Network Sharing and Slicing For Railway

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European Railway Spectrum challenge

— Challenge: Harmonized LTE spectrum to replace GSM-R in Europe
  — GSM-R 921-925 DL and 876-880 UL
— Candidate Bands under analysis at PT 1
  — 918.3 − 921 DL and 874.3 − 876 UL
    — Pros: Adjacent to GSM-R with feasibility to reuse existing GSM-R sites
    — Cons: PT 1 may recommend power restriction on DL due to risk of desensitizing B8 UL
      — Germany and Belgium plan to extend GSM-R in this band to provide sufficient traffic channels for ETCS Level 2 train control
      — New device chipset ecosystem to support/3GPP standardization needed for new band
  — 1900-1910 TDD (Band 33 A)
    — Pros : Already a standard 3GPP band
    — Cons: CEPT report 39 recommends power restrictions on 1905-1910 to protect B1
      — Railways would need to double the amount of cell sites
      — Ecosystem limited to Chinese devices

Network sharing 4G Ran Architectures
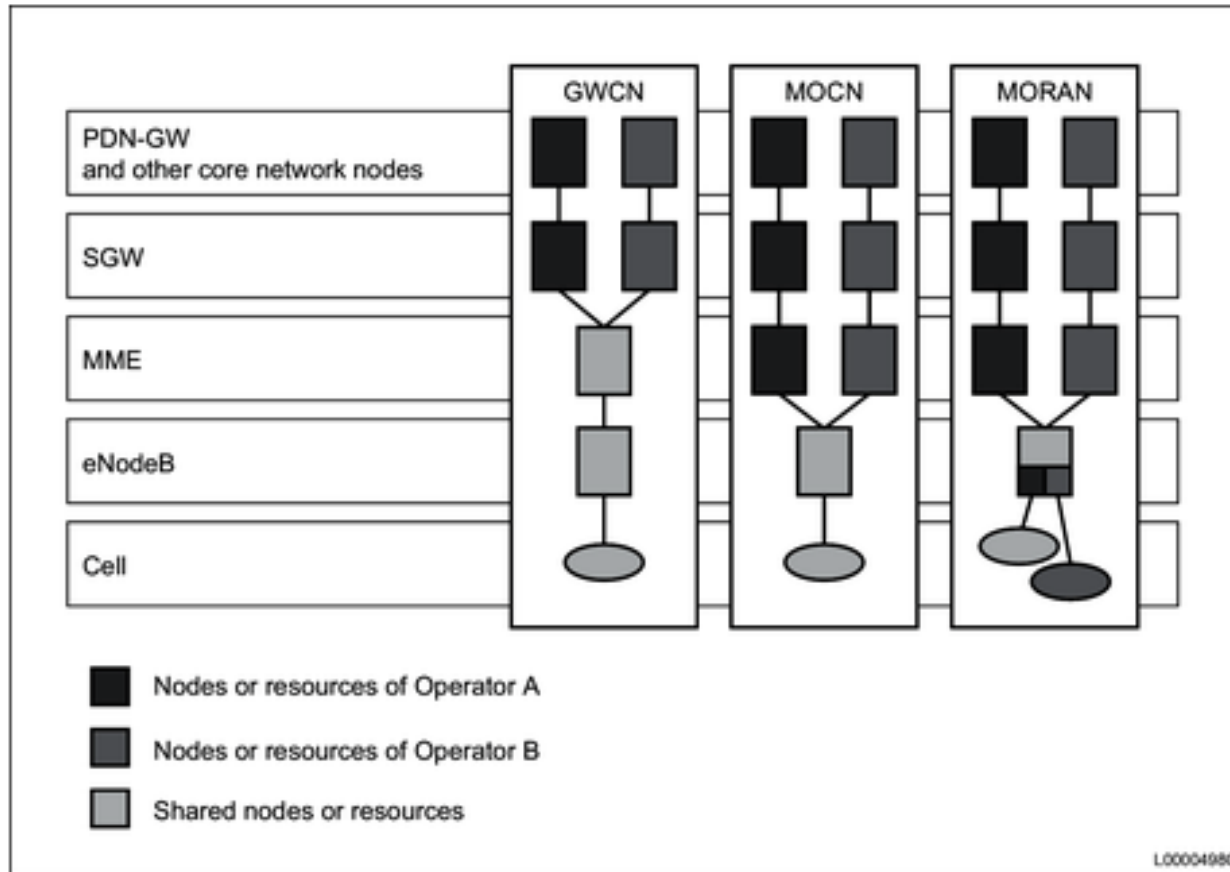
Gateway Core Network (GWCN)
- Radio Sector, eNodeB and MME shared between MNO and railway

Multi-Operator Core Network (MOCN)
- Radio Sector and eNodeB shared between MNO and railway

Multi-Operator RAN (MORAN)
- Radio shared between MNO and railway

4G Radio Slicing Techniques

— Radio Resource Partitioning (using ENodeB special scheduler based on UE Subscriber Profile ID)
— QCI prioritizations within a partition
— Access Class Barring — for congestion scenarios
— ARP — Allocation and Retention Policy - for congestion scenarios

RAN Network Slicing

— RAN slicing enables network operators to guarantee a defined Radio network resource share

— A RAN slice
  — will provide a minimum network capacity at high load
  — can use all available capacity at low load

Resource usage

Slice B- Mobile Network Operator

Slice A- Railway
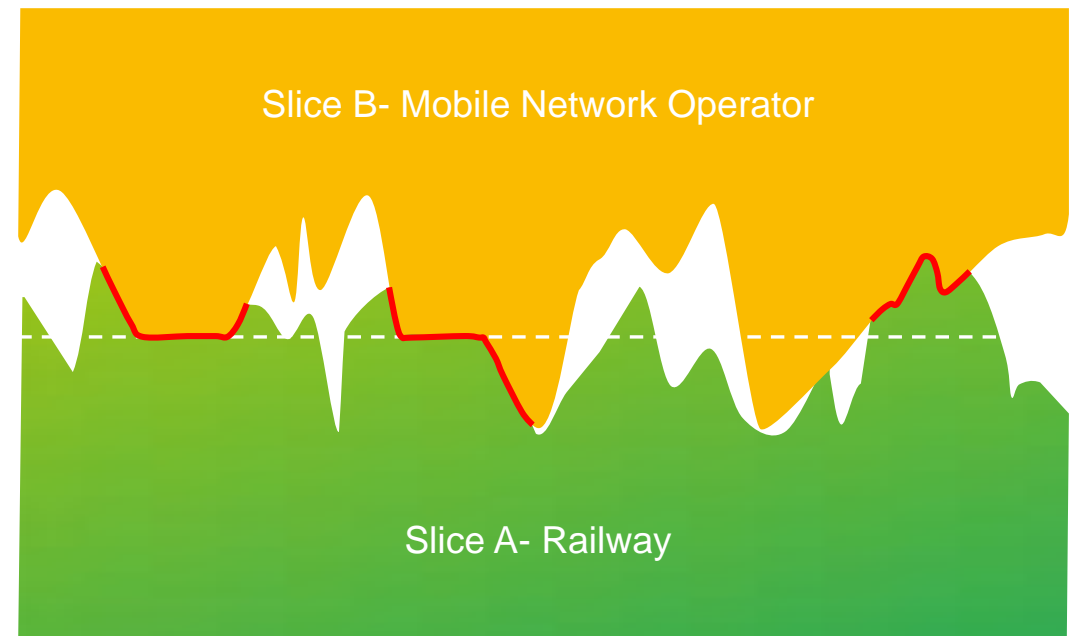
Time

RAN Network Slicing

— A UE's non-GBR bearers are mapped to a particular resource partitioning based on PLMN ID or on SPID value for the UE

