UIC HIGHSPEED Morocco 2023

HIGH-SPEED RAIL : THE RIGHT SPEED FOR OUR PLANET

Under the High Patronage of his Majesty King Mohammed VI

Session 5.4 , Room Fez 1

Superstructure / Design

Moderator : Mr. Said NASSIRI

Directeur Pôle Voyageurs, ONCF, Morocco

ONCF UIC

Session 5.4
Superstructure / Design
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South Korea

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Brahim BENCHELHA

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11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

FRMCS Bearer Network Solution for Smart Railway

Lyu Liang
Director of Transportation Industry, Data Communication Product Line
Solution Dept, Huawei, China
Session5.4 Superstructure / Design

Booming High-Speed Railway Industry, More Intelligent Innovations

FRMCS Future Railway Mobile Communication System

High-bandwidth mobile communication

Intelligent dispatching and command

Automatic train control

Visualized O&M

350+ km/h

Speed

3 min

Headway

3934

HS trains

FRMCS is On the Way …

- Introduced FRMCS use cases in Rel-16
- Estimated to allocate n100 & n101 for FRMCS into Rel-17
- Study NR narrow band structure for Railway Scenario in Rel-18

- Finish FRMCS system architecture and user requirements
- Define FRMCS FRS and SRS through ETSI, will be released soon

- Modular design for wireless, compatible for 4G/5G
- Decoupling network and service, use standard IP interface. Fast service provisioning and rollout
- IPv6 supported, architecture to support future evolution

New Service and Requirement Driving Network Upgrade

New requirement of FRMCS/5G-R

- Communications: 30 mission-critical services, 25 performance services, and 4 business services
- Support: 11 mission-critical services and 1 business service

	Average latency	Jitter	Packet loss rate
Core network	< 50 ms	< 25 ms	< 0.1%
Signalling network	< 10 ms	< 10 ms	< 0.1%
Bearer network of NG interfaces	< 10 ms	< 10 ms	< 0.001%
Bearer network of Xn interfaces	< 4 ms	< 2 ms	< 0.001%
Clock synchronization	Time accuracy: smaller than ±1.5 µs		

Wide bandwidth and low latency

- 100 Mbps/train (FRMCS)
- Millisecond-level low latency

High reliability

- 99.999% reliability
- Multi-service security isolation

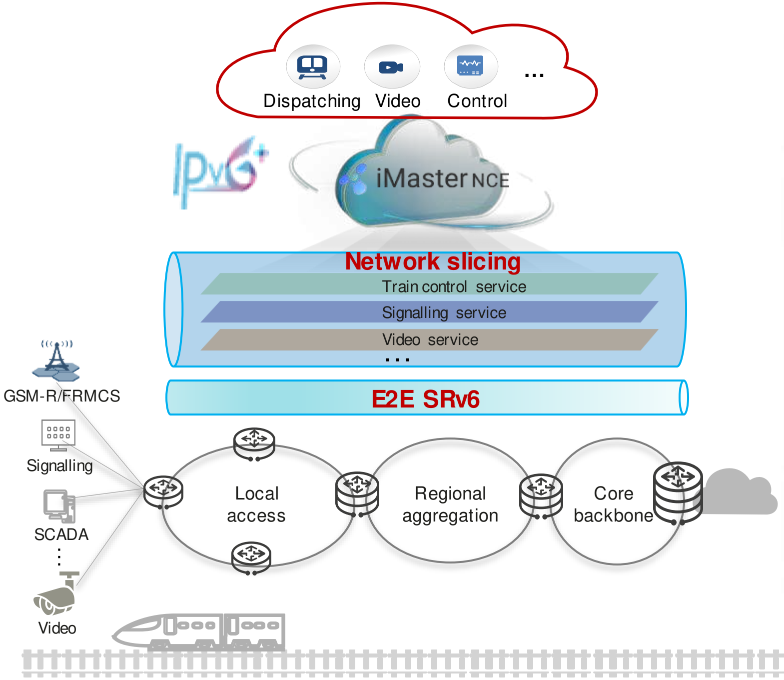
Elastic scalability

- Industry-leading architecture, flexible three-layer capabilities, supporting diversified service development

Easy O&M

- Unified management and service-based visualization
- Accurate fault locating and quick response

FRMCS Bearer Network Solution for Smart Railway



High reliability and Smooth evolution

- Bandwidth: GE->10GE->50GE->100GE->400GE, E1、STM-1、PCM interface.
- High precision clock for 5G: support G.8275.1/G.8271.1, Class C for 30ns and Class D for 10ns

One-network bearing

- All-IP unified bearing: hard slicing–based differentiated services, achieving security isolation

