Railway Networking

Setting the scene on current and future railway services

IETF 118, Prague, Railway networking side meeting

Huawei EU Datacom SID

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Agenda

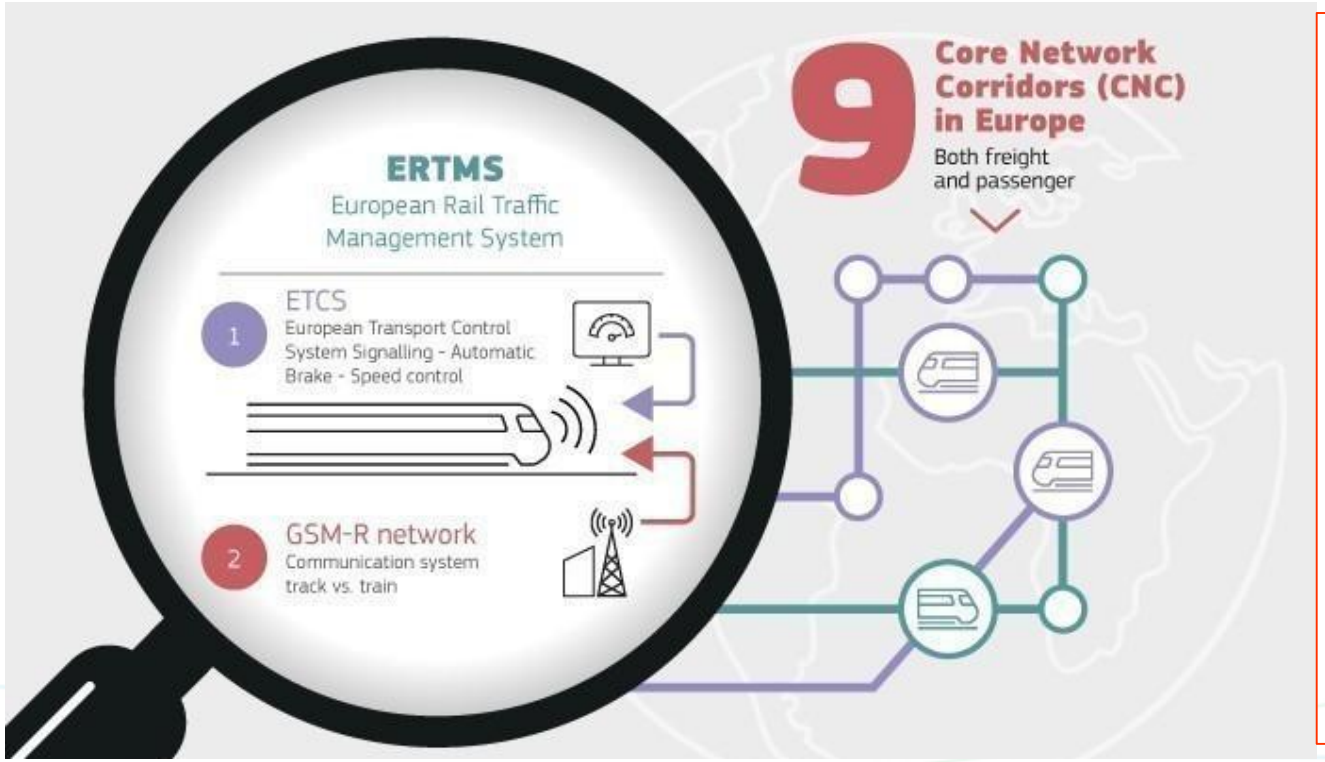
- The European Rail Traffic Management System (ERTMS)
- The present (GSM-R) and the future (FRMCS)
- Summary
- References

Railway Networking: An Introduction

- Often, railway companies run a few networks in parallel:
  - An IT network for office, ticket selling, corporate intranet, etc.
  - A dispatch network for controlling trains and supporting European Train Control System (ETCS) applications
  - In some cases, another physically disjoint dispatch network as a backup
- The sites of each network are the train stations, offices, etc.:
  - These networks are similar to common enterprise/backbone networks
  - The size of these networks is 1-5% of the national operator network
- The dispatch networks also include the trains:
  - Trains are connected and controlled today via trackside equipment and radio
  - The current generation of radio equipment is based on Global System for Mobile Communications-Railway (GSM-R)
  - Future Radio For Mobile Communication System (FRMCS) is the next generation mobile network to support the evolution of the railway telecommunication services with fewer track signs and signals, and control the trains uniquely via radio.

