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independent wireless experts

Technologies, Spectrum and Capacities for Passenger Connectivity

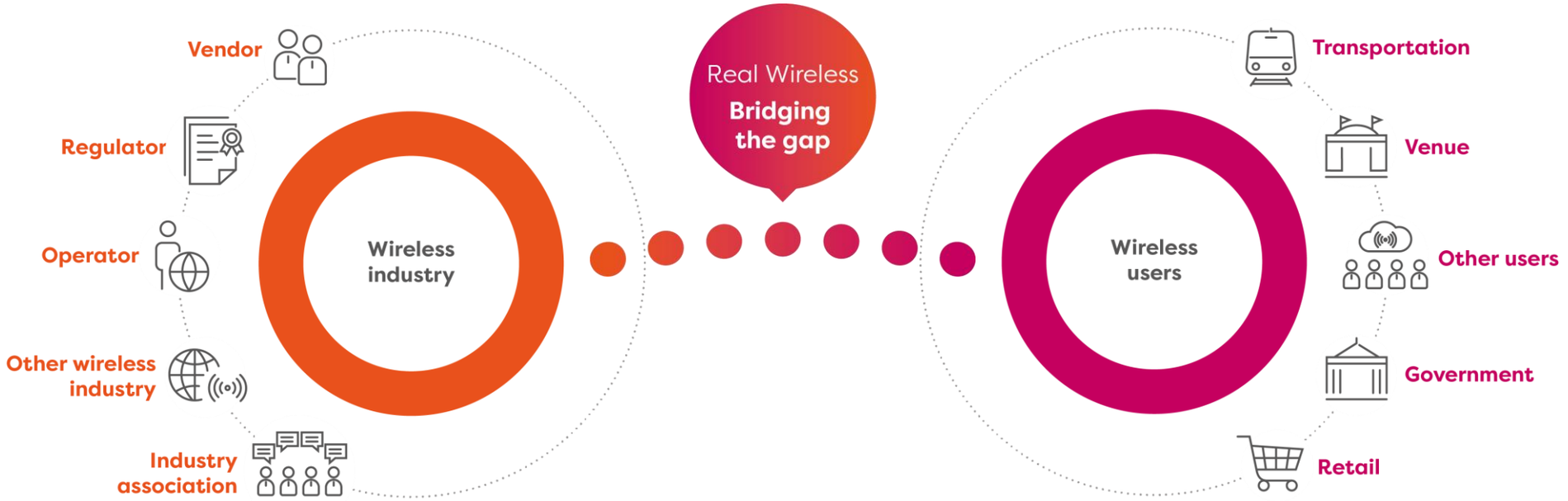
What's required for a good user experience and the challenges in providing it

Event:	UK SPF Cluster 1: Future Spectrum Demand for Rail
Presenter:	Oliver Bosshard, COO
Date:	29 March 2022
Location:	Virtual by TechUK

uk spectrum policy forum

Introduction to Real Wireless

- Leading independent expert wireless advisory firm
- Technology and business of wireless
- Real Wireless builds bridges between the wireless industry and wireless users



Help the wireless industry to better understand and meet the needs of its customers

Help wireless users to get the best from wireless technologies to benefit business