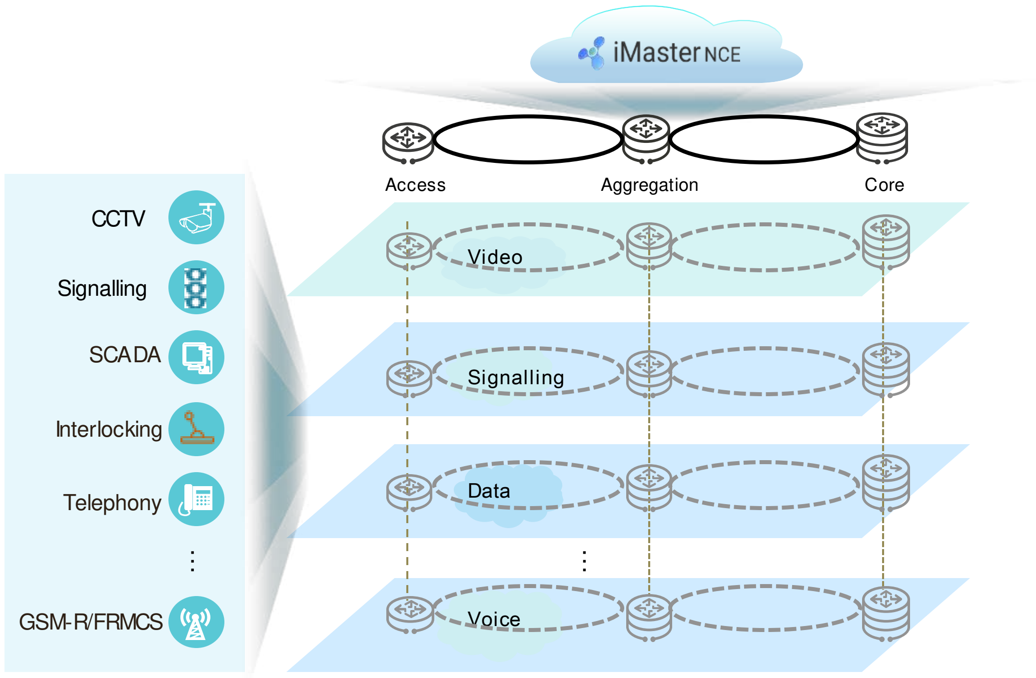
Flexible deployment

- SRv6-based intelligent traffic steering, enabling intelligent optimization and flexible connection

Intelligent O&M

- Real-time network digital map, six-layer visibility, facilitating minute-level fault locating

One-Network Bearing: Multi-Slice Hard Isolation for E2E Bandwidth Assurance



Hard isolation

Hard isolation for multiple services

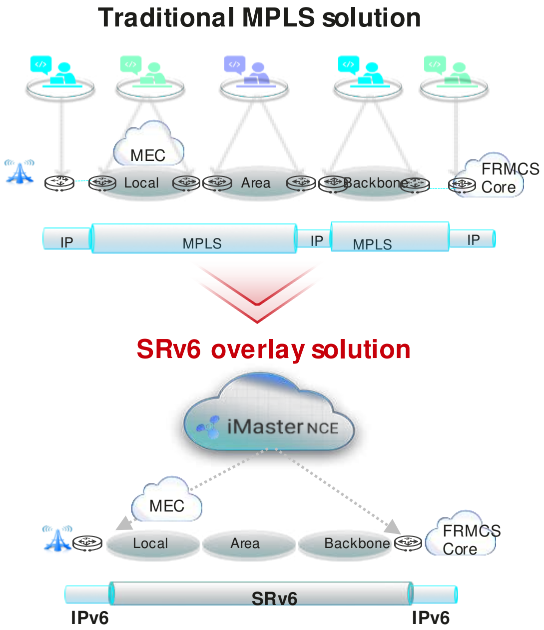
Flexible granularity

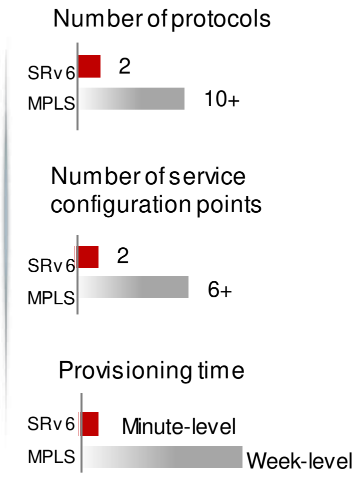
On-demand flexible planning and use from Mbps-level to 5Gbps

Network-wide assurance

Network-wide E2E bandwidth assurance for service slices

Flexible Deployment: SRv6 Enabling One-Hop Service Connection and Application-Level Interconnection





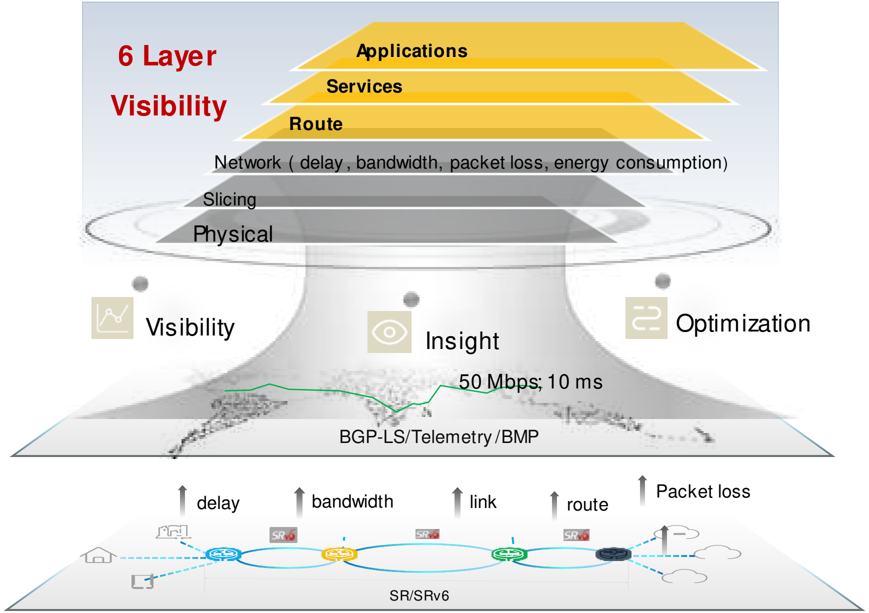
Enablement of SRv6 on the ingress and egress for **one-day service provisioning**

