Session3.1, Room Karam3
Operational performance / Signalling and control

Moderator : Mr. Jean-Michel EVANGHELOU
Deputy Director of Rail Systems Dept.,
UIC, France

Session3.1
Operational performance / Signalling and control
Speaker Lists;

1	2	3	4	5	6
					
Mr.Navneet Kaushik	Mr.Stefano Marcoccio	Mr.Dong Il SUNG	Mr.Sergio Repetto	Mr.Thomas Denis	Mr.LIANG Jiawei
India	Italy	South Korea	Italy	France	China

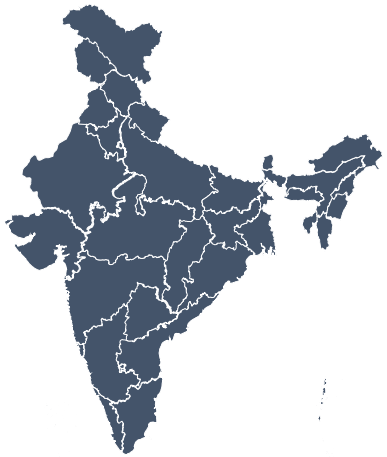
11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

IMPLEMENTAION OF ERTMS HYBRID Level 3 CONCEPT BY NCRTC

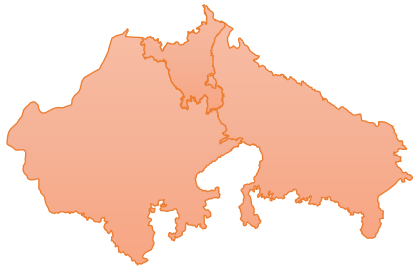
Sh. Navneet Kaushik
Director (System & Operations), NCRTC, INDIA
Session1-3.1 Operational performance / Signalling and control

RRTS – filling the gap of regional commute



National-level (>150 km)

- National Railways
- National Airlines
- High Speed Rail



Regional-level (20-150 km)

- Passenger Trains
- Inter-state Buses
- RRTS (Semi-high Speed rail)

City-level (10-25 km)

- Metro Rail Transit
- Bus Rapid Transit
- City Buses

Last Mile (<10 km)

- Autos / Shared Autos
- E-Rickshaws
- Feeder Buses

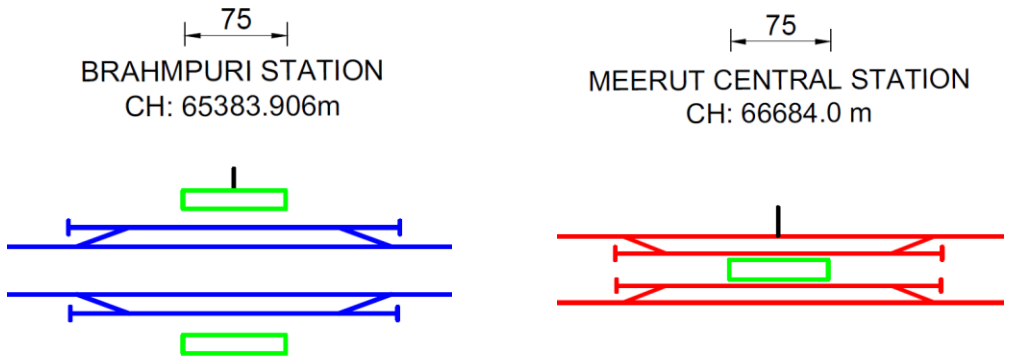
High Speed Rail & Semi-High Speed Rail are in nascent stages of implementation

- Implemented already
- Under implementation for first time

Why ERTMS hybrid-level 3

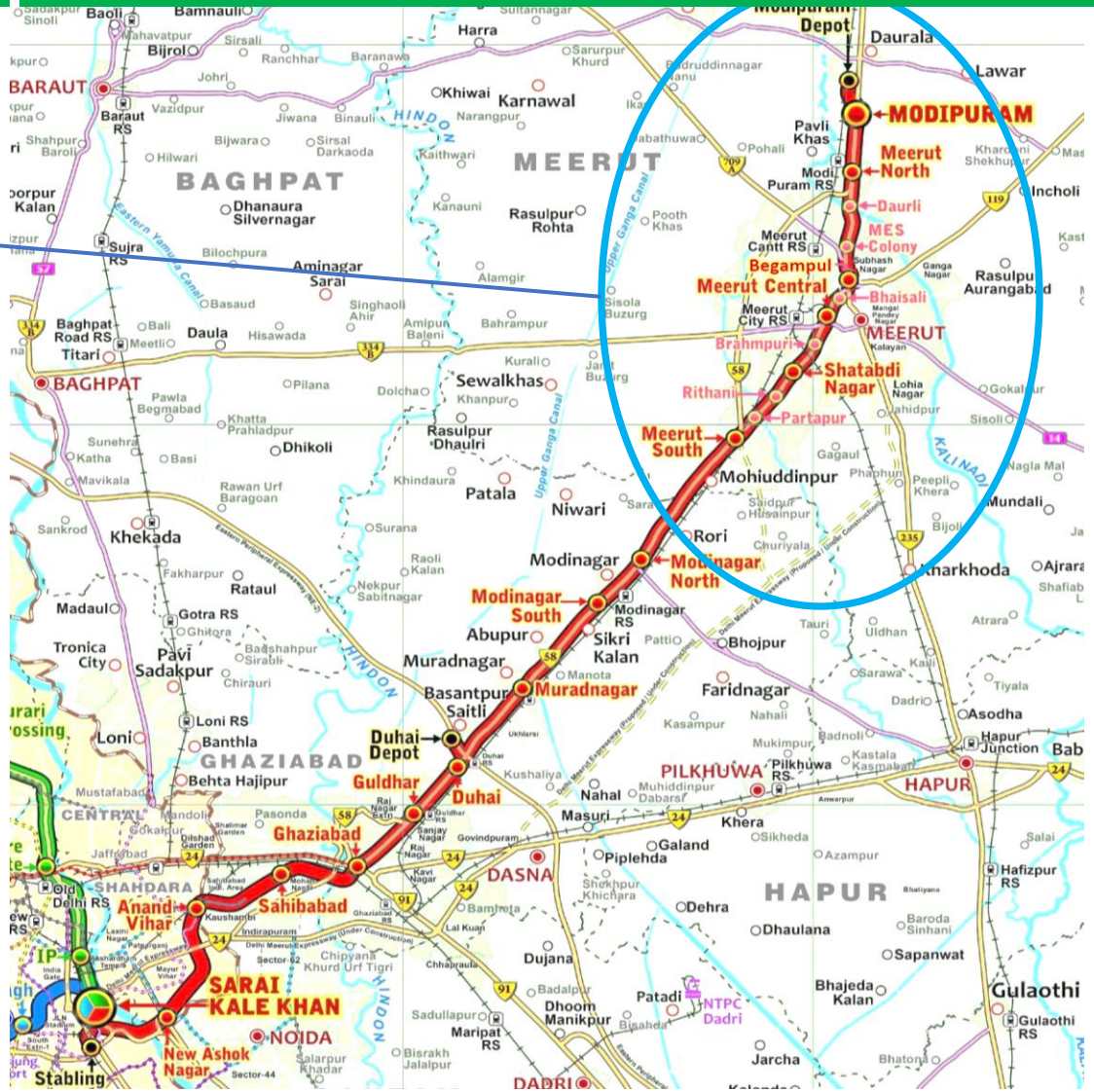
❖ **Unique Operational Requirement :**

Catering to High Speed RRTS and Metro on same Track infrastructure and stations where both MRTS and RRTS Trains runs.



Need reliable, safe, **high frequency (shorter headways)**, at high speed i.e. 160 Km/hr. – **ERTMS hybrid-level 3**

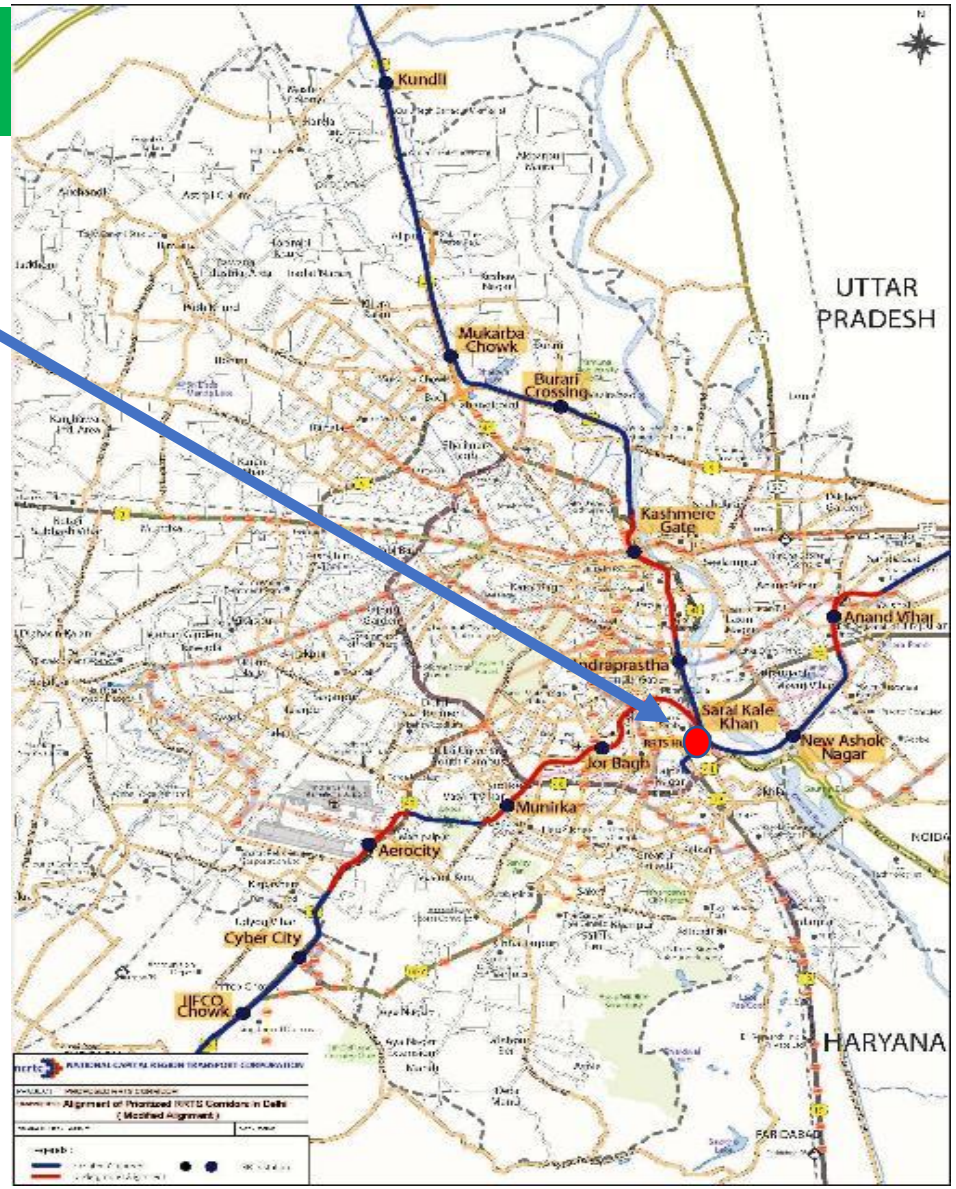
Delhi – Meerut RRTS Corridor



IMPLEMENTAION OF ERTMS HYBRID Level 3 CONCEPT BY NCRTC

Why ERTMS hybrid-level 3

- **Need interoperable signalling solution:** Three corridors converging at one point.
- **System must cater to shorter headways.**
- **RRTS + MRTS on shared infrastructure.**
- **Optimization of track side infrastructure.**
- **Technology should be proven.**



ERTMS level 3 Full Moving Block – does not exist and Level 3 with virtual block meets the requirement.

Implementation of ERTMS hybrid-level 3

- **Requirement for ERTMS Level 3 and Hybrid Level 3 (moving block or virtual moving block):**
  - Train Integrity Monitoring (TIM): Fixed composition train, TIM available through train lines.
  - Positioning system: Balise, Odometer, Radio backbone.
- **Green field work** - convenient to implement ERTMS Hybrid Level 3 with Fixed Virtual Blocks, with Trackside Train Detection (TTD).
- **Capacity increase depends upon length of virtual block.**
- **Fall back system availability:** In case of system vide communication failure, operation possible under fixed block sections.
- **Implementation of ERTMS hybrid-level 3 will lead to reduction of axel counters on field, increase system capacity.**
- **Requirement of Enhance bidirectional communication between the trackside and trains, and inter-train connections.**
  - Migration toward LTE and 5G technology,
  - Modular approach.
- **An effective approach to reduce cost and less complex systems**.
  - Reduce the number of wayside components.
  - Pivot the system as a whole towards mobile equipment.
- **Redundant Axle counters to increase reliability of fixed block.**

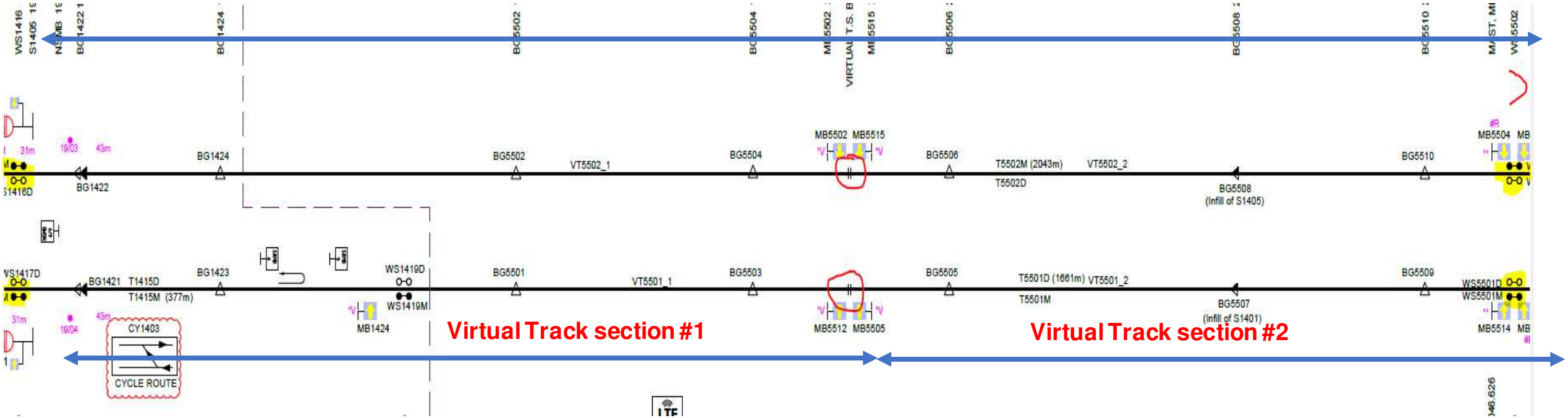
Advantages of having ERTMS hybrid-level 3

- Interoperable with future corridors. Same trains can move smoothly in both ETCS Hybrid Level 3 and ETCS Level 2 environment.
- For implementing ETCS Hybrid Level 3, no change is required in IXL and Onboard.
- Virtual blocks are defined inside RBC only.
- Future lines or future expansions are vendor independent.
- Simultaneous movement of trains with integrity and without integrity is possible on same infrastructure.

Hybrid Level 3 implementation in NCRTC

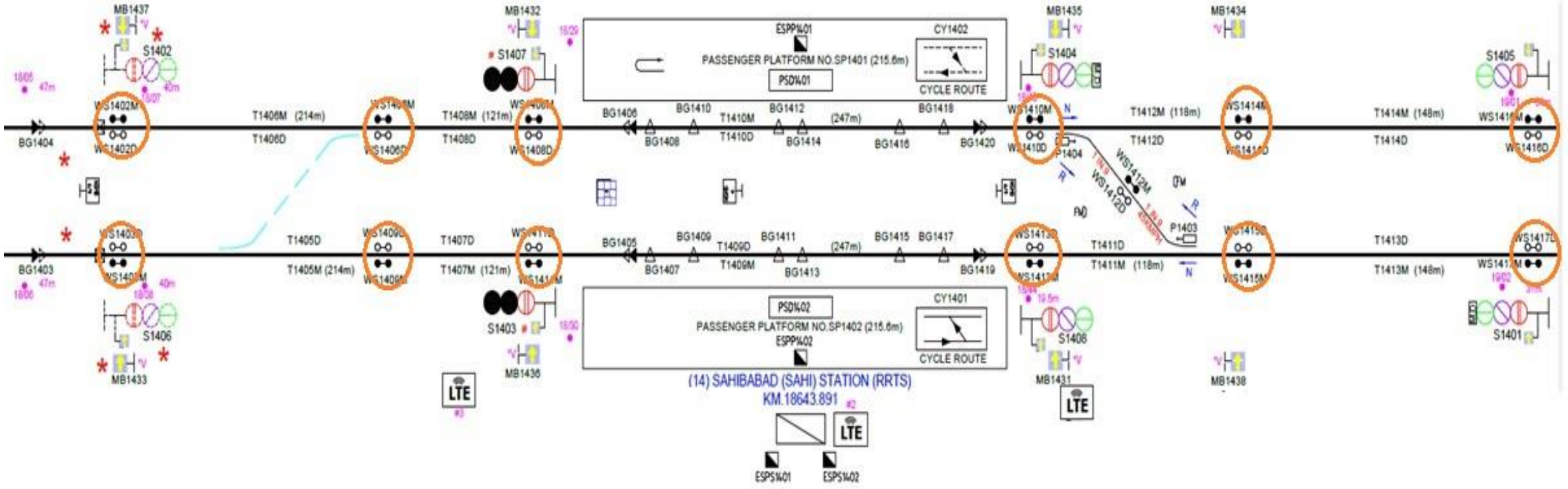
- Virtual track length are decided based on the headway simulation considering the design headway of 120 sec.
- Minimum length of virtual section is more than the train length. Approximate maximum length of Virtual section is 1 Km.
- All the mid section physical axle counters are bifurcated at least into 2 equal virtual sections.

Physical Track section

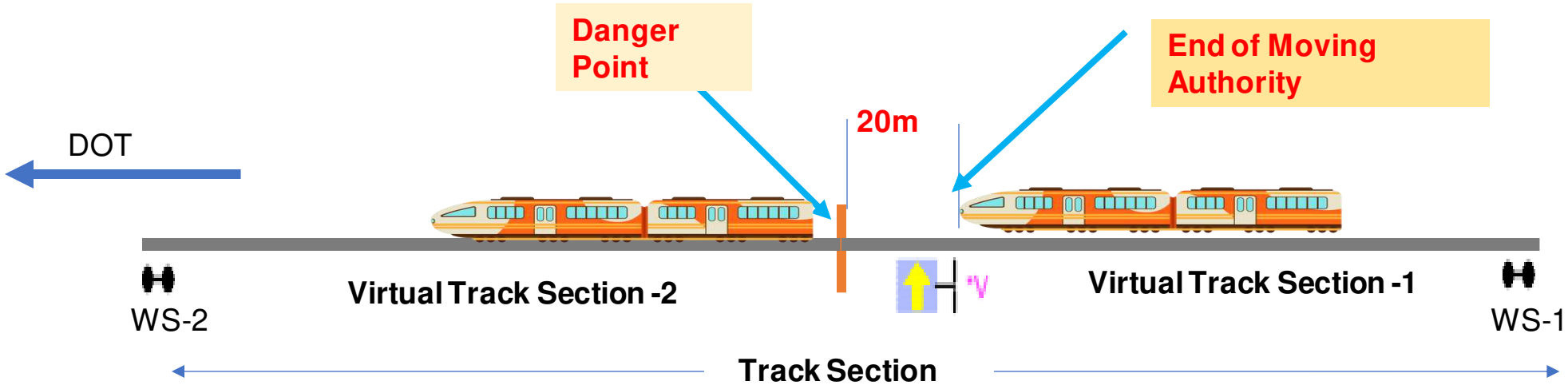


Why Virtual blocks are not considered in the station area

Station area is equipped with required number of axle counter to ensure the maximum operational requirements and no physical axle counter section is more than one train length. So, It is not technically valuable to include virtual sections in station area.