— Up to 6 resource partitions (slices) per cell

— QoS settings and QCI usage within a slice does not impact other slices
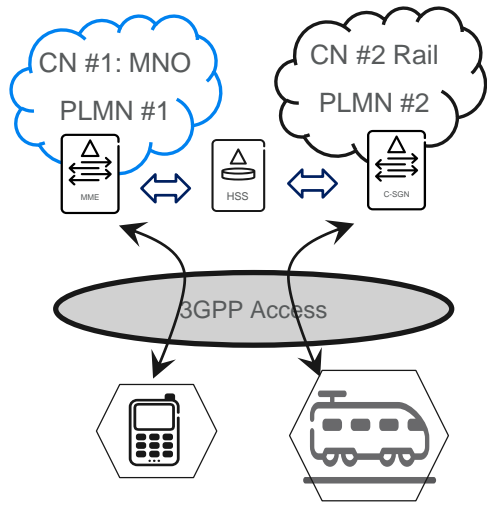
Resource usage

Slice B- Mobile Network Operator

1
2
3

Slice A- Railway
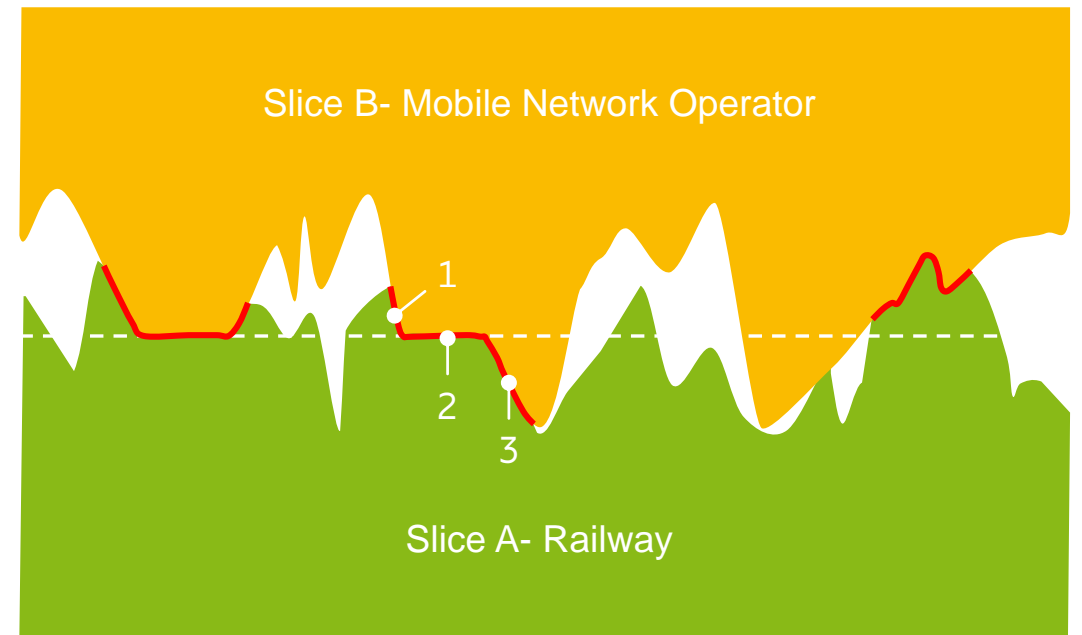
Time

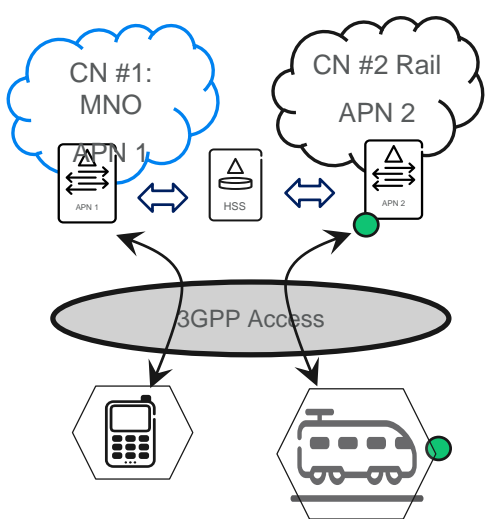1: Slice B limits slice A-
2: Slice A and B follow partition
3: Slice A limits slice B