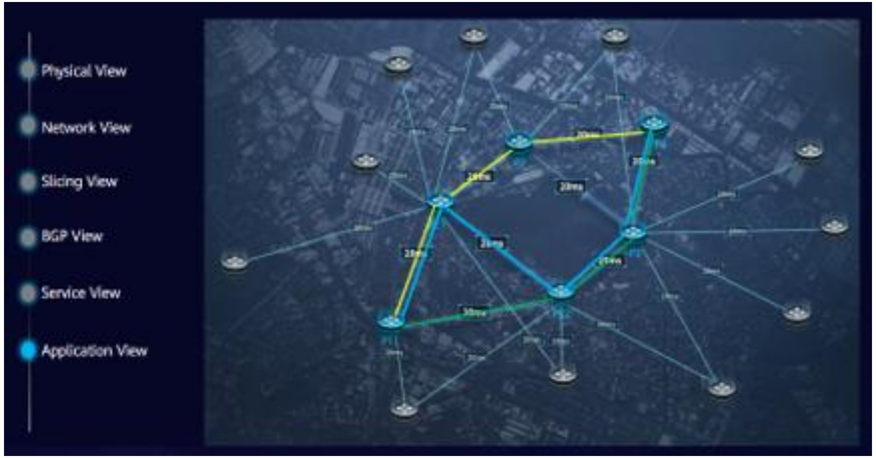
Service intent-based forwarding with **committed latency**

50 ms protection switching across 100% topology-independent scenarios

Intelligent O&M: Realizing Six Layer Visibility by Real-time Network Digital Map

Digital Twin: Physical > Slicing > Network > Route > Services > Applications





Network Visualization

- Physical to application, real-time visualization
- Second-level awareness of network SLA changes

App Level Differentiated Assurance

- Combination of 20+ factors for path computation
- Accurate locating of service SLA deterioration in minute-level and automatic traffic optimization

THANK YOU

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11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

Introduction to IRS 60681

Design of a high speed railway – Communication and Signalling

Hongwei, YAN
Engineer, China Railway Economic and Planning Research Institute, China
Session4-5.4 Superstructure / Design

ONCF UIC

1. Background and Working Process of IRS60681

Design of a High Speed Railway series IRSs:

- IRS60680 *Infrastructure*
- IRS60681 *Communication and Signalling*
- IRS60682 *Energy*
- IRS60683 *Interface*

→ High-speed IRS programme of UIC Intercity and High-Speed Committee (ICHSC).

Item set-up	Initial draft	Draft versions and comments review	Final draft version	Committee final review and endorse	Approval by PGF	Published
2018.03	2019.06	2019.06-2020.09	2020.6	2020.06	2020.08	2021.11






1. Main Content of IRS60681

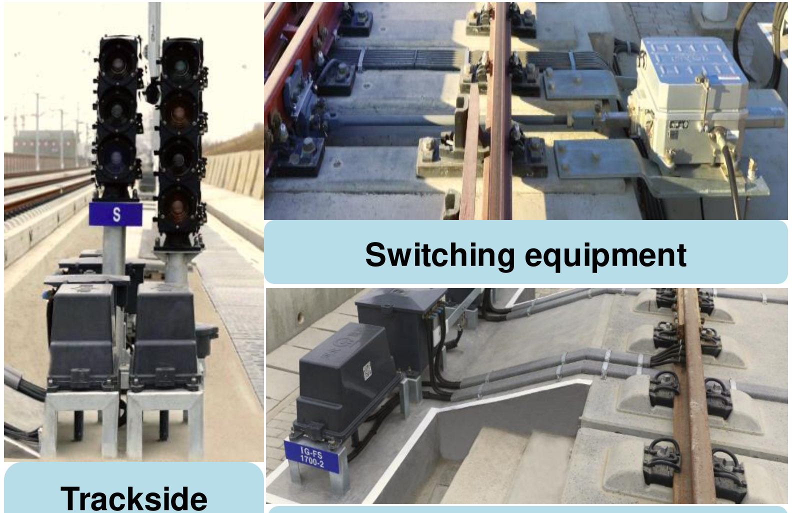
- Foreword
- Executive summary
- Field of application
- Reference documents
- Abbreviations and symbols

General Part

1- Introduction
2- Signalling
3- Communication
4- Supporting equipment and facilities

2. Signalling

2.2 Trackside signal, switching equipment, and track occupancy detector



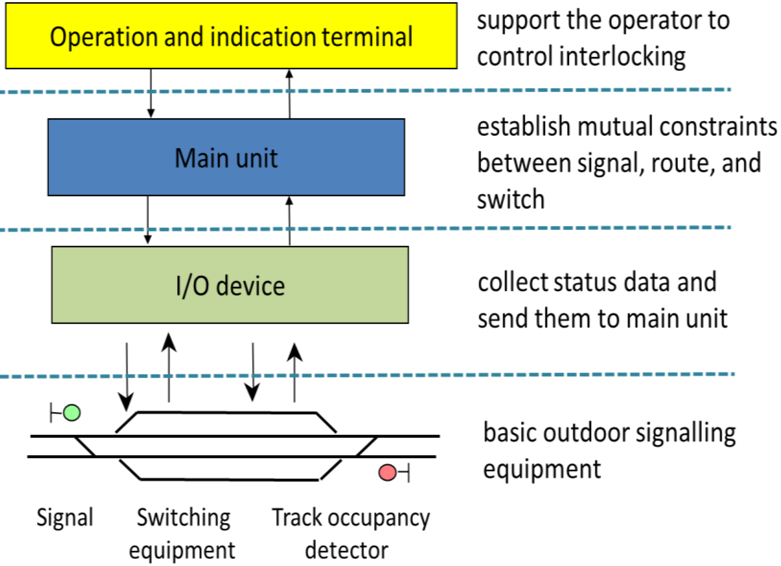
Switching equipment

Trackside signal

Track occupancy detector

2.3 Interlocking system

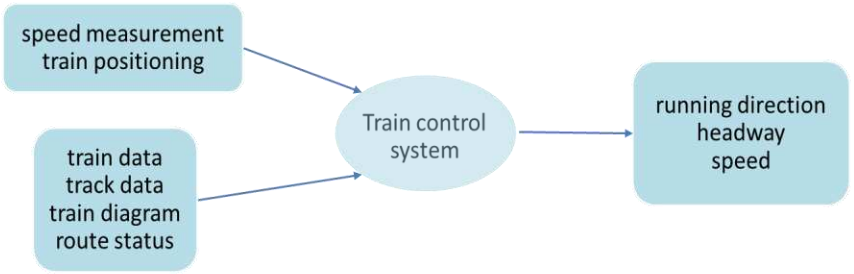
mutual constraints between signal, route, and switch to guarantee safety.



