Nokia response:

ACMA’s options paper on replanning of the 1.9 GHz band

March 2023

Disclaimer: This response is based on Nokia's current understanding of the market dynamics and various standards bodies; these dynamics are changing and hence our views may update with these changes

1 About Nokia

At Nokia we create technology that helps the world act together. We develop and deliver the industry's only end-to-end portfolio of network equipment, software, services and licensing that is available globally. Our customers include communications service providers whose combined networks support 6.1 billion subscriptions, as well as enterprises in the private and public sector that use our network portfolio to increase productivity and enrich lives.

With an end-to-end portfolio that is unique in the industry, Nokia can work in partnership with operators and directly with enterprises to deliver "real 5G". Nokia's in house 5G mmWave Small Cells and AirScale BTS provide in-building and outdoor coverage, while our Microwave Anyhaul, Cloud native RAN, antennas, and 5G cloud-native core are part of approximately half of our agreements to date. Beyond our mobile networks portfolio, Nokia has excellent FP5 network processor-based IP routers and PSE-6s chipset powered optical networking - our customers can use the Nokia Network Services Platform to make this into full-5G-strength software defined connectivity 'smart network fabric' secured by Nokia Security Orchestration, Analytics and Response (Nokia SOAR) to ensure resilient 5G. Globally Nokia has been selected by more than 230 operators to supply 5G networks.

Nokia is a global leader in 5G standardization and technology innovation with a strategy specifically designed to support the Australian market – with Nokia’s 5G mmWave technology supporting high-capacity areas together with low band 5G supporting rural and regional areas. In 2021 Nokia together with TPG Telcom set a 74km 5G cell range world in regional NSW, a record that still stands today. Nokia is proud to be a strong partner in the current roll-out of 5G in Australia, continuing our 120-year presence here.

Because the security of our technology is integral, Nokia has always undertaken extensive monitoring and testing (including independent validation) of our products, at all stages from inception, development, manufacturing, deployment, and maintenance. All Nokia products and our supplies are subject to the same security verification procedures to ensure their integrity, regardless of their place of development, manufacture, or operation.

Through our research teams, including the world-renowned Nokia Bell Labs, we are leading the world to adopt end-to-end 5G networks that are faster, more secure and capable of revolutionizing lives, economies and societies. We have invested in two state of the art 5G experience centres in Australia, the 5G Futures Laboratory in Sydney and the 5G Industrial Incubation Laboratory in Adelaide.

Nokia adheres to the highest ethical business standards as we create technology with social purpose, quality and integrity. For more information: https://www.nokia.com/networks/5g/

2 Introduction and submission summary

Nokia welcomes the opportunity to respond to Australian Communications and Media Authority Consultation options paper on replanning of the 1.9 GHz band. As a leading player in the global communications sector, and contributor to the Australian market over many decades, Nokia is well placed to provide insight on market and technology trends, including industry structure and regulatory practice.

Nokia has contributed to many of ACMA's spectrum papers including both the ACMA's "Five-Year spectrum outlook 2022-2027" and November 2021, discussion paper on exploring future use of the 1.9 GHz band. Through both submissions we re-iterated the position relating to the 1880–1920 MHz and the possible use that include the modernization of train communication system.

The rail sector worldwide is on the verge of a technological leap into the digital future. The rail system of the future will be characterized by data-intensive and partially latency-critical applications, which is one of the reasons why European railway operators are currently striving to soon introduce the 5G-based Future Railway Mobile Communication System (FRMCS).

5G offers a major opportunity for Australian rail operators to transform their operations for the better. Its high speed and extreme traffic handling capacity, together with ultra-low response times, highest reliability and support for massive machine type communication (IoT), will allow rail networks to improve safety, optimize costs and make their services more attractive to passengers in many ways. Such capabilities will make the telecommunication network the cornerstone of railways' ambitions for further digitization and automation.