Minimum Distance between two train



- Maximum distance between balise groups is 500 mtrs. With 1% rate, maximum error accumulation through Odometer is only 5 mtrs.
- No physical marker at virtual section boundary.
- Minimum distance between two trains has been checked at site through physical measurement during train testing phase.

Capacity improvement test results

- **Line comparative capacity analysis using open track simulation tool:**
  - Study performed on a commuter rail line in NCRTC (peak hours, 8 am to 10 am)

S.no.	Section	Block	Headway (Excluding Turn Back)
1	Sarai Kale Khan - Modipuram	Moving Block	65 Sec
2	Sarai Kale Khan - Modipuram	ETCS Level -2 without virtual Block	320 sec
3	Sarai Kale Khan - Modipuram	ETCS L-2 with virtual block sections	172 sec

Point for further consideration

- Larger virtual sections – Need for physical marker boards to be seen to provide required information to Train Operator or text message on DMI to indicate cause of train stopping.
- In case of failure of TIMS, degradation from Hybrid Level 3 to Level 2.
- Redundancy of TDD.

THANK YOU

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Marrakech, 7-10 MARCH 2023

ETCS/ERTMS INTEGRATION BETWEEN HI-SPEED AND CONVENTIONAL NETWORK

Fabio Senesi, Gallo Gianvito, Stefano Marcoccio, Claudia Bafunno, Ylenia Ferlazzo,
Vito Mastrapasqua, Andrea Tredicine, Giovanni Antonio Vita
ERTMS National Plan, RFI, Italy
Session1-3.1 Operational performance / Signalling and control

ONCF UIC

The Italian Rail Network – Functional Needs

(6%) **~ 1000 km** — **High Speed Network**

Command Control System : ERTMS/ETCS L2
Train spacing with radio block

→ **Speed/Interoperability**

(5%) **~ 950 km** — **Metropolitan Traffic Lines**

Command Control System : CTC, SCC, SCC-M
Train spacing with short block sections (High Capacity)

→ **Increase capacity**

(18%) **~ 2.900 km** — **Fast Lines**

Command Control System : CTC, SCC
Train spacing with SCMT

(23%) **~ 3.900 km** — **Middle performances + Freight lines**

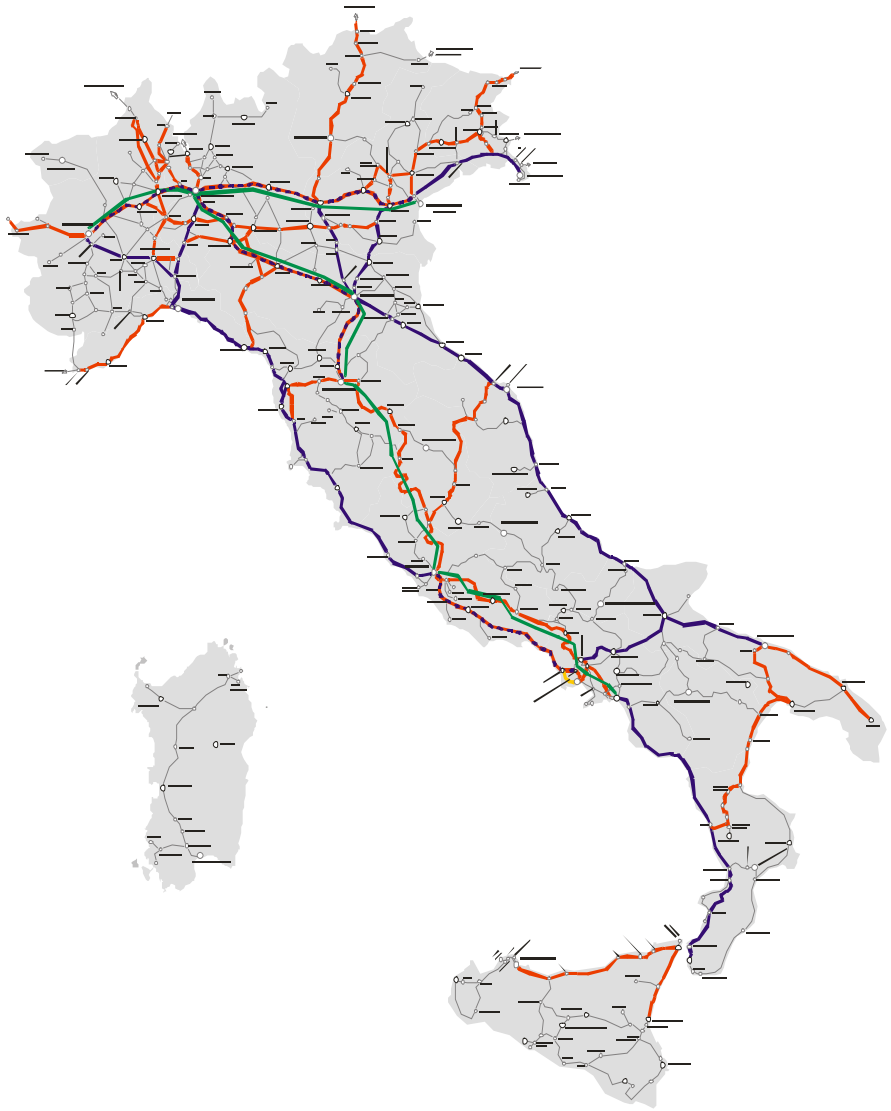
Command Control System : CTCev, SCC
Train spacing with block sections: SSC,SCMT

→ **Interoperability**

(48%) **~ 7.950 km** — **Subsidiary + Low Traffic Lines**

Command Control System : CTC
Train spacing with block sections: SSC

→ **Economic Sustainability**



Needs, Obligation, Opportunities from a National Accelerated ERTMS Plan

Obligation

- Interoperability
- More Safety functionalities

Needs

- Avoid Obsolescence
- More Avaibility
- More Capacity
- Reduce Cost of Ownership

Opportunities

- Digitalization
- New Performance (Anticipate Benefit)
- Saving Energy
- Innovation (GNSS, 5G…)

The ERTMS Accelerated Plan trackside: technical - financial dimension

A great challenge for the whole country and a new governance of investments

The ERTMS National accelerated Plan consists of:

Accelerated and extended ERTMS over the ***whole*** **railway infrastructure** **(IT: 16.800 km)** ***by 2036*** **(TEN and Off-TEN)**

- ***Synchronized and harmonized ERTMS (trackside/on-board) deployment***
- ***Simultaneous decommissioning of the national Class B system, with incentives for the RUs, as of 2023***
- **Technological renewal of Control Command and Signaling (CCS) (Digital Interlocking, Traffic Management System (TMS), TLC (GSM-R/FRMCS based), and ERTMS/ETCS), coordinated and driven by ERTMS system**

INTEGRATED MULTI-TECHNOLOGICAL PLAN AND REALIZATION OF INVESTMENTS DRIVEN BY ERTMS

ERTMS L2	Interlockings	TLC	TMS	TRACK CIRCUITS AUDIO FREQUENCY

THE WHOLE ERTMS TRACKSIDE PLAN requires a total budget of 13B€
and 2022 - 2026 deployed with resources granted BY EC RECOVERY PLAN (3B€)

ERTMS ON BOARD: IT retrofit strategy for the Circulating Fleet

ITALIAN MINISTRY OF INFRASTRUCTURE AND TRANSPORT

RFI - Infrastructure Manager
Coordination of deployment
Trackside and On-board

Integrated planning

ALL Railway Undertakings

Government decision n. 121/2021 to grant 50% of total cost On board

Retrofitting/upgrading
Of the Types of Vehicles
from Class B to ERTMS + Class B system
(120 Types)

"Technological credit" in Italy deriving from the recent equipping of rolling stock with a Class B system Upgradable to ERTMS

Retrofitting/upgrading
of the Series of Vehicles
from Class B to ERTMS + STM Class B System
(5.000 Onboard in circulation)

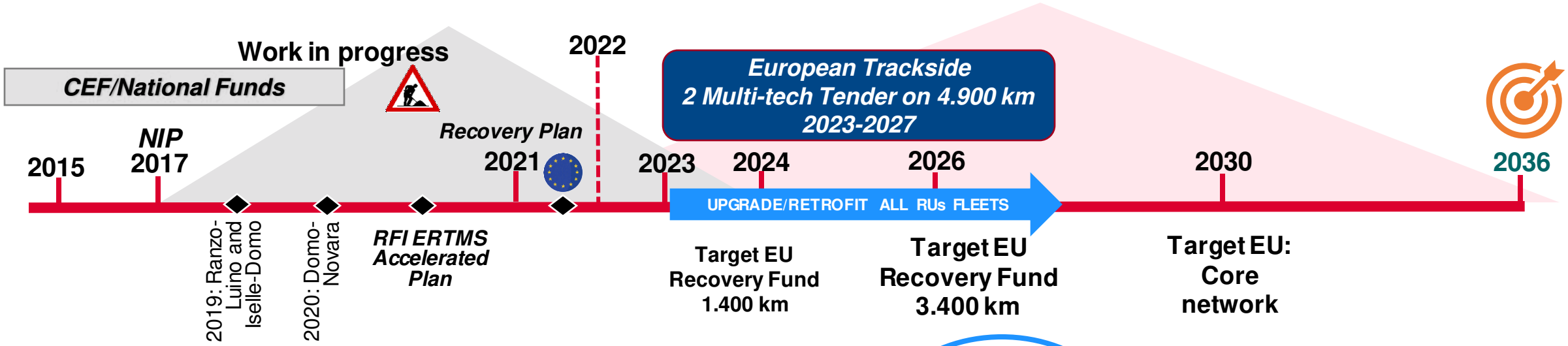
This model *will be successful in EU* if:

Incentives on Series and Vehicles are granted up to 100% of the cost for ALL Rus
Conformity checks on Series of Vehicles (NSA/ERA) are carried out in shorter timing

Milestones of the ERTMS Accelerated Plan trackside/onboard

Previous strategy: Dual on Track *(Breakthough Programme) 1200km*

New Accelerated Plan: Dual OnBoard and technological renewal

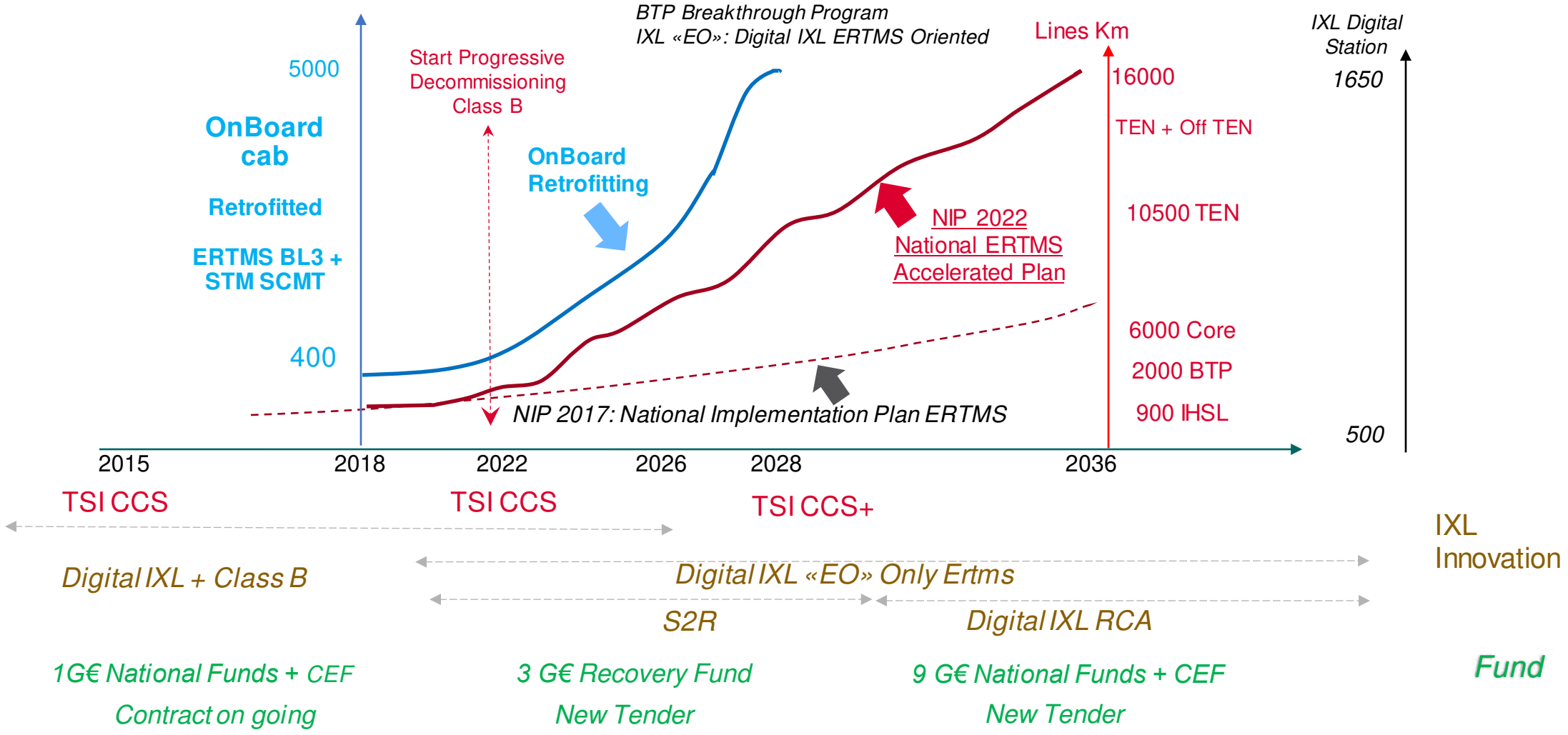


	Until 2026	2027-2030	2031-2036
Core network	40%	60%	
Comprehensive	26%	22%	52%
Off TEN	30%	8%	62%

Firstly, investments on regional off-ten network (smaller fleets) as requested by RUs

Core TEN-T: ≈5.800km
Comprehensive TEN-T: ≈4.600km
Off-TEN: ≈6.400km

Forecast ERTMS Trackside and OnBoard migration



Framework Agreement Phase 1 and Phase 2

500 Mio€

Multi-technology Framework Agreement Phase 1
ERTMS Plan Lines:
Sicilia and Roccasecca-Avezzano

Roccasecca-Avezzano
(pilot line)
≈ 80 km

Sicilia (first implementation)
≈ 513 km
Canicattì-Siracusa + Lines of 2024

≈ 593 km up to 2024 (PNRR ERTMS)

Additional 152 km for two non-Plan ERTMS lines (PNRR)

2,7 Mrd€

ERTMS Plan
Multi-technology Framework Agreement Phase 2
A total of 4.223 km including 2.617 km (PNRR ERTMS) + 1606 km

LOT 1 central-northern Italy
≈ 1.887 km
DOIT: Firenze, Milano, Torino, Venezia, Verona, Bologna, Genova, Trieste

1,3 Mrd€

LOT 2 central-southern Italy
≈ 1.396 km
DOIT: Roma, Napoli, Bari, Cagliari

900 Mio€

LOT 3 center of Italy
≈ 534 km
DOIT: Ancona

323 Mio€

LOT 4 south of Italy
≈ 407 km
DOIT: Reggio Calabria

251 Mio€

≈ 777 km up to 2024 and ≈ 1840 km up to 2026 (PNRR ERTMS)
≈ 175 km for ERTMS Plan lines at 2025 and 2026 (not financed by PNRR ERTMS)
971 km for lines at 2027 + additional 460 km as backup at 2027

Additional 250 km of lines to be contracted under the ERTMS Rev.P Plan in DOIT Palermo by 2026

ERTMS Accelerated Plan in a nutshell

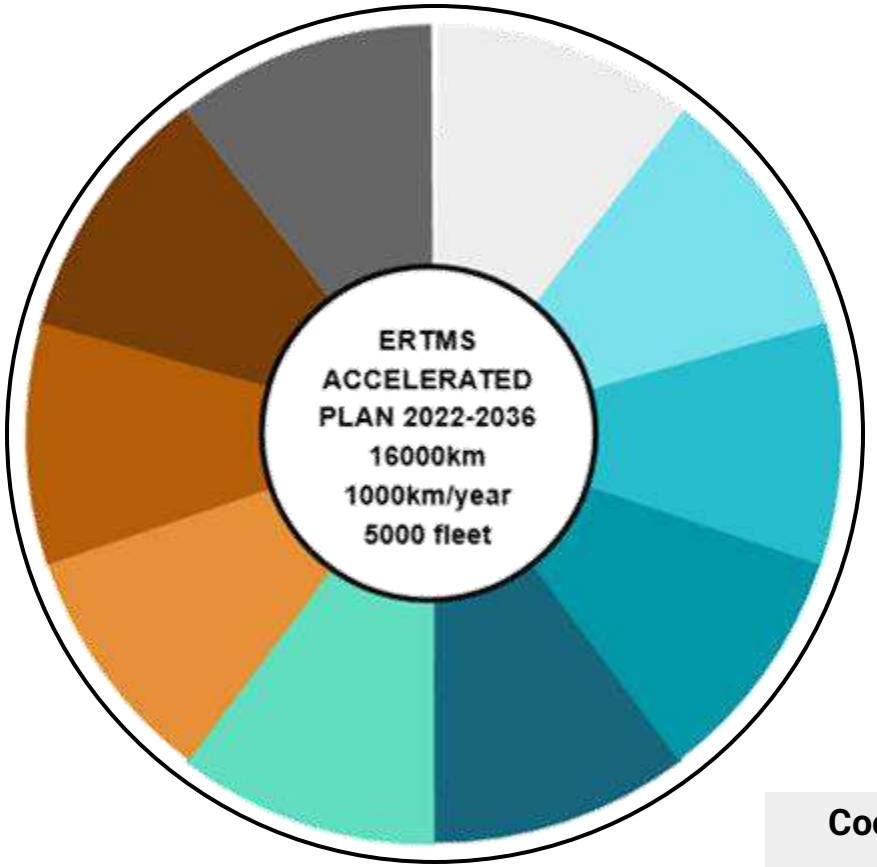
Increase SAFETY Function (NSA request) and Interoperability (EU)

Unique EU Standard Command and Control System, Centralized, Digital Radio Based, for all the Railway Network

Higher Performances , Speed , Capacity, Flexibility for different context and services, Olystic Modal Shift Design

Innovation by ERJU (FRMCS, ATO GoA4, GNSS, Smart Road sinergy..). Managing ERTMS Baseline System Vesion Management and Cybersecurity

Energy Saving by ATO over ERTMS up to 20%



PNRR , Recovery Fund, Member State Budget for IM and Compatible Help Aid for IIFF