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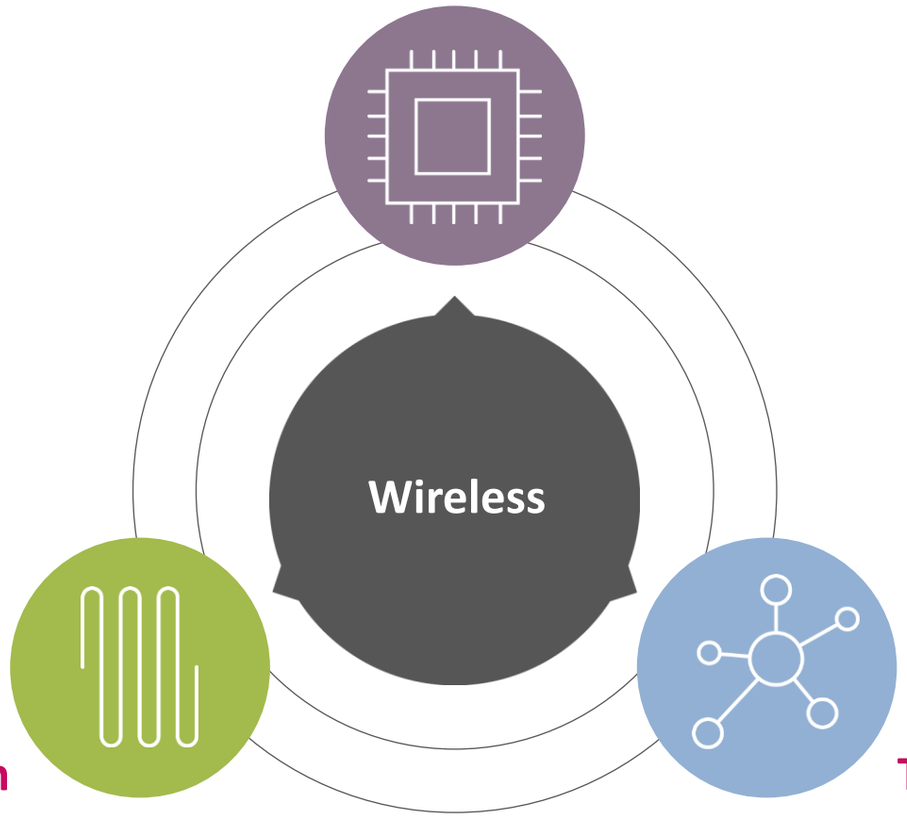
Starting with the basics

The components that makes wireless solutions work



The 3 main components

Technology:
- Cellular
- Wi-Fi
- PMR
- RFID
- ZigBee
- DECT
- NB-IoT
- Bluetooth
- DAB
- DVB-T / DVB-S
- TETRA / ESN

Topology:
- Macro Cells
- Small Cells
- Femtocells
- Picocells
- DAS
- Relays
- Repeaters
- PTP/PMP
- Mesh

Spectrum:
- VHF/UHF/SHF
- White Spaces
- UWB
- mmWave
- Harmonisation
- Licenced
- Licence exempt

The 3 main options for track-to-train:
- Cellular (Mobile), <= 3.8 GHz
- Wi-Fi, 5 GHz
- mmWave, 26 – 60 GHz

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Infrastructure requirement for track-to-train connectivity

The wireless infrastructure components that enable operational and passenger connectivity:

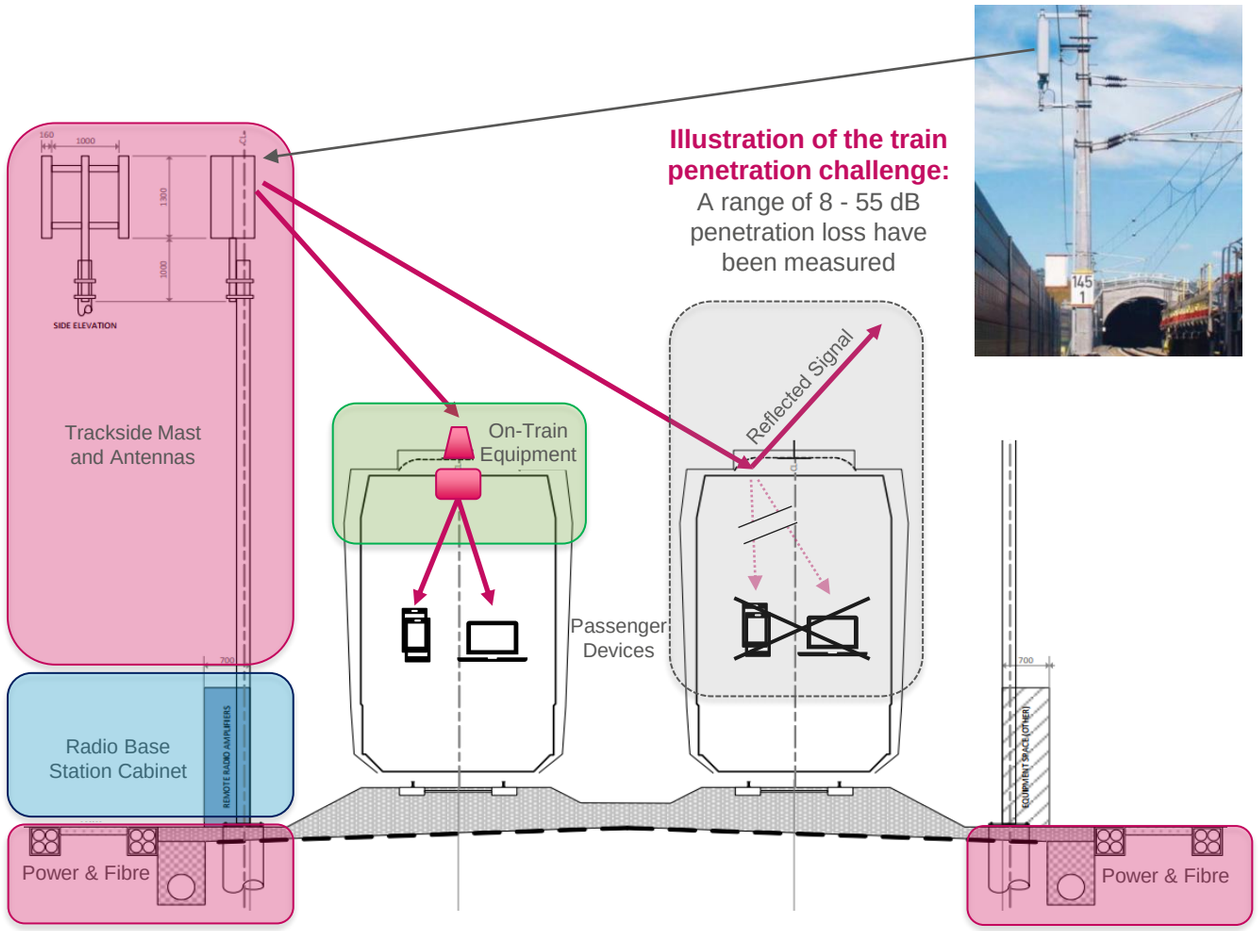
- Trackside Infrastructure (passive components)
- Wireless Technology (active components)
- On-Train Wireless Equipment

The role of "On-Train Equipment":

For Wi-Fi and mmWave solutions, the onboard component (antenna and gateway) are indispensable.

For cellular technologies, onboard equipment will deliver superior service to passengers. But Wi-Fi Gateways don't support MNO voice service.

For trackside infrastructure to achieve comparable cellular service without on-train equipment, we expect the required number of sites to double[1], unless trains are fitted with low (RF) loss windows.



Wireless Infrastructure Components in a Rail Environment

[1] *Source: Real Wireless modelling exercise based on a specific set of assumptions*

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Technical options for track-to-train connectivity

Comparing technology & spectrum options

Technology options:

- Standard cellular (< 3.8 GHz)
- Wi-Fi (5 GHz)
- mmWave (26 / 28 / 60 GHz)
- Laser / Light (optical – nmWave)

These technologies fit into typical spectrum ranges and have their advantages and disadvantages:

Typical Technology	Cellular	Wi-Fi	mmWave	nmWave
Frequency Range	< 3.8 GHz	5 GHz	26, 28, 60 GHz	Laser/Light
Train Penetration Loss	Lower			Higher
Cell Range	Larger			Shorter
LOS Condition	Non LOS	Near LOS	Full LOS	
Capacity (Bandwidth)	100s of Mbps	1 Gbps	Multi-Gbps	10s of Gbps
Onboard Kit Requirement	Maybe	Yes, indispensable		