Core selection mechanisms

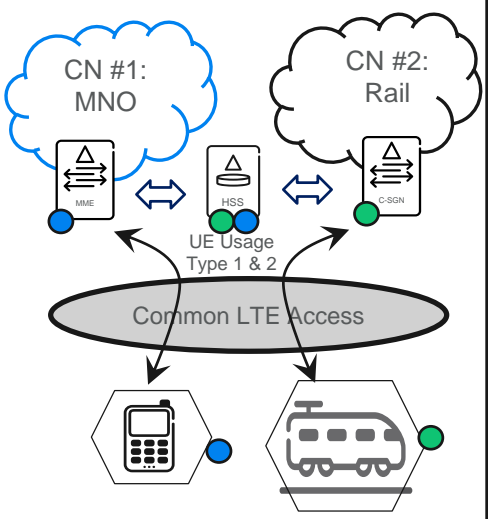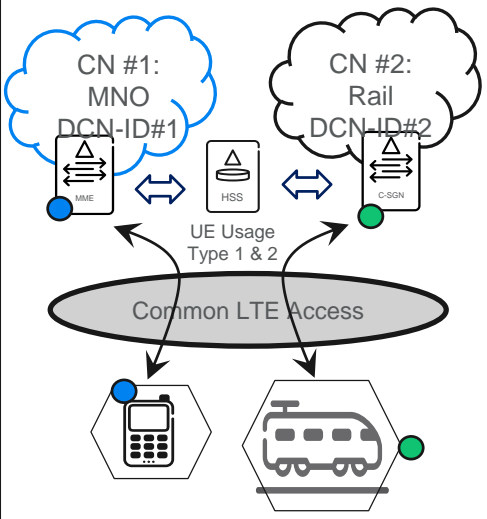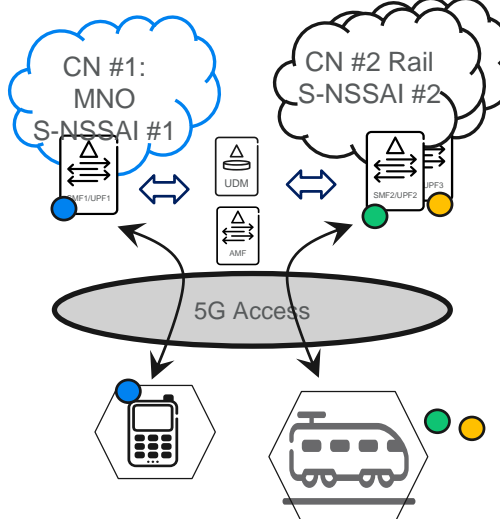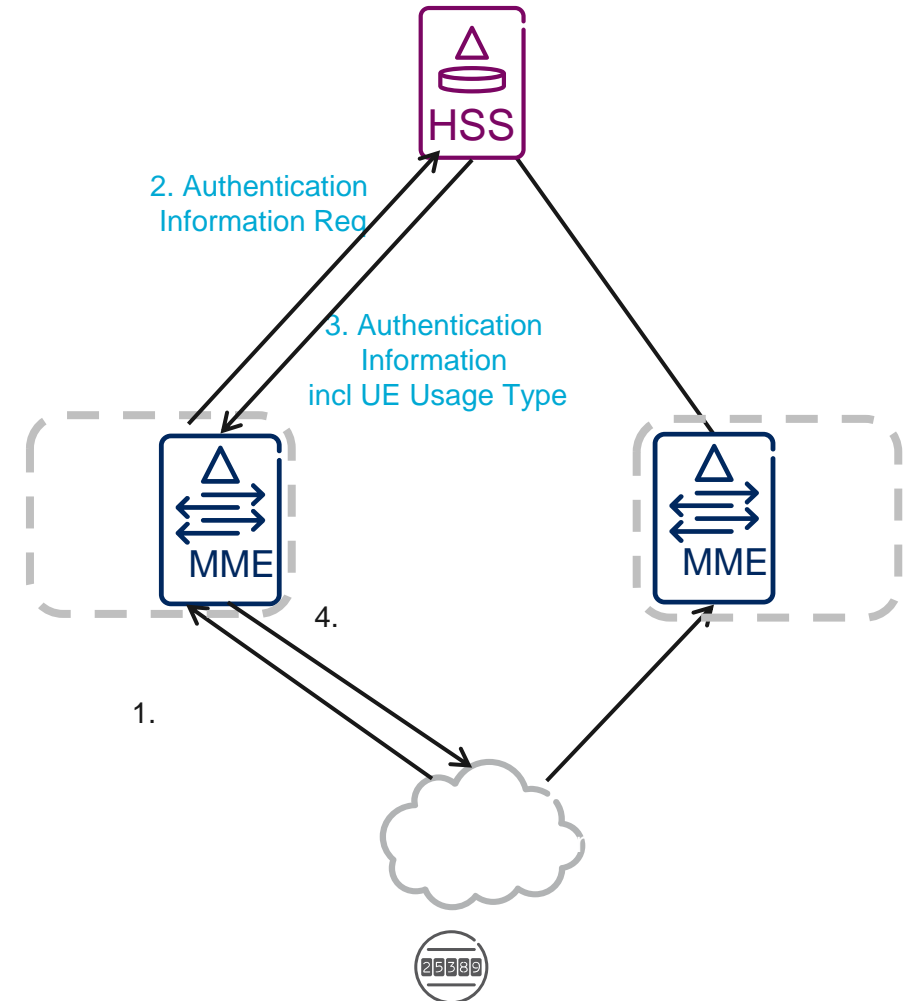| PLMN	APN	DECOR	eDECOR	5G Slicing
— CN selection by RAN using PLMN ID's	— Separate APNs for isolating UP sessions	— CN selection using HSS info (UE Usage Type)	— CN selection by RAN using UE info (DCN-ID)	
— Requires RAN and Core support	— Requires CN support	— Requires CN and RAN support	— Requires UE, CN and RAN support	
— All device types supported	— All device types supported	— All device types supported	— Enhancement of DECOR - backward compatible	

DEDICATED CORE NETWORKS (DECOR) –

— Based on UE Usage Type(UUT) in subscription data, MME redirects the UE to a Dedicated Core Network (DCN) via Attach, TAU and HO procedures

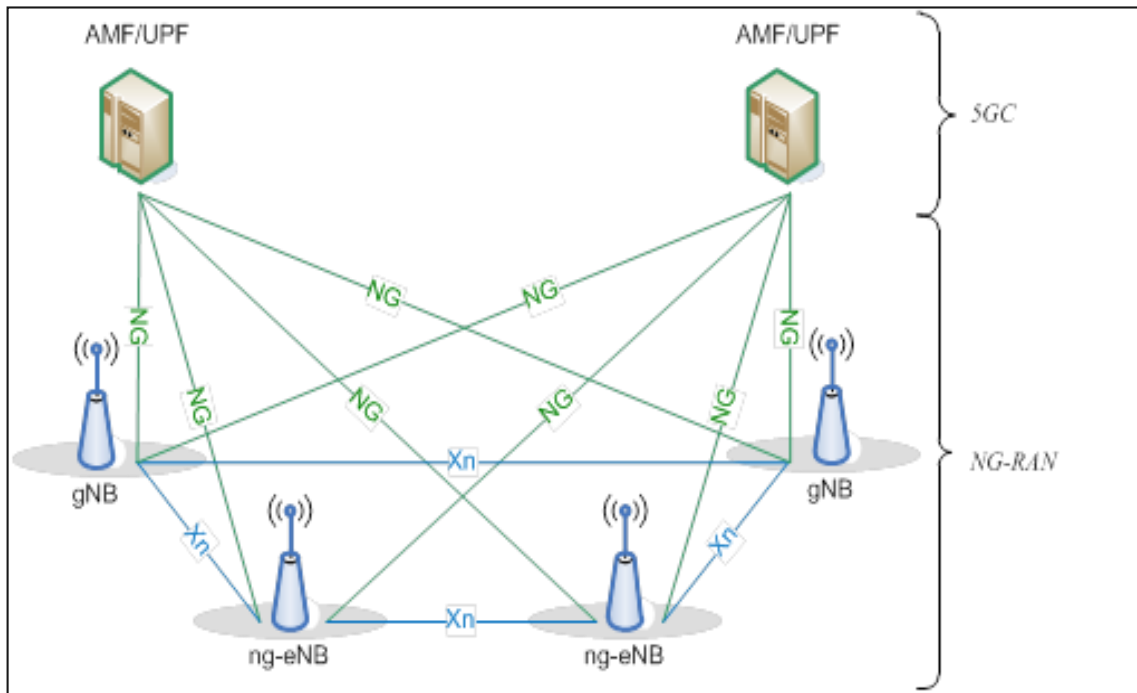— DCN is reselected when UUT is changed or MME configuration is changed, causing UE not to be served by the current DCN

Benefit

— Enables **multiple Core Network Segments in one PLMN**, for operator services differentiation. e.g., Rail, MVNO and enterprises.