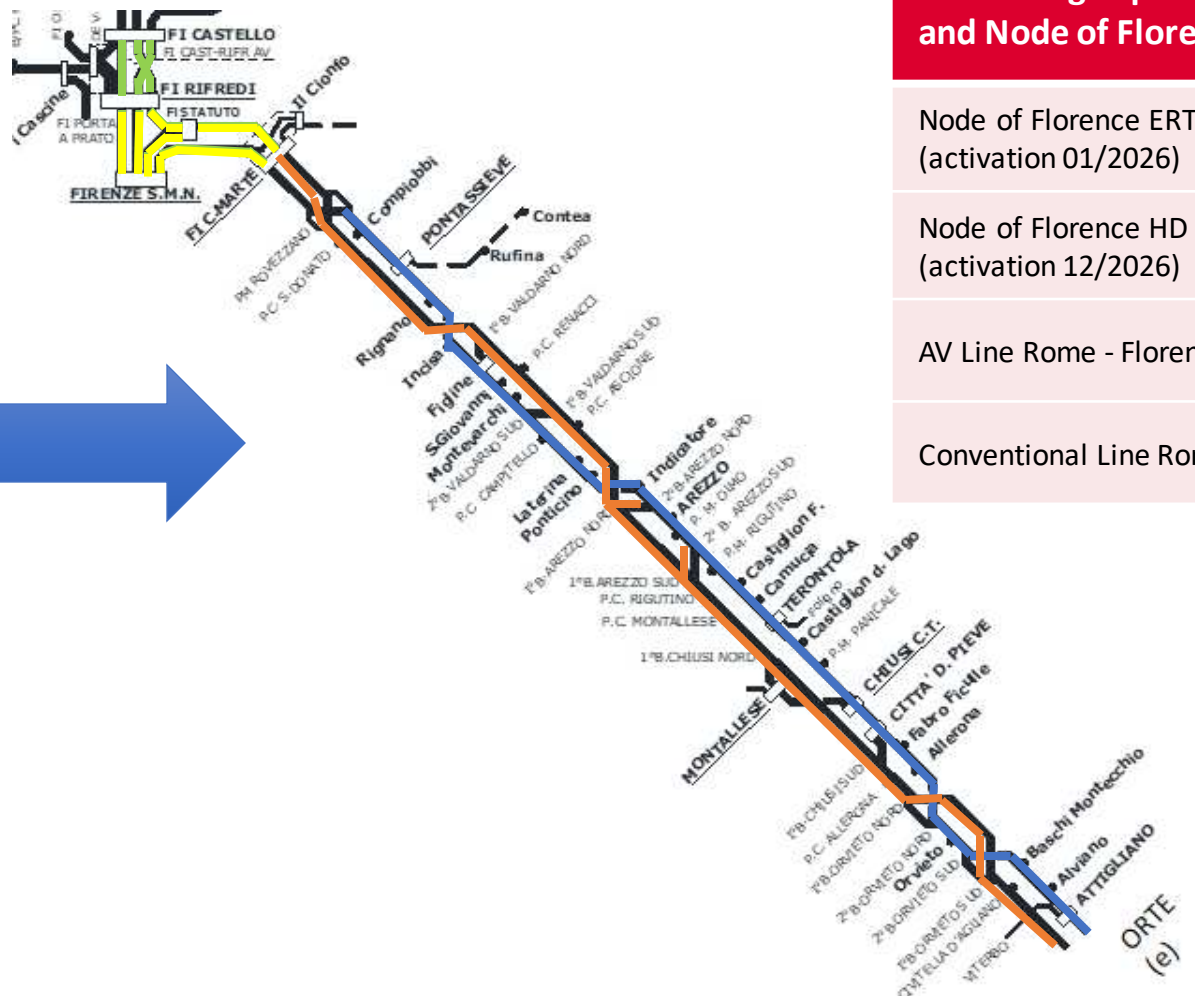
Anticipate benefit, reduction CAPEX&OPEX avoiding obsolescence

Great deal and effort for Supplier, NSA, RUs, IM, NoBo, Assessor

Awesome Cultural Transformation and Migration for IM and RUs staff

Coordinated Trackside and Train borne ERTMS investement and commercial services by permanent consultation (RUs, IM, Member State, Supplier, NSA)

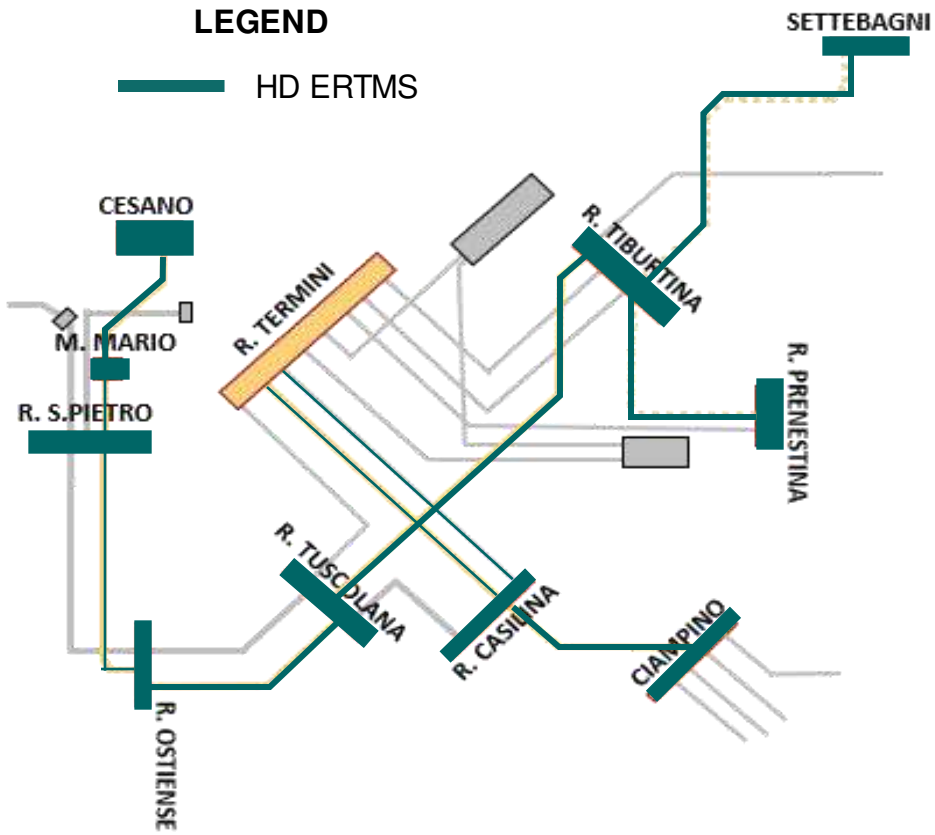
ERTMS High Speed Network and Node of Florence



ERTMS High Speed Network and Node of Florence	
Node of Florence ERTMS (activation 01/2026)	
Node of Florence HD ERTMS (activation 12/2026)	
AV Line Rome - Florence	
Conventional Line Rome - Florence	

Node of Rome

- 1.1 M. Mario(e) - RM Ostiense(i) **12/2024**
- 1.2 Cesano(i) - M. Mario(i) **12/2025**
- 2 RM Termini - RM Casilina – Ciampino **12/2025**
- 3 RM Ostiense(e) - RM Tiburtina(e) **06/2025**
- 4 RM Prenestina - Settebagni **10/2027**



I° Sem. 2022 | II° Sem. 2022 | I° Sem. 2023 | II° Sem. 2023 | I° Sem. 2024 | II° Sem. 2024 | I° Sem. 2025 | II° Sem. 2025 | I° Sem. 2026 | II° Sem. 2026 | I° Sem. 2027 | II° Sem. 2027

1.1 M. Mario – RM Ostiense

3 RM Ostiense – RM Tiburtina

1.2 Cesano - M. Mario

2 RM Termini – RM Casilina - Ciampino

4 RM Prenestina – Settebagni

THANK YOU

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Korean Train Control System (KTCS) using LTE-R based ETCS

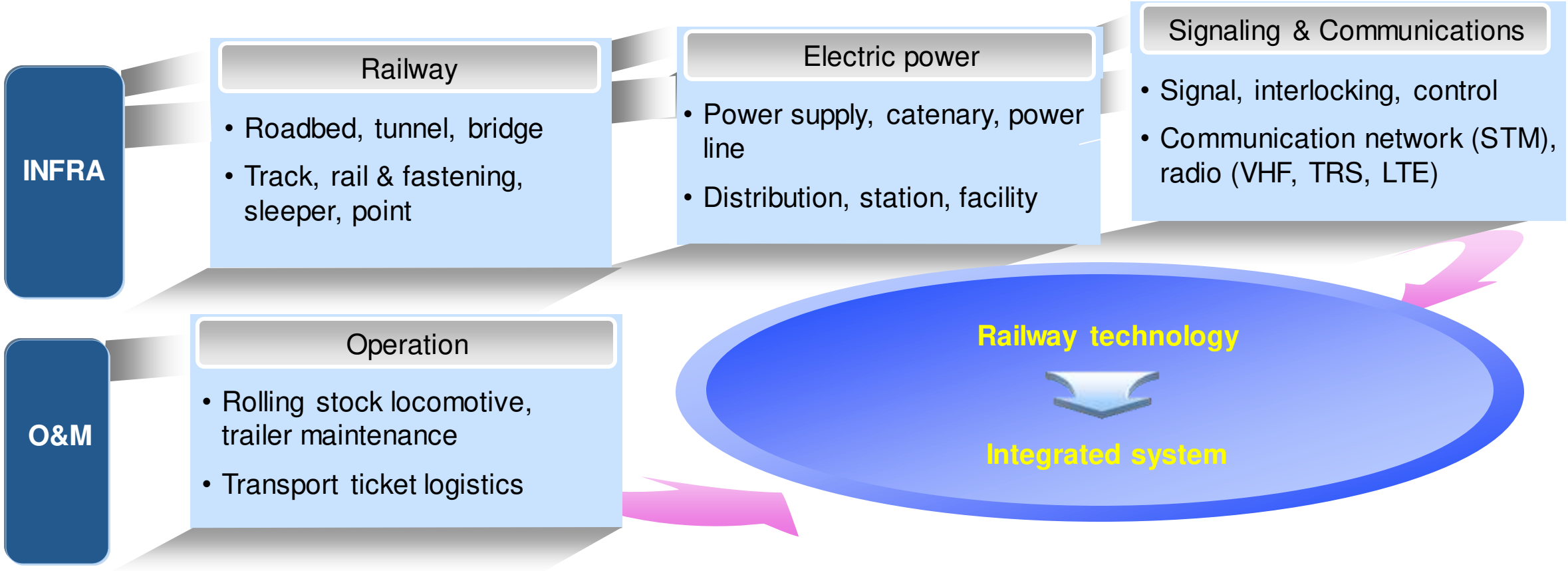
Dongil SUNG
General Manager, Korea National Railway, Korea
Session1-3.1 Operational performance / Signalling and control

ONCF UIC

I. Railway Technology

Management directive from Mr. Kim Hanyoung, Chairman and CEO of KNR:

"Enhance speeds and efficiency of the rail network, and build eco-friendly & carbon neutral railways"



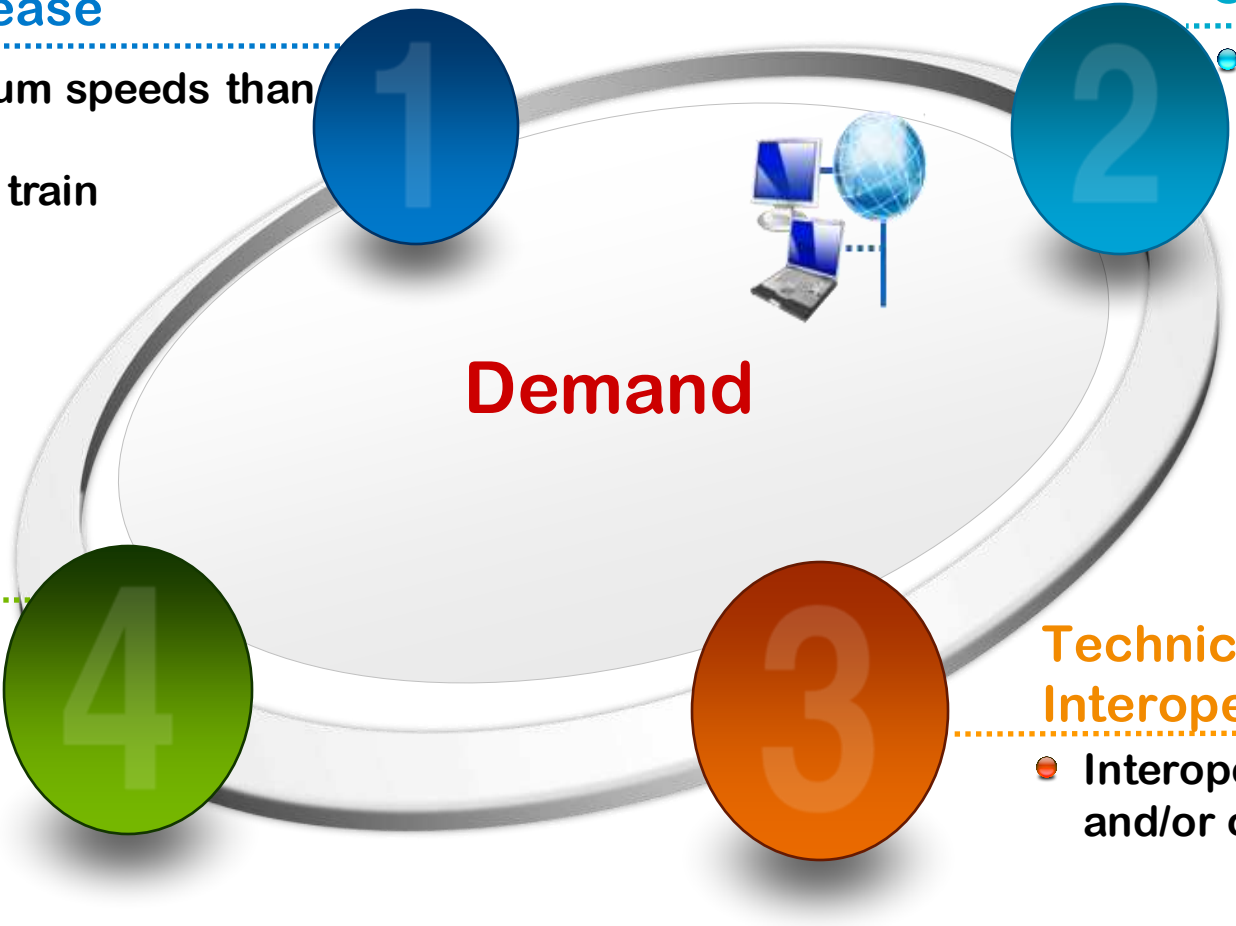
II. Development of KTCS – New train control system for high speed rail

Capacity Increase

- Higher maximum speeds than existing lines
- More frequent train operations

Cost Down

- Less track facilities



Safety

- Immediate response in case of emergency [e.g. obstacle)

Technical Specifications for Interoperability

- Interoperable with adjacent and/or connected lines

II. Developmentof KTCS

KTCS - 2 & 3 (Korean Radio-based Train Control System)