European Rail Traffic Management System (ERTMS)

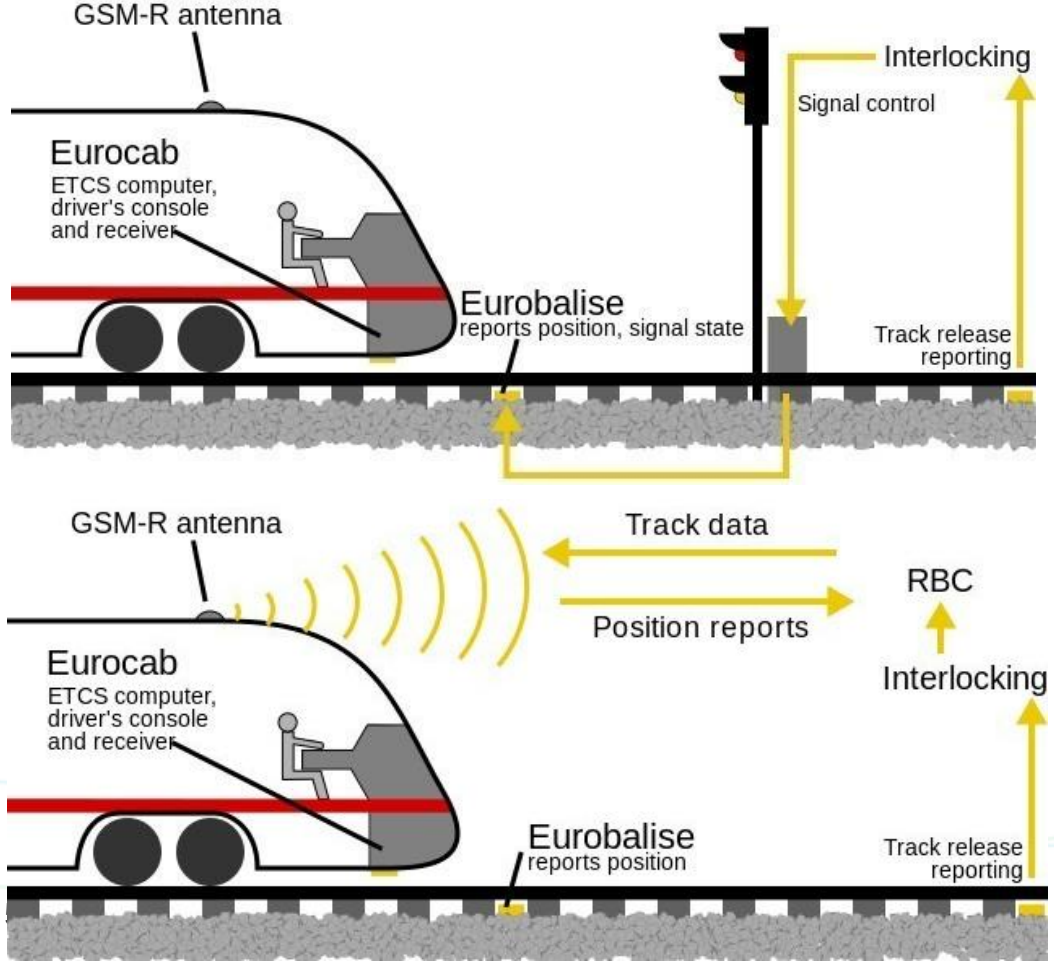
- ERTMS [1] is a major industrial project implemented by the EU to make rail transport safer and more competitive:
  - Is a European standard for the Automatic Train Protection (ATP) and command and control systems
  - Allows cross-border interoperability to ease rail operation between the EU Member States
  - Enforces safety and compliance from trains with speed restrictions and signaling status.



- ERTMS is based on two main components:
  - ETCS is a train control standard, based on in-cab and trackside equipment to supervise train movements. Information on track description is received from the ETCS equipment installed beside the track, balises or radio equipment
  - Railway Mobile Radio (RMR) is the European radio communications system for railway operations. It is comprised of two radio systems: GSM-R (present) and FRMCS (future)
- The combination of the two allows Automatic Train Operation (ATO).