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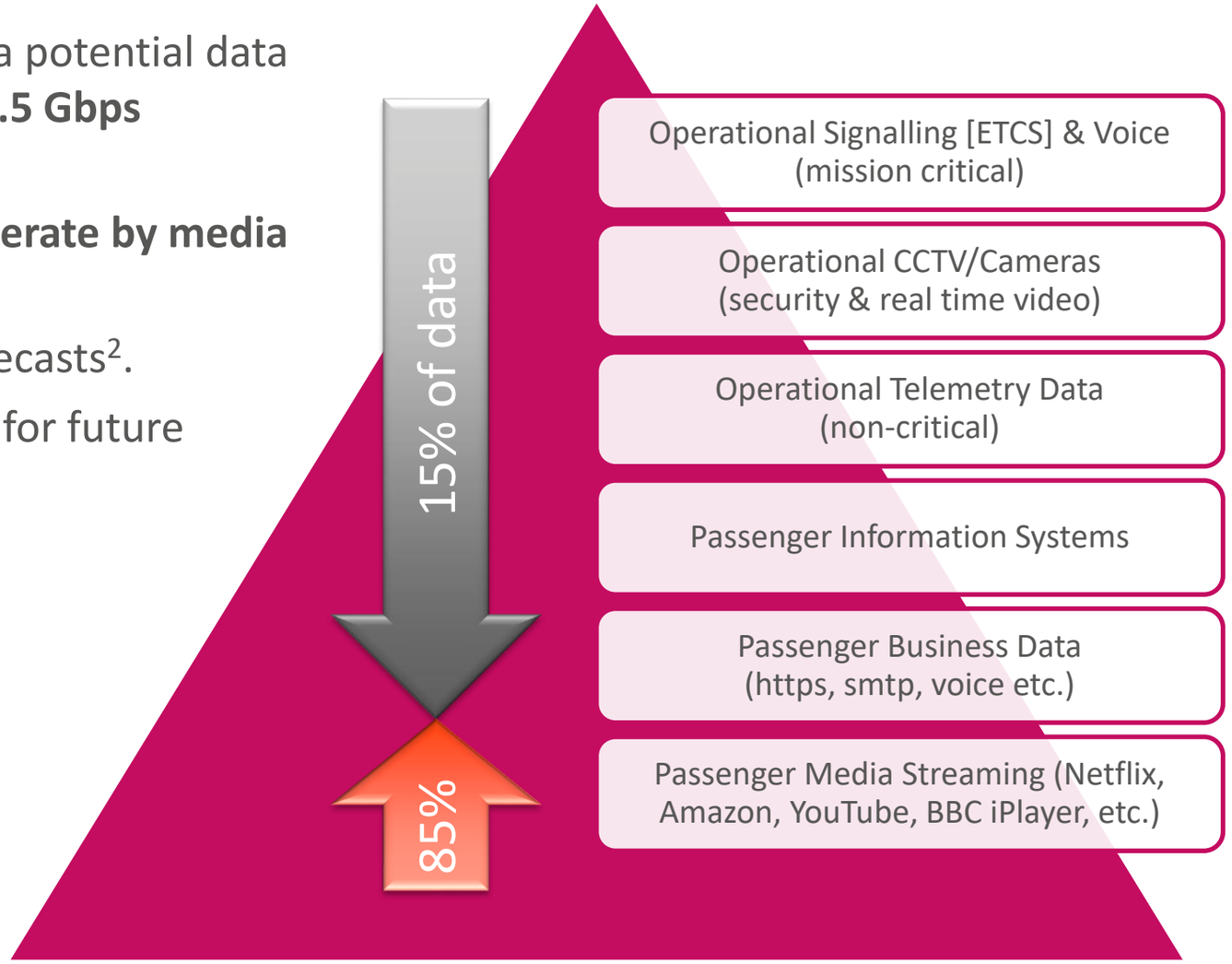
A critical view on demand and required capacity in rail

- Recent Real Wireless calculations[1] revealed a potential data requirement **from 0.5 Gbps** (low usage) **to 2.5 Gbps** (unrestricted usage) for a **1,000 seat train**.
- We identified that **~85% of this traffic is generate by media streaming**.
- The high usage figure is close to Ofcom's forecasts[2].
- What about future data growth, 47% CAGR[3] for future demand?

"We believe that we can cope with substantially less than 500 Mbps[4] per train, if we use traffic prioritisation"



[1] *Based on 2019/2020 calculations*
[2] *Based on Ofcom Report "Improving rail passenger access to data services"*
[3] *Cisco VNI – mobile traffic high growth numbers, 2022*
[4] *This is total UL & DL data rate (i.e. TDD capacity)*

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What's really needed?