HSS

2. Authentication Information Req

3. Authentication Information incl UE Usage Type

MME

MME

4.

1.

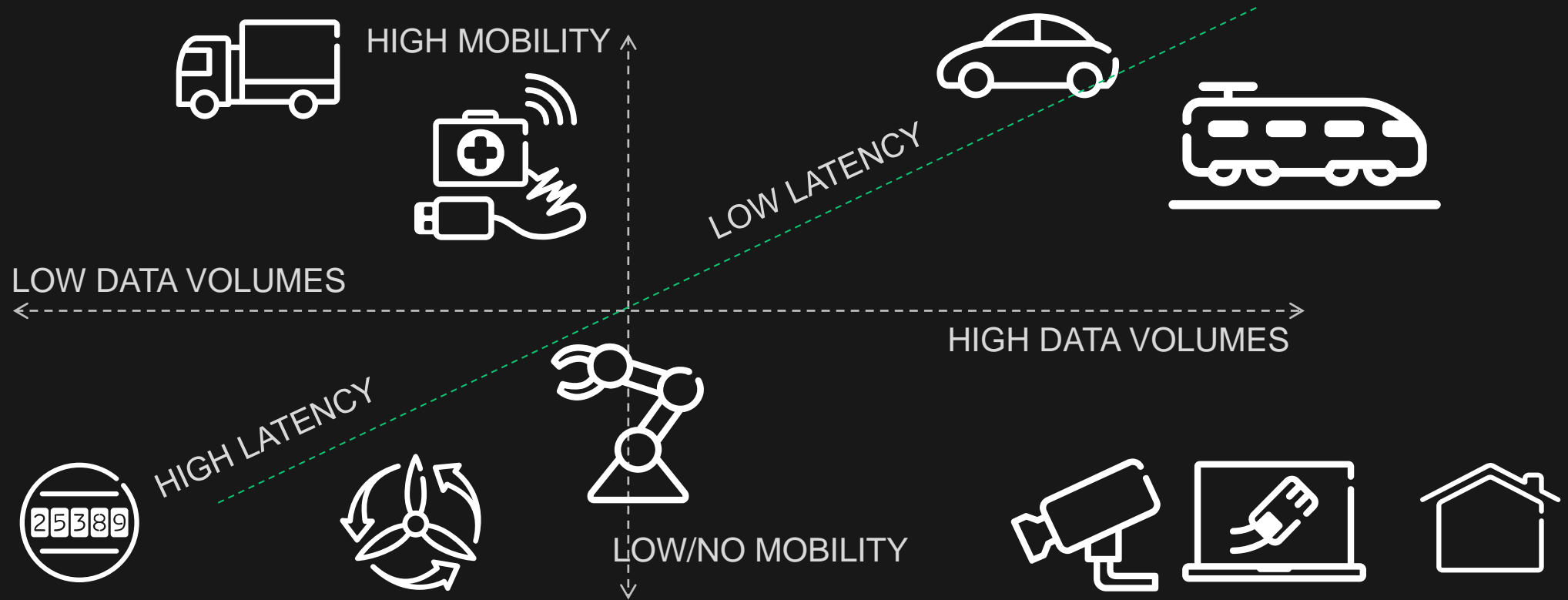25389

NG-RAN (5G) supporting E-UTRA

- gNB provides NR user plane and control plane protocol terminations towards the UE
- ng-eNB, provides E-UTRA user plane and control plane protocol terminations towards the UE.
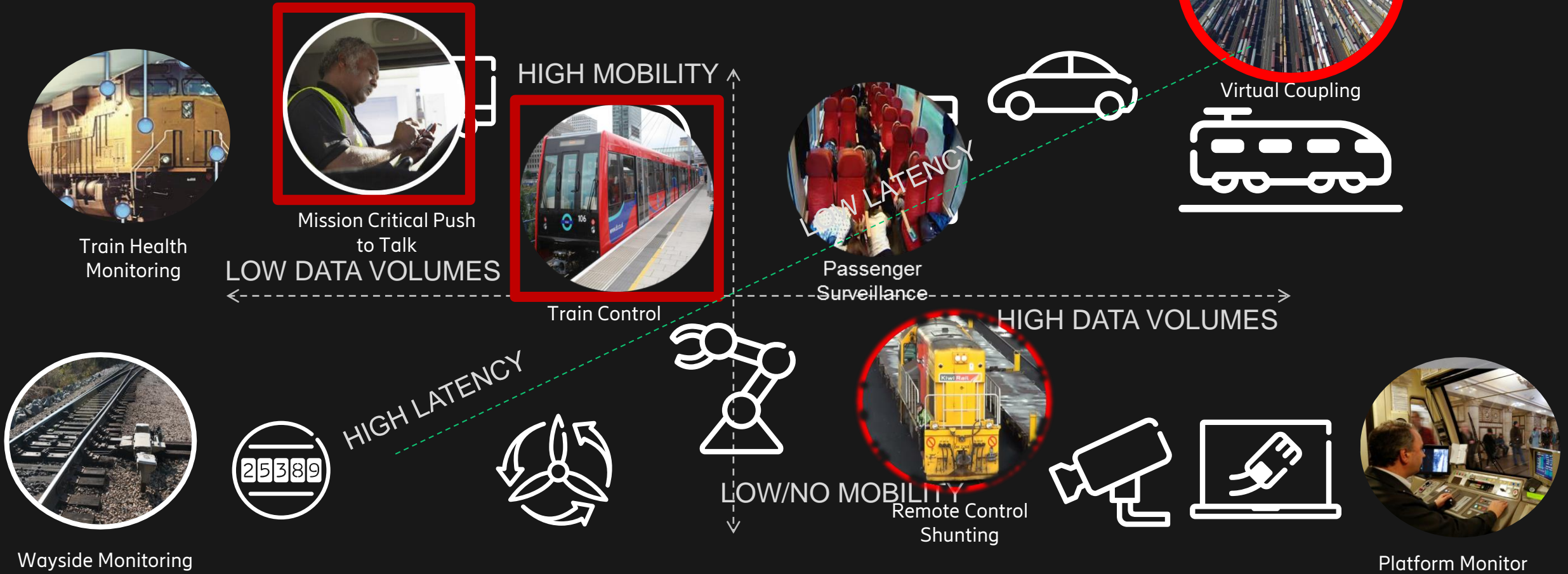
Network slicing: the basis
Railway use cases have a large span of characteristics

