Great Leap Forward:
From GSM-(R) to 5G SA in one hop

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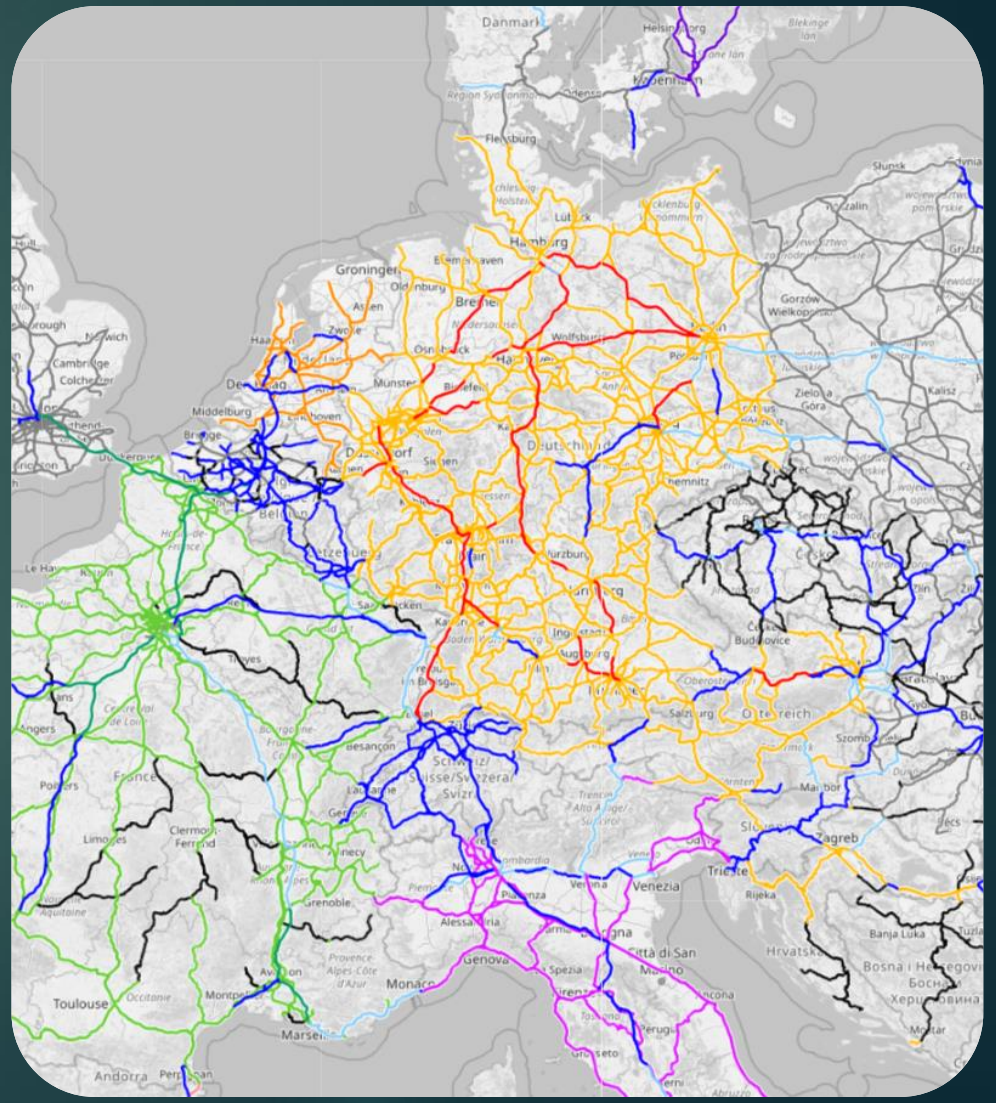
GSM-R(eally)? This day and age?