KTCS LTE-R

ETCS Levels 2
Level 3

+

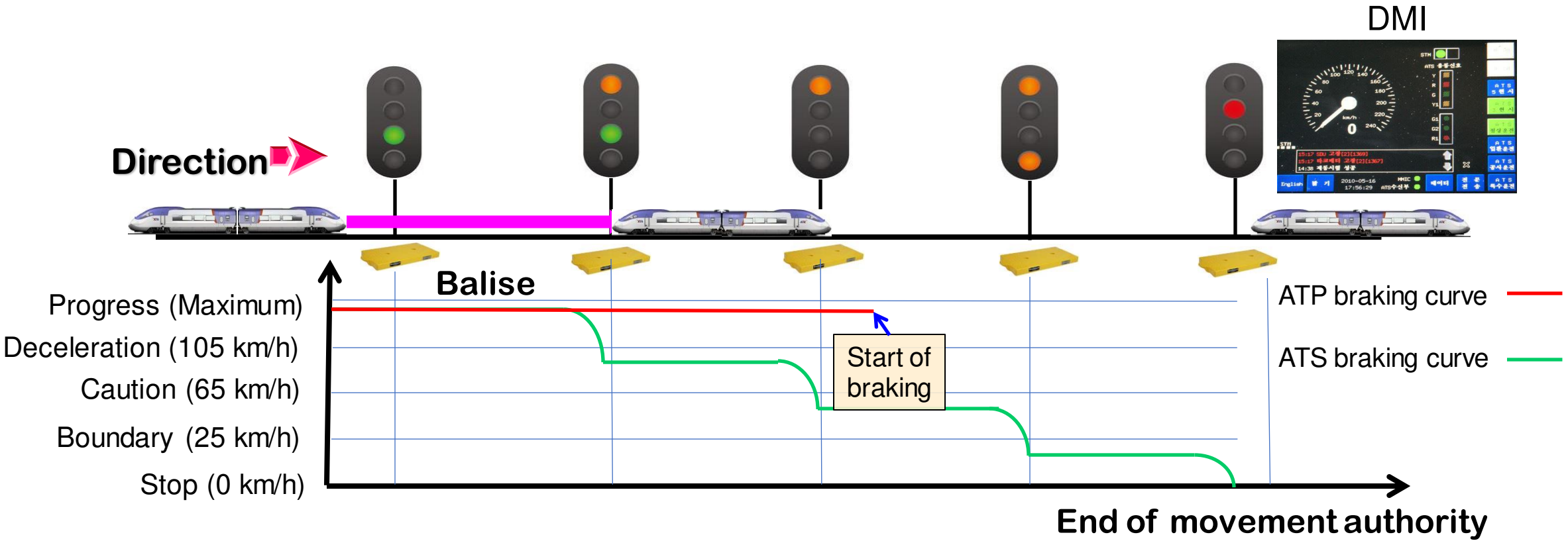
Interface standard

+

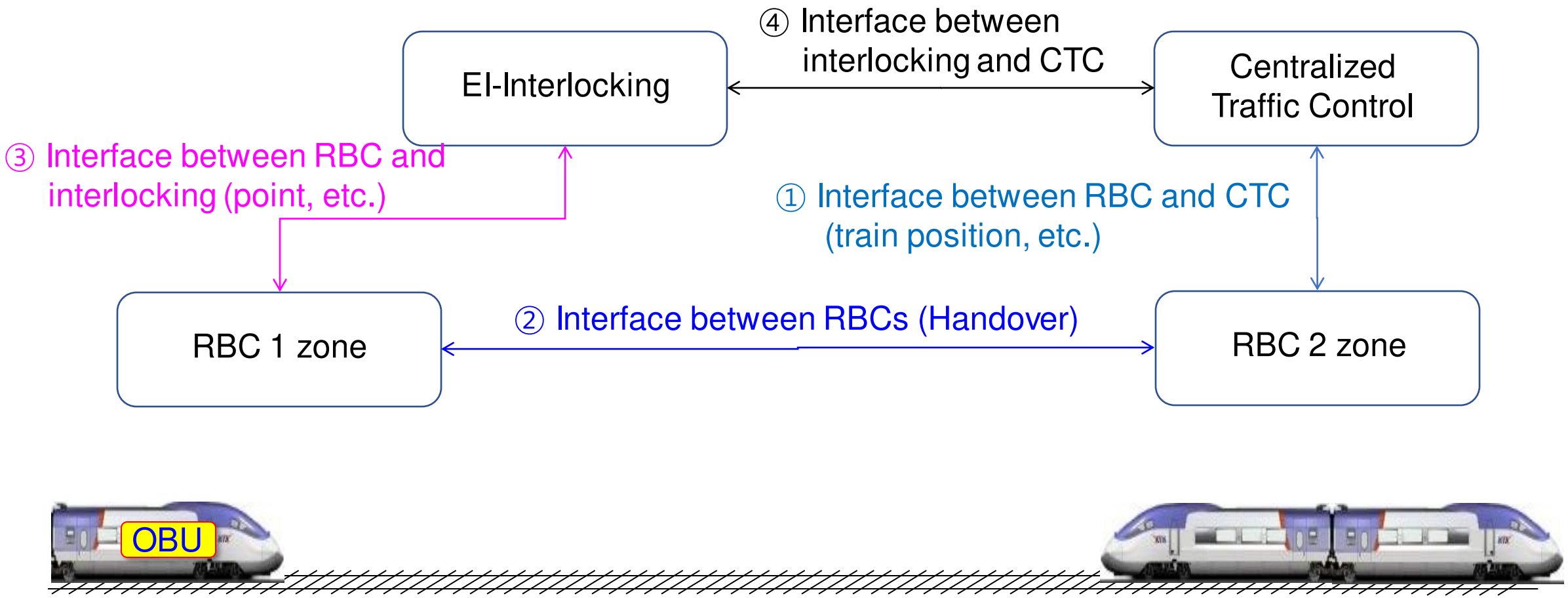
Lte RAILWAY

II. Development of KTCS – KTCS technology

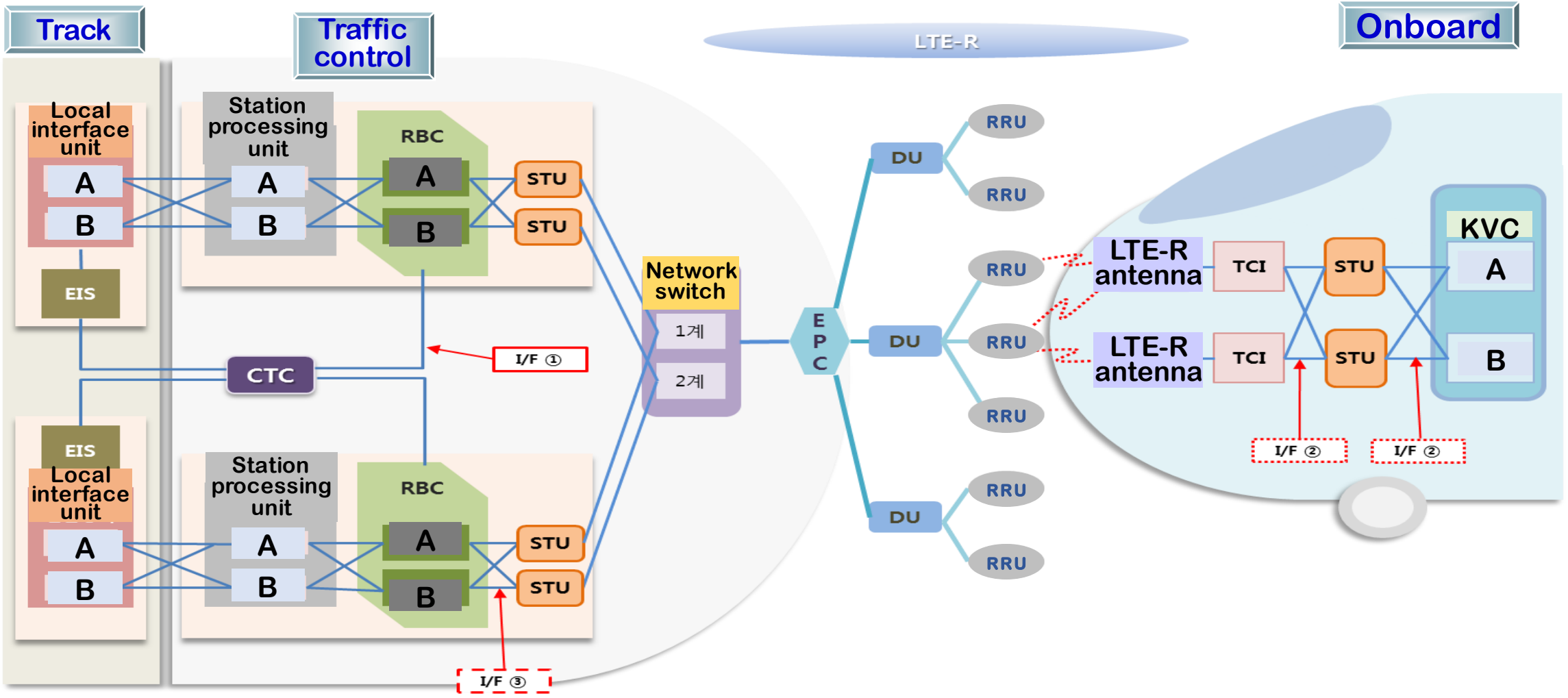
ETCS (European Train Control System)
Train protection system that continually checks train speeds to ensure compatibility with allowed speeds by signaling.
If not, ATP activates service brake to reduce speed or an emergency brake to bring the train to a stop.



II. Development of KTCS – KTCS technology



II. Development of KTCS – KTCS technology



II. Development of KTCS – Subsystem: Trackside

Trackside RBC transmits messages to train
by receiving trackside information from an interlocking.

LCD/KVM CONSOLE

- MAINTENANCE SERVER
- CHECKING CPU MODULE

LOG DATABASE SERVER

STORING LOG DB FROM ATP & OTHER EQUIPMENT

VITAL COMPUTER

2 OUT OF 3 SYSTEMS USING REDUNDANT OPERATION

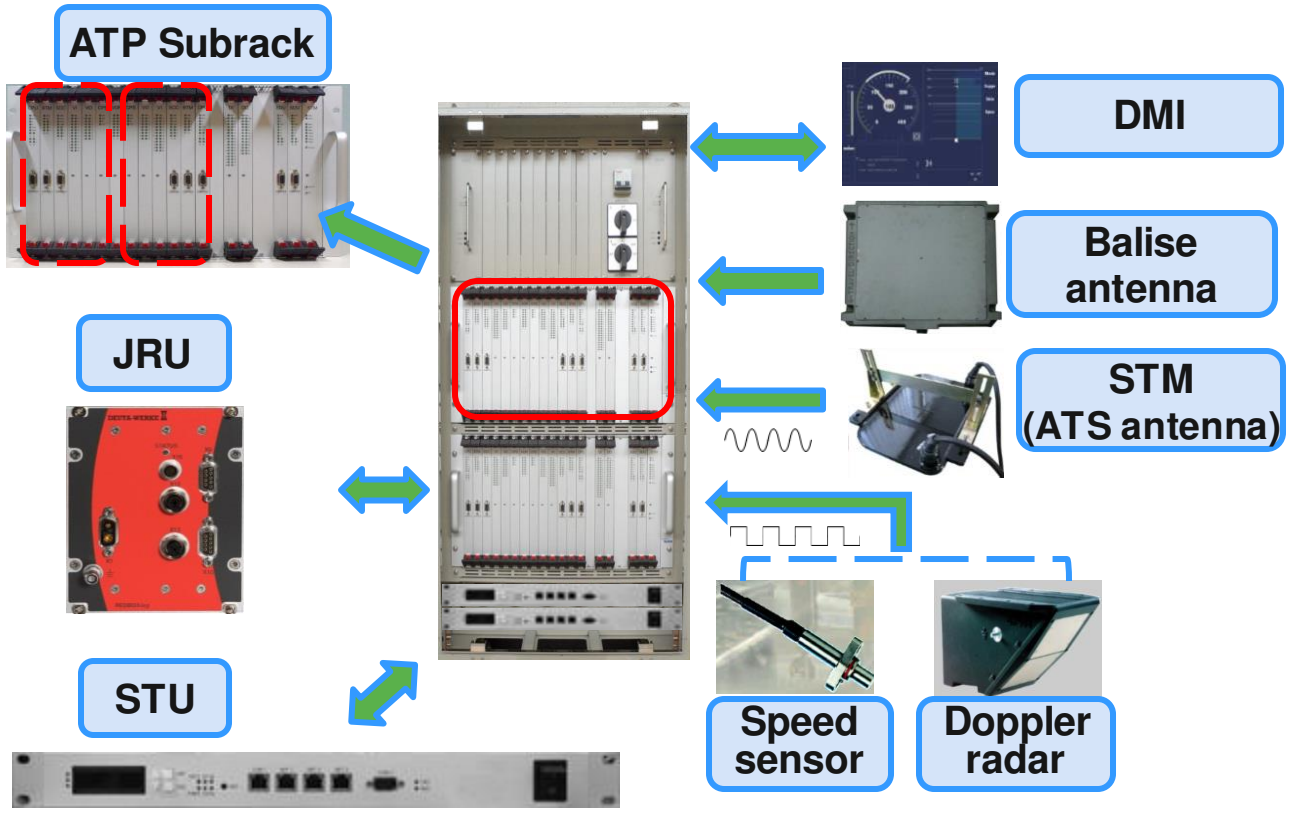
SAFETY TRANSMISSION UNIT

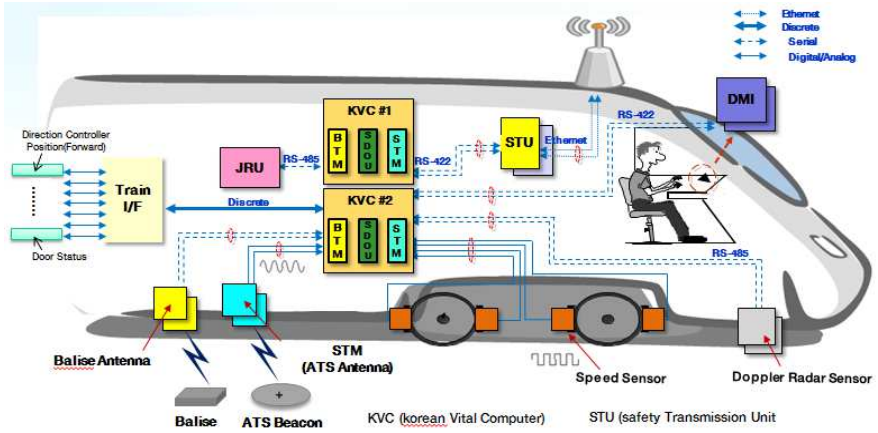
- INTERFACING ATP WITH OTHER EQUIPMENT

- Generate movement authority
- Send messages to moving trains
- Generate speed restriction profile
- Self-testing operation
- Stable operation in an emergent situation
- Registration of trains within RBC coverage
- Routes set by interlocking

II. Development of KTCS – Subsystem: Onboard

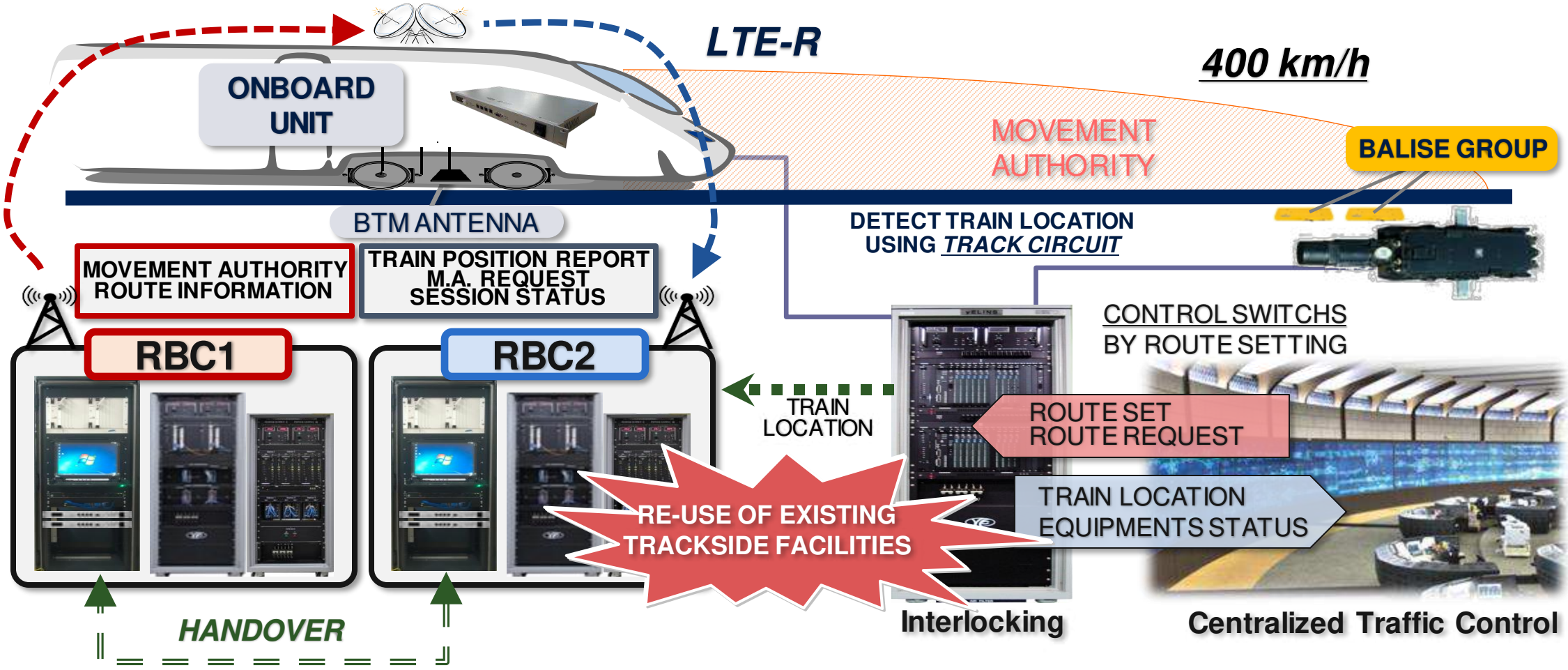
Onboard unit controls a train safely by using automatic train protection and receiving movement authority and temporary speed restrictions from trackside ATP.





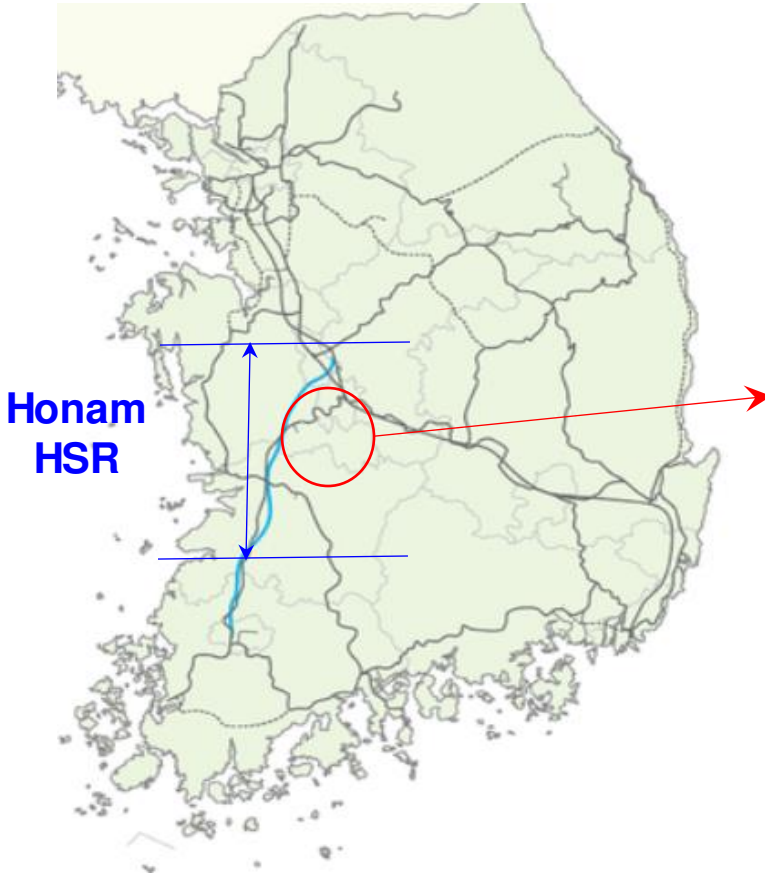
- 2 out of 2 full duplex structure
- Monolithic design for BTM, SDOU, STM
- Collect, store and retrieve vital train-borne information
- Encrypt/decrypt transmitted data using safety transmission unit

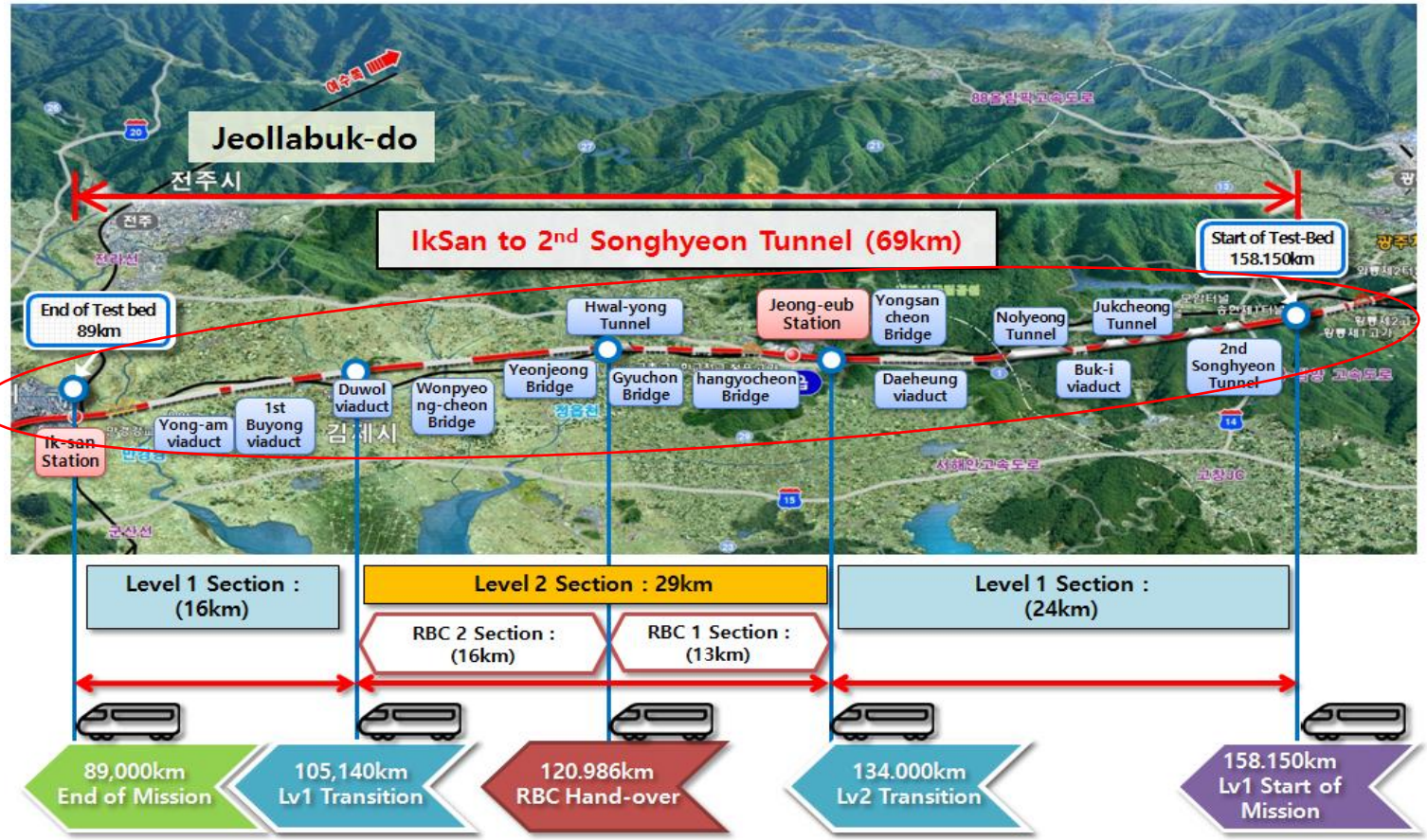
III. Test and Verification of KTCS – Overall system configuration



III. Test and Verification of KTCS – Field demonstration test

- Maximum 400 km/h acceleration test on 69-km Honam HSR testbed
- Performance test for level transitions, RBC handover, and movement authority