HIGH MOBILITY

LOW LATENCY

LOW DATA VOLUMES

HIGH DATA VOLUMES

HIGH LATENCY

LOW/NO MOBILITY

NETWORK SLICING FOR RAIL
Mapping railway use case characteristics

HIGH MOBILITY

LOW LATENCY

HIGH LATENCY

LOW DATA VOLUMES

HIGH DATA VOLUMES

LOW/NO MOBILITY

Train Health Monitoring

Mission Critical Push to Talk

Train Control

Passenger Surveillance

Virtual Coupling

Wayside Monitoring

Remote Control Shunting

Platform Monitor

Network Slice definition
One Network – Multiple Industries and Use Cases

Services/Products

| Logical MCPTT | Logical Video | Logical TCMS | Logical ETCS |

Network

Network Slices

NW Slice Mgmt

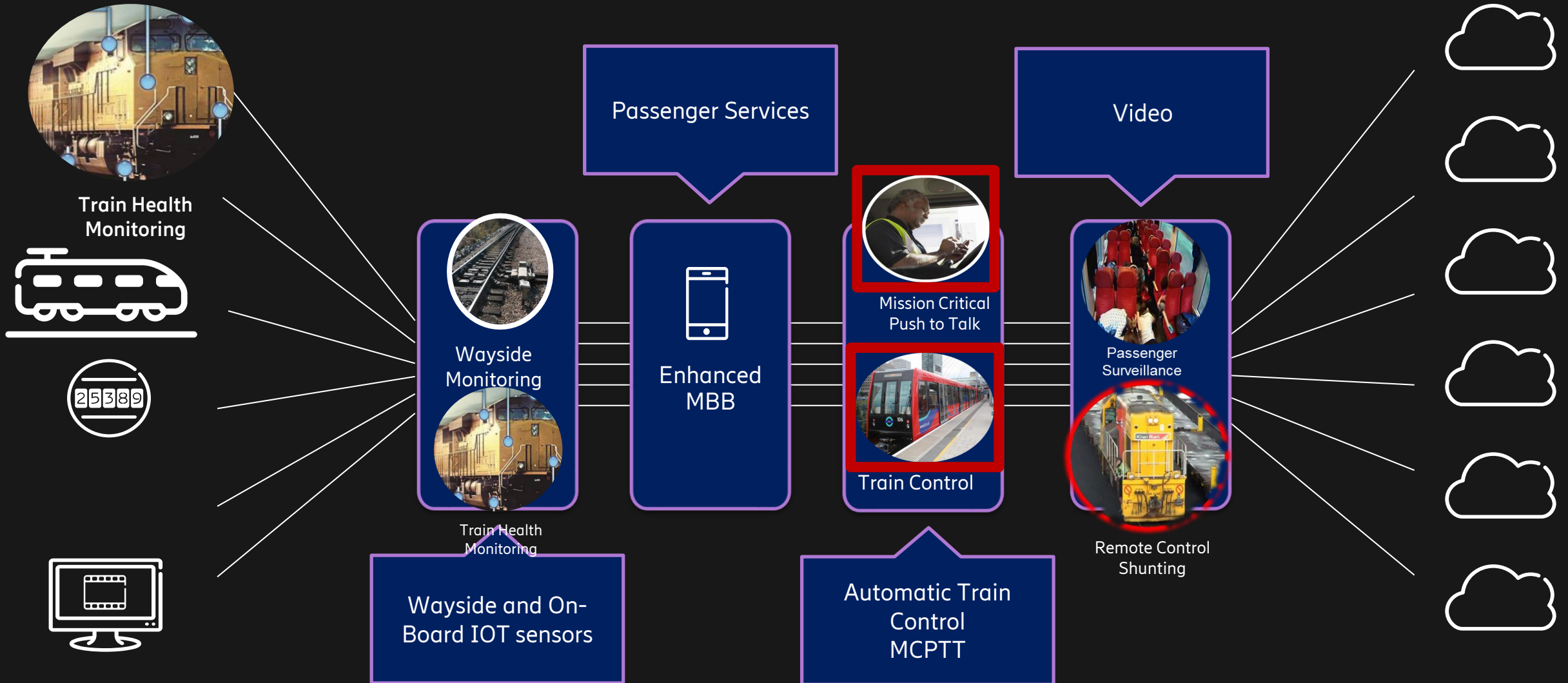| Access Resources | Transport Resources | Cloud Resources | Nw Function | Netw. Mgmt |

Resources/Components
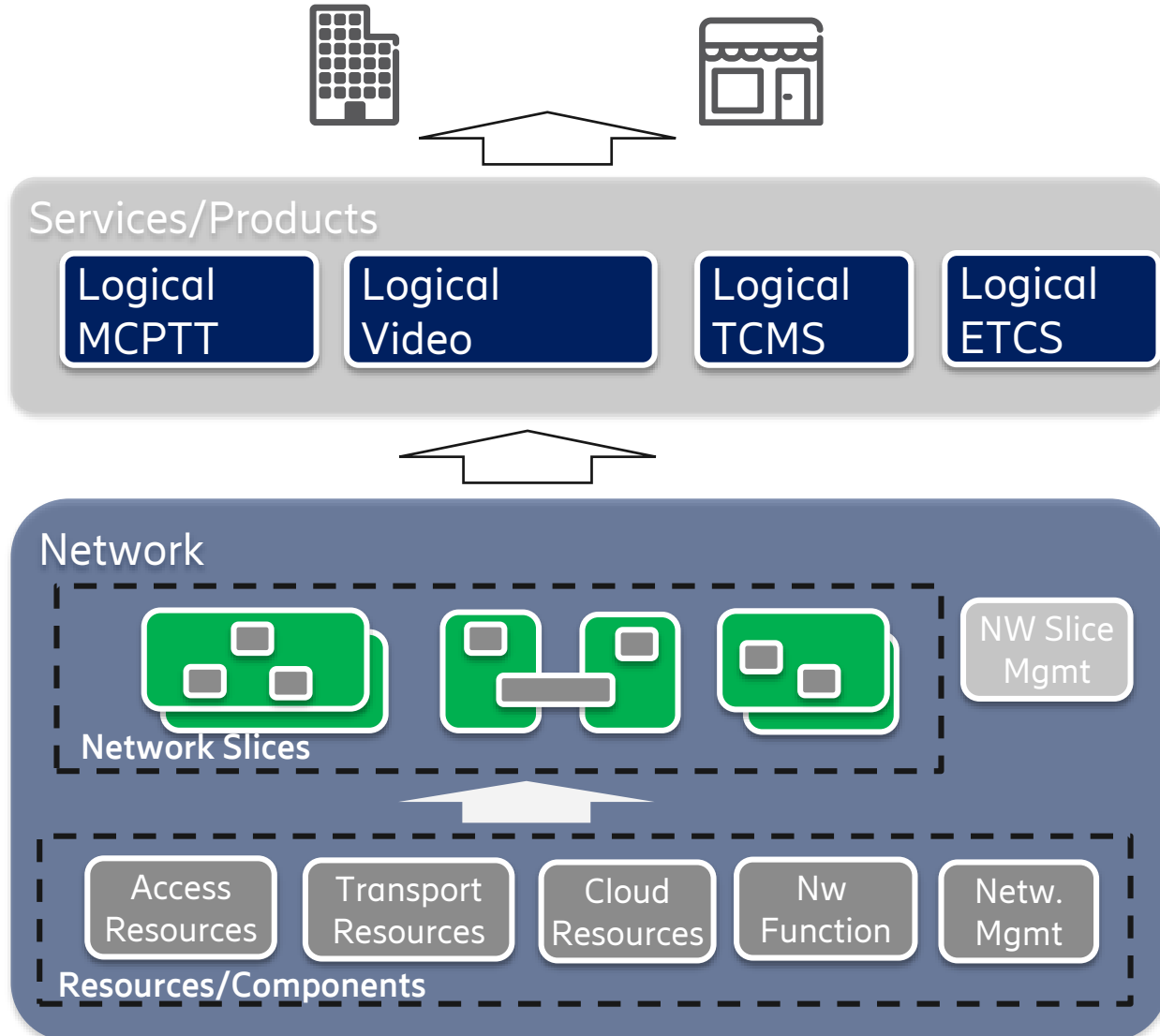
Network slice is a **logical network** serving a defined **business purpose**, consisting of **all** required network resources **configured** together. It is created, changed and removed by management functions.