In support of ensuring alignment between the Australian Rail Industry and FRMCS standards being developed for the Global Rail environment, Nokia recommended that ACMA aligned any technical decision with global standards such as 3GPP to allow licensees to benefit from the associated global economies-of-scale and more diverse product ecosystem, hence supporting overall 5G deployment. *The ECC Decision 20(02) Harmonised use of the paired frequency bands 874.4-880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR)*[1] clearly indicates 1900-1910 Band for FRMCS as a way forward but more importantly is that this band will be part of 3GPP Rel. 17 for the initial planned deployment.

[1] [1] The ECC Decision 20(02) Harmonised use of the paired frequency bands 874.4-880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR) ECC Decision (20)02 (cept.org)

From Australian railway operators' perspective, alignment with the larger European market means access to wider choice of suppliers and User Equipment's. However, it is important to note that GSM-R and FRMCS will co-exist for a certain period.

We also highlighted that the portion 1880MHz-1900MHz should be further considered and co-existence between DECT(-2020 NR) and other wireless technologies (IMT or MulteFire) should be further studied so business enterprise services operated by private entities within the confines of their own premises (i.e. Indoor use only) may be possible. In such a scenario where DECT and other wireless technologies are allowed to coexist in indoor environments in 1880-1900MHz, Nokia recommend that the spectrum from 1910-1920MHz remain as a buffer or guard band.

Railway operators have an opportunity to update their legacy networks and move to a new world of supreme safety, high operational efficiency and on-train mobile broadband. Offering high speed, high capacity and low latency, 5G can provide enormous benefits and will help rail operators move to a new era in automated operations and customer service. The FRMCS, based on 3GPP evolution towards 5G, has been proposed as a single global standard for railway communications. With GSM-R expected to be supported until around 2030, rail operators (including those in Australia) need to start planning early to migrate their existing networks to the new standard if they are to take full advantage of the opportunities.

Therefore, it is essential that spectrum requirements of Australian Rail Operators are addressed on a long-term basis in line with Nokia's responses to Options 3 and 4 as set out in the replanning paper.

For further detail on FRMCS please refer to Appendix 1 of this submission.

3 Comments on each of the Options identified

Option 1: Maintaining existing arrangements

Maintaining existing arrangements. Regulatory arrangements in the 1880–1900 MHz frequency range may require minor amendments to ensure some new SR WBB technologies can be accommodated in this segment.

3.1 This option does not provide spectrum for the Rail Industry and the transition to 5G/FRMCS. Furthermore, there would be interference concerns should there be a future allocation of 1900-1910 MHz to Rail operators, especially in Metro regions if SR WBB technologies were permitted to operate without any restrictions.

Option 2: Expanding SR WBB arrangements

3.2 *Expanding SR WBB arrangements from exclusive use in 1880–1900 MHz to include shared use in the 1900–1920 MHz frequency range Australia-wide, with no other changes to current arrangements.*

This option does not provide spectrum for Rail Industry and the transition to 5G/FRMCS. Furthermore, there would be interference concerns in Metro and Regional regions, especially near the Rail corridors should there be a future allocation of 1900-1910 MHz to Rail operators.

3.3

Option 3: Introducing arrangements to allow RMR in 1900–1910 MHz

Introducing arrangements to allow for RMR in the 1900–1910 MHz frequency range on an Australia-wide basis, with no change to current arrangements in the other segments.