ERTMS Levels

- The ERTMS “levels” define different uses of ERTMS as a train control system:
  - Level 0 is based on the specific national Automatic Train Protection System. The driver commands the train in the conventional way according to the signaling set by the Movement Authority, and the timetable.
  - Level 1, 2, and 3 provides track to train communications with increased role of radio communications.
- Level 1 already brings significant advantages for the railways and allows for High Speed travel.



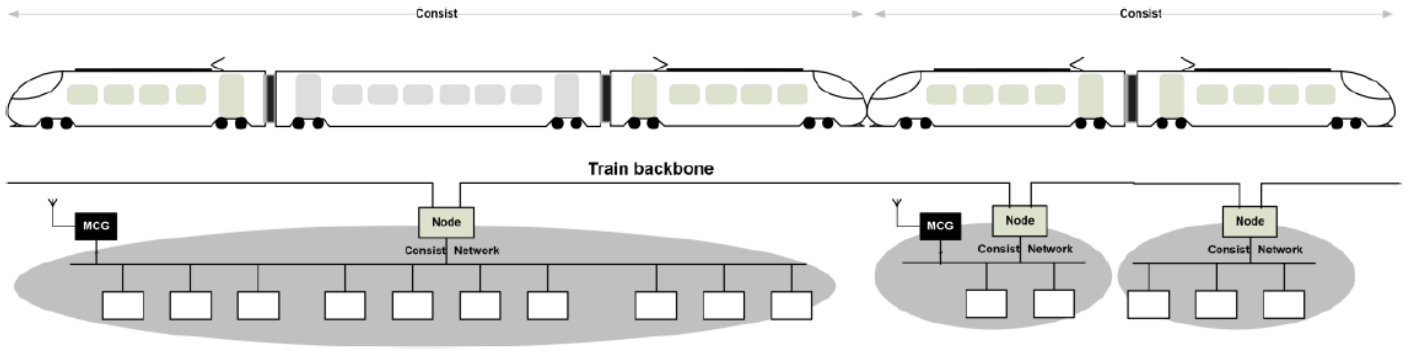
Level 1

- **I**nvolves continuous supervision of train movement (i.e. the onboard computer supervises permitted speed) while non-continuous communication occurs between train and trackside.
- Lineside signals are necessary. Train detection and train integrity checks are performed by the trackside equipment.

Level 2

- **I**nvolves continuous supervision of train movement with constant communication via GSM-R between the train and trackside.
- Lineside signals are optional and train detection and train integrity checks are performed by the trackside equipment.
- The Radio Block Control (RBC) handles the go/no-go onto the next railway segment.