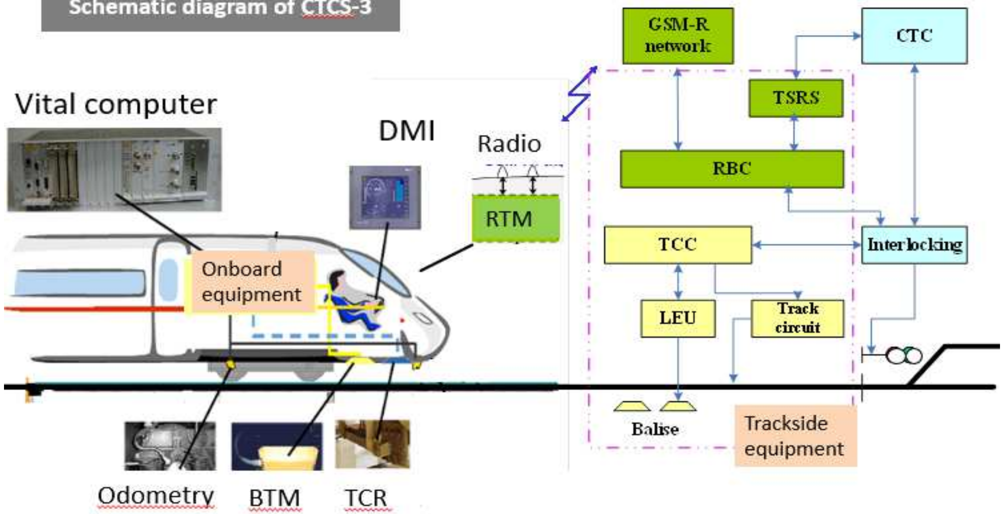
2. Signalling

2.4 Train control system

- Train control system can be classified into several application levels according to functional requirements and equipment configuration.
- A fallback train control system may be provided as needed.
- Train control systems used worldwide：ETCS in EU; CTCS in China; Digital ATC in Japan.



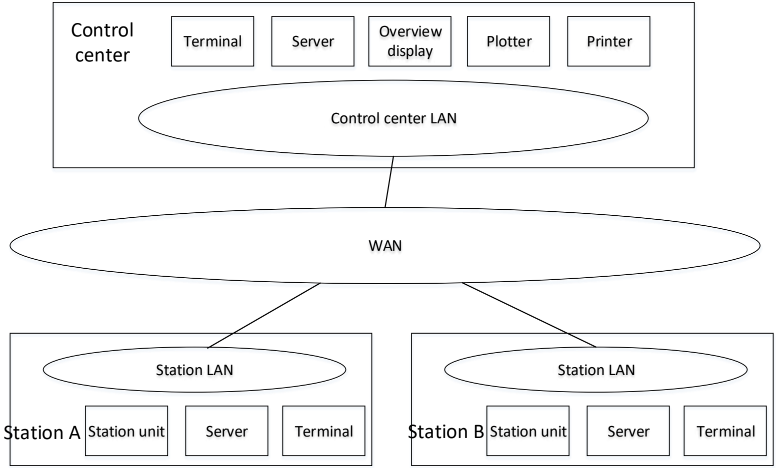
Schematic diagram of CTCS-3



2. Signalling

2.5 Traffic control system

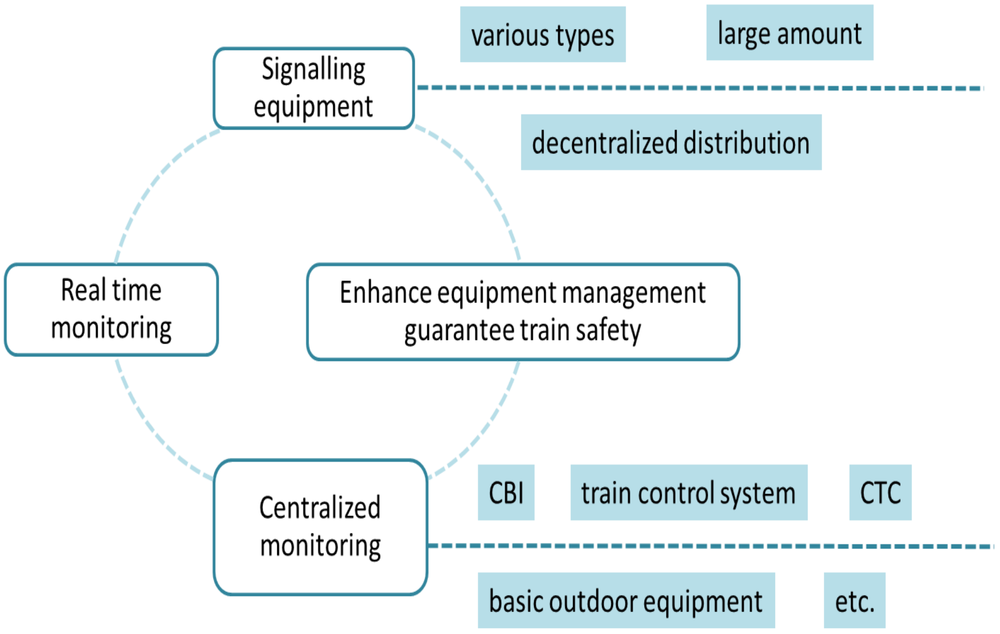
- Centralized traffic control (CTC) system should be used for HSR.
- CTC realize : real-time train tracking display, generation of actual train diagram, adjustment of operation plan, issue of dispatching command, etc.
- A CTC system can be structured in two levels: control center and station.
- Control-center mode is used under normal conditions, and emergency control mode will be used in case of failure of control center equipment or transmission channel.