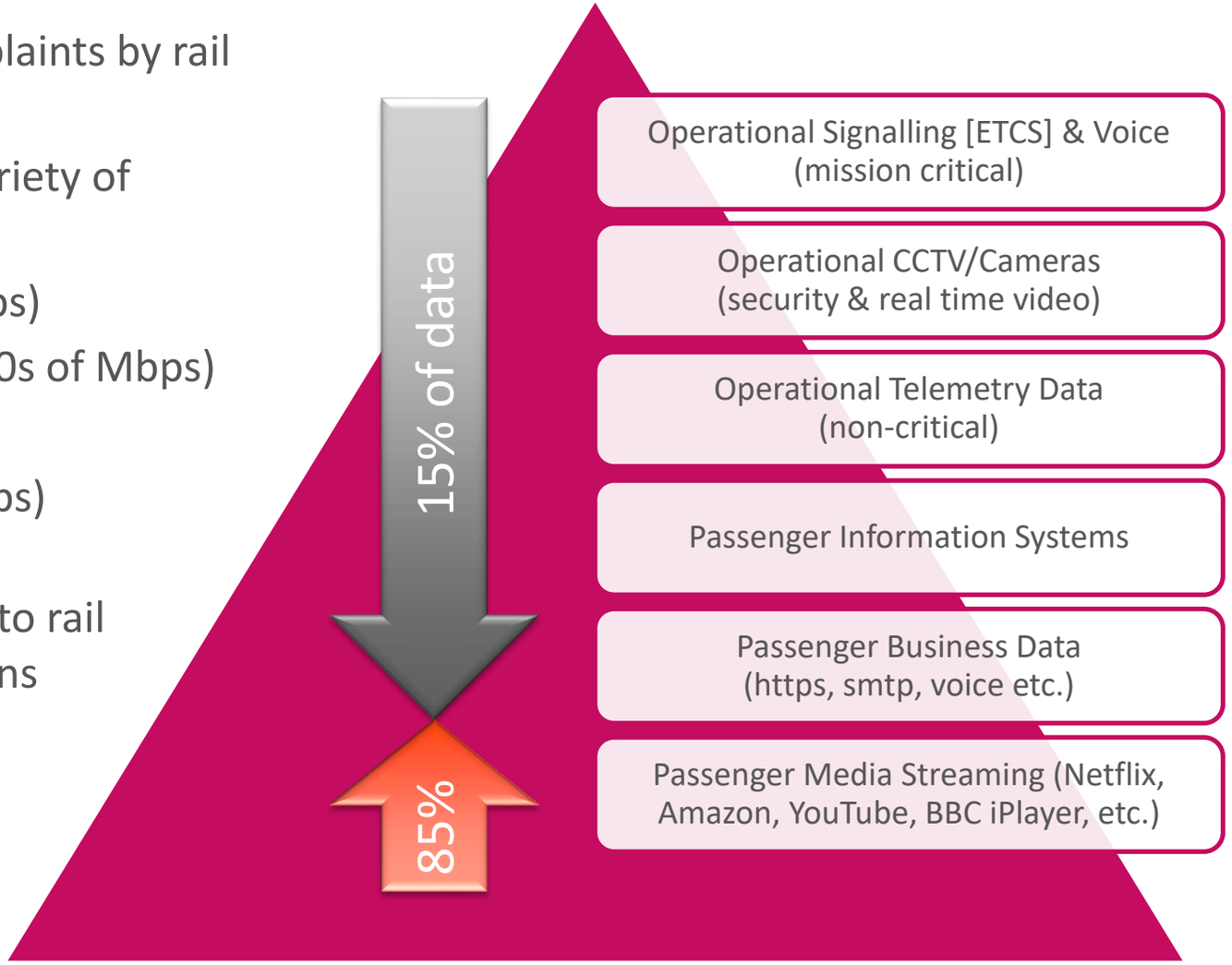
Lack of coverage is still one of the biggest complaints by rail passengers.

We worked with the rail industry based on a variety of connectivity requirements:

- Ability make and sustain a voice call (no drops)
- Basic and ongoing passenger connectivity (10s of Mbps)
- Good passenger experience (100s Mbps)
- Unrestricted usage, including streaming (Gbps)

Whilst e.g. Neutral Hosts would like to invest into rail infrastructure, the commercial challenge remains a challenge:

- Who will pay for the benefit of connectivity?
- What is the most cost-efficient approach?
- Who will cover rural and branch lines?