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Marrakech, 7-10 MARCH 2023

The RFI Computer-Based Interlocking Standard Platform

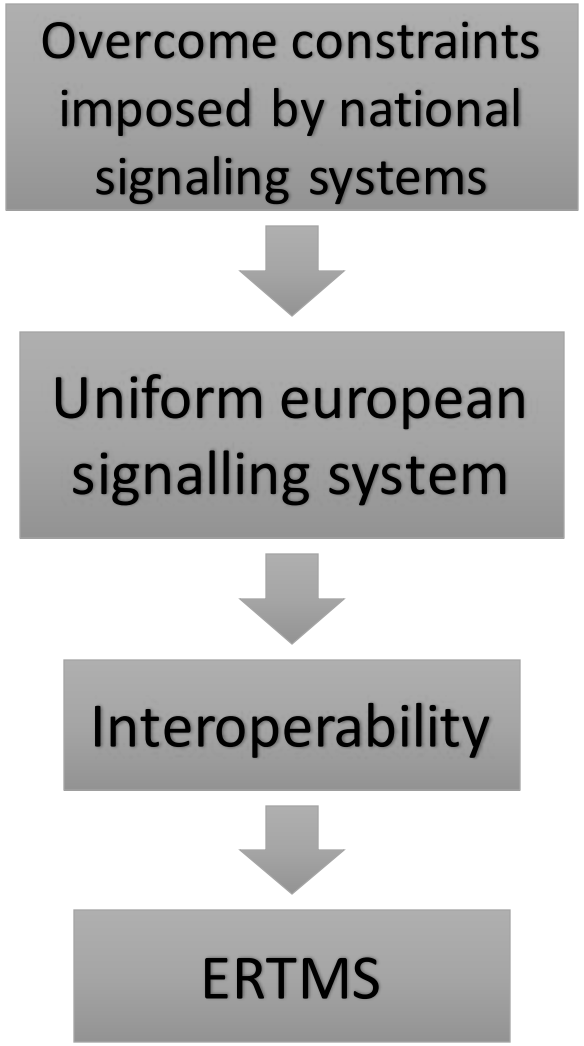
Sergio Repetto
Head Of System Development (Research & Development Dept.),
Rete Ferroviaria Italiana S.P.A.
Session1-3.1 Operational performance / Signalling and control

ONCF UIC

THE NEED OF A STANDARD CBI PLATFORM IN THE ITALIAN ERTMS PLAN

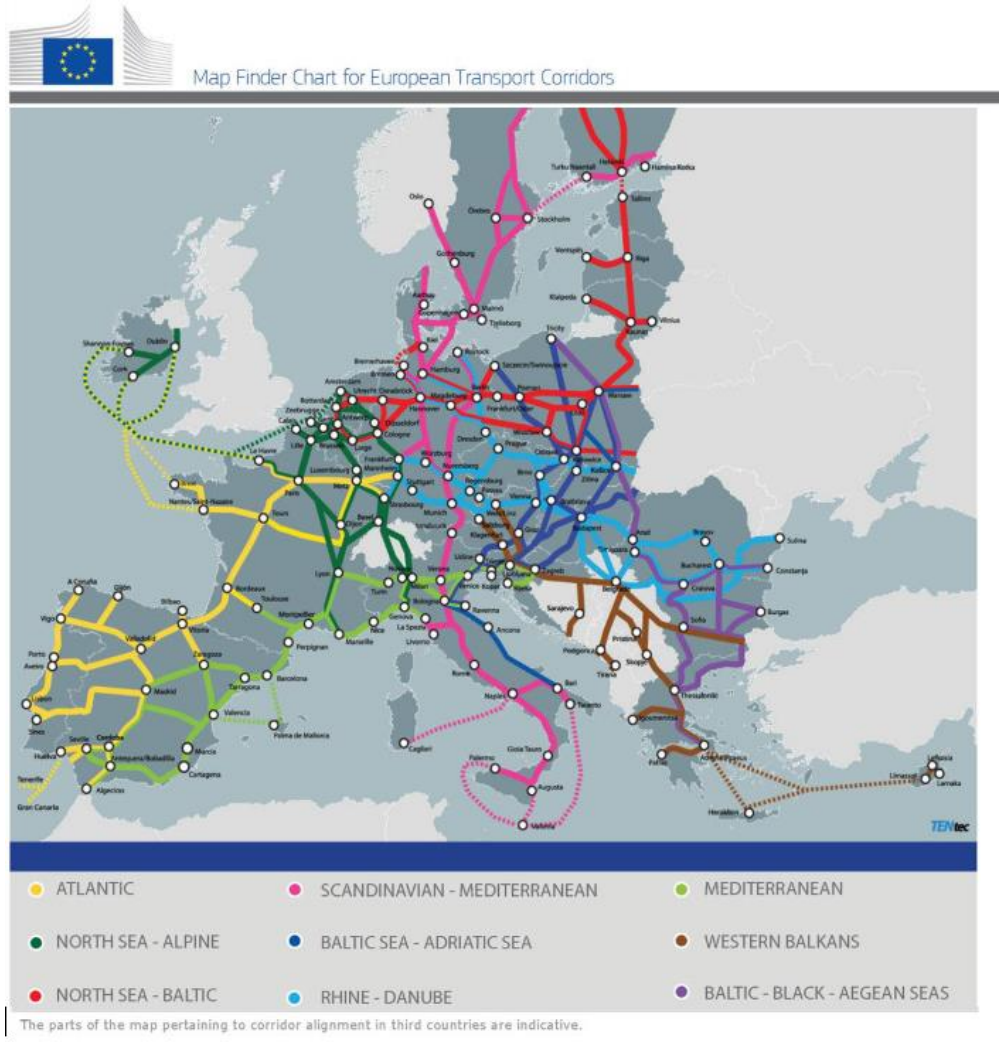
Classification	
Main lines	6.486 km
Complementary lines	9.396 km
Metropolitan lines	950 km
Infrastructure	
Double track lines	7.732 km
Single track lines	9.100 km
Typology	
High Speed lines	1.467 km
Conventional lines	15.365 km

THE NEED OF A STANDARD CBI PLATFORM IN THE ITALIAN ERTMS PLAN



- The experiences gained on the ERTMS system by the European Community Member States have allowed over the years the development and issue of increasingly detailed technical specifications for interoperability
- Interoperability grants greater sharing of transport policies and mobility management at European level
- Analysis carried out by Member States of the European Community to implement the ERTMS system for high-density rail transport at the metropolitan nodes and on the low-traffic line confirm the maturity and potential of the System
- **RFI has then set up an accelerated ERTMS deployment plan**

THE NEED OF A STANDARD CBI PLATFORM IN THE ITALIAN ERTMS PLAN



The RFI accelerated ERTMS deployment plan allows to cope with:

- EU commitment to develop a trans-european interoperable transport network
- Regulation evolution towards greater protection functions that can be implemented better, quicker and cheaper with ERTMS
- International research and development programs involving ERTMS (e.g. Shift2Rail, NTGC, FP7, etc.)
- Cooperation programs with other railways regarding the implementation of ERTMS (e.g. Memorandum of Understanding and Cooperation Agreement signed with SBB)
- Business opportunities: commercial and savings

Implementation of TEN-T Core is expected by **2030**
Extended Core by **2040** and Comprehensive net by **2050**

THE NEED OF A STANDARD CBI PLATFORM IN THE ITALIAN ERTMS PLAN

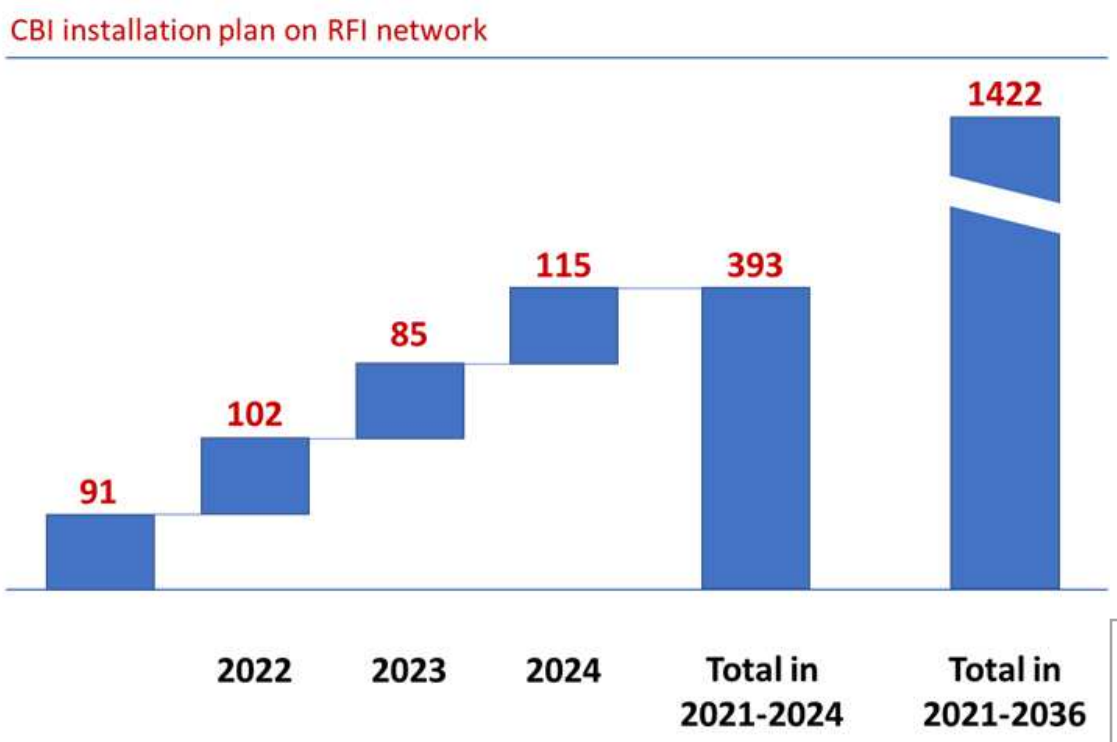
The RFI accelerated ERTMS deployment plan strategy

- Deploy ERTMS to all the Italian railway infrastructure (approximately 16,800 km) by **2036**
- Simultaneous disposal of the national systems
- Progressive and coherent equipment of trains with ERTMS on-board system (over 5000 circulating)
- Provide the necessary resources through different funding sources (CEF, structural funds, national funds, private funds…)

The plan optimizes the implementation of the ERTMS system on the railway network by

- Replacing **all** legacy relay-based signalling systems with Computer Based Interlocking (CBI)
- Reconfigure existing Computer Based Interlocking systems

THE NEED OF A STANDARD CBI PLATFORM IN THE ITALIAN ERTMS PLAN



- The RFI accelerated ERTMS deployment plan foresees to commission about **100** new CBIs per year from **2025** to **2036**
- At end of 2022 the number of CBIs in operation in the RFI network is about 400
- CBIs are supplied by 5 different manufacturers each one having supplied a number of CBIs from 20 to 150

- High total cost of ownership of CBI systems for **maintenance** and **update** due to lack of homogeneity of the technologies

RFI STANDARD CBI PLATFORM – CHALLENGES AND OPPORTUNITIES

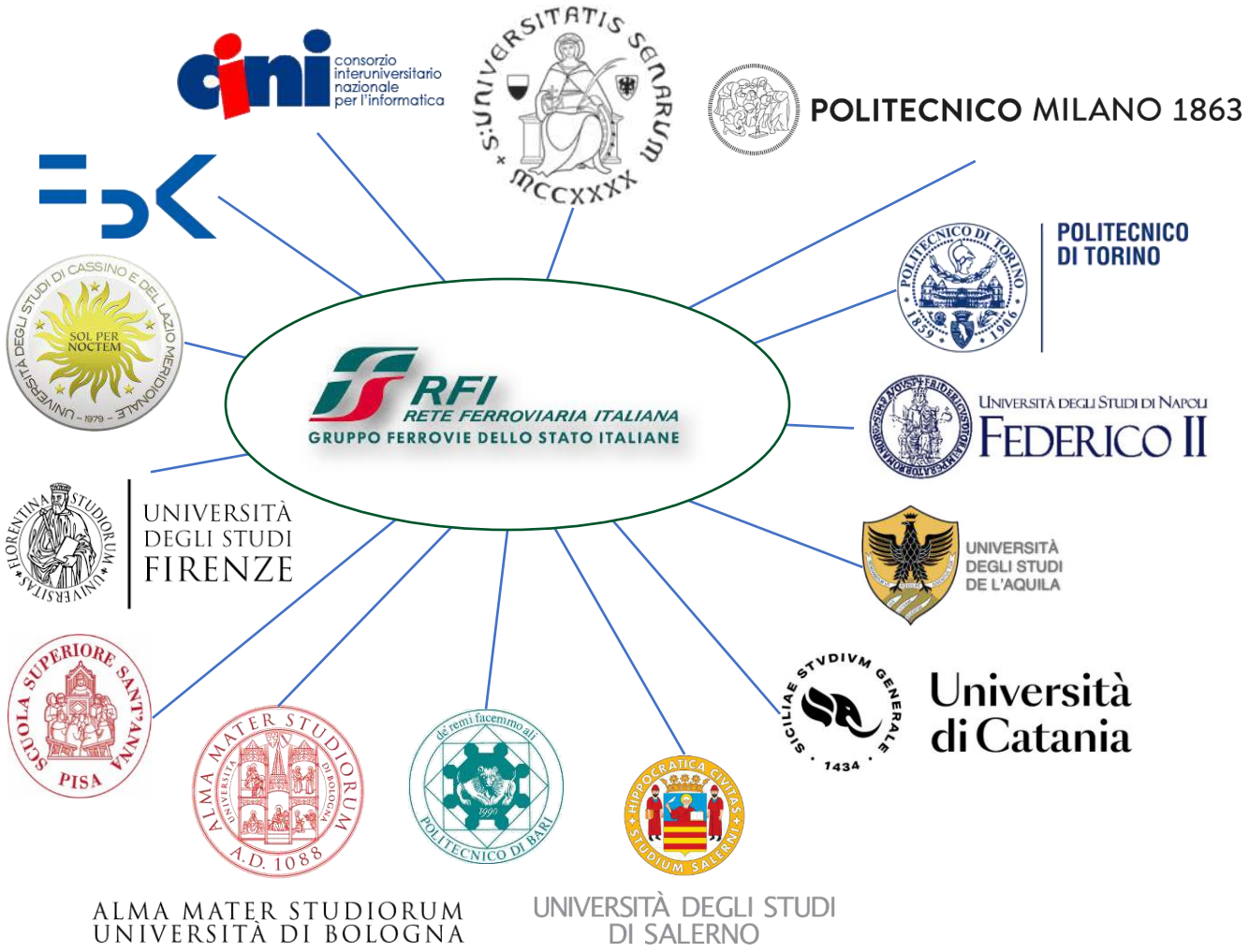
MAIN CHALLENGES

- Deliver the RFI standard CBI platform for revenue service by **2024**
- Start the roll-out of systems based on the new platform by **2025**
- Build an internal R&D design and development organization to meet the deadlines

OPPORTUNITIES

- Delivery of a state-of-the-art hardware and software platform, exploiting innovative principles to implement system safety and security requirements
- Full intellectual property of the CBI platform
- Platform designed internally meets end user requirements
- Easy to use for the application design, installation, upgrade and maintenance
- RFI – through R&D engineers involved in the CBI development – RFI will have full governance of interlocking technologies

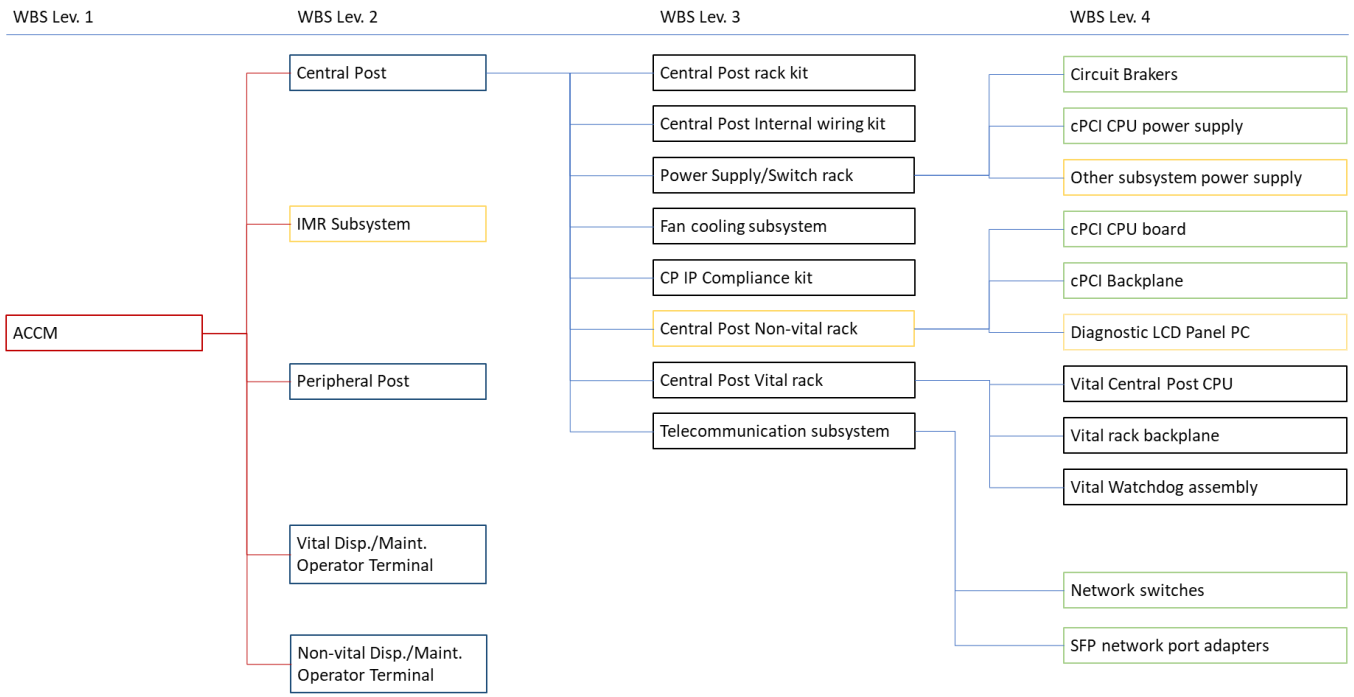
RFI STANDARD CBI PLATFORM – ORGANIZATION STRATEGY



- A dedicated team for CBI HW and SW design created in RFI R&D Department in 2018
- Standard CBI Platform project start in early 2019
- Technical lead, system architecture design and integration in charge of RFI R&D Department
- Involvement of the prominent Italian Research Institutions
- The project leveraged on an already existing network of the Italian centers of research excellence in railway technologies and on Research Framework Agreement with 24 Research Institutes

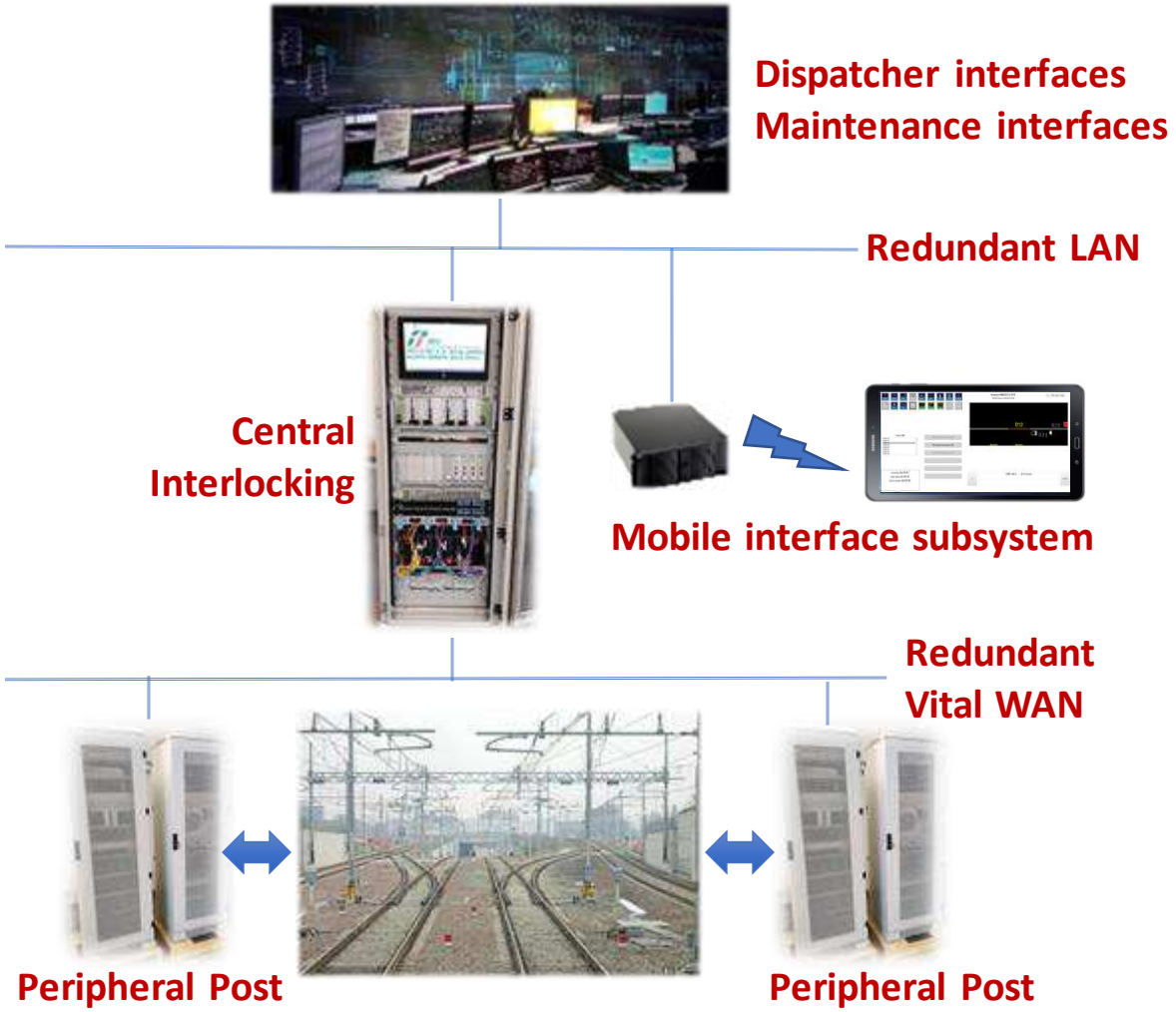
RFI STANDARD CBI PLATFORM – DESIGN STRATEGY

