 5G radio for the FRMCS bands, mission-critical cores, support for FRMCS RAN sharing with mobile network operators, slicing orchestration to separate safety-related domains, network automation capabilities, and native observability tools to correlate radio events with application impacts.

The company's competitive strength derives from the breadth of its 5G portfolio and its ability to extend network functions toward open APIs, enabling integration with railway signaling platforms and traffic management systems. At present, Ericsson is working on pilot projects and private networks, where data ownership, predictable latency, and geographically distributed resilience are non-negotiable requirements.

Looking ahead, the company aims to consolidate managed service models for railways, with contracts measuring reliability and availability parameters on an end-to-end basis, providing operators with tools to transparently verify compliance with contractual commitments.

2.3 Frequentis: Mission-Critical Focus and Centrality of Operational Control

As a joint-stock corporation, Frequentis AG is an international provider of communication and information systems for control centres with safety-critical tasks. They operate in sectors such as Air Traffic Management, Public Safety and Public Transport, serving clients like fire and rescue services, railway organisations and air traffic control. Frequentis Public Transport solutions leverage more than seventy years of experience focusing on safety-critical communications and applications. Cross-industry expertise gained from supporting control center communication sets the foundation for industry-leading railway and urban transport solutions. With its strong position in operations communication, Frequentis supplies service and application layers as well as control room solutions for GSM-R, and will do so for FRMCS well. Frequentis actively contributes to the development of FRMCS with strong focus on the operator-centered experience in control centers, voice and data

dispatching, MCX flows, and bridging functions toward legacy environments to maintain operational continuity during network evolution

2.4 Kontron Transportation: Embedded Platforms and Industrial Reliability for Onboard and Wayside

Kontron Transportation GmbH is a leading global supplier of end-to-end communication solutions for mission-critical networks. Its core customers are railways across Europe and beyond. The company specializes in systems that produce, transport, and process voice, data, and video — reliably, securely, sustainably, and efficiently. Kontron Transportation's solutions include GSM-Railways, FRMCS (Future Railway Mobile Communication Systems), and MCx (mission-critical over public networks) with IWF (interworking functions). The company also provides enhanced radio solutions, radio access networks for 4G/5G private networks, transmission networks, and cybersecurity solutions. In addition, its portfolio comprises communication products for Secondary Lines and other mission-critical network operators, as well as mobility products such as validators and fare collection systems for public transport operators.

For over 25 years, Kontron Transportation has been fully dedicated to the railway sector. Today, the company continues to drive the evolution of broadband solutions for mission-critical networks..

2.5 Nokia: GSM-R Legacy, Private 5G Networks, and Mission-Critical Managed Services

With decades of experience in railway communications, Nokia is a worldwide supplier for both GSM-R and 5G FRMCS technologies. With over 150+ existing railway customers, Nokia offers end-to-end architecture of FRMCS with a full 5G portfolio spanning from radio to fronthaul to backhaul to core, including orchestration and security tools. Its strategy is based on offering private 5G networks for the railway domain, with integrated mission-critical functions, domain separation via slicing, and a set of management tools designed to provide railways with visibility and control.

The company is investing in managed service models where availability, latency, and resilience become contractual indicators, with particular emphasis on demonstrable compliance and auditable processes. Looking forward, Nokia aims to tightly integrate the network with signaling and automation ecosystems, offering a coherent design in which data travels through protected paths and critical functions enjoy immutable priority even under network stress.

2.6 POLOMARCONI: Critical Communication Expertise, Antennas, RF filters and tailor made solutions to Local Needs.

POLOMARCONI represents a long-standing Italian tradition in Critical Communication solutions, finding in FRMCS a field for concrete value creation. The company focuses its efforts on radio equipment, antennas, and components capable of operating reliably within the bands and profiles required by the new standard.

Its proposed to adapt solutions to the specific needs of projects, addressing details such as installation, antenna coupling, resilience against interference, and link budget optimization under real-world line conditions. This operational proximity supports implementations that comply with design requirements and commissioning schedules, which is particularly important during the transition phase.

Looking ahead, POLOMARCONI aims to consolidate its role as a flexible partner for radio adaptation of fleets and infrastructures, working alongside major system integrators to ensure that the physical layer of connectivity meets the ambitions of FRMCS.

2.7 Softil: MCX Stack as an Enabling Software Infrastructure

Softil plays a distinctive role by providing the software that allows many solutions to implement MCX services in a standards-compliant manner. In the FRMCS context, this means reducing the time-to-market for terminals, CAB radios, TOBA and TS gateways, dispatching platforms, and applications that require native integration of MCPTT, MCData, and MCVideo.