Train On-board Communication System



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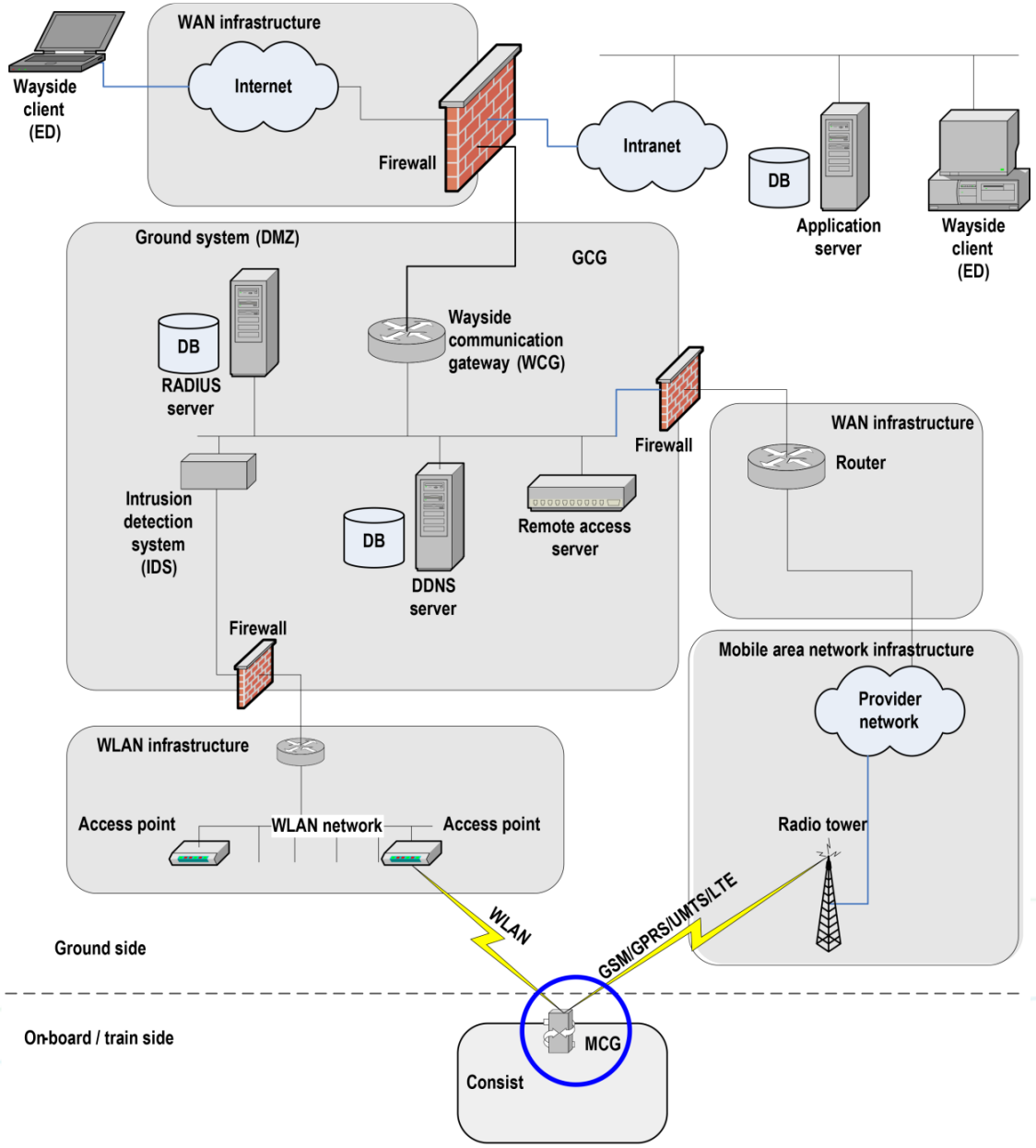

- The train on-board communication network is structured [2]
  - As a hierarchical structure, with a train backbone for the communication along the train and subordinated consist networks
  - A Mobile Communication Gateway (MCG) connects the on-board network to the Ground Communication Gateway (GCG)
  - MCG is a router + firewall / ALG
- UIC, ETSI defines the functional specifications of the on-board system for FRMCS [3], [4].

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The Two Telecommunications Standards: GSM-R and FRMCS