The CBI platform architecture design has been carried out by a bottom–up approach, leveraging on the RFI internal competences of engineers involved in CBI installation operation and maintenance



- CBI architecture breakdown structure definition
- Development activity breakdown definition
- Issue of requirement specifications
- HW/SW development assigned to Research Institutes on the basis of specific competences
- Research Institutes are delivering TRL5 demonstrators of CBI HW/SW components
- Component integration and engineering performed by RFI R&D

RFI STANDARD CBI PLATFORM – ARCHITECTURE



- Central Interlocking Unit based on state-of-the-art technologies: Xilinx UltraScale+ and Intel 9th-gen core
- Peripheral Posts provide reduced size fully redundant field device controllers with minimized wiring
- Use of open networks, using COTS equipment
- Use of standard protocols for subsystem connection
- Data encryption/decryption via hardware acceleration
- Fail-safe remote operator interface, connected through wireless cellular network
- model-driven approach for safety logic development and Data Preparation Process

RFI STANDARD CBI PLATFORM – FIGURES AND ACHIEVEMENTS

- The introduction of the standard platform along with the ERTMS-Level 2 program implementation, will provide a uniform operation on the overall network, being it high-speed or conventional, simplifying network management and increasing service level on the overall infrastructure
- A benefit/cost analysis performed by an international business consulting company stated that the cost reduction of the interlocking upgrade programme, due to the introduction of the RFI Standard CBI Platform is estimated to be around 35%, as a lower bound, in a CBI lifecycle of 20 years:
  - Interlocking Building: 20%
  - Upgrade / update: 45%
  - Maintenance: 35%
- RFI will own the full intellectual property of the Standard Platform
- Standardization will increase the supplier competition and expand the market as suppliers will be allowed to build interlocking systems using the RFI project.

THANK YOU

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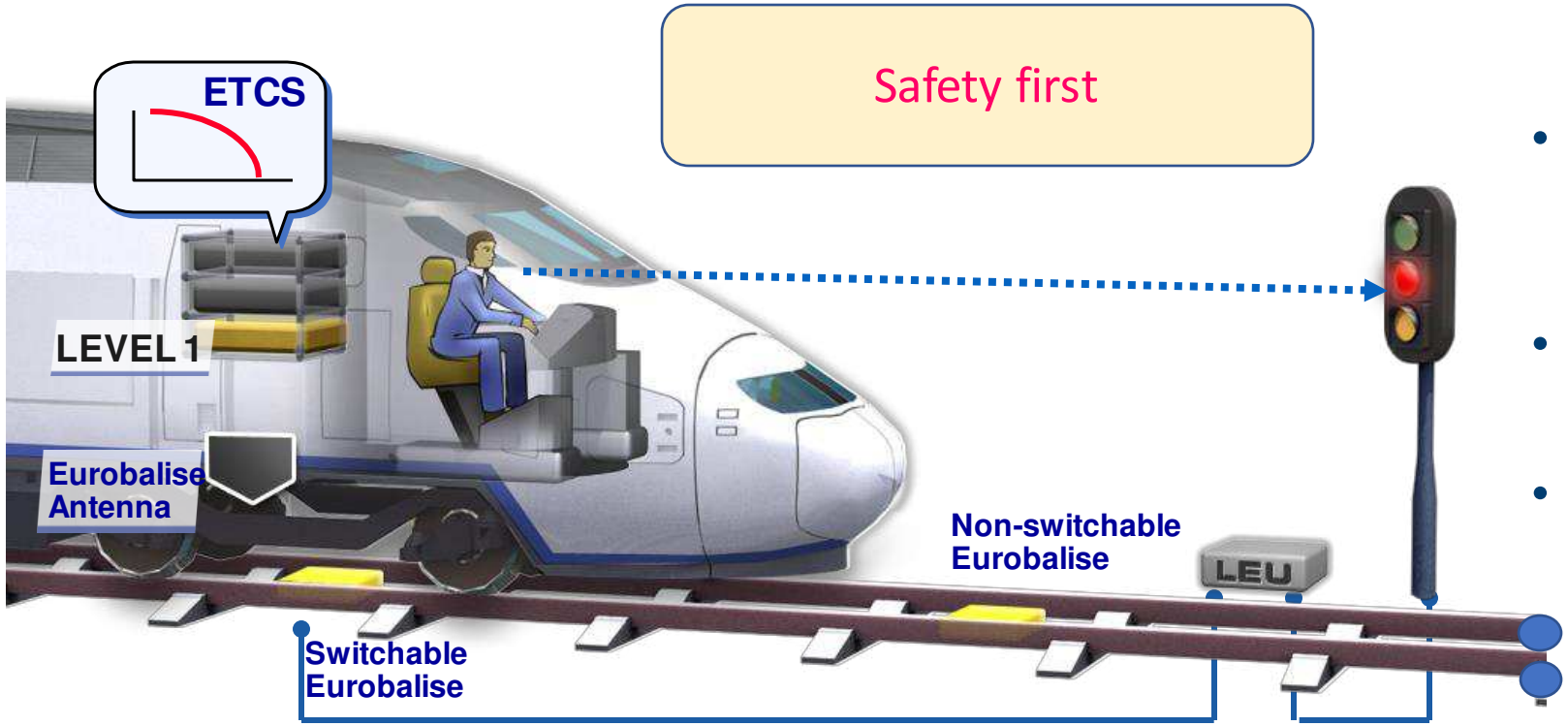
Marrakech, 7-10 MARCH 2023

SIGNALLING FOR HIGH-SPEED TRAIN
How ETCS continues to support High-Speed Network through Hybrid Level 3 technology

Thomas DENIS
Mainline Wayside Segment Director, Alstom
Session1-3.1 Operational performance/ signaling and control

ONCF UIC

Driving under ETCS Level 1



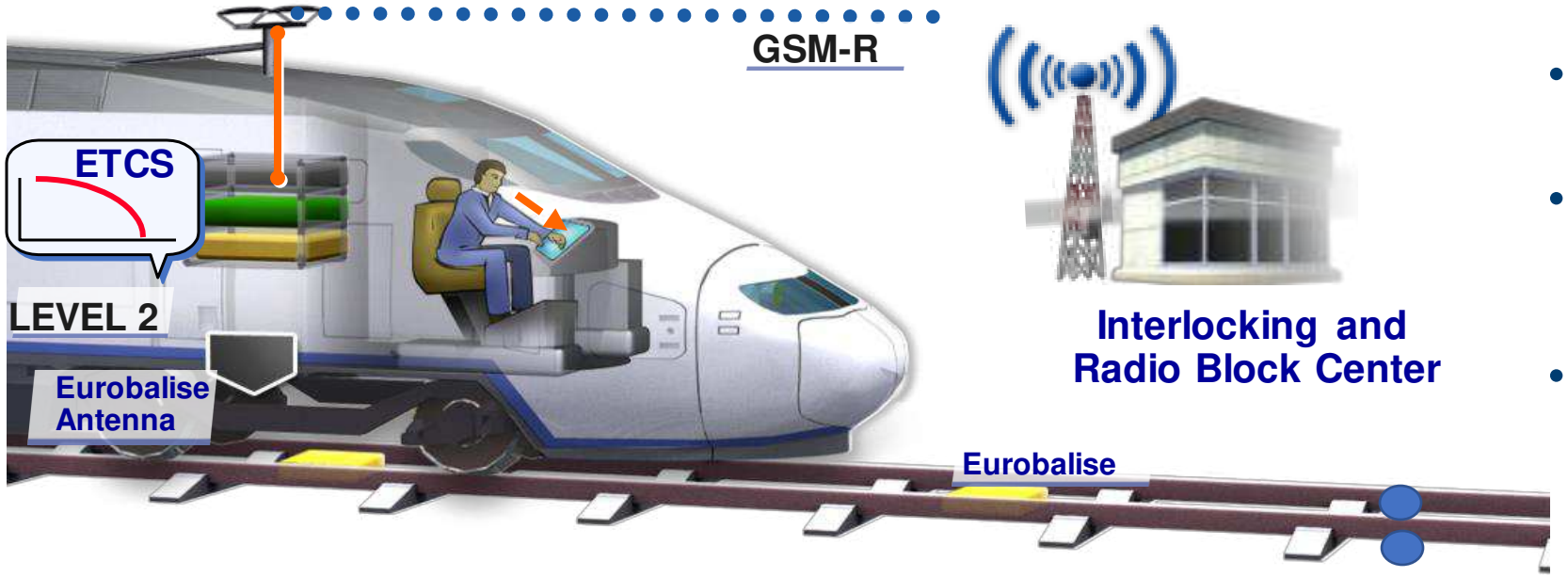
- Overlaid on existing signalling, adding Automatic Train Protection
- **Movement authority through Lineside Encoder Units (LEU) & Eurobalises**
- Laterals signals usually maintained
- Traditional detection devices (track circuits or axle counters)

Track vacation proving device

Lineside signals information transmitted on driver's panel by means of coders and balises
Train behaviour monitored in real time «not too far nor too fast»

Driving under ETCS Level 2

Performance increase (capacity and speed)



- **Continuous Radio Communications between trains and RBC is performed through radio (GSM-R)**
- **Laterals signals no longer required**
- Traditional detection devices (track circuits or axle counters)
- Only fixed balises, for reference purpose

Lineside signals information transmitted on driver's panel by centralised radio
Train behaviour monitored in real time «not too far nor too fast»

Driving under ETCS Level 3

Performance increase
Infrastructure cost reduced

- **Train integrity and position provided by the train**
- **Laterals signals, track circuits and axle counters no longer required**
- Only fixed balises, for reference purpose

Lineside signals information transmitted on driver's panel by centralised radio
Train behaviour monitored in real time «not too far nor too fast»

Hybrid Level 3 principle

- **Train integrity and localisation performed by trains**
- virtual and adaptive block
  - reduced infrastructure (no trackside detection devices required)
  - Improved performance (dynamic sub-sectioning)

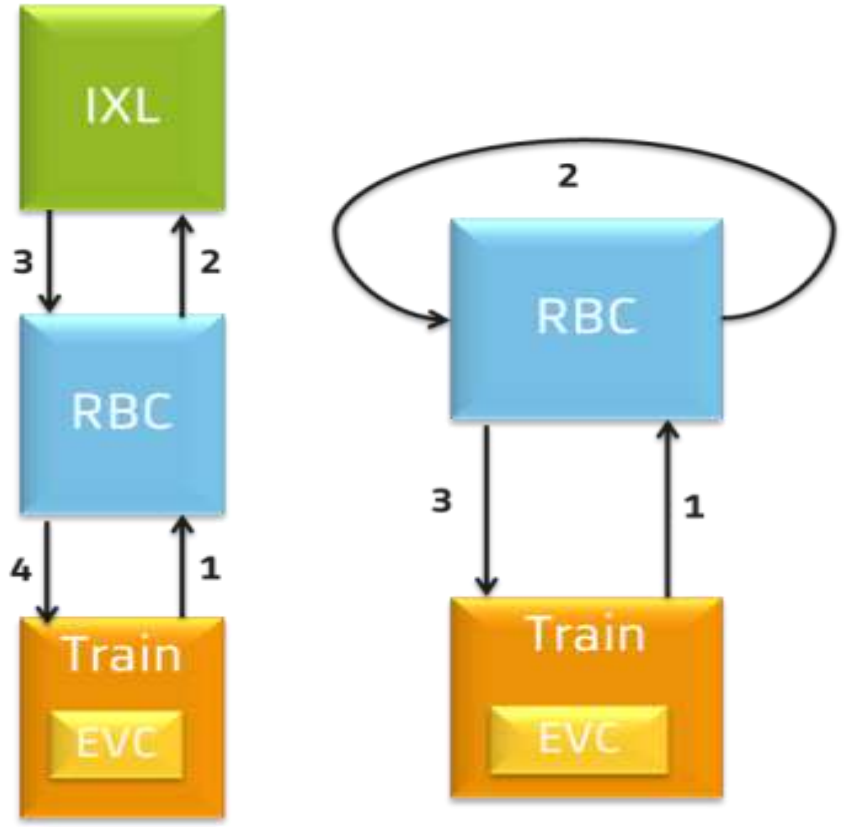
1. Train reports its position and integrity to the RBC

IXL is kept for route locking:

1. RBC established virtual block occupation and forwards train position as block occupation to the IXL;
2. IXL uses block occupation information from RBC rather than from IXL to know the track occupation status. IXL locks routes as in conventional L2;

Hybrid L3:

1. Based on the virtual block occupation, the RBC loops on itself to autolock the routes
2. Based on the locked route, the RBC sends MA's to the corresponding trains, as for conventional L2



Hybrid ETCS Level 3: The digital train signalling of the future, today

Add Virtual Sub Sections to Trackside Vacancy Detected section

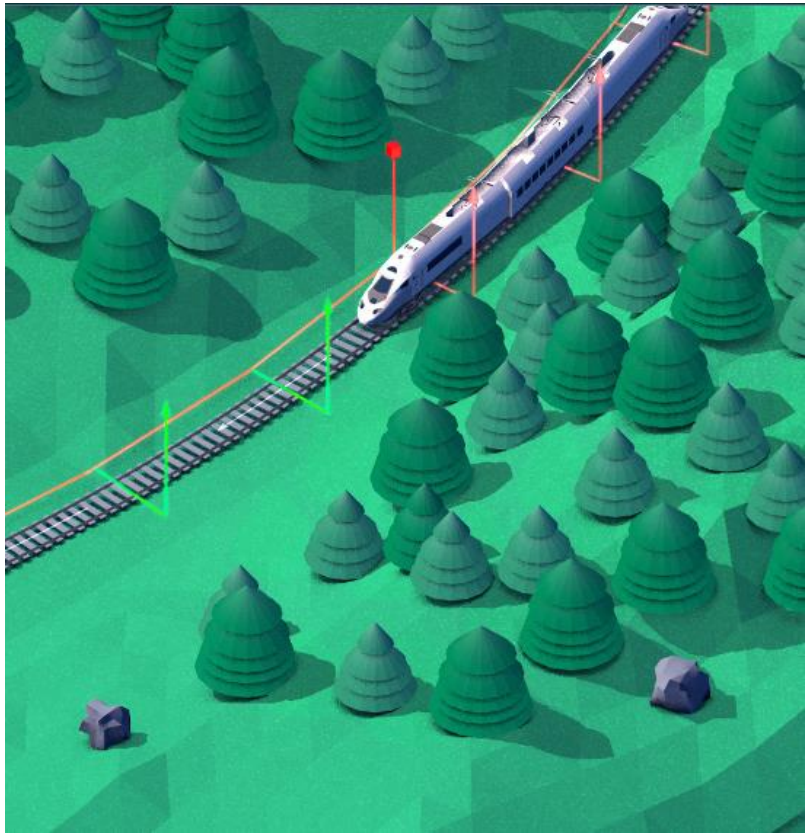
Combines ERTMS Level 2 with flexibility of Level 3

Advantages for low to high density networks

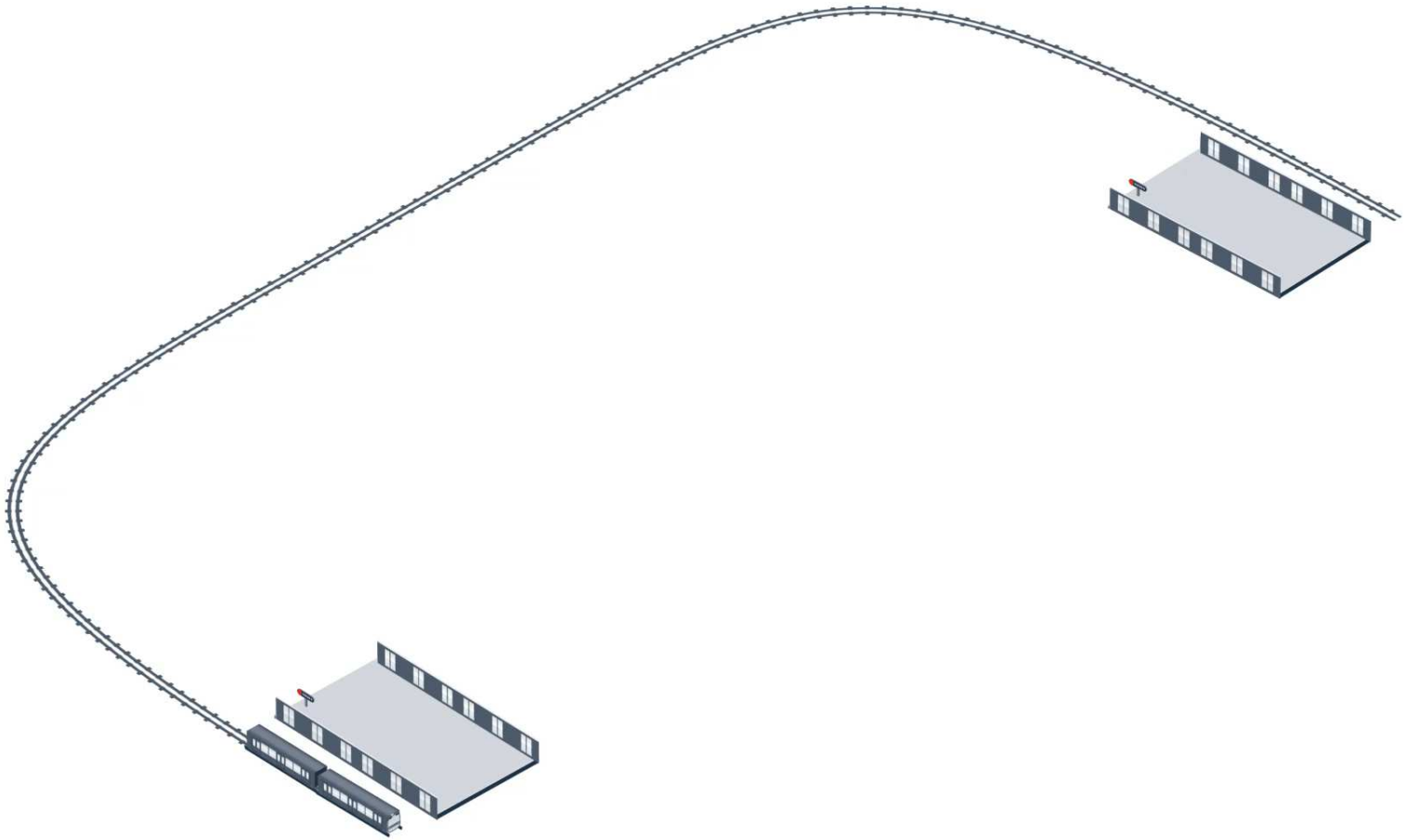
- Increase railway capacity to shorter headways,
- Improve network reliability and availability,
- Reduce investment & maintenance (less equipment, construction and maintenance costs),