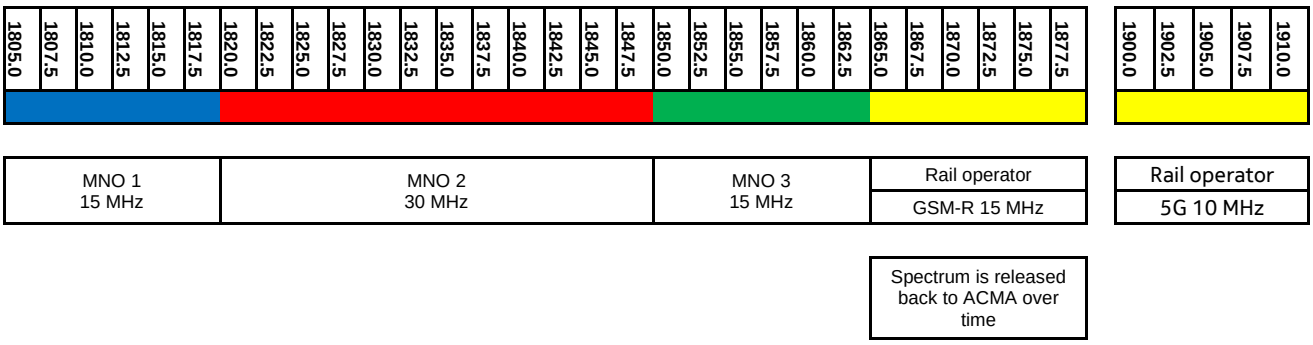
Nokia support this option as this allows Rail Operators to introduce 5G/FRMCS. As there is no change to current arrangements, there are potential Interference concerns, especially in Metro areas closer to Rail corridors.

In such an option, Nokia would recommend the ACMA to consider keeping 1800 MHz for GSM-R and/or keep 1800 MHz for GSM-R/LTE and allow Rail operators to introduce 5G/FRMCS at 1900 MHz. The 1800 MHz spectrum can be released post migration or kept for enhanced operations. Note 10 MHz at 1900 MHz is fairly small allocation especially when considering a 5 MHz + 5 MHz deployment to support geo-redundancy at frequency layer. Rail networks are considered Mission Critical networks and as such required to support availability in the range of 99.9999%.

Examples GSM-R deployed in Melbourne / Victoria at 1800 MHz, GSM-R deployed in Sydney / NSW at 1800 MHz, GSM-R currently being deployed in QLD at 1800 MHz and WA currently

being deployment of an LTE 15MHz carrier at 1800 MHz. It is envisaged such a scenario can be described by the following diagram

Figure 1 - Frequency allocation with 1800 MHz (initially only) and 1900 MHz bands



Option 4: Extending arrangements for SR WBB to the 1880–1920 MHz

3.4 *Extending arrangements for SR WBB to the 1880–1920 MHz frequency range to allow shared use of the 1900–1920 MHz frequency range Australia-wide. Introducing arrangements to allow for RMR in the 1900–1910 MHz range Australia-wide, on a shared and coordinated basis with other services while maintaining arrangements for LA WBB and PTP in regional and remote areas.*

Nokia also supports this option as this allows Rail Operators to introduce 5G/FRMCS. There are potential Interference concerns, especially in Metro areas closer to Rail corridors. This highlights the need for carefully coordination between LA WBB, PTP and other services and proposed RMR services. In such a scenario, Nokia would assume DECT and Multefire would be limited to indoor use, especially in close proximity to Rail corridor.

In addition, for any SR WBB services that are allocated to 1880-1920 MHz, there needs to be careful coordination to minimise interference concerns and proposed RMR Services, especially given that RMR services operating in 1900-1910 MHz band are TDD based and susceptible to interference

Note: Rail is a Mission Critical service and as highlighted in Section 2, 5G/FRMCS will bring a lot of automation and safety and mission critical services. As such, it is imperative that the Rail corridor is well protected from any interference from the shared use scenario as proposed by this option.

Appendix 1 - Future Railway Mobile Communications (FRMCS)

Since the introduction of the current railway mobile communication standard GSM-R, the number of use cases and their requirements have drastically increased. Moreover, GSM has been in service for more than 25 years and reaches its end of life. The future of rail transport critically depends on taking advantage of advanced communications systems to increase safety, cut operating costs and improve the experience for rail passengers towards a digital railway.