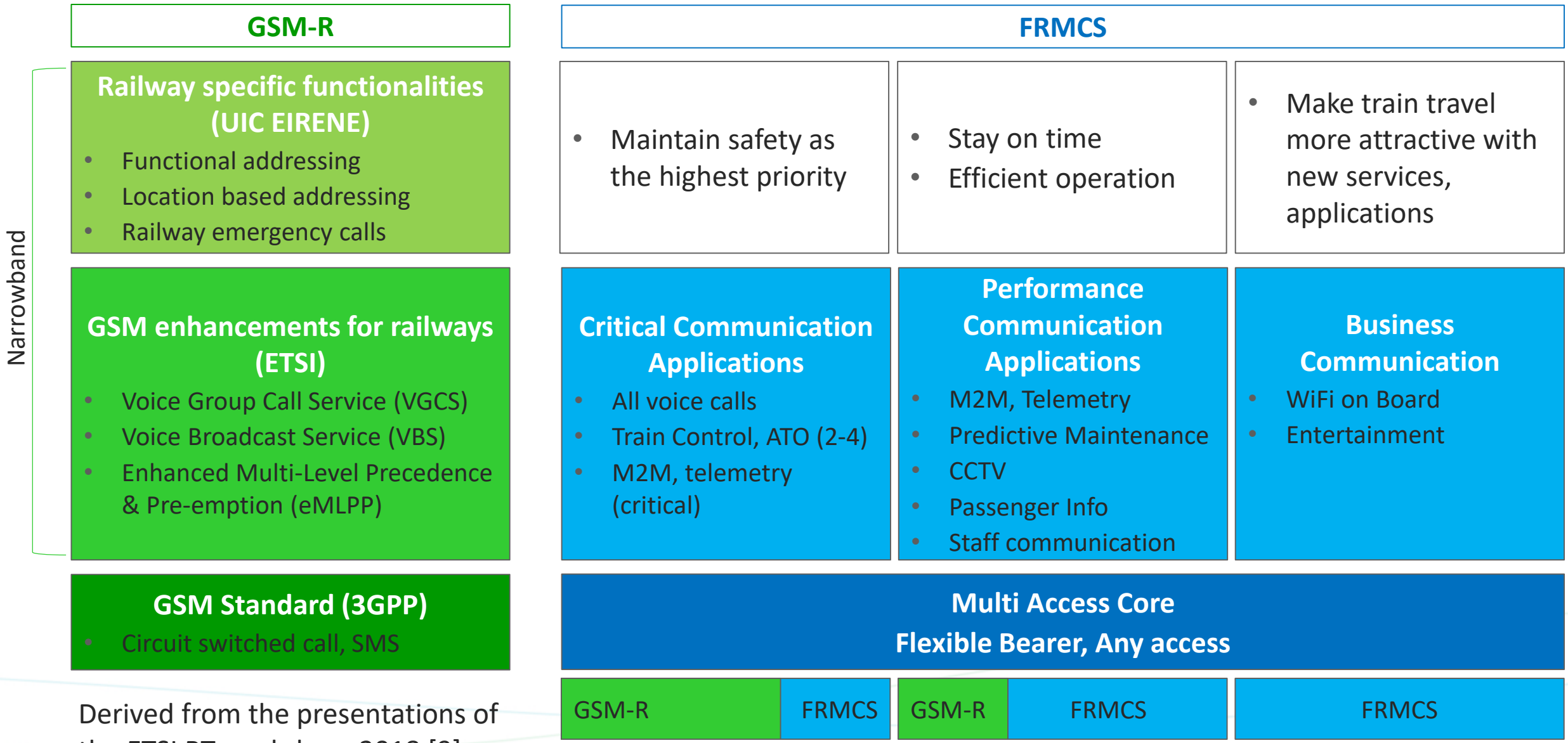
GSM-R

- UIC selected in early ‘90s GSM as the train-to-ground wireless communication system [5]
  - In 1992, UIC launched project EIRENE (European Integrated Radio Enhanced Network) to specify the requirements for mobile networks to support railways services
  - In 1995, work with ETSI groups started to bring the requirements into the GSM standards
  - In 1997, a Memorandum of Understanding (MoU) committed the 32 signing EU railways to no longer invest in analogue radio systems, but just in GSM-R. First deployments started in early 2000.
- GSM-R was allocated by the EU two frequency bands [6]:
  - 876-880 MHz (train to ground), and
  - 921-925 MHz (ground to train)
- In Europe more than 100,000 Km of railway tracks are daily operated through GSM-R
- Supported until 2030.

FRMCS

- UIC started work in 2012 to deliver new User Requirements, as a basis for the development of the GSM-R successor [7]
  - Following, UIC worked on system and use cases
- Incorporated into the corresponding functional and technical standards within telecom standardization
  - ETSI TC-RT, and
  - 3GPP Technical Specifications Groups (TSG), in particular the Service and System Aspects (SA).
- In November 2020, CEPT assigned the paired frequency band 874.4–880-0 and 919.4–925.0 MHz and the unpaired frequency band 1900–1910 MHz (channel B39/N39) for usage by Railway Mobile Radio (RMR) [8]
- FRMCS aims to support the evolution of ETCS applications, achieving denser train scheduling by automation and higher operational efficiency
- Video and data intensive applications are expected to have a strong role in newer applications.