Easy migration, with non-homogeneous on-board ETCS fitting (trains with or without Train Integrity - TIMS),

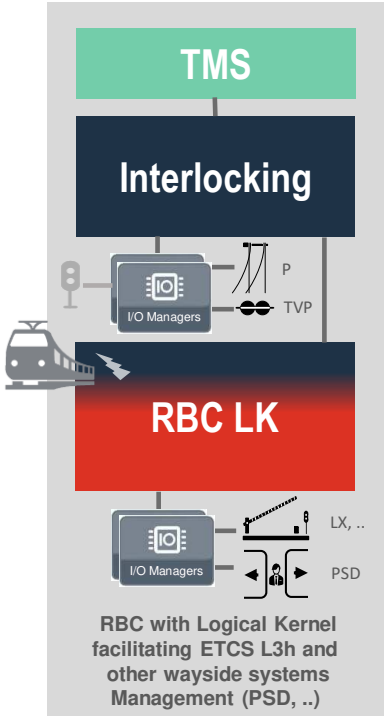
Available today, mature, as per EEIG ERTMS Users Group “Principles - Hybrid ERTMS/ETCS Level 3” Ref. 16E042



The advantages of the ETCS L3 in a realistic migration path and in forehand of future EU Rail standards



Hybrid ETCS Level 3 in Alstom



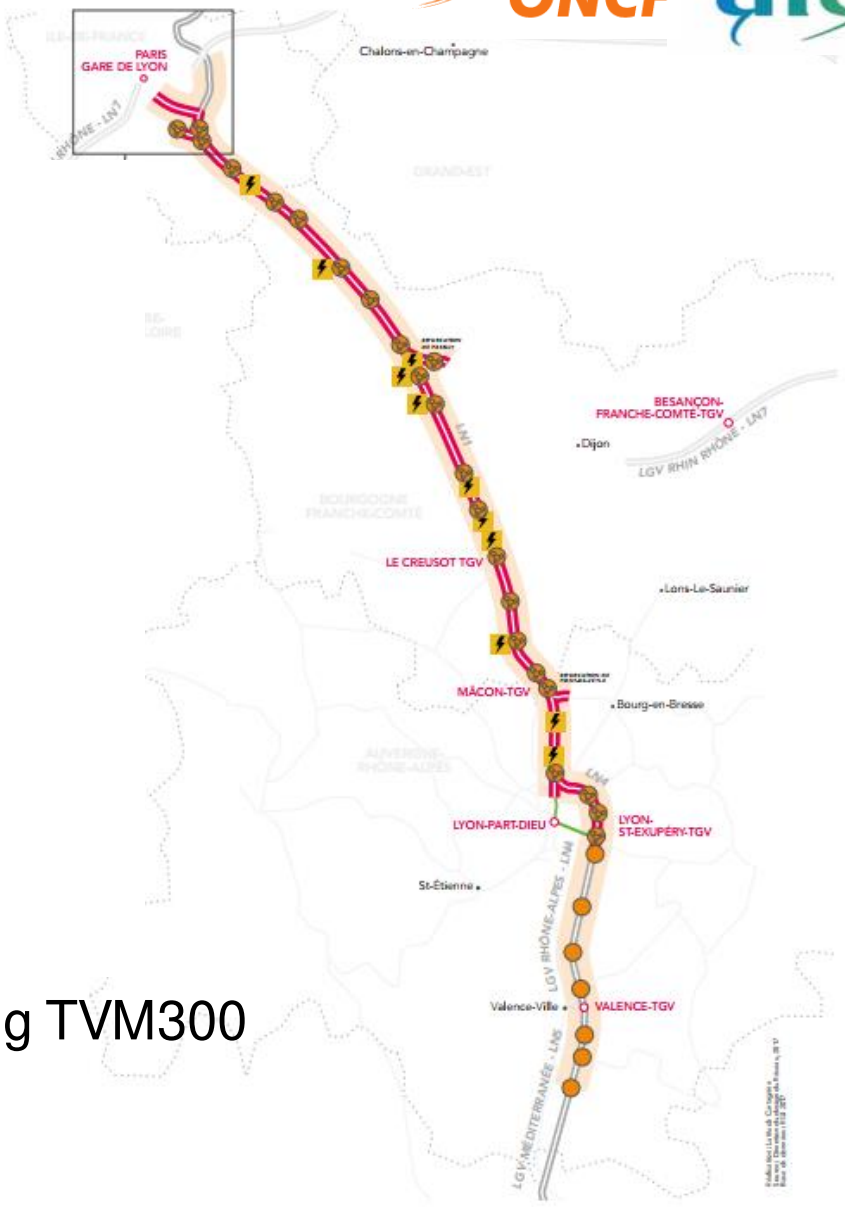
Railway line in ETCS Level 2 or Hybrid L3

- ATLAS RBC embeds all functions to manage EUG Principles for Hybrid ERTMS/ETCS Level 3 (Ref. 16E042)
- Allows customization of Hybrid Level 3 to country's specific ETCS principles and operating specificities
- RBC's Hybrid ETCS Level 3 functional package customisation by parameters and Boolean Logic
- RBC Logical Kernel (LK) cancels complexity of Hybrid Level 3 in the Interlocking design

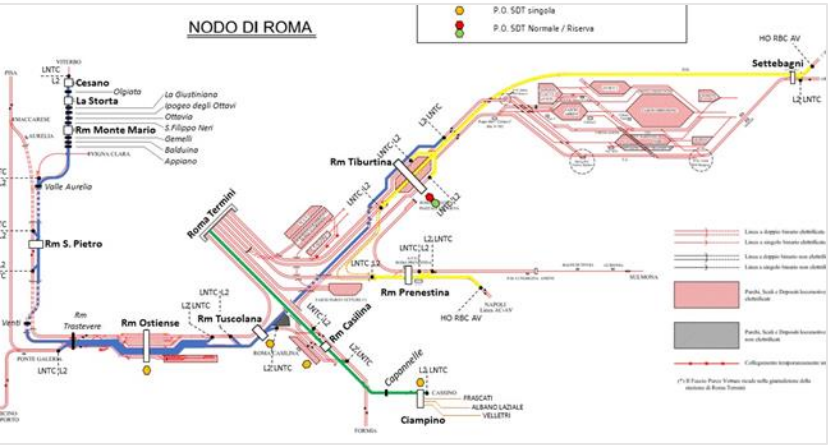
Effectiveness and Efficiency in Deploying Hybrid ETCS Level 3
Could be deployed in step-up to ETCS Level 2

France Paris Lyon HSL / ETCS2 Project : Main characteris

- Line to be equipped with ETCS L2:
  - Zones:
    - HSL1 (Paris-Lyon)
    - Interconnexion IdF
    - Lyon Nord bypass line
    - HSL4 (Lyon-Valence - option)
  - Length: 483 km
  - 50M passengers / year
  - 1st European HSL corridor
- Performances :
  - 16 trains/hour (+3) at 300 km/h
  - 150 simultaneous train movements
- ATC/IXL sub-systems specifics:
  - IXL : upgrade RRI ➔ CBI
  - ATC : ETCS L2 (prepared for Hybrid L3) on top of existing TVM300
  - ATC : Subset BL3.6.0 R2 (GPRS)



Alstom ERTMS Hybrid Level 3 reference projects



NCRTC - in execution

- Delhi Rapid Transit System – **Hybrid Level 3** solution with **ATO over ETCS** and LTE & WiFi telecommunication system on 82km section Delhi – Ghaziabad – Meerut Regional Rapid Transit System Corridor

Roma High-Density Nodes - in execution

- Update of existing national signalling system (with lateral signals) to **Hybrid Level 3** solution on 56km of line of Rome Node. The new signalling system (based on Alstom TMS, RBC and IXL) will be overlayed to the existing one for interoperability with the old fleet

Paris-Lyon High-Speed - in execution

- Design, equipment supply, installation, testing, and maintenance of ETCS Level 2 solution on 480 km of high-speed line allowing movement of trains in Hybrid Level 3. Revenue services will commence in 2024. From 2025, 14 trains will be able to operate in each direction during peak hours, then, following additional infrastructure work, 16 trains by 2030 compared to 13 at present

THANK YOU

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Huawei FRMCS, Facilitates Railway Digital Transformation

Jiawei LIANG
Wireless Solution Director, Huawei, China
Session 3.1 Operations Operational performance/Signalling and control

ONCF UIC HUAWEI

ICT is Accelerating Railway Digital Transformation

2021 European Railway Year

- Increase railway capacity, speed-up green and carbon-neutral target achievement
- Double passenger transport by 2030, double freight transport by 2050

China Railway Development Outline

- Build world-class railway infrastructure and technical equipment
- Achieve 200k kilo railway line by 2035

ICT Accelerating Railway Digital Transformation

- Next Generation EU and China New Infrastructure Construction both put railway digital investment in high priority, ICT can speed up the digital transformation.
- Key ICT techs also in evolution procedure, such as GSM-R migration to **FRMCS**, fixed-line migration to IP and fiber.

Larger Capacity

- Support high speed train to **500km/h**
- Shorten train headways
- Support Multi-locomotives freight train,
- Support ATO and ATP

Efficient O&M

- Real-time On-board video backhaul
- On-board data transmission to support predicative maintenance.
- Massive track-side devices status detection

Better Experience

- Journey Information broadcast in real-time
- High speed internet connection
- On-line ticket booking, shopping

Construct Wireless Foundation for Smart Railway

Perception	Connectivity	Transmission
All-weather, multi-dimension, and all-domain sensing	Low latency and all-domain connectivity	All-scenario transmission capacity
Video + IOT	**FRMCS**	Broadband Capability

GSM-R is Facing Obsolescence, Constraining the Innovation of the Digital Railway

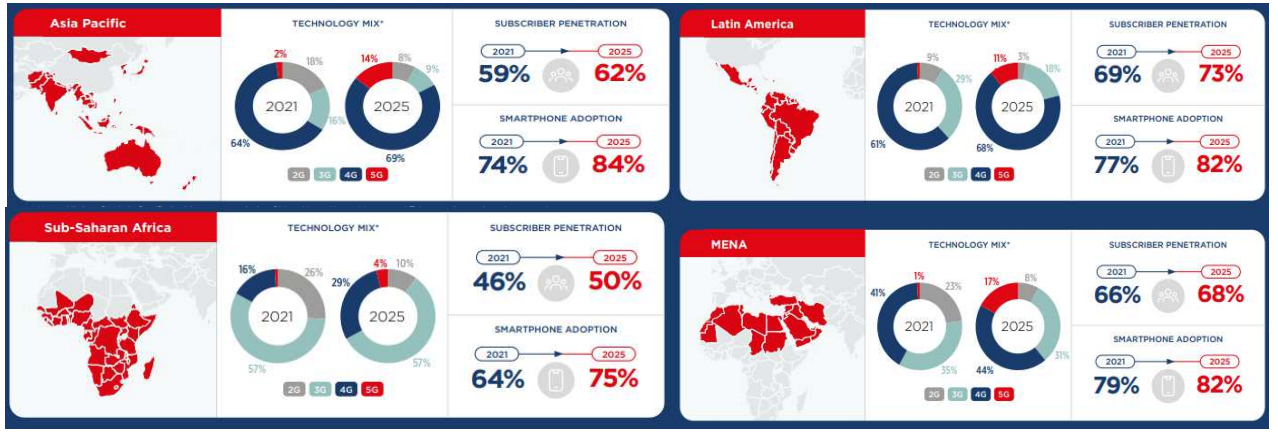
GSM-R

- Limited Capability
- Complex Architecture
- Declining Ecosystem
- Costly Migration

GSM: **8%** by 2025

VS

LTE: **69%** by 2025
5G: **14%** by 2025



** Source <GSMA>*

4G/5G, and Beyond

- Long Term Evolution, Future Proof
- Cloud-native, Decoupled Architecture
- A Mature and Growing Ecosystem
- Cost-efficient with Reused Assets

Huawei Future-proof 4G towards 5G, the Path for Digital Railway Innovation

GSM-R

Reliability

99.99%

Complex architecture

Efficiency

350~400km/h

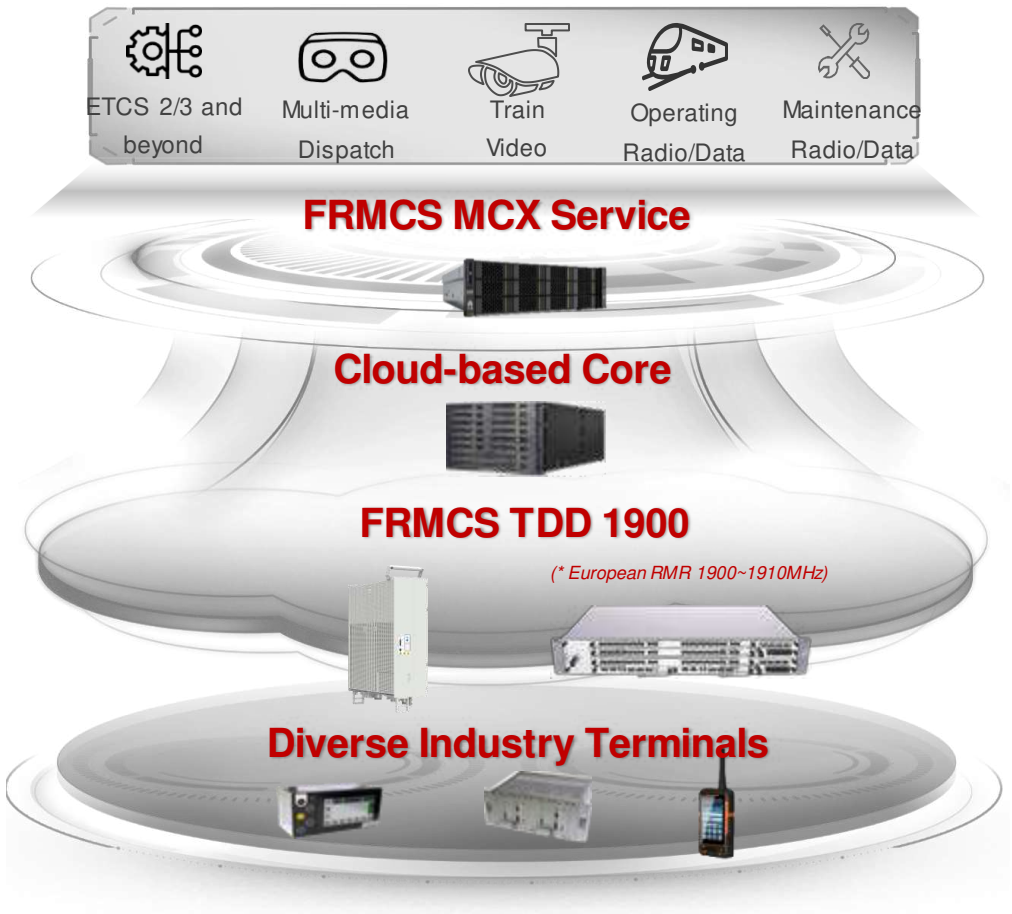
Fixed Block

Experience

9.6Kbps

Low data rate
Text and small size data only

Huawei FRMCS Solution



Huawei FRMCS

Reliability

▲ **99.999%**

Cloud-based / Decoupled architecture

Efficiency

▲ **500km/h**

Moving block / Virtual Coupling, Shorter Train Headway

Experience

▲ **> 20Mbps**

PIS, On-board CCTV, Trackside IOT

Railway Wireless Communication Standard leading to FRMCS

1994 GSM-R research launch → 1999 GSM-R First implement → ETSI standard → Ecosystem Declining

- 2G Technology
- Voice and circuit-based small data
- Standard for European (ETSI)
- Complex architecture
- Expensive dedicate hardware

No Direct Path to FRMCS

Software upgrade

2012 FRMCS research launch → 3GPP/ETSI standard → FRMCS EU Standard

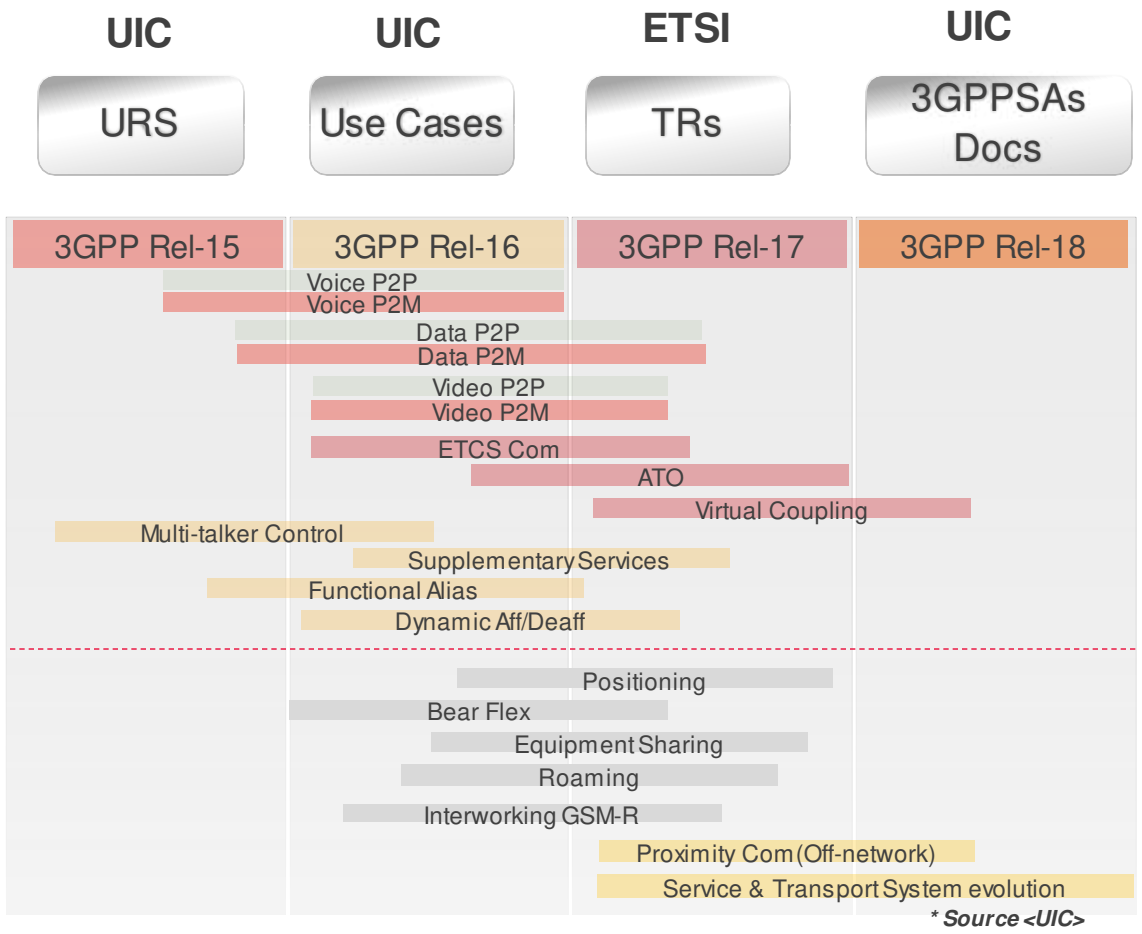
- 4G and Beyond Technology
- broadband services capacity
- Facing global industry (UIC/3GPP)
- Decouple architecture
- Cloud-based
- General platform