2. Signalling

2.5 Centralized signalling monitoring

- Centralized signalling monitoring system conducts real time monitoring over equipment working status, fault analysis and troubleshooting.
- CBI, train control system, CTC, etc. should be monitored to facilitate maintenance staff to learn the status of equipment.
- Supporting data acquisition, fault diagnosis, alarm, data storage, etc.



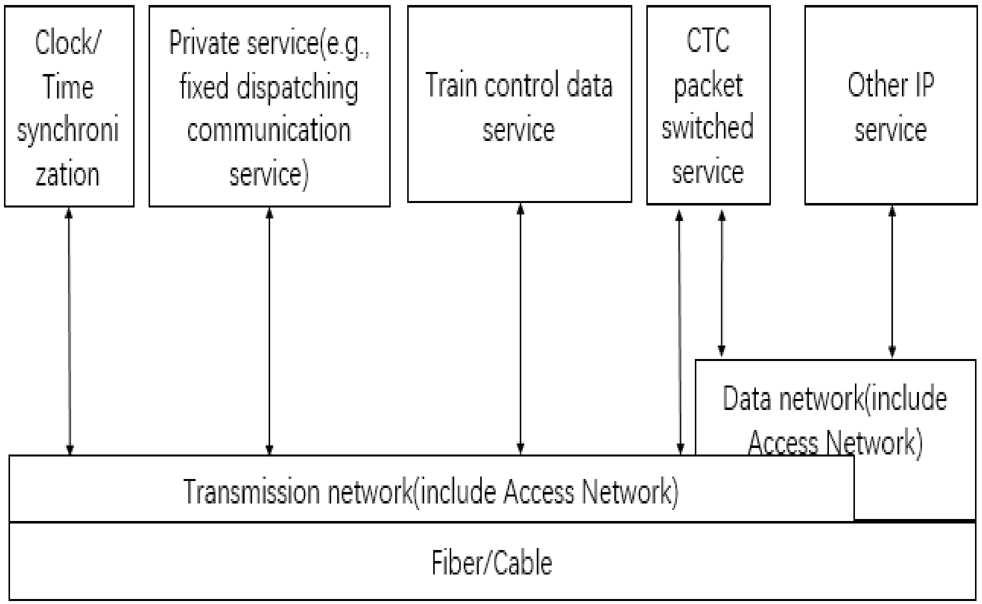
3. Communication

communication networks:

- Transmission network
- data communication network
- access network

communication applications:

- clock/time synchronization
- private services (e.g., fixed dispatching communication service)
- train control data service
- CTC packet switched service
- other IP services



Relation between communication networks and their services

3. Communication

3.5 Radio communication

- Services：
  - Voice services, e.g. general calls, dispatching calls；
  - Data services, e.g. train control, traffic control, operation and management.
- Covering areas：
  - Main track, siding, connecting track;
  - railway stations;
  - Test area for cab radio in rolling stock depot.

EU and China are currently using GSM-R

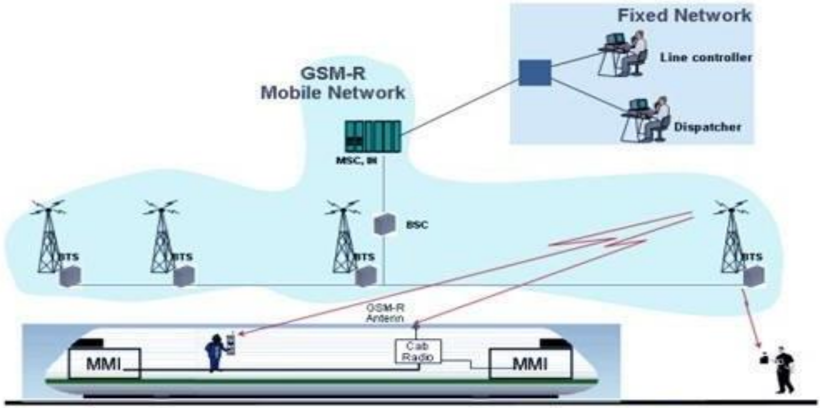
- Under normal conditions, the radio coverage is realized by base station with antennas.
- In areas with weak field strength, the radio coverage may be realized by base station and repeater with LCX.

Japan is currently using LCX based train radio communication system.

- LCX is used along the railway. Through cables and onboard antennas, radio communication between base stations and mobile stations is enabled..

3. Communication

3.6 Dispatching communication system



❖ a dedicated communication system， provides：
- dispatching telephone
- railway station telephone
- inter-station train operation telephone

3.7 Video surveillance system

❖ monitor the activities concerning transportation and security.

❖ support audio/video acquisition, processing, storage, playback.

❖ composed of servers, storage devices, cameras, surveillance terminals, etc.

4. Supporting equipment and facilities

4.1 Cables

- Type and capacity should be selected based on the requirements of equipment and ambient environment.
- Cables should be laid in cable ducts.

4.2 Power supply

- Mode and capacity of power supply equipment shall meet the service requirements and load requirements.
- Power supply panel is recommended for signalling system.

4.3 Equipment room

- Classified into different levels according to the impact of the equipment on train operation safety and transport efficiency.
- The temperature, humidity, smoke, and water immersion can be monitored as needed.

4.4 Lightning protection and earthing

- Indoor : shielding net, equipotential bonding, SPD, etc.
- Outdoor: designed respectively based on specific condition .