5G is set to be the wireless technology of choice to support Rail as it provides efficient broadband capabilities, 5G networks will offer measures to build ultra-high reliability networks with ultra-low latency. It will also serve the need of massive Machine Type Communication (mMTC) by allowing a huge number of subscribers in a single cell. This along with the fact that 5G devices can be built with very low power requirements is the base for sensors and predictive maintenance that train operators will increasingly need in the future to improve and optimize their services. With huge performance improvements over previous generations of mobile technology, 5G delivers high speeds of up to 10 Gbps and very low latency, the time for the network to respond to requests from the mobile device. Furthermore, 5G also achieves such performance at much lower cost than other technologies.

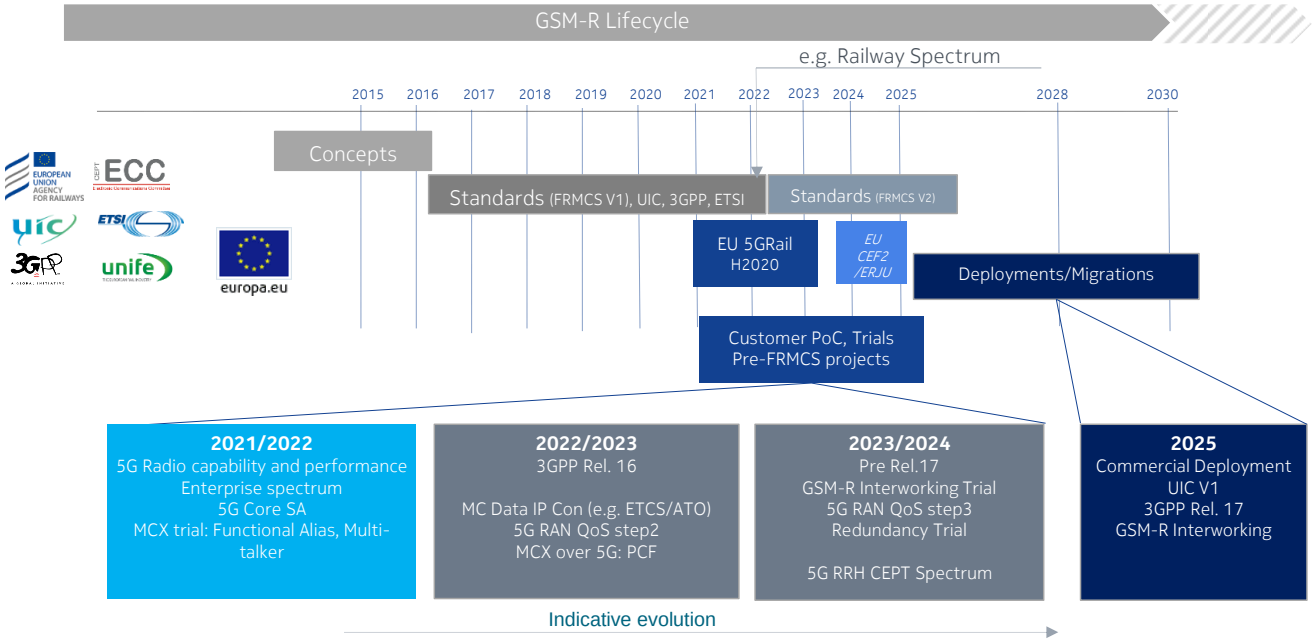
Applications supported by FRMCS can be categorized into three segments:

- **Critical:** applications essential for train movements and safety or a legal obligation, such as emergency communications, shunting, presence, trackside maintenance, Automatic Train Operation (ATO), Automatic Train Control (ATC) and Automatic Train Protection (ATP).
- **Performance:** applications that help to improve the performance of the railway operation, such as train departure procedures and telemetry.
- **Business:** applications that support the railway business operation in general, such as wireless internet for customers and ticketing support (Note: depending on spectrum availability and national regulation).