- "End to end" within a provider
- Enabler for services, not a service
- Mobile and fixed
- Resources may be physical or virtual, dedicated or shared
- Independent/"Isolated" but may share resources
- May integrate services from other providers, facilitating e.g. aggregation and roaming

Network Slicing – Rail Examples

Train Control

Very high availability
Very high reliability
Very low latency

MCPTT

High availability
High reliability
Low latency

Passenger Connectivity

Wide area coverage
Internet access
Operator services

Massive IoT/TCMS

Low cost
Low energy
Massive numbers

NG RAN

Customer Premises · RB · Access · Aggregation · Regional · Primary
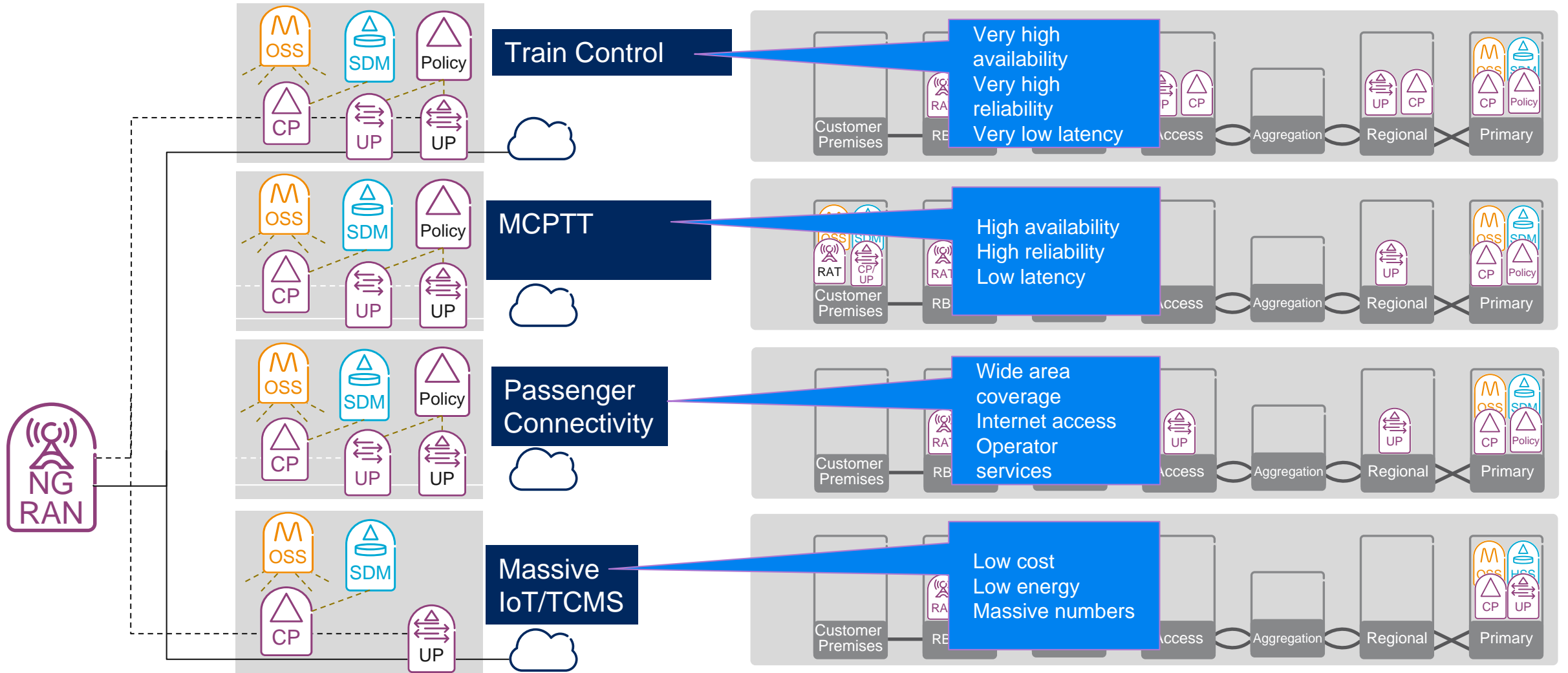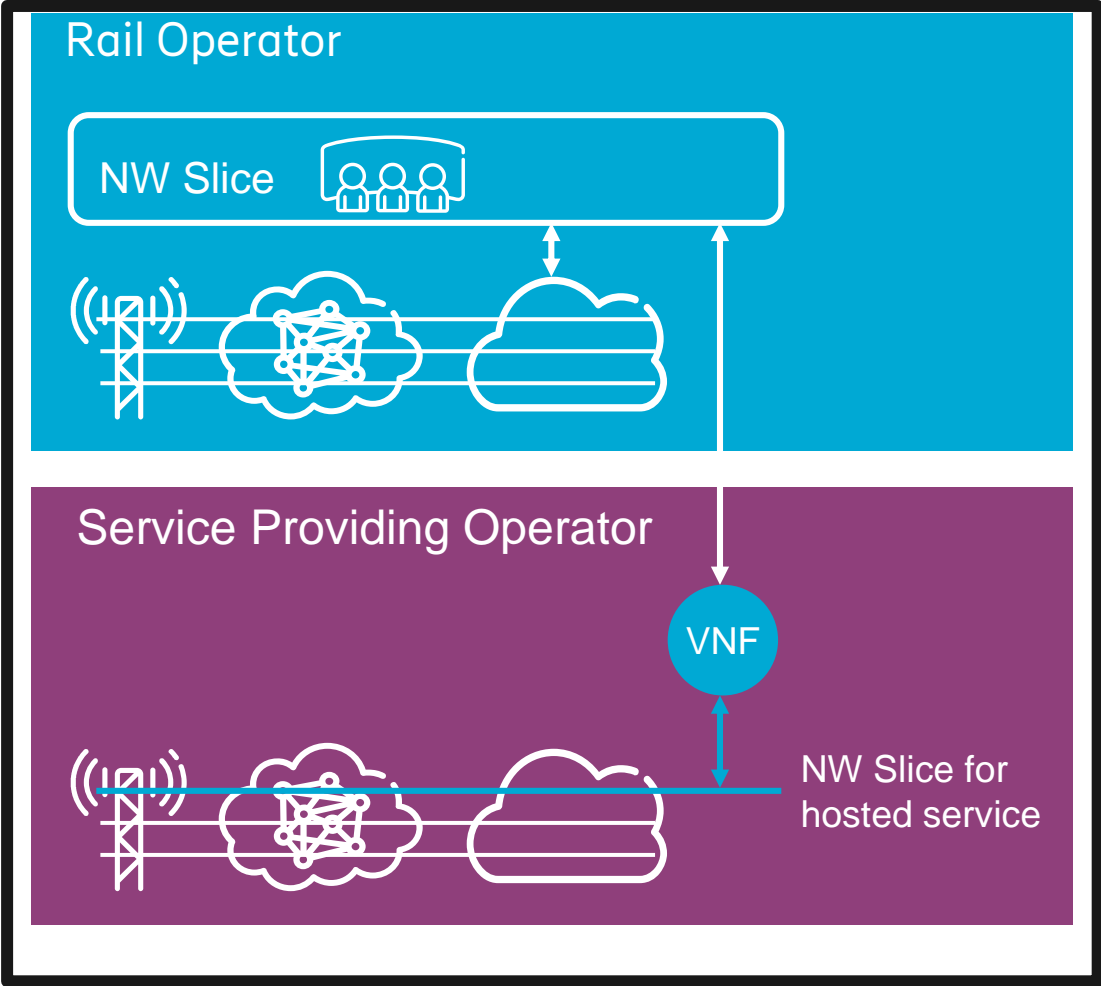
Railway Network Slices