THANK YOU

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11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

TRACK STRUCTURE FOR RRTS IN INDIA

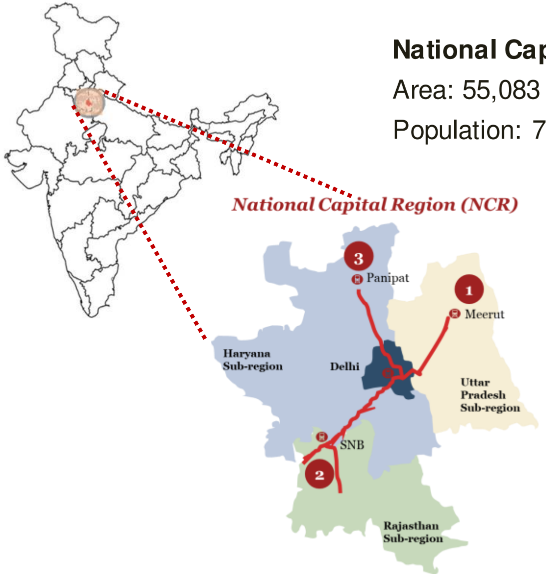
Vinay Kumar Singh
Managing Director, NCR Transport Corporation, India
Session4-5.4 Superstructure / Design

ONCF UIC

RRTS: FILLING THE GAP OF INDIA'S REGIONAL COMMUTE

Rail based high speed, high-capacity service - delivering a comfortable and safe commuter experience

3 RRTS corridor under implementation

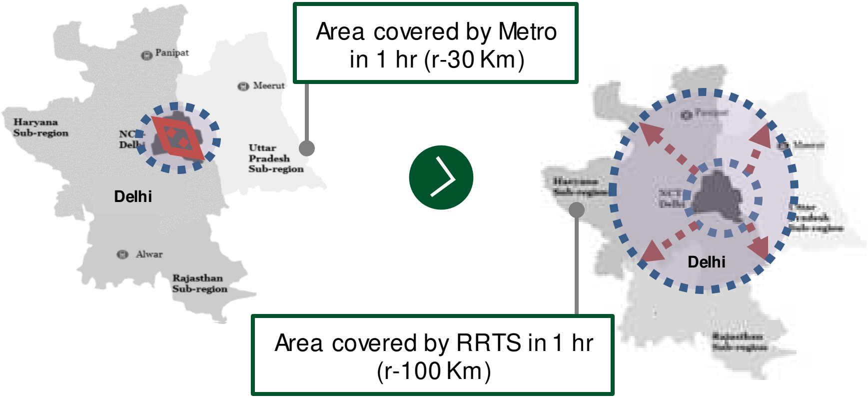


National Capital Region of India

Area: 55,083 km^2

Population: 70+ Million

Objective of RRTS



- Design speed of 180 Kmph—Operational 160 Kmph
- Average speed approx. 100 Km/hour with stoppages
- Train every 5 minutes. Stations every 5-10 Km
- Multimodal integration with Airport, Rly System, Metro & Buses
- Property development & TOD in RRTS project area

SELECTION OF TRACK SYSTEM FOR RRTS

Prioritized track system basis functional requirements and industry research on existing systems

Functional requirements

- Proven performance record over elevated as well as underground section
- Reliability of system for uninterrupted operation
- Ease of replaceability in case of damage, particularly within tunnels
- Suitability for keeping noise and vibration within permissible limits
- Suitability for environmental conditions within the Project area

Various systems prevalent were examined through interaction with experts & Industry

Austrian Slab Track System developed by OBB & Porr selected through RFP. Salient features:

- Depth & width of slabs is same throughout for elevated & UG
- Turnouts can be installed with this system
- System suitable for various fastening systems
- Separation layer enables ease of replacement in case of damage to track slabs
- Thicker separation can be provided which helps in noise and vibrations mitigation also
- Slabs can be designed with derailment guard

DESIGN OF SYSTEM AND EXECUTION PLANNING

Design conducted in conjunction with industry experts, which fed into the execution plan for the system

1 Design of system – Customized for RRTS requirement

- Design of proven system developed by Porr & OBB was customised for RRTS requirement considering:
  - Axle load,
  - Speed,
  - local temperature range & seismic conditions,
  - statuary requirement of regulator/Indian Codes
- Vienna Consulting Engineers (VCE) customised design which was proof checked by KRTC-Primerail JV (Korean Rail & Primerail, an Indian company)
- Design was reviewed by Prof. Coenrad Esveld, eminant Prof. Delft University, Netherlands
- Track Design Expert of M/s Italfer & M/s Ayesa reviewed and accepted customised design

2 Execution – Collaborated with System provider, & Exec. Agency

- Customised design and IPR provided by System Provider (M/s Porr)
- Technical specifications & bids' technical requirement including equipment, procedures, suggested methodology & BOQ etc provided by System Provider
- Execution contract finalised on item rate basis & indigenous agency having experience of precasting and track selected
- Execution plan, precast factory & installation planning, deployment of equipment reviewed by System Provider
- Slab Production & Installation expert deployed by system provider for initial handholding & for ensuring conformity to specifications

3 Followed by Monitoring

1.1 MATHEMATICAL MODELLING FOR PARAMETERS OF ROLLING STOCK, CIVIL STRUCTURE AND TRACK

Mathematical modelling/similation considering bearing, superstructure, track structure, fastening system and Rolling stock parameters was done to assess:

- Stress levels on fastenings, and tension clips are in permissible range
- Stresses on fastening system & tension clip based on modelling and technical specifications/test results of fastening system
- Confirmation of elimination of resonance conditions for speed upto 250 Kmph and suggest remedial measures, if any

Conclusion of the analysis

- Stresses on fastening system are found within permissible range
- Possibility of resonance upto design speed of 180 Kmph +/1 20% is ruled out. However, as precautionary measures rail grinding at regular interval recommended

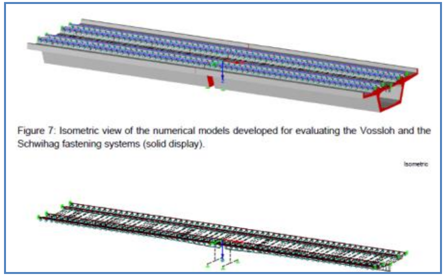


Figure 7: Isometric view of the numerical models developed for evaluating the Vossloh and the Schwihag fastening systems (solid display).

