

How to prepare the **railway communications network for FRMCS,** end to end

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When FRMCS gets introduced — and in many countries will replace GSM-R, especially across European railways — the changeover won't be a simple radio upgrade. Instead, it requires a transformation of the entire communications architecture, so planning should begin now. Here's what rail operators need to address, layer by layer.

The Future Railway Mobile Communication System (FRMCS) is the next-generation standard for railway communications. It provides a foundation for enhanced capabilities and enables an array of operating benefits. Yet many rail operators don't realize it's time to begin key preparations for implementing this new standard.

The meticulous FRMCS standardization process is progressing through the International Union of Railways (UIC) — and the European Railway Agency (ERA) is not expected to release the final Technical Specifications for Interoperability (TSI) until approximately 2028.

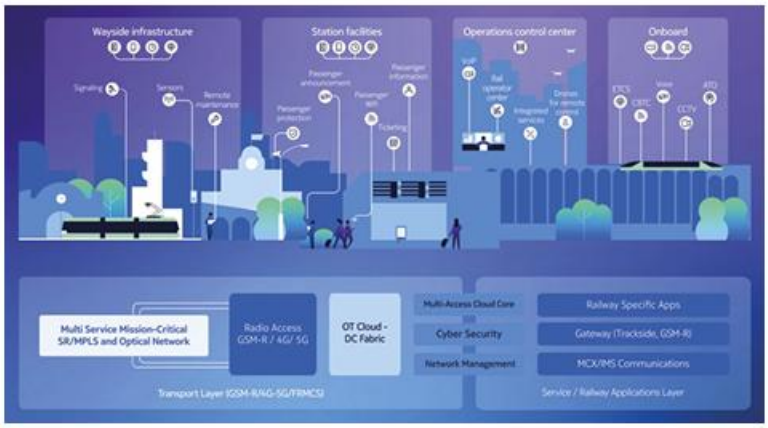
The migration to FRMCS is a complex endeavor. It first requires the transformation of a railway infrastructure manager's entire mission-critical communication architecture, touching every layer of the network stack. Consequently, the lead times for FRMCS readiness are substantial. And crucial steps should be addressed as quickly as possible.

Here's one approach to making necessary changes:

Focus first on the transmission backbone

This fixed IP and optical network provides the foundation for everything else that will be built, and it must be fully ready before any further steps are taken. Readiness includes:

- Establishing IP/MPLS connectivity at every base station
- Ensuring that routers support 5G's synchronization demands
- Making changes to the IP network's physical topology, where needed; for instance, ring sizes must match strict 5G synchronization requirements.



Nokia solutions for railways

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Consider what's needed for the RAN

The first step in radio access network (RAN) planning is to determine what will actually run through the network, because those requirements will help create a proper network design, including the number of radio sites that will be needed.

Initially, FRMCS planning assumed far more radio sites would be needed, when moving from GSM-R's 900 MHz band to FRMCS at 1900 MHz (n101). In fact, that's not always correct. If railway operators are first focusing on basic ETCS signaling and mission-critical voice — and the GSM-R network has already been designed to serve ETCS — the same cell sizes for GSM-R should work for FRMCS. This is due to the fact that cell sizes are mainly dominated by the available bandwidth at the cell edge, in contrast to GSM-R where coverage level was the main planning parameter to be obeyed.

However, there are times when additional sites may be needed. This can occur when operators want to run higher-throughput use cases on top, such as automated train operation (ATO) with a higher grade of automation that includes video. So keep in mind that goals like this can require a denser network.

BBU architecture options are the next essential consideration for the RAN. Operators can choose a distributed architecture — where each site has its own baseband units (BBUs) — or a hotel architecture, where resources are pooled across multiple sites. The distributed architecture is more costly, while the hotel architecture offers significant savings. But if a pooled BBU fails, every connected site goes down. By providing a second BBU at a separate location as backup in case of failure, the hotel architecture can offer a balance of cost and resilience.

Understand the potential of a 5G core

The transformative capabilities of FRMCS rely on a resilient 5G core designed to meet the specific demands of railway operations. That means it can deliver high throughput and low latency for safety-critical services, while enabling high availability, resilience, and reliable operations.