GSM-R to FRMCS Comparison



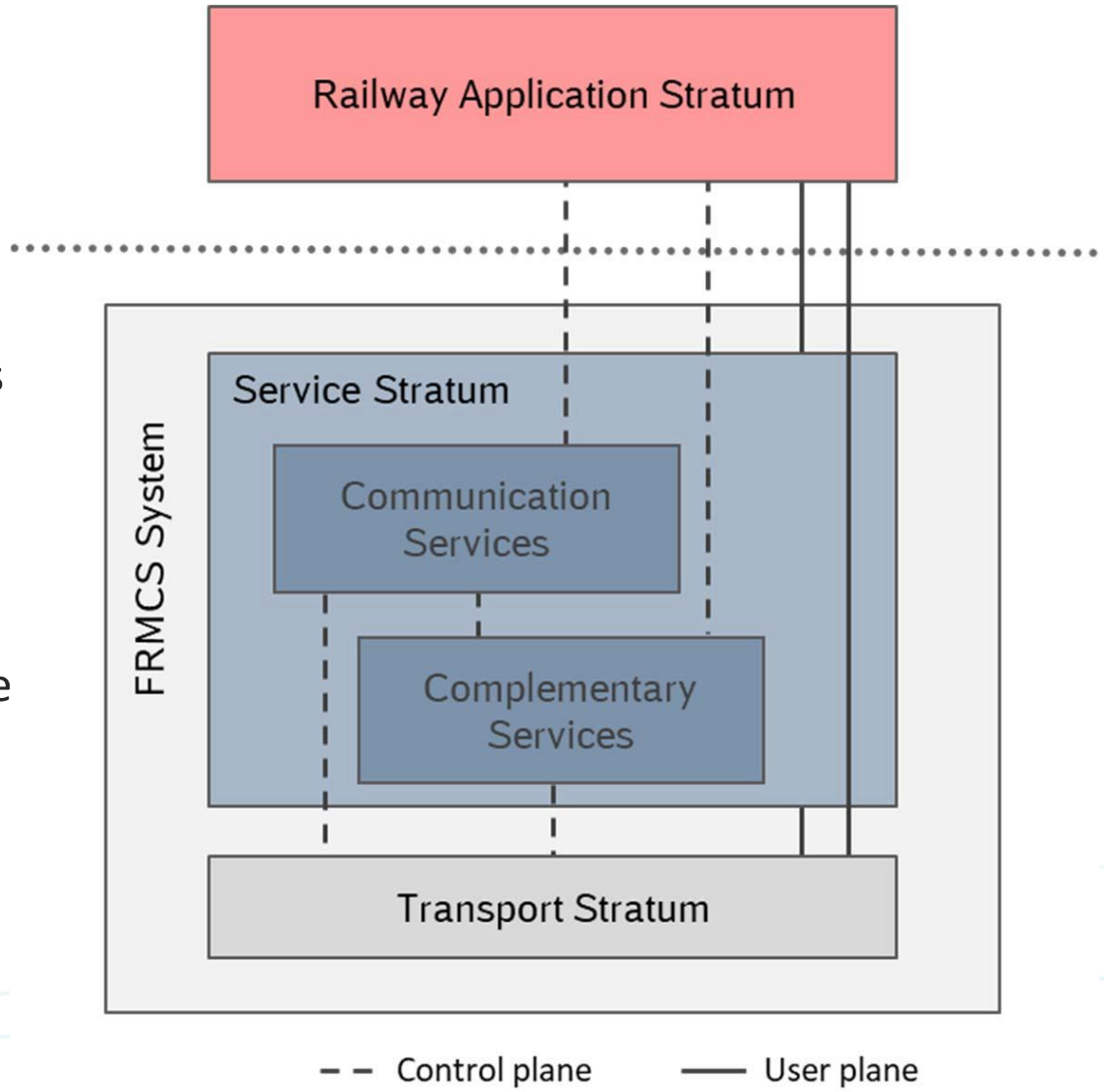
Derived from the presentations of the ETSI RT workshop, 2018 [9]