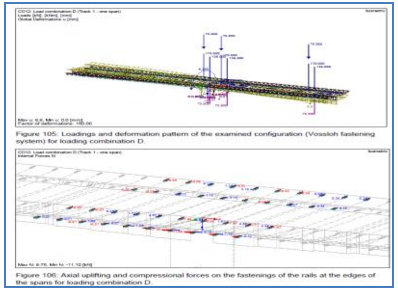


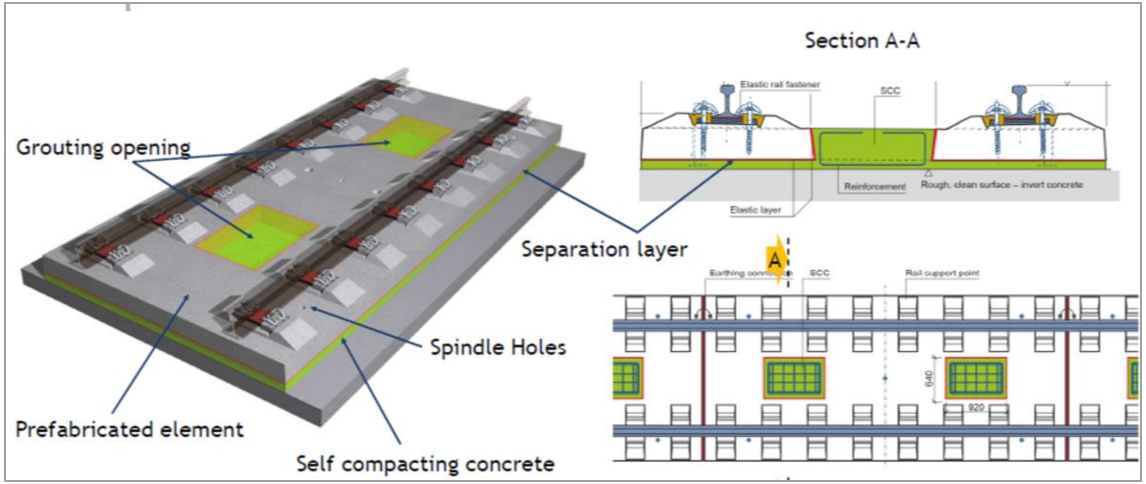
Figure 105: Loadings and deformation pattern of the examined configuration (Vossloh fastening system) for loading combination D.

Figure 106: Axial uplifting and compressional forces on the fastenings of the rails at the edges of the spans for loading combination D.

- **Permissible Deflection values in Dynamic Behaviour for 37m span is L/1400 and for 25m span L/1200–Expected deflection as per Dynamic Analysis comes to 12.87mm (aganinst 25.34mm) & 2.93 for (19.53mm)**

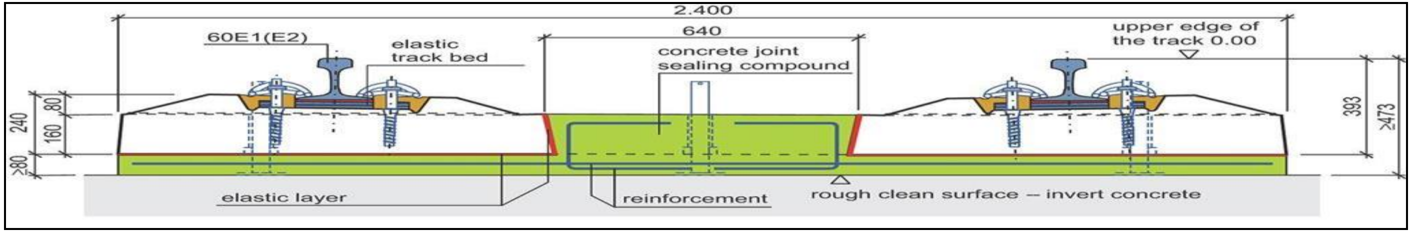
1.2 SLAB DETAILS

Prefabricated elements made of self compacting concrete



Typical slab Detail

Length	3.98 m
Width	2.4 m
Height	0.16 m
Concrete Qty.	1.75 Cum
TMT Qty.	368 Kg
Weight	4.35 MT
Slab conc.Grade	M55
Grout grade	M40



1. Design 2. Execution 3. Monitoring

2.1 PRECAST SLAB PRODUCTION FACTORY SET UP

State of the art facility with high focus on automated operation

Salient details

- Production scope – 42000 slabs (164 km)
- Area of factory – 450,00 sqm
- No of moulds – 90
- Cycle time – Normal 24 hrs reduceable to 18 hrs with steam curing
- Slab production period – **27 months**
- Production commenced – Dec 2021
- Progress as on 01.01.2023 – **16000 slabs (60km)**
- Infrastructure created in factory

Two automatic batching plants, flying buckets with concrete distribution system, compressed air system for compaction, steam curing system, RO system, etc.

Automated operation–10 minutes from concrete production to slab casting

2.2 ADVANCED SURVEY SYSTEM (FARO) & ADVANCED QUALITY CONTROL SYSTEMS

Minimal scope for human errors for checking accuracy

Laser based technology for checking accuracy of moulds & slabs

- 3D model of mould is used as input tool
- No scope for human error-**compares 'As Manufactured' with 3D model**
- Records variation as small as 0.1mm (**acceptance tolerances upto 0.3mm & 0.5mm for various parameters**)

Automation

- Real time concrete demand generation
- SDS > Batching plant > Flying bucket > Traverse > Moulds

Triggers automatic concrete ordering for the ready to cast mould

Quality Management

- Documentation of Batch Material, Timeline, & slab photos
- Mould Examination
- Auto blocking- In case of mismatch

Slab Traceability

- Keeps account of the **slab location at Factory Storage Area /Installation** through bar code scanning
- 4G enabled scanners