- Oh yes, GSM was extended for Railways to cover **voice communication plus mission-critical** features:
  - push-to-talk, location-based addressing and calls, group/broadcast calls, emergency calls
  - Perfect coverage with dedicated trackside BTS
- Standardized in 2000. **Still on newly built railway lines**, implemented on 130.000km in Europe and 210.000km worldwide.
- Today, with modern Remote Radio Units, COTS-based basebands, **IP/MPLS backhaul** and **virtualized Core**.
- Will be here to stay **until 2040 and beyond**

Railway signalling challenge

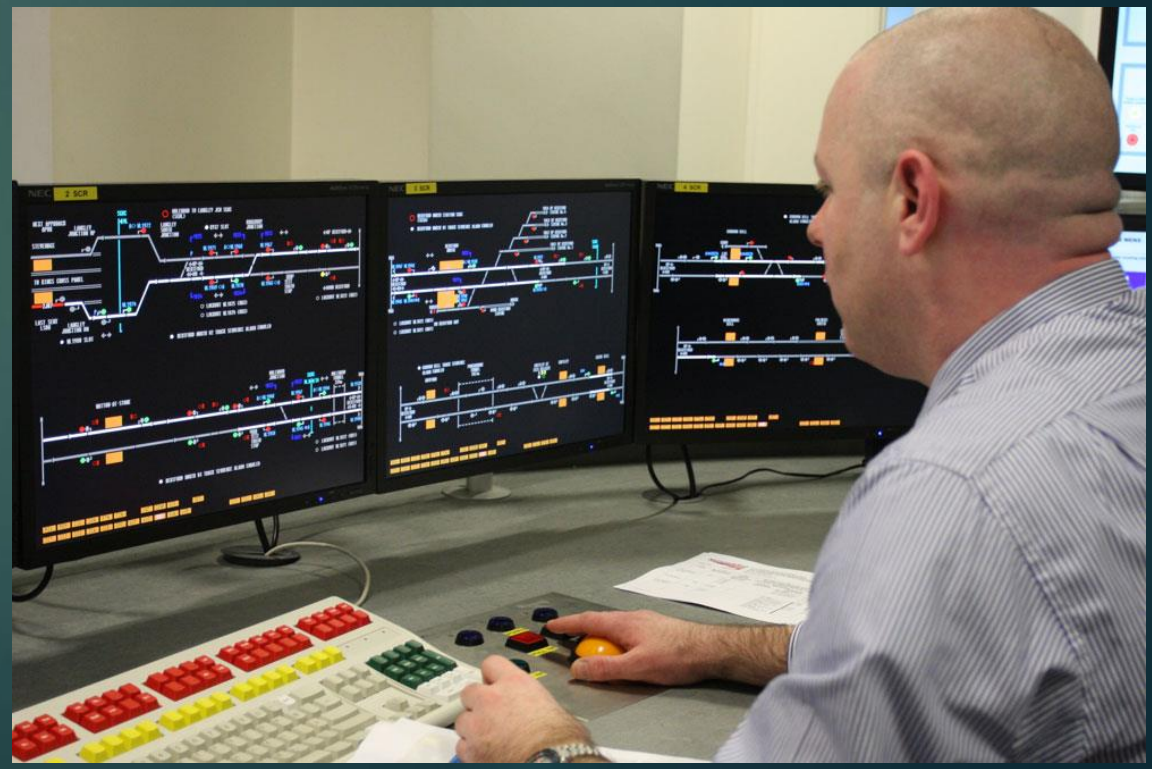
- Different countries have historically **different railway signalling systems**
- Goal is standardized train protection system **ETCS (European Train Control System)**
- It uses GSM-R, but today it is lacking capacity for new applications like Automatic Train Operation
- European Union requires the ETCS deployment on all (major) railways to enable **cross-border interoperability**
- Solution to the challenge is FRMCS **Future Railway Mobile Communication System**



https://www.openrailwaymap.org/

Railway signalling in two minutes…

- Two separate but integrated systems – **station interlock** and **line signalling**
- **Station Interlock** controls which track sections and turnouts (switches) are occupied within a station – from vintage physical, relay, solid-state to virtualized systems today.