FRMCS Use Cases

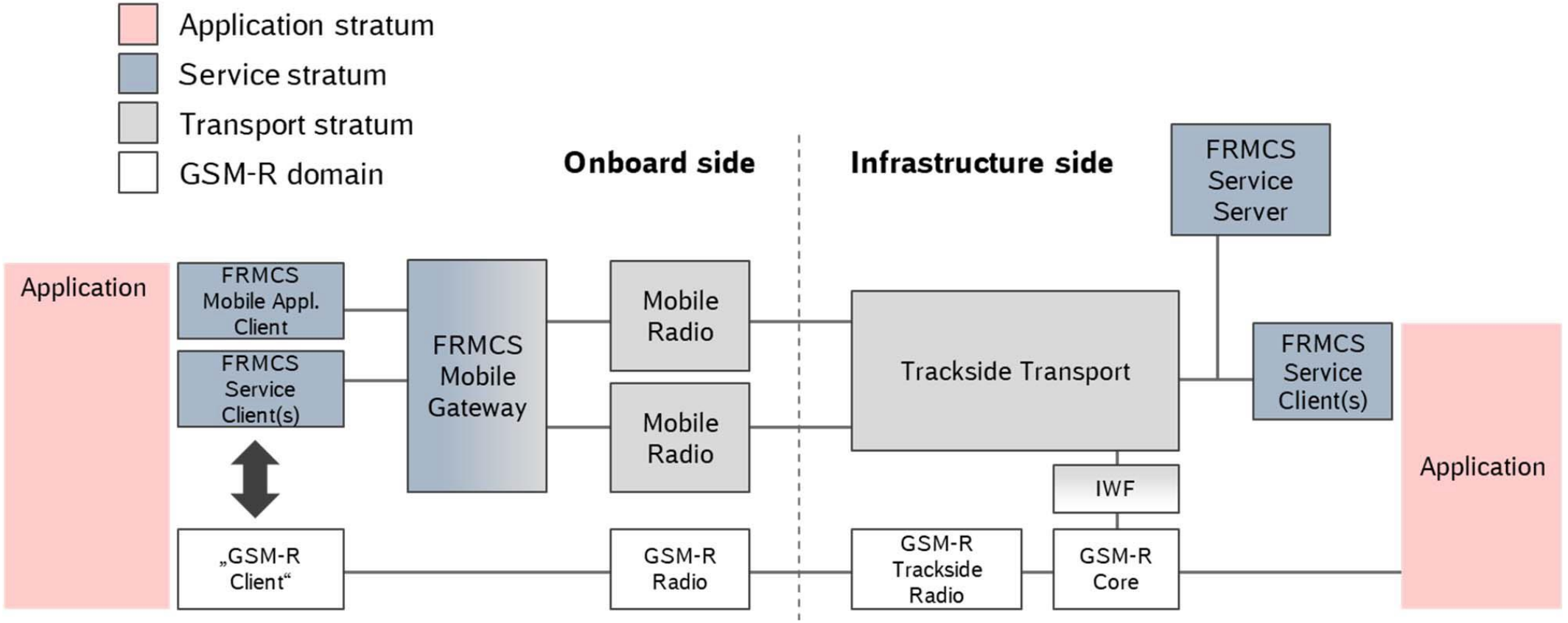
Use Case	Description
Voice Services	• Already implemented in GSM-R, used for communication in incident and emergency • Comprise features as location dependent addressing, and group call services
European Train Control System (ETCS)	• Enable higher degree of safety and automation • ECTS L1 and L2 allows trains to travel in minimum distance through the usage of train-based train integrity information and advanced train-based localization
Automatic Train Operation (ATO)	• Operation is based on “Journey Profiles” (JP) to run the train safely under the best working conditions • JP are used to control the driving behavior of the train (e.g., intended acceleration and breaking according to the maps and segment profiles) • Onboard devices send status information to trackside control (e.g., running speed, train control policy, accurate intra-station stopping)
Remote Driving	• Operate the train in case of incidents (in case no staff is on the train), with remote driver located at a distributed operation center receiving video data from the train cameras and operates the train remotely on sight
Onboard / Lineside Video Surveillance	• Aim to improve efficiency of operation and safety • Empower remote staff located at a distributed location to identify and act on critical situations inside and outside the train • Supported as P2P, P2MP, area- or user-based video group call services

FRMCS System Architecture

- Key objective of FRMCS design is a clear separation between the Railway Application Stratum, Service Stratum, and Transport Stratum [10]
- The Railway Application Stratum provides railway-specific functionalities using services offered by the Service Stratum
- The Service Stratum comprises Communication services and Complementary Services:
  - Communication Services enables the exchange of information between two or more service users
  - Complementary Services are ancillary services, e.g. providing and/or utilizing the location of the service user, supporting Communication Services and the Railway Application Stratum
- The Transport Stratum comprises the set of access and corresponding core functions applicable for the FRMCS system.