Because this 5G core is cloud-native — unlike the GSM-R core network — it can provide other crucial advantages as well, such as running on an on-premises cloud platform. Or enabling more flexible operations, because software functions run in containers with spare capacity built into the platform. In addition, updates, security fixes, capacity changes, automation, and new applications can be managed as part of normal lifecycle operations, because the 5G core is modular, software-defined and standards-based.

Be aware of mission-critical communications (MCX) advances

Using a standardized MCX framework, FRMCS provides interoperable voice, data, and video capabilities for railway operations. These offerings incorporate the resilience and prioritization required for safety-critical use, along with the functionality defined in 3GPP mission-critical domains. For example, this includes mission-critical push-to-talk (MCPTT), the 5G evolution of group voice communications that is central to railway operations. MCPTT delivers higher quality audio, faster push-to-talk setup and group management, along with advanced features such as dynamic group management and user prioritization.

MCData enables secure, reliable exchange of operational information, including ETCS train control data and critical messaging. MCVideo adds real-time video to and from moving trains, supporting applications such as HD CCTV, incident management and future automated train operations.

Strengthen security measures

This step is highly important, because moving to a 5G IP-based network expands the possibility of cyber attacks. That's because the foundation of GSM-R's time division multiplexing (TDM) provided a degree of natural protection, but a change to FRMCS extends the »attack surface.« As a result, operators need to take more deliberate security steps.

The first step is to recognize the Third Generation Partnership Project (3GPP) requirements for IPsec encryption from radio to core. In addition, European regulations are beginning to establish policies that consider secure rail communication a matter of national infrastructure protection.

However, compliance alone is not enough, and a more robust »zero-trust« approach is needed. This means limiting the ability of attackers to enter the network, while simultaneously using zoning to contain any potential damage if they do intrude. The goal, in other words, is to restrict what any attack can reach. Every network element should play a role in this approach, rather than relying on a single security measure, such as a firewall.



Nokia 7705 Service Access Router – Hx

Clearly, this can be a significant challenge for large organizations that still run applications developed before modern security policies were put in place. Nevertheless, the challenge must be dealt with at the infrastructure level, rather than addressed in a more superficial way.

Consider new applications carefully

It's tempting to plan for everything at once. However, getting ETCS signaling and mission-critical voice operational is the first priority. That's because they need to run reliably on FRMCS before GSM-R can be switched off step by step. In other words, the architecture should be designed with evolution in mind — but without trying to build for all sorts of applications at the outset. It's better to start with critical elements. Prove they work. Then build on that foundation.

Once GSM-R can be decommissioned line by line, the full 900 MHz FRMCS spectrum (n100) becomes available for an additional layer of redundancy or new use cases, such as higher grades of train automation, driverless services, and IoT-based predictive maintenance.

Depending on national rollout strategies, of course the FRMCS 900MHz spectrum (n100) could be an option or alternative to 1900MHz (n101) for lines without GSM-R today, meaning FRMCS greenfield.

The final step: the transition to FRMCS

Operators will need to run FRMCS and GSM-R simultaneously for a couple of years. One practical approach is to deploy FRMCS without altering any of the existing GSM-R infrastructure. This means keeping them separate, running in parallel. Then GSM-R should be decommissioned in stages, as FRMCS services have proven to be stable.

Any operators still running GSM-R over obsolete synchronous digital hierarchy (SDH) networks can follow a well-proven migration path to IP/MPLS which requires no changes to the GSM-R configuration. This method essentially moves cable connections to the IP/MPLS network and maintains the connectivit to the existing radio infrastructure until the last day of GSM-R operation.

End-to-End assistance

All these often-complex transition processes can pose challenges, such as capacity constraints and the pressures put on internal teams. If internal resources face heavy workloads, one option is to rely on professional services, which can cover everything from initial network planning, deployment, and long-term operations. The services also allow existing staff to focus on using their unique skills and experience to continue running the railway efficiently, while the transition takes place.

Conclusion

FRMCS will do much more than replace GSM-R. It will create a future-proof communications foundation for more efficient, more automated, and more data-driven railway operations. But realizing this potential requires a structured, end-to-end approach covering the entire connectivity infrastructure. By preparing essential elements now — the transmission backbone, RAN, 5G core, MCX services, security model, applications roadmap, and migration strategy — rail operators can reduce risk, control complexity and move toward FRMCS with greater confidence. ●



Nokia AirScale Radio for 1900 MHz (n101 band)

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