Railway signalling in two minutes…

- **Line signalling** controls train movement on the open line and thru stations (in agreement with interlock), using physical or logical blocks where one train at the time is permitted, using physical trackside signals or radio communication.
- Most legacy (Class B) systems and **ETCS Level 1** use **fixed-size blocks** (1-3km) and run on **two/three-aspect signalling** logic using trackside signals with transmitters on **signal points** controlling the trains (trackside magnets in Punktförmige ZugBeeinflussung or contact brushes in Crocodile).
- **ETCS Level 2** uses fixed blocks with radio communication and in-cab signalling, while **ETCS Level 3** uses „moving block" adjusting and maintaing the distance between trains based on their speed and train characteristics.
- GSM-R was providing voice communication and also ETCS Level2/3 signalling

FRMCS Introduction

- European railway industry (and UIC) decided for **5G SA**
- FRMCS is **5G SA Network + Mission Critical (MCx)** layer
- Implementing 3GPP MC features (Release 13 - 19)
- Using **standardized railway spectrum for Private 5G,** both 900MHz GSM-R (below n8/B8) and new 1900MHz (former n33)
- 1900-1910MHz was reassigned across the Europe to railway application (RMR) and considered to be huge victory for FRMCS development in 2020.

EU Plan for Railway

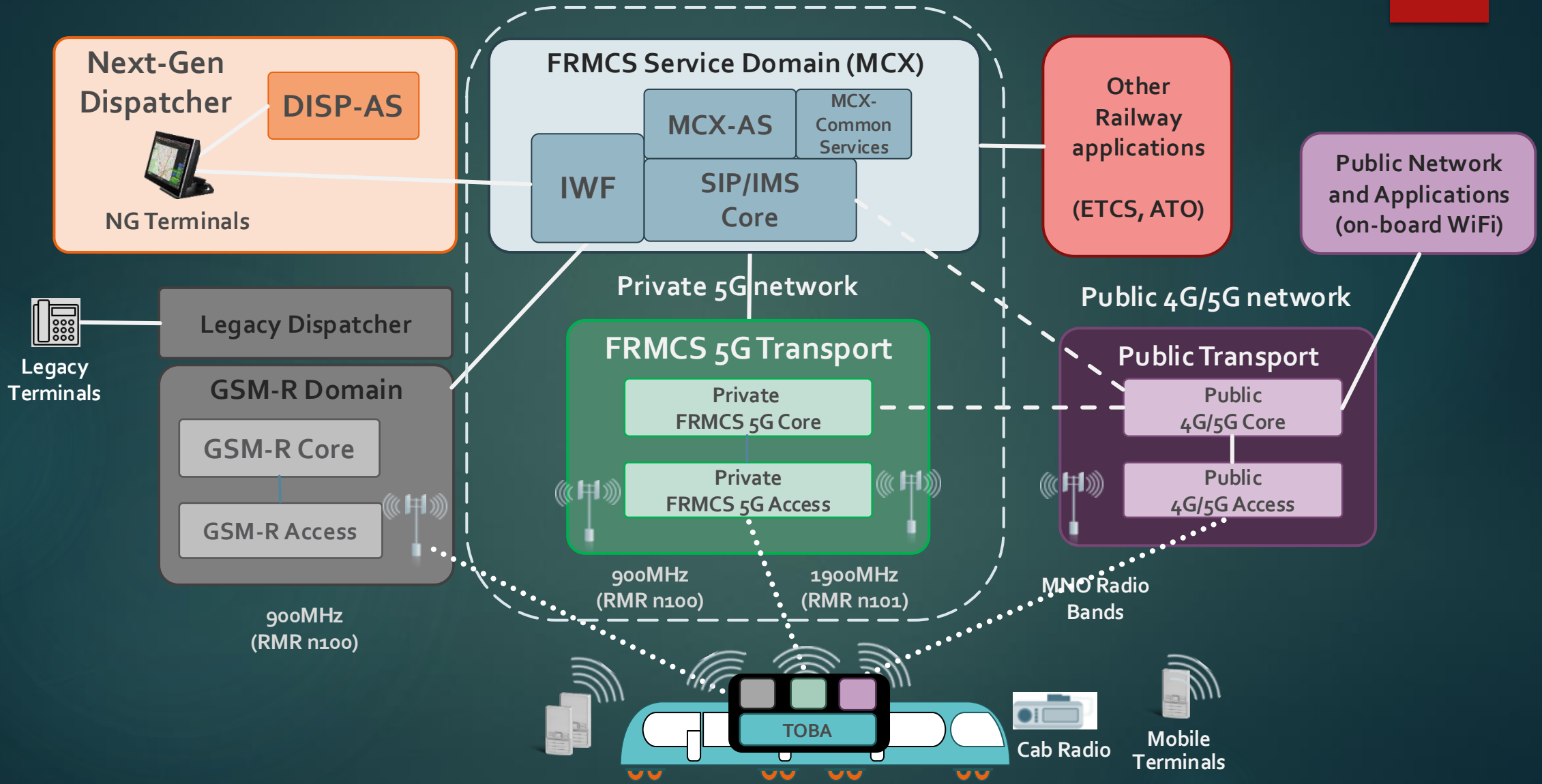
Railway Mobile Radio

900MHz (n100)
2x5,6MHz FDD

1900MHz (n101)
10MHz TDD

https://www.3gpp.org/news-events/3gpp-news/mc-services https://www.era.europa.eu/