Led by UIC and the European Railway Agency (ERA), the Future Railway Mobile Communications System (FRMCS) is the single global standard for railway communications. While FRMCS will be functional in nature, 3GPP technologies such as 5G will be best positioned to meet all the needs of railway operators.

The figure shown below depicts the estimated timeline from standards development to deployments/migration for FRMCS.

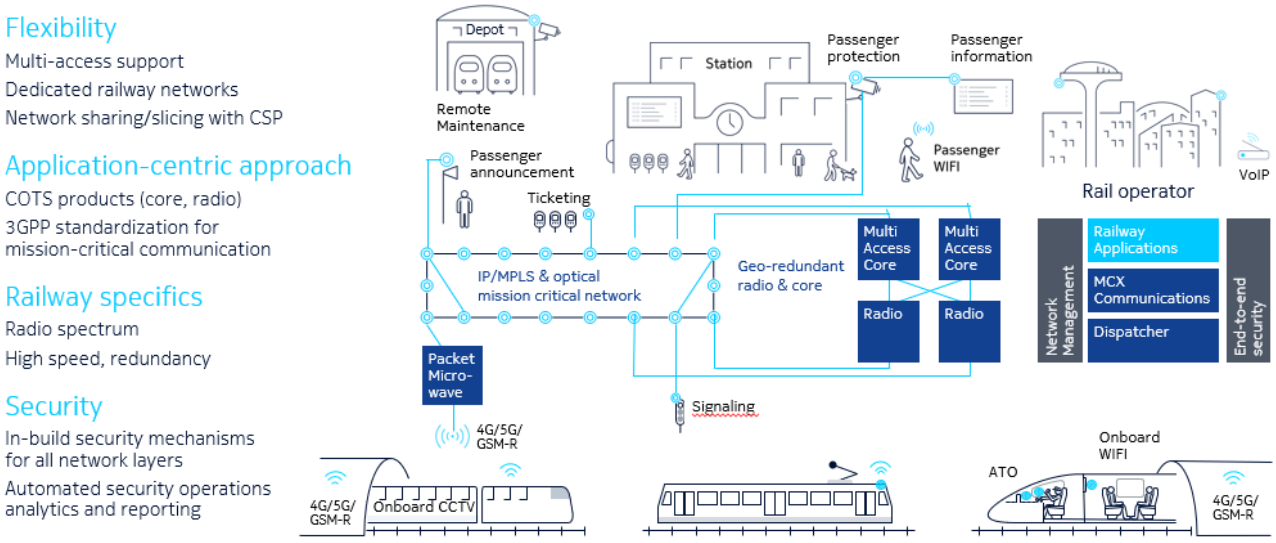
Figure 2 – FRMCS (estimated) timelines - standards development to deployments/migration



3.5

The mobile broadband opportunity for railways

For rail, the benefits realised by FRMCS will be many, including enhanced safety, improved operational efficiency and innovative passenger services, helping operators achieve further digitization to make the railway more competitive. To meet its priorities, the rail industry needs a communications technology that offers high speed, high security and high capacity to support passenger connectivity needs, as well as safety-critical operational applications such as train signaling, and safety-related applications like CCTV and on-board communications. All this can be achieved with a single, converged and flexible network, sweeping away the complexities and inefficiencies of managing a mixture of several network technologies, including GSM-R, TETRA, DMR, Wi-Fi and even analog technologies like VHF/UHF.



3.5.1 FRMCS – a global standard for rail communications

The FRMCS is intended as a single global standard for railway communications. A successor to GSM-R, FRMCS conforms to European regulations while also meeting the needs and obligations of rail organizations outside Europe. As well as the mainline railways, UITP (Union Internationale des Transports Publics), the International Association of Public Transport, also supports FRMCS. A new platform for rail communications – adopting 5G for railways As a mobile broadband-ready technology, FRMCS will support the needs of rail in six ways:

Demand for broadband

- Automation for self-driving trains
- Increasing operational efficiency
- Improving customer experience