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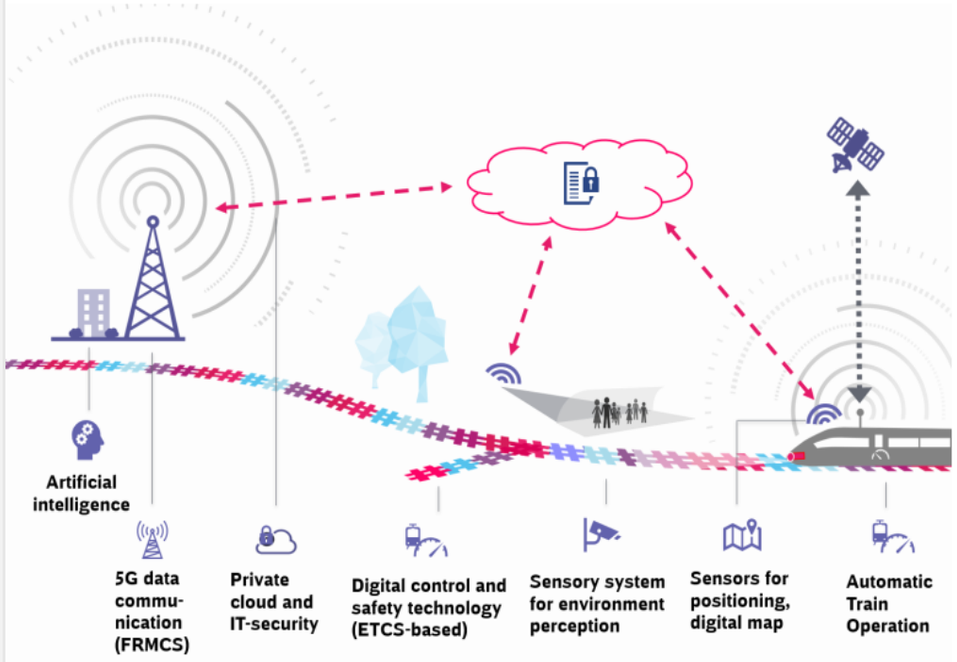
The introduction of FRMCS, a passenger connectivity opportunity?

The view of DB (Deutsche Bahn / German Railway)

5G at Rail: FRMCS for digital rail and Gigabit mobile coverage required but feasible only with massive sharing

Essential Technologies of Digital Rail Operation



Rail Operations:
FRMCS = Future Rail Mobile Comm. System

- 5G at 1900 MHz across Europe
- Migration from 2G to 5G between 2027 – 2035
- Massive investments: Double of trackside infrastructure
- New train equipment (>450 Railway Undertakings in D)
- Status: Ongoing FRMCS Standardization

Passenger Experience:
Gigabit Train

- Gigabit train: >1 Gbps at trackside
- Current coverage macro network insufficient – move to trackside special mobile network
- Massive trackside investments into public mobile networks: 5G at 3,5 GHz
- Sharing is key: Infrastructure competition between mobile operators not feasible

Doubling the number of sites is an opportunity to improve passenger connectivity.

But 1900 – 1920 MHz was auctioned to MNOs in the UK. And the harmonised FRMCS band at 1900 - 1910 MHz is allocated to EE.

Source: *Key elements for 5G corridors along railways - Gigabit train, FRMCS, ERTMS, Dr. Karsten Kemeter, CTO Communications Technology, Deutsche Bahn AG, 21 October 2021*