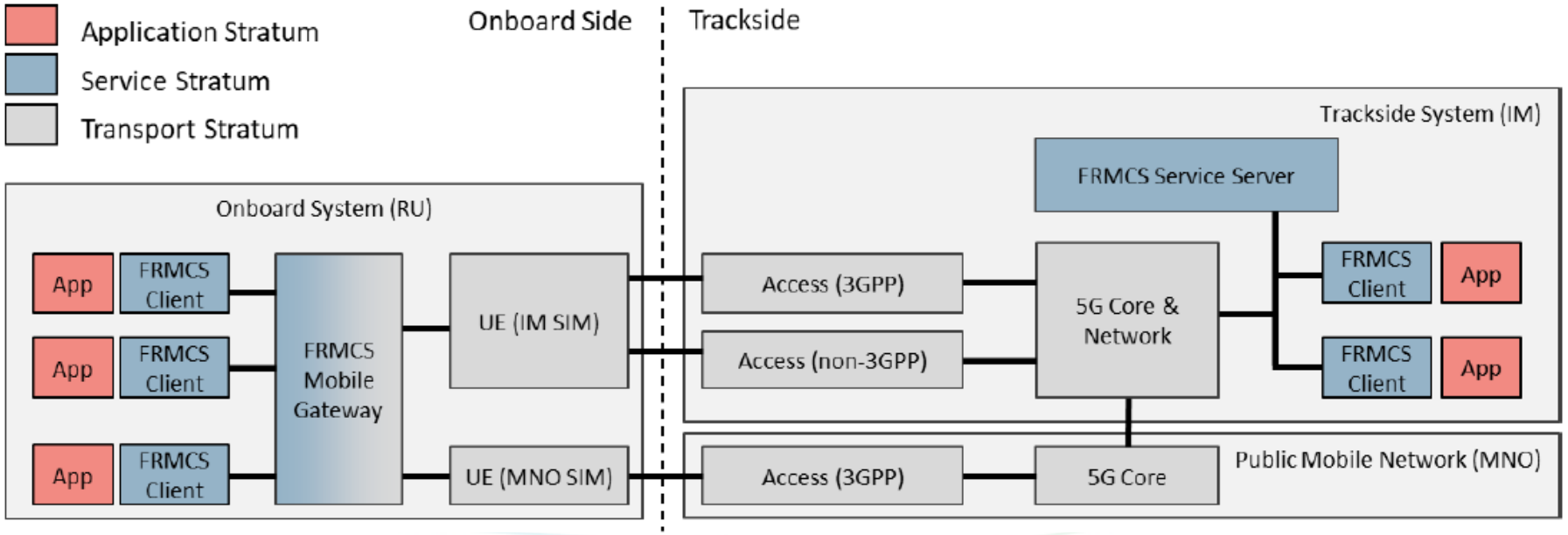
Relationship between FRMCS and GSM-R



- GSM-R system is excluded from the FRMCS System.
- The FRMCS onboard system provides protocol conversion to interface legacy equipment
- The FRMCS trackside system interfaces to GSM-R via IWF connected to GSM-R Core
- Service migration between FRMCS and GSM-R should be controlled by the Application Stratum.

Multiple Mobile Radios Support

- **Bearer flexibility.** To operate with different kinds of Trackside Transport domains (railway dedicated or public) sequentially or simultaneously using different transport technologies (e.g. 4G, 5G, Wi-Fi, Satellite)
- **Availability, reliability, and the avoidance of single points of failure.** High availability and reliability of the connection to the trackside may be instrumental in establishing redundant nodes (avoiding single points of failures) and/or redundant radio links
- **Capacity.** Especially for capacity-demanding communication use cases, it may be needed to aggregate capacity over different transport domains.



- The FRMCS trackside network is owned and operated by the infrastructure manager (IM)
- The FRMCS onboard system can be operated by a railway undertaking (RU), while the IM provides specific configurations
- For increasing service quality, some railway applications might be allowed to utilize public mobile network operator (MNO) infrastructure

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Summary

- This presentation is just an introduction to the topic.
- FRMCS is still in its incubation stage:
  - If there is interest, future side meetings will discuss open aspects of the current standardization phase
- Key aspect is to understand the impact over the IP/MPLS network:
  - New requirements based on the expected applications and services
  - Role of IPv6 vs. IPv4 in the overall architecture
  - Multipath, multihoming
  - Security

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References

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Thank You.