5G Federated Network Slicing

Train Roaming to a foreign railway while retaining slice
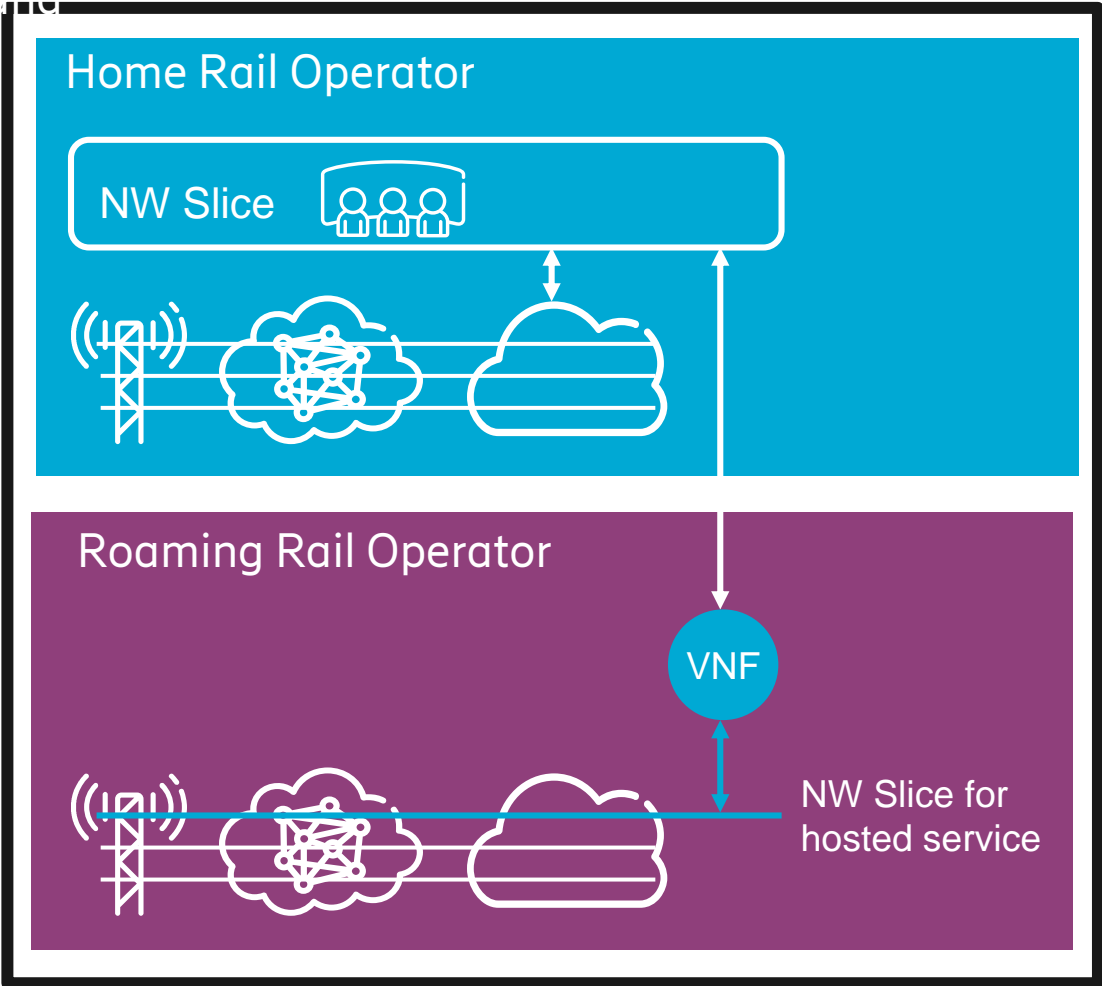
Train Roaming to an MNO while retaining slice

Railways Needs- MNO Provides

Low Latency

Dedicated railway RAN Network Slice and Core

Coverage

Railway may need to supplement coverage in unserved areas using MNO spectrum and site sharing mechanism