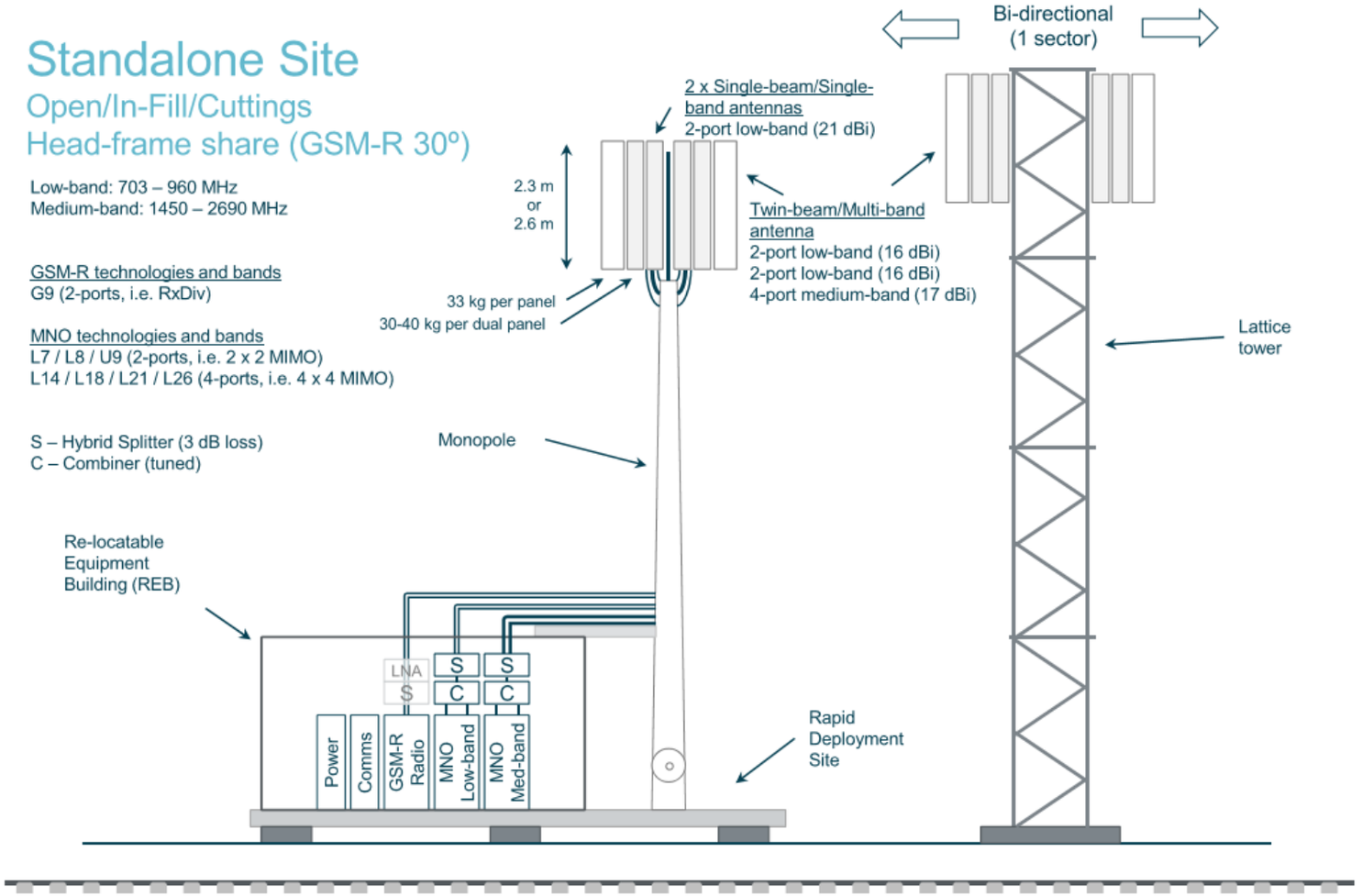
There are different viable options, JOTS* Rail is one of them

Joint MNO Standardisation of Rail Coverage Solutions

Cellular, Wi-Fi and mmWave can all be fit for purpose, and the best approach has to be analysed on a case by case basis.

JOTS* Rail is just one option of many. The aim here is to take advantage of existing, country wide cellular networks and fill coverage gaps based on standardised JOTS Rail (joint MNO) infrastructure.

* Joint Operator Technical Specification



Source: *JOTS Rail, Reference Architecture and Requirements (REC/18/002, Issue 2.0, 19/01/18)*