Optimization of networks

- Further unifying network technology towards IP
- Reduce complexity
- Increase flexibility

Long term support

- Support for ERTMS/ETCS (as examples) for the next decades
- Manage the obsolescence of GSM technology

Critical communication

- Voice, evolving to group video calls
- Train control, automated train operation

- Machine-to-Machine (M2M) and telemetry for critical elements

Performance communication

- M2M and telemetry
- Predictive maintenance
- CCTV for passenger security and train movement control, passenger Information, staff communication, lineside (fixed)

Business communication

- Wi-Fi on board

One of the main targets of FRMCS is to achieve maximum flexibility by separating the railway functions from the network and radio bearer that carries them.

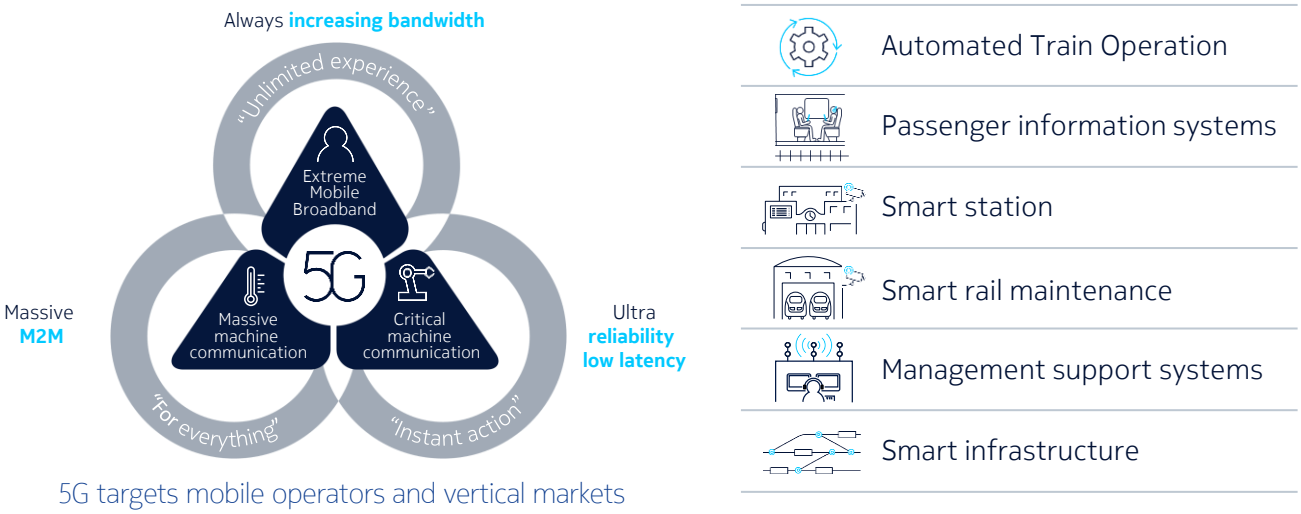
A compelling case for 5G enabled FRMCS

3.6 There are several reasons for choosing 5G technology as the basis for the future of rail communications. FRMCS based on 5G is expected to be introduced in Europe around 2025, by which time it is likely that the 3GPP will have ceased standardization work on 4G LTE technology. Additionally, 5G can be expected to serve railways for much longer, extending over the next decades.

Many of the future uses for railway communications will demand minimal delay between the radio and the network, known as latency, as well as the ability to work in the Cloud. Examples include automated train operation and broadband M2M communication. Although today LTE provides limited QoS within a cell (this is a major shortcoming for mission critical communication), 5G is specifically designed for these kinds of ultra-reliable, low latency mission critical communications, which also include video applications. This is supported by 5G flexible deployment schemes using cloud and mobile edge computing.

There is also a huge effort to use 5G technology for the forthcoming Industry 4.0 transformation, and it is expected to become the dominant technology for vertical markets.