Capacity

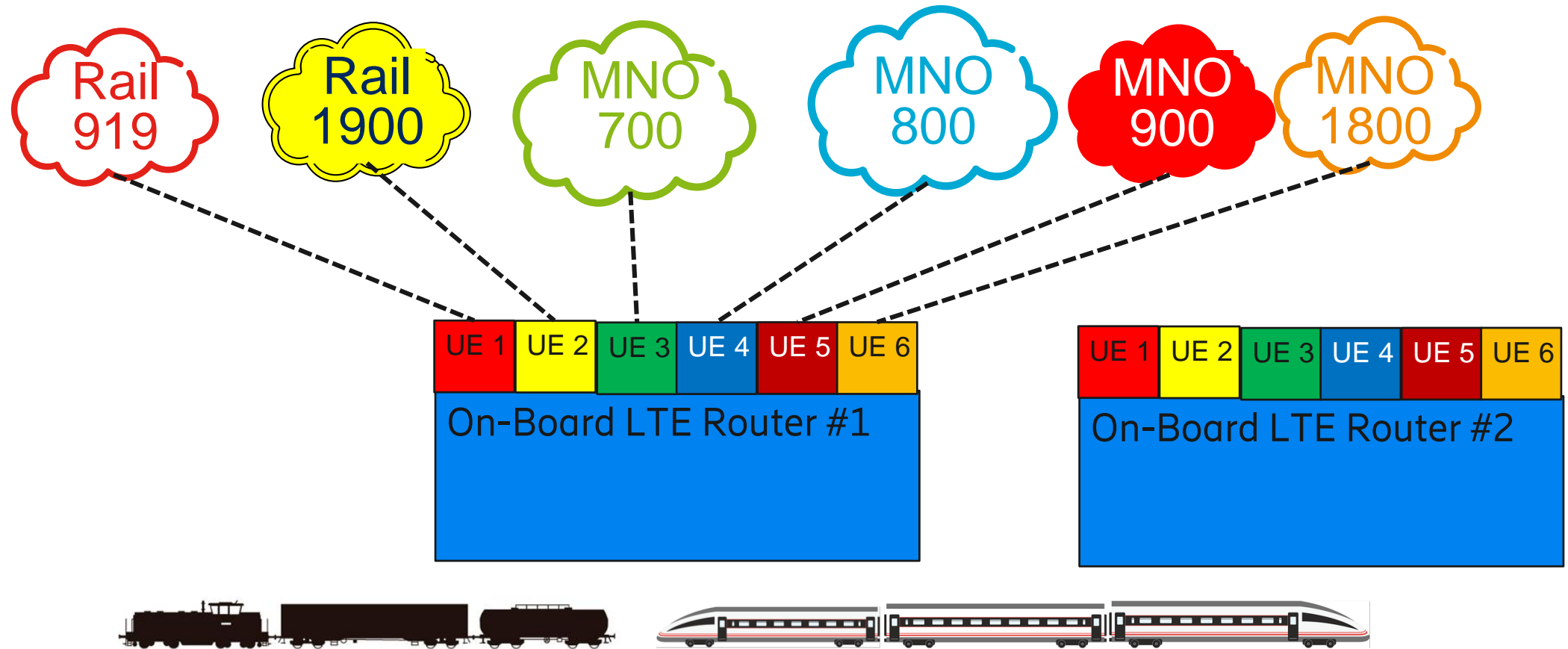supplement capacity in rail yards using MNO spectrum

European rail corridors

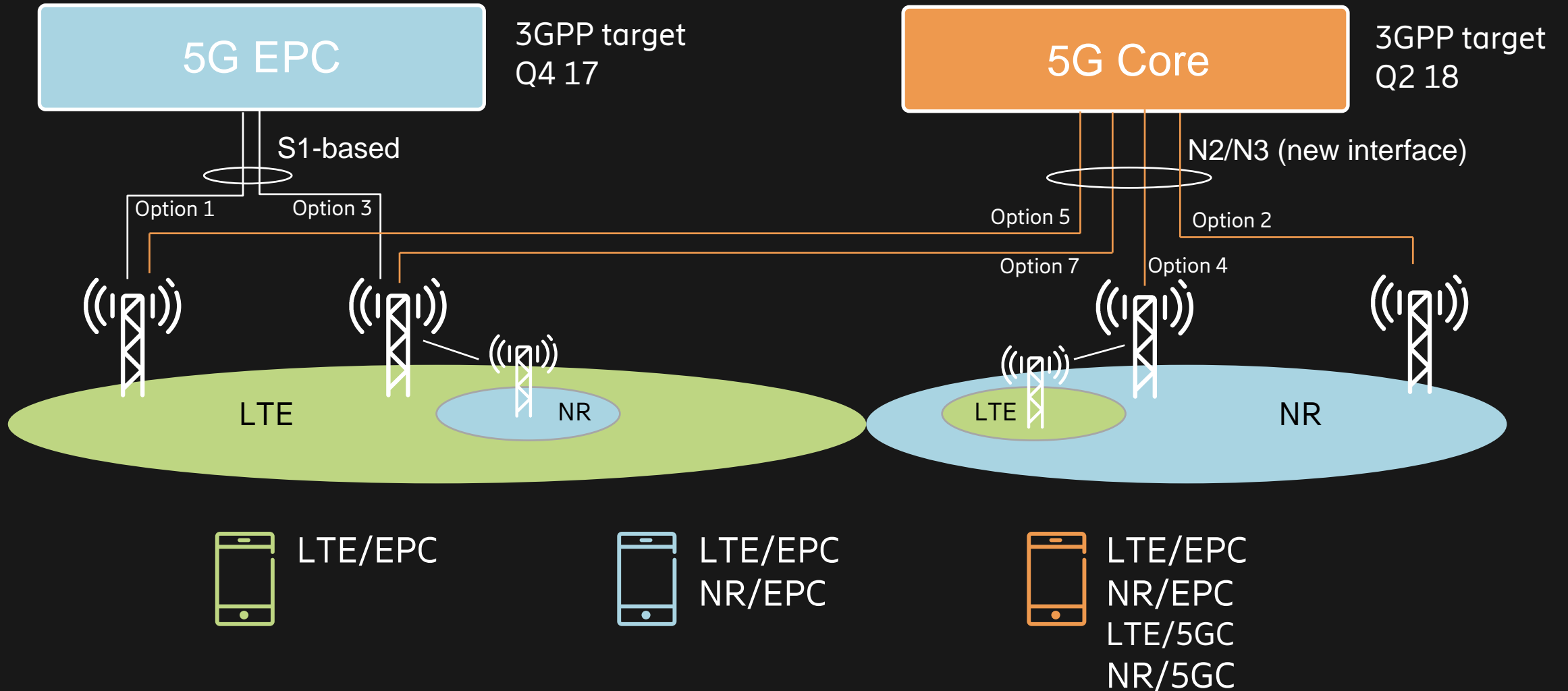Challenge of universal connectivity of freight and passenger trains across borders

Multiple UE On-Board Gateway

Mission Critical Rail Services use multiple parallel connections for 100% availability

5G RAN-CN Connectivity options
Two architecture tracks in 3GPP rel15

5G STANDARDS PLAN

2015	2016	2017	2018	2019	2020

ITU

IMT-2020 Evaluation

IMT-2020 Requirements | WS | IMT-2020 Proposals | IMT-2020 Specs

WRC

WRC

3GPP

Rel-13 | Rel-14 | Rel-15 | Rel-16 | Rel-17, ...

LTE evo | LTE evo | LTE evo

5G Study Item | 5G Phase 1 (Rel-15) | 5G Phase 2 (Rel-16)

Non Standalone 5G-NR
LTE as Control Plane anchor - Option 3
Stage 3 Dec. 2017
ASN 1 Freeze March 2018

Standalone 5G-NR
Option 2, 4, 5, 7
Stage 3 June 2018
ASN 1 Freeze Sept 2018

Stage 3 Dec 2019
ASN 1 Freeze March 2020

ericsson.com/ourportfolio/networks-solutions/mission-critical-and-private-networks