FRMCS Architecture



https://uic.org/rail-system/telecoms-signalling/frmcs

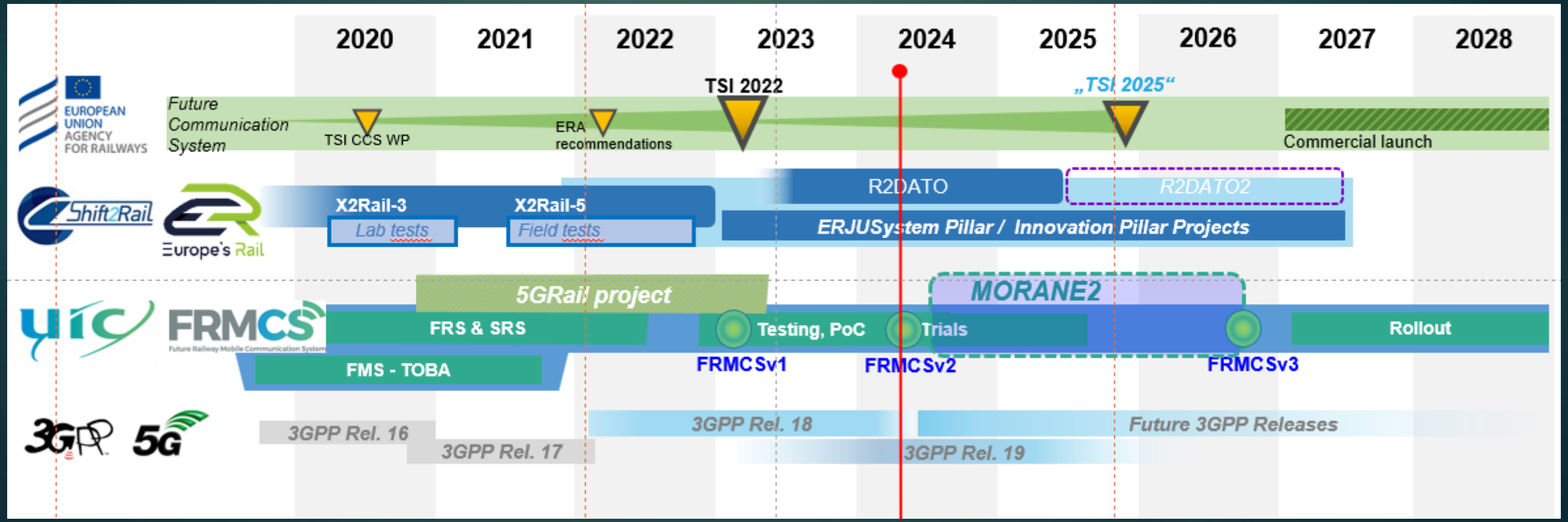
But something went seriously wrong

- In 2022 I decided to quit telecoms and go back to my IKIGAI (railways)
- I went to biggest world railway fair (InnoTrans in Berlin, next one in two weeks) and everyone was big on 5G and on FRMCS, with message – just a year or two and we will have the FRMCS ready and we can start migration from GSM-R.
- Even wrote 1100-word submission in 2022 to public consultations on Croatian Railways development strategy arguing that Croatia should skip GSM-R and wait just for few more years for the successor technology to be ready…

- And then I started working for the company working on development and standardization finding out the (horror) story behind…

The Timeline

- Original timelines planned Testing, PoC and Trials in 2020-2022 period
- But we are quite late, items on timeline below don't change but years on x-axis keep getting bigger and bigger with every year.



When will V3 standard be ready?

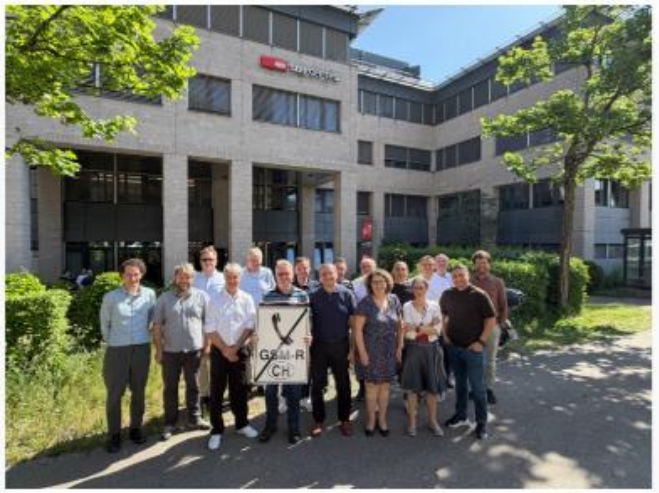
- This has become a running joke in the Industry, as answer depends when You asked about it (FRMCS v3 is fully-featured standard version for deployment):

- 2018 -> V3 will be ready to be included in TSI CCS (signalling) revision in 2022
- 2020 -> by the end of 2024, might slip in 2025
- 2022 -> second half of 2025
- 2024 -> end of 2026 or early 2027
- 2026 -> end of 2027 or mid 2028, but TSI CCS revisions are slipping to 2029
- Anyways, compatible ETCS (signalling) will not be available before 2032.

I couldn't figure out the sarcasm or not

Friday 12 June 2026

ATWG reaches a milestone with its 100th UIC FRMCS Meeting



The UIC FRMCS Specifications activity is carried out through six working groups, governed by a steering committee and ultimately overseen by ERIG – the UIC Heads of Telecom forum. This work complements UIC's active participation in 3rd Generation Partnership Project (3GPP) meetings representing the railway sector, as well as its strong support for European Telecommunications Standards Institute (ETSI) Technical Committee on Rail Telecommunications (RT) activities, including holding the chairship.

https://uic.org/com/enews/article/atwg-reaches-a-milestone-with-its-100th-uic-frmcs-meeting

But problems come from many places

- „Main problem with Railways is that **everything is a problem**" (MV, age 45)