Figure 3 – 5G offers extremely high performance to support the needs of rail operators



3.6.1 5G enabled FRMCS capabilities put full automation within reach

One of the major goals of many industries, not least rail operators, is to make greater use of automation, to cut costs but also to remove human error and promote greater safety. With its high speed and capacity, 5G offers the data handling abilities that extensive automation demands.

Automation has already made great inroads in rail transport, such as people movers at airports, various metro lines across the globe and in special freight applications like mining trains. Enhancing ETCS, Automated Train Operation (ATO) is being introduced to mainline rail services. Although train control as well as rolling stock solutions are commercially available today, several challenges remain. Solutions that offer precise yet affordable location of trains, obstacle detection and a sufficient and reliable communication system are yet to be developed.

When it comes to maintaining rolling stock, the first steps towards automation are complete. However, preventive maintenance is still the most common philosophy, whereas industry generally is moving more towards condition-based maintenance, where interventions are made only when issues start to occur. Even so, this is often too late, so a newer trend is predictive maintenance. So far, few pilot projects have proven successful in this area. This is because solutions are often too siloed - even restricted to vendors of components of rolling stock. Rail operators often face the issue that these solutions are not open, and data cannot be shared.

Trackside maintenance is one of the most challenging tasks to automate. However, there are some promising solutions being created by start-ups. In trackside maintenance, more

than in any other case, it is important to find solutions where only minor deployments in the field are required.

Today, most automation is occurring in railway stations. Elevator and escalator maintenance is often already based on their condition. However, these solutions are siloed, as they are often provided by the elevator vendors. Another issue is that solutions are often driven by large deployments in central or major stations, but the biggest benefits can be achieved by optimizing maintenance at small, unstaffed rail stations.

3.7 Use Case and Benefits of 5G based FRMCS

Seamless 5G connectivity, cloudified data and analytics engines will enable railway operators to partner with third parties to offer innovative applications and services.

Mission-critical applications

Mission-critical reliability is mainly required by CBTC/ETCS systems, although operational voice services also demand extreme network prioritization as they help to ensure security and provide an essential means of manually sustaining train operations should the CBTC/ETCS system fail. A CBTC/ETCS application will typically tolerate a communications loss of no more than a few seconds, while a mission-critical voice service will usually have higher tolerance of communications loss. Further Automation even increases the demand.

Predictive maintenance and operations intelligence

The maintenance and repair of rolling stock, track components, depots and stations, often across large geographies, poses challenges in planning the use of repair equipment and teams. Predictive maintenance applications, using IoT asset management and advanced data analytics promise to reduce costs, increase asset utilization, enhance safety, minimize delays and reduce revenue loss. Digital twin systems can be introduced to increase efficiency through the simulation of trains and rail infrastructure.

Video surveillance for operational security

A typical railway operation has multiple, high-quality CCTV systems generating many video streams. This requires a cost-effective and reliable high capacity communications network able to handle traffic of several Mbps per camera and thousands of video streams. Video analytics can automatically discover anomalies in people's behaviour, alerting safety and security personnel so they can intervene. In fully automated mode, video is important for obstacle detection, or providing situational awareness, for example degraded train operation.

High-capacity and low latency connectivity will support applications that help improve passenger safety and security. These will include driver video for advance views of platforms and level crossings, as well as remote supervision of passengers through on-board closed CCTV.

Such CCTV systems will contain innovative features such as video analytics software to automatically detect intrusions, strange behaviour or unattended baggage.

On-board CCTV services require high uplink throughput, while the platform CCTV service requires high downlink throughput. Of all types of application traffic for rail operations, CCTV traffic probably takes up the most capacity.

The digital passenger

The modern passenger expects to be connected constantly and be provided with personal, bespoke communications and services. Making sure the passenger has full broadband access in-station and onboard is only the beginning. Their smartphone and wearables, such as a watch, can provide important information such as directions, alerts and information updates.

