

FRMCS Deployment Strategies: insights from the Deployment Group

An overview of industry players shaping the FRMCS ecosystem

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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 and migration scenarios, while ERA and ETSI provide the regulatory foundation by publishing artifacts ranging from SRS to interoperability specifications 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.

In this article, initiated by the EU-RAIL European Deployment Group, we present the strategic elements for the development of FRMCS, gathered through a series of bilateral meetings with leading companies in the railway telecommunications sector.

1. FRMCS strategic pillars: technology, standards, migration, security and mobile operators

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 those based on 5G standards.

FRMCS arises from the need to ensure superior performance, safety, 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, and above all, capable of ensuring interoperability at the international level. In this context, FRMCS positions itself as the single global standard for mission-critical communications in the railway domain. It is not merely a technological replacement, but a common strategy involving equipment manufacturers, railway operators, software solution providers, 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 most mature form, the FRMCS network must coordinate the mission-critical control plane with best-effort domains for non-safety-related services, ensuring a clear separation of responsibilities and security domains. Design therefore shifts from a monolithic logic to a platform-based logic, where MCX services, quality-of-service

orchestration, network API exposure, and end-to-end observability become integral elements of daily design and operations.

The frequency issue holds strategic importance. The European 1900–1910 MHz band constitutes the cornerstone of dedicated spectrum availability, but national plans and future global harmonization will shape the morphology of networks, balancing spectrum portions reserved for the railway domain with controlled sharing models when 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. 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 railways. 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 environment where vendors, operators, and railway organizations can jointly ensure that equipment from different manufacturers works seamlessly together. 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 flows 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 5G and FRMCS, the attack surface expands, increasing the need for a zero-trust approach adapted to railway specificities. 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 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 through public cellular infrastructure, primarily using mechanisms such as Multi Operator Core Networks (MOCN) sharing and multipath support. This duality ensures that trains can rely on dedicated, highly controlled bands for mission-critical communications while also having the possibility to exploit MNO coverage for resilience, cost efficiency and broader service availability. In practice, adoption is still cautious. Most railway operators continue to prioritize dedicated FRMCS deployments, particularly in the 900 and 1900 MHz railway bands, because of the stringent requirements for reliability, latency and security. Nevertheless, hybrid approaches are increasingly being tested, such as combining dedicated infrastructure with MNO-provided coverage to fill gaps or extend services into less accessible regions. These hybrid models are seen as a pragmatic step toward ensuring continuity of service, especially during the early roll-out phases of FRMCS.

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, full integration of MNOs is expected to mature with the arrival of FRMCS V3 around the end of 2026, where cross-border interoperability, hybrid operation and advanced QoS mechanisms will be more firmly established. Until then, MNO participation in FRMCS remains more of a pilot and planning exercise, preparing the ground for a future in which railway communications can seamlessly combine dedicated spectrum with public mobile networks in a secure and reliable way.

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 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.

2. Bilateral meetings with Industries

Based on the FRMCS cornerstones described, a series of bilateral meetings were organized in collaboration with ERJU with the most active players currently engaged in the development of the future railway telecommunications system. Below is an overview of the key concepts exchanged with many of the companies already involved in UNITEL.

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 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 — for instance, as an associated member of Europe's Rail Joint Undertaking (EU-Rail) — making it the ideal partner for FRMCS.

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 trusted partner 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.

Its credibility built in the traditional railway world becomes a competitive advantage in persuading operators to entrust Nokia with the transformation of railway communications.

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 strength lies in the ability 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 translates into implementations that meet design parameters and commissioning timelines—qualities essential 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.

The value of Softil lies in 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.

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 demand and verify measurable service levels. The measurement of end-to-end latency on safety-related paths, the availability of priority functions, behavior under congestion, and resilience to multiple failures must translate into precise indicators. Observability tools, event logs, and auditing capabilities are not optional extras but prerequisites for building trust between operators and suppliers. In this context, major network vendors hold an advantage through their management 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 (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 is certified end-to-end and operational procedures are fully adapted to the new network. 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. Strategic Conclusions and Outlook for the Analyzed Players

FRMCS is the platform on which the next decade of railway mobility will be defined. Siemens appears well positioned to lead complex transformation programs thanks to its deep integration between communication and signaling. Frequentis brings the excellence of mission-critical experience into the heart of control centers, becoming a reference point for operators and for managing MCX flows in full alignment with processes. Ericsson and Nokia, leveraging their strength in the

5G domain, offer dedicated railway networks with slicing, security, and observability, targeting contracts based on measurable outcomes. Alstom exploits its natural convergence with automation and ETCS, providing on-board and system solutions that highlight communication as an enabler. Funkwerk safeguards and strengthens its niche of robust, manageable on-board devices, essential for gradual and reliable migrations. Softil delivers the MCX software layer that allows many to accelerate without compromising compliance, while Kontron provides the embedded and edge foundation on which to securely run critical and pre-processing functions. Finally, Polmarconi contributes radio expertise and adaptability, decisive for transforming technical specifications into stable, target-compliant connections.

Competition will be less about individual components and increasingly about integration and the ability to measure and guarantee performance in real-world scenarios. Railways will choose partners who not only promise reliability but demonstrate it through tools, data, and transparency. 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, observable FRMCS network—open to standards and integrated with railway processes—will be the lever for safer, more punctual, and more efficient mobility. Those who embody this vision will secure a lasting competitive advantage.

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