- China, 2015, LTE
- Korean, 2017, LTE
- India / Australia, 2022, LTE
- Mozambique, 2022, LTE
- Malaysia, 2022, LTE

- EU: Plan to launch 5G from 2025，1.9GHz & R900MHz
- China: 4G 1.8GHz and 5G 2.1GHz for railway

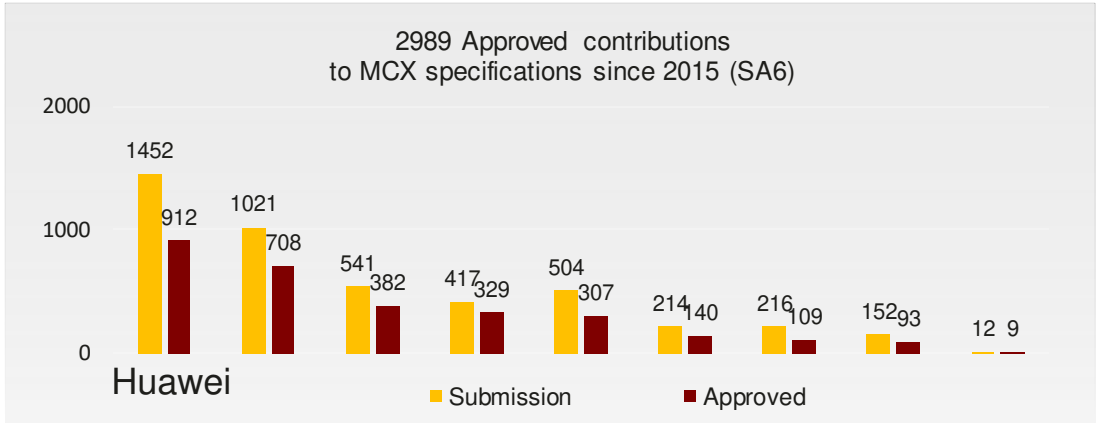
FUTURE
RAILWAY
MOBILE
COMMUNICATION
SYSTEM

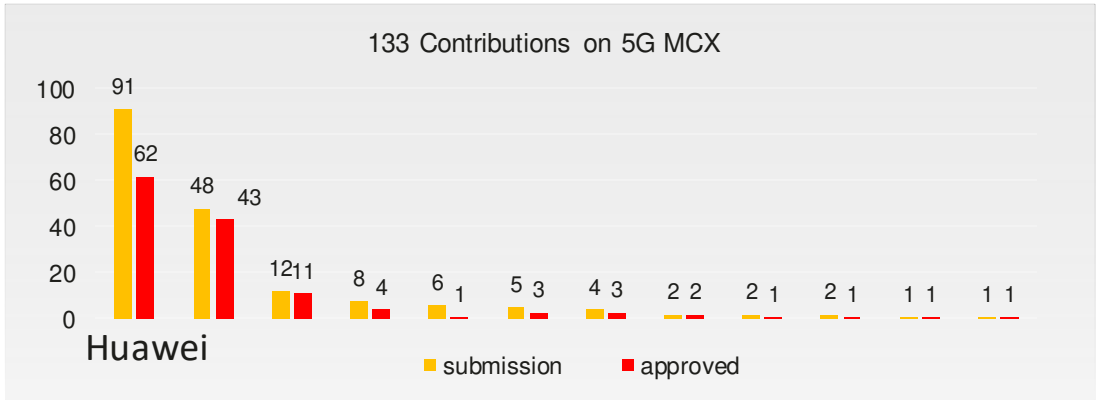
FRMCS Standard Progress and Contribution of Huawei



Maximize MCX Functions in 3GPP Release 16&17

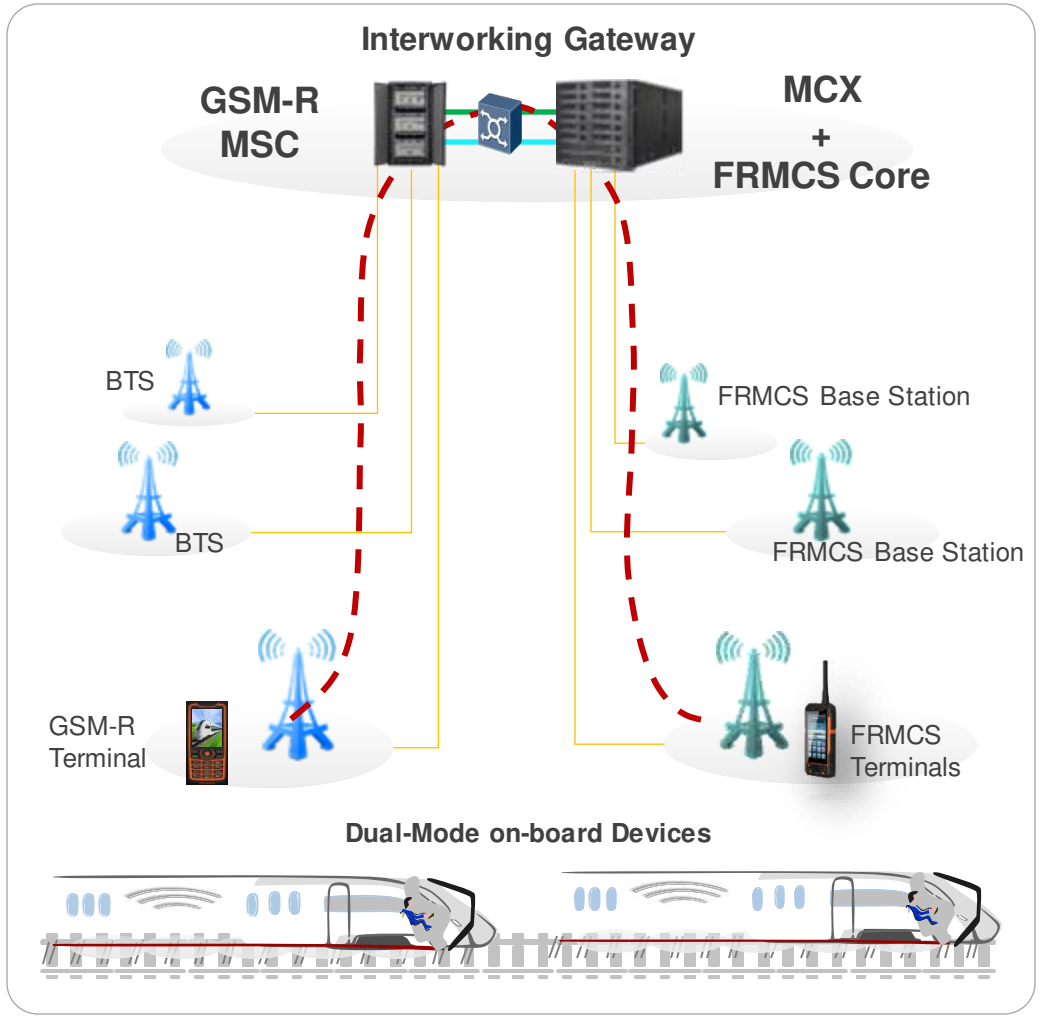
Standard Contributions at-a-Glance



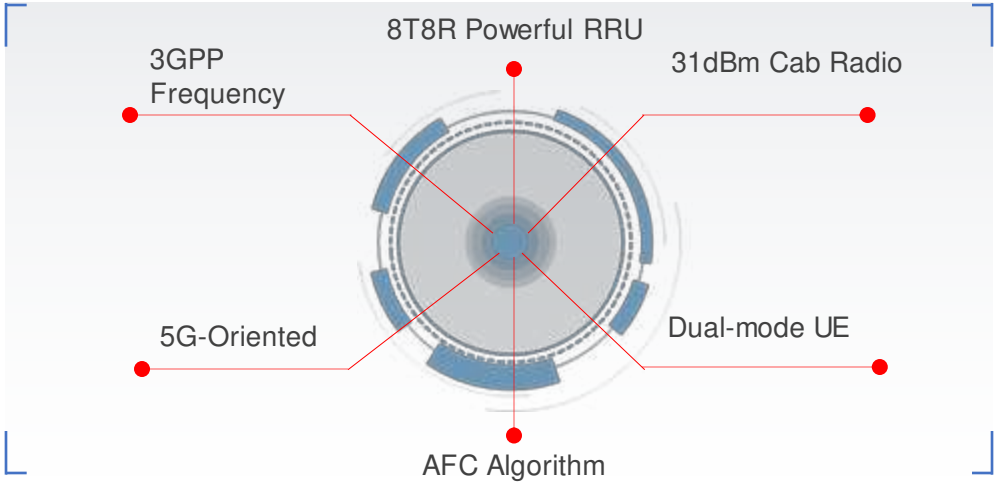


Huawei is the leading contributor

Huawei FRMCS, a Solution for Now and Future

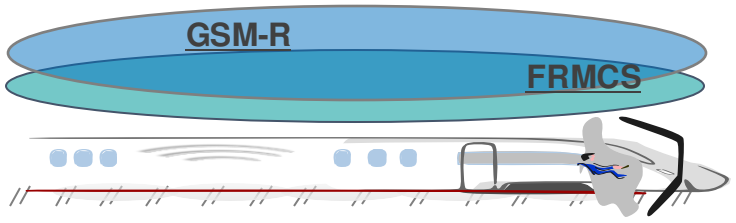


6
Capability

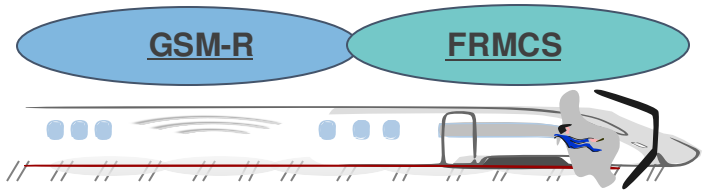


2
Solutions

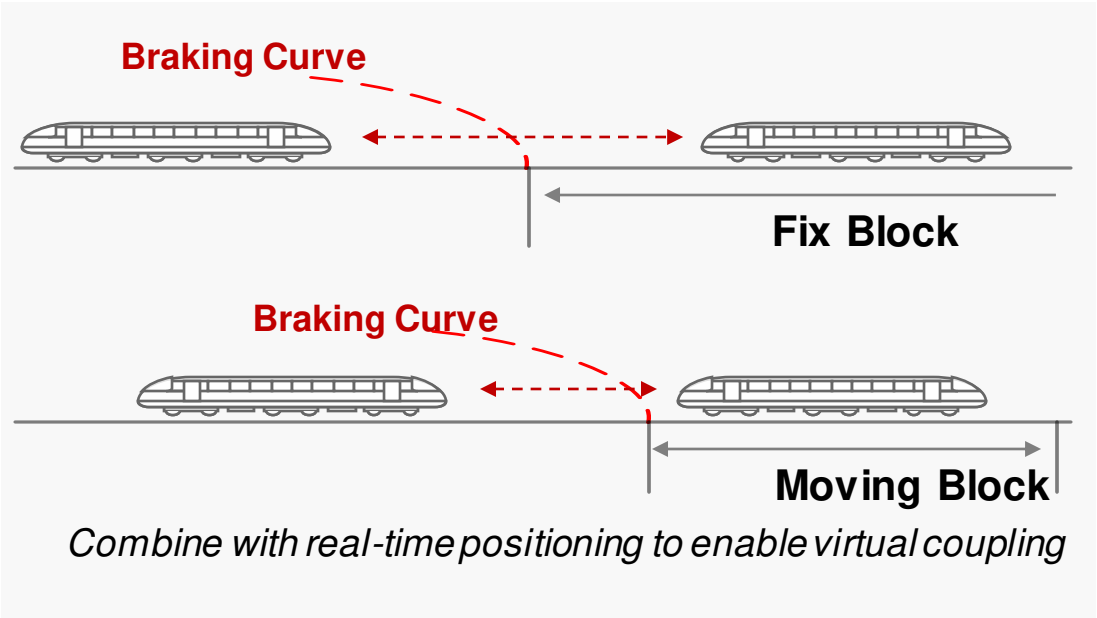
GSM-R/FRMCS Overlapping



GSM-R/FRMCS Interworking



Huawei FRMCS, Realizing Digital High Speed Railway to Improve Safety and Efficiency



Combine with real-time positioning to enable virtual coupling

Reliable connections for Critical Data

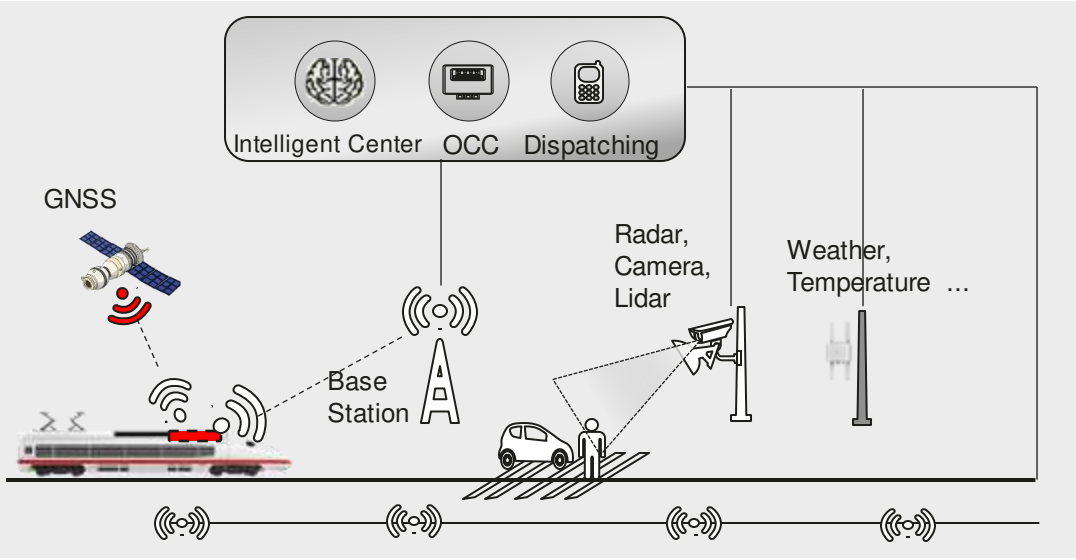
- Moving block reducing railway occupation size
- Virtual coupling increasing operation efficiency
- Automated shunting, marshalling and train operation
- Precise and real-time positioning

All – in – One Voice / Video Dispatching

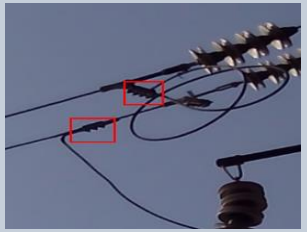
- Visualized operation
- Real-time steering and control of trains
- Smart infrastructure
- Efficient maintenance with precise digital map

Huawei FRMCS, Forging an Future Intelligence Railways with Industry Partners

Smart Management	Intrusion Perception	Precise Positioning	Status Detection
➢ Management Visualization ➢ Real-time response ➢ Prediction maintenance	➢ Human intrusion ➢ Rock intrusion ➢ Animal intrusion	➢ GNSS + Cellular positioning ➢ Digital Map	➢ Weather ➢ Temperature ➢ Balance weight ➢ Landslide

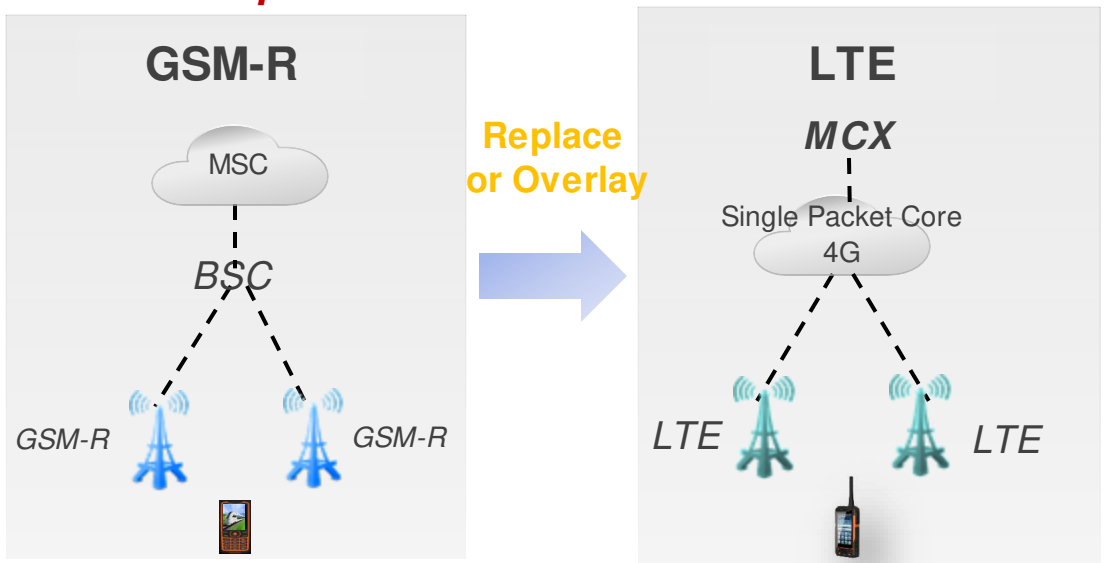


A Fully Connected Rail --- the Guardian for High Speed Rail Operation

Cable Tensor Force Detection	Catenary Temperature Monitoring	Trackside Equipment Status
		
Landslide Warming	**Falls / Flooding Monitoring**	**Level Crossing Perception**
		

Huawei FRMCS Migration Strategy

Step 1: GSM-R to FRMCS LTE

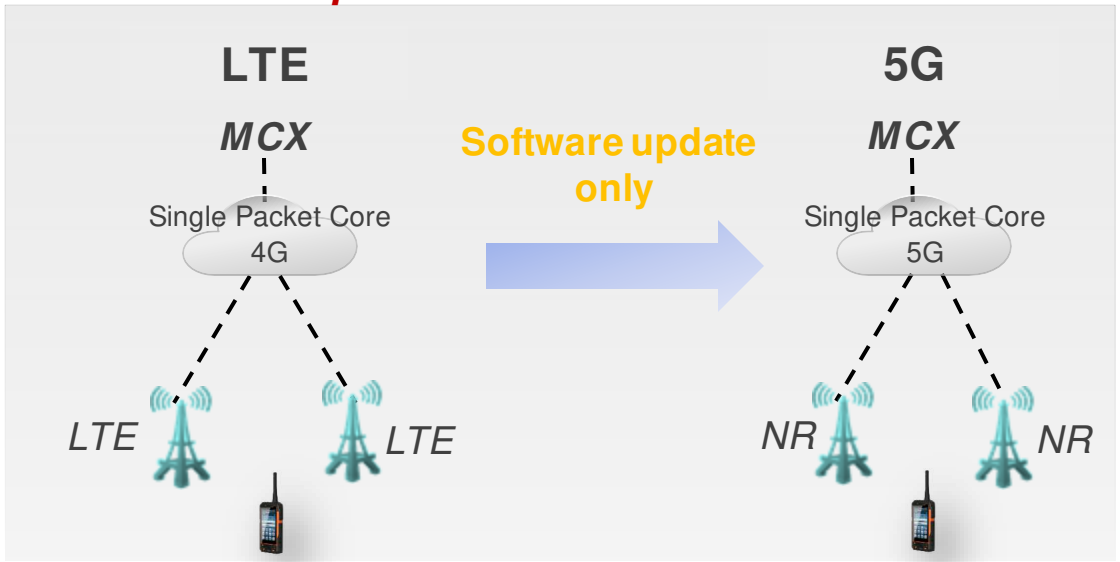


Narrow Band to Broadband

1.9GHz LTE ecosystem is mature

- GSM ecosystem declining
- Architecture is out of date
- Capacity constraining evolution
- 1.9GHz LTE is mature, short TTM

Step 2: FRMCS LTE to 5G



Economical

Hardware would be Re-used

- Future proof architecture
- Software update only
- 5G-ready hardware
- Cloud-based Core

THANK YOU