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JOTS Rail

Sample of a Tunnel Portal Solution

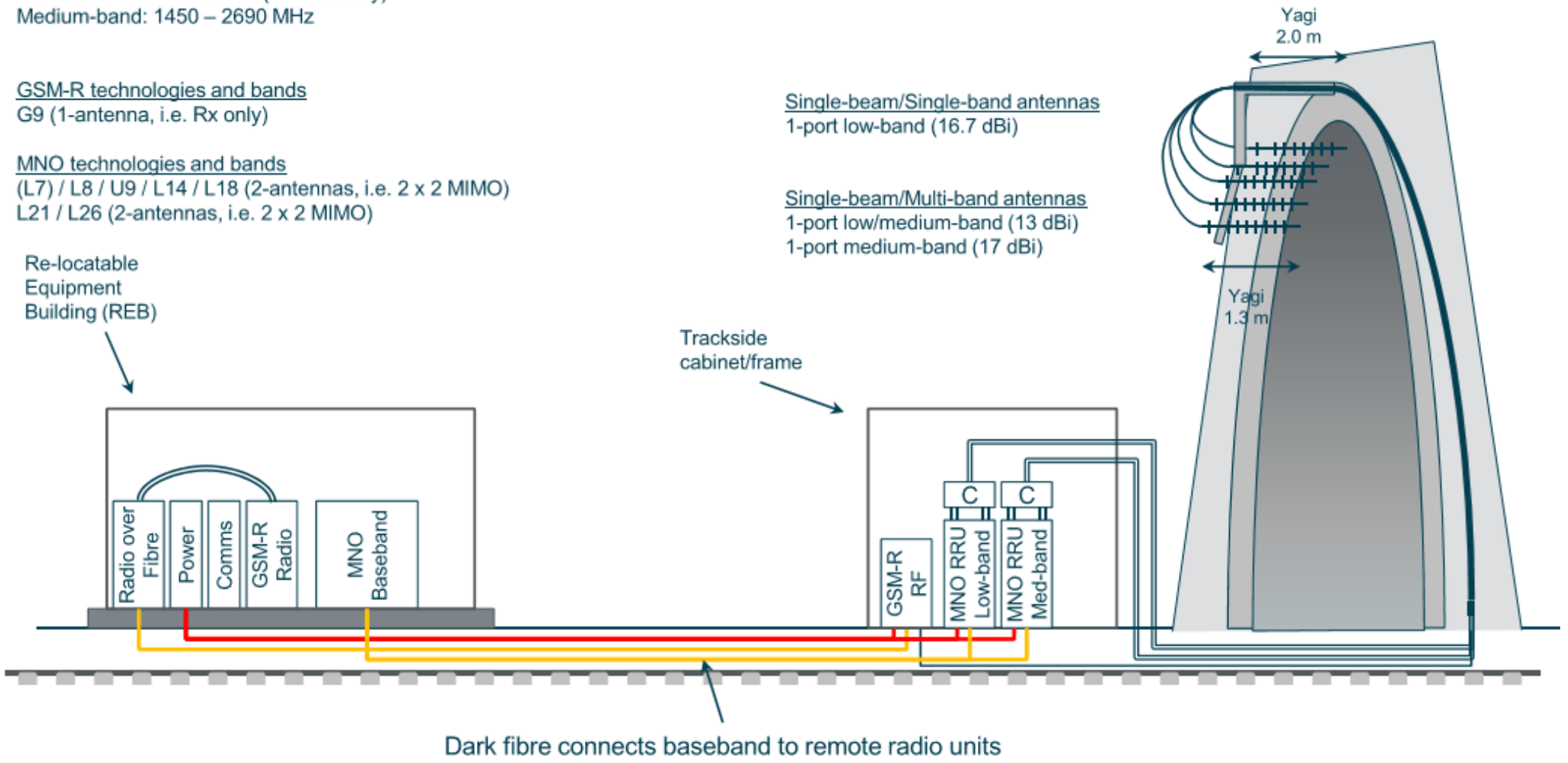
Low-band: 876 – 925 MHz (GSM-R only)
Medium-band: 1450 – 2690 MHz

GSM-R technologies and bands
G9 (1-antenna, i.e. Rx only)

MNO technologies and bands
(L7) / L8 / U9 / L14 / L18 (2-antennas, i.e. 2 x 2 MIMO)
L21 / L26 (2-antennas, i.e. 2 x 2 MIMO)

Single-beam/Single-band antennas
1-port low-band (16.7 dBi)

Single-beam/Multi-band antennas
1-port low/medium-band (13 dBi)
1-port medium-band (17 dBi)



Source: *JOTS Rail, Reference Architecture and Requirements (REC/18/002, Issue 2.0, 19/01/18)*

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Thank you

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