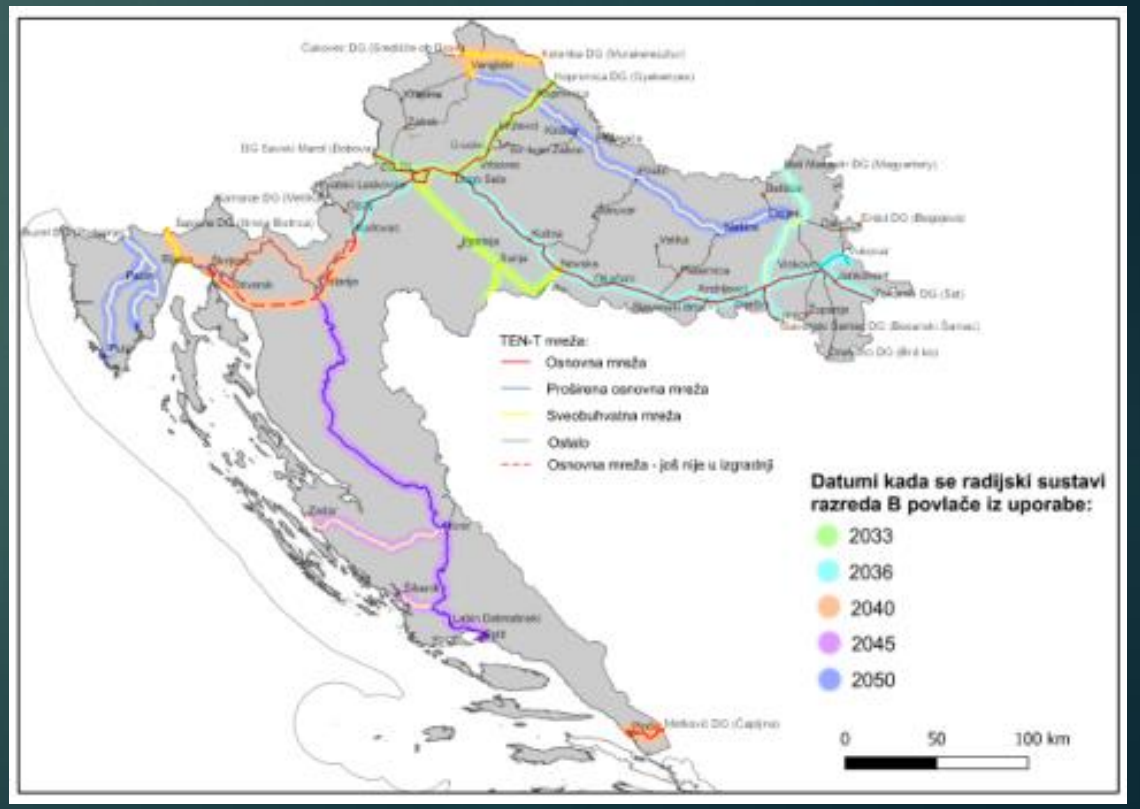
- There are two big reasons from outside of railway world, actually from Telco:
  - Total lack of 5G SA (especially in Europe)
  - Spectacular failure of Private 5G (apart from some limited EU-funded trials)
- Expectation was that there will be a rich ecosystem of 5G solutions from RAN to Core, with substantial workforce well acquainted with the 5G SA technology.
- None of this has happened, so FRMCS is basically first massive and international 5G SA implementation with full feature set - roaming with both local breakout and home routing, location-based services, MC voice/data/video.

How can I find my way out of this maze

- Field trials are in progress – MORANE2 project runs five testbeds around Europe (Spain conventional and high-speed, Germany on test track in Erzgebirge, Sweden and Netherlands) testing vendor and component interoperability.
- Rail Baltica in Estonia should run on (more-or-less finished) standard in **2030** with some pre-standard ETCS integration (using existing ETCS to GSM-R/GPRS integration) with upgrade to full standard in **2033.**
- Then we can start talking about deployment and migrations from existing GSM-R networks and their gradual phase-out. Apart from smaller trials and testbeds, most railways are thinking of 2035+ for deployment and migration.
- Croatia might have a different path, though…

And, to end with – Croatia

- Croatia does not operate GSM-R network, there were 4-5 attempts to do it, first in 2004 (I was there) and last one failed in 2024 (I was there, too). We still use the previous generation ZugFunk on 450MHz on mainlines and PZB / Indusi-60 signalling with just some ETCS Level 1.
- Current National Implementation Plan says we wait for FRMCS, hoping to deploy it as early as 2033
- We are greenfield - no GSM-R and no ETCS Level 2 - so this might be a good country-level testbed that industry needs to get all things working (first voice and then only signalling).



Q & A

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