Railway personnel can provide better services by being equipped with handheld devices that can immediately identify the passenger and provide them with key contextual information.

Enhanced passenger experience

Enhancing the passenger experience can be achieved through passenger information and multimedia entertainment applications. For instance, passenger information applications can provide route information and weather forecasts. Entertainment applications can provide video streaming. This type of “Infotainment” traffic is typically low priority and may consume only a low to moderate amount of network capacity. It also tolerates relatively high network latency. However, passenger Internet services could eventually become the single highest consumer of network capacity.

Reducing operational costs

Lower maintenance and operational costs will be achieved through the efficient operation of rolling stock, based on real-time information and improved communication between moving trains, maintenance staff and track-side systems. Operational costs will also be reduced by introducing new applications (for example remote diagnostics and Augmented Reality (AR) based remote maintenance) and services to simplify and automate operational processes, as well as by consolidating fragmented legacy networks with a unified 5G network capable of running multiple services.

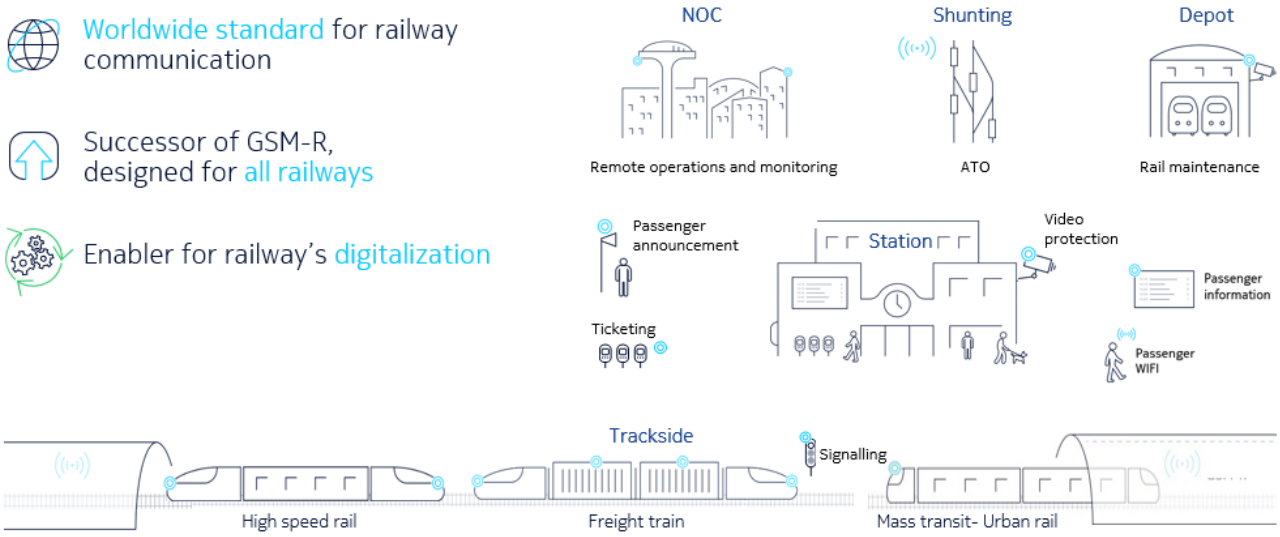
3.8

Categories of application that may be enabled and supported by FRMCS

The International Union of Railways (UIC) defines three categories of application that may be enabled and supported by FRMCS:

- Critical: applications essential for train movements and safety or a legal obligation, such as emergency communications, shunting, presence, trackside maintenance, ATC, etc.
- Performance: applications that help to improve the performance of the railway operation, such as train departure, telemetry, etc.
- Business: applications that support the railway business operation in general, such as wireless internet, etc.

Figure 4 – Applications enabled in an FRMCS environment



Source: Future Railway Mobile Communication System: User Requirements Specification https://uic.org/IMG/pdf/frmcs_user_requirements_specification_ version_4.0.0.pdf".