Softil works on the depth of its stack, its strict compliance with standards, and its ability to evolve in parallel with timely updates. The company positions itself as a transversal partner for equipment manufacturers and system integrators, quickly enabling mission-critical functionalities that would otherwise require substantial investment if developed from scratch. Looking ahead, Softil is enhancing testing, simulation, and validation tools to ensure true interoperability, offering partners a solid foundation on which to build user interfaces and application logic without compromising compliance.

3. Additional Considerations on the Evolution of FRMCS

This section presents the set of additional considerations and topics strictly connected with the evolution of the FRMCS.

3.1 Operational Integration, Control Centers, and HMIs for Personnel

Beyond individual suppliers, the success of FRMCS will depend on the quality of integration within control centers and operational rooms. Mission-critical communication exists at the intersection of people, procedures, and tools, and requires interfaces aligned with staff cognitive loads, clear escalation paths, and visualizations that highlight essential elements in degraded conditions. Dispatching platforms must make the use of MCPTT functions, the distribution of vital data, and the sharing of video when needed, feel natural—without overburdening operators. Collaboration between network providers and HMI specialists will be a decisive factor in avoiding solutions that are technically sound but operationally burdensome.

3.2 Telemetry, Predictive Maintenance, and the Value of Data

FRMCS enables a new era of data-driven maintenance. Trains and infrastructure become nodes that generate information which, when transmitted reliably and with adequate latency, feed predictive models capable of anticipating failures, optimizing inventories, and scheduling interventions with minimal impact on fleet availability. The economic return does not derive from the mere availability of the radio channel, but from the ability to integrate the data pipeline with data lakes, analytical engines, and planning tools. Suppliers able to deliver complete value chains—from sensor to decision—will stand out, especially as the standardization of network components levels hardware differences.

While limited forms of telemetry were already possible under GSM-R, its narrowband, circuit-switched architecture, low data rates, and lack of native support for IP-based services significantly constrained data volume, transmission frequency, and real-time analytics. As a result, GSM-R was primarily optimized for voice and basic signaling rather than continuous data streaming and large-scale data integration. FRMCS, by contrast, is designed from the outset as a broadband, packet-switched system, enabling scalable telemetry, low-latency data transport, and seamless integration with modern IT and cloud-based analytics platforms.

3.3 Governance, Contracts, and Quality Measurement

The maturity of the FRMCS market will also be measured by the quality of contracts and the railways' ability to define, demand, and verify measurable service levels. The measurement of end-to-end latency on safety-related paths, the availability of priority and pre-emption functions, behavior under congestion, and resilience to multiple failures must translate into precise and auditable indicators. Observability tools, event logs, and auditing capabilities are not optional extras but prerequisites for building trust between operators and suppliers. This represents a significant evolution compared to GSM-R, where the technology was largely delivered as a vertically integrated system with limited visibility into internal network behavior. GSM-R provided

deterministic performance for a narrow set of services, but offered few standardized mechanisms for fine-grained, end-to-end performance measurement, dynamic QoS enforcement, or independent verification of service levels. As a result, contractual arrangements were typically based on availability targets rather than on continuously monitored, multi-dimensional service indicators.

In the FRMCS context, major network vendors hold an advantage through their advanced management and observability platforms, while railway system integrators and software specialists can add value by building correlation maps between network metrics and their impacts on railway operations.

3.4 Timelines and Evolutionary Trajectories

The FRMCS timeline will begin with an initial phase dominated by pilot projects (EU-Rail FP2-MORANE2, FRMCS_LAB), private network segments, and circumscribed use cases that allow experience to be accumulated without exposing overall operations to risk. This will be followed by a prolonged coexistence phase with GSM-R, during which fleets will increasingly adopt dual-mode terminals while control centers gradually learn to exploit MCX services. Full maturity will be reached once the interoperability chain—covering onboard, trackside, telecommunications, and operational procedures— is certified end-to-end as part of the Testing & Validating and ERA authorisation process for ERTMS, prior to the start of revenue operations.

In parallel, optimization algorithms, analytics, and value-added applications will find fertile ground to grow, supported by a network capable of guaranteeing predictability and reliability.

4. Conclusions and Outlook for the Analyzed Players

FRMCS will serve as a foundational communications platform supporting the evolution of railway operations over the next decade, pparticularly in areas such as train control, operational resilience, and data-enabled services.

Competition will be less about individual components and increasingly about integration and the ability to measure and guarantee performance in real-world scenarios. In this balance, collaboration and interoperability will not be mere slogans but conditions for the very existence of the market, since no player, however large, can single-handedly oversee the entire value chain.

The direction is clear: a resilient FRMCS network—equipped with observability capabilities that provide continuous visibility into network performance, events, and service quality—and open to standards and integrated with railway processes, will act as an enabler for safer, more punctual, and more efficient mobility.

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