60_7_0.0 SMS46

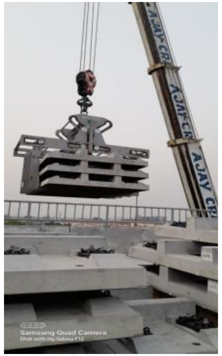
Seriennummer : SDS51-60_7_0.0 SMS46

2.4 TRACK INSTALLATION ON VIADUCT SECTION

40 TKm installed using gantries

- Slabs transported on viaduct during night during road traffic blocks
- Brought to location using indigenously developed gantries
- Parameters controlled with spindles &checked with track master
- Installation commenced – 15/02/2022
- Present status – **40 Tkm installed using 4 gantries**
- Planned progress after initial learning 8 Tkm with 4 teams

Parameter	Acceptance criteria
Gauge (with reference to 1435 mm)	±1mm
	1mm base plate
Difference of any point in relation to the designed layout (horizontal)	+/-4 mm
On constant grade and vertical curves (vertical)	-4mm/+4mm
Cant/Cross Level (to be measured at every 3m/ at the end of each slab)	± 1mm
	± 1 mm
Twist	1mm/m



2.5

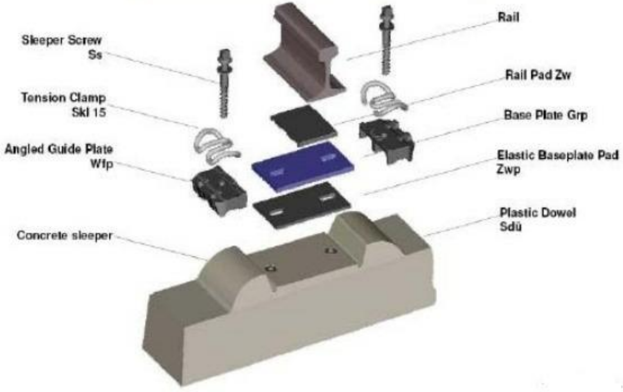
FASTENING SYSTEM FOR RRTS TRACK & TURNOUTS

Fastening system selected basis suitability for high-speed network

300-1 type direct fastening system selected – **Prime criteria compatibility with Porr slab and proven performance**

Supplied by M/s **Schwihag of Switzerland**

- Compatible with Porr slab track system
- System having proven record of supply on high-speed network of VDE 8.1: Erfurt-Halle project & Lainz & Wienerwald tunnel
- System test conducted in Technical University of Munich for compliance to EN 13481 specifications
- Special fastening to permit uplift upto 2mm at end of each span to account for rotation/deflection of spans supplied.



Turnout (1 in 9 ballastless R-300)

Designed & manufactured by M/s **Vostalpine VEEKYN**

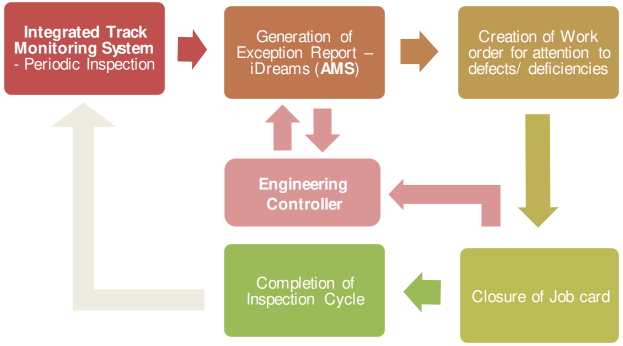
- Installed on precast slab for ensuring same stiffness and ride quality
- Steel Derailment containment guard fixed with special designed brackets & UIC 33 check rails

3.1 INTEGRATED TRACK MONITORING SYSTEM (ITMS)

Integration with AMS for generation of reports, & creation of work orders etc

Integrated Track Monitoring System (ITMS) with all related instrumentation / electronic system will be installed on a NCRTC - SG (1435mm) Engineering Maintenance Vehicle (EMV)/ Rolling Stock. ITMS will include following sub-systems:

- Track parameters recording system
- Full rail profile and wear measurement system
- System for measurement of acceleration on one pivot of EMV and on both side axle box of one axle of EMV
- System for identification of any obstacle in SOD
- System for Rear Window Video Recording of track
- System for video recording of track components and analysis by image processing for status of track components



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progress through speed

THANK YOU

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Website ncrtc.in

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Marrakech, 7-10 MARCH 2023

LTE-R Demonstration & Application for High Speed Rail in Korea

Taegil HA
LTE-R Team Leader, Korea National Railway, Korea
Session4-5.4 Superstructure / Design

ONCF UIC

1. Background

Legacy railway radio comm. (VHF 150 MHz band & TRS 800 MHz band)

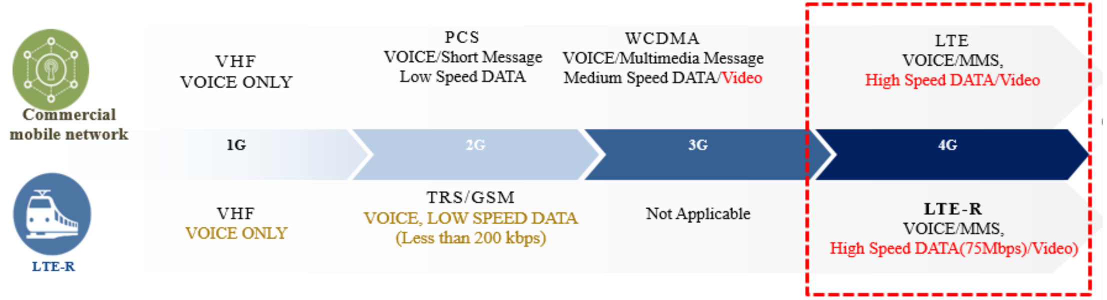
Railway		Radio System: VHF	Radio System: TRS-ASTRO	Radio System: TRS-TETRA
Conventional rail		◎		
High speed rail	Gyeongbu HSR Phase 1		◎	
	Gyeongbu HSR Phase 2			◎
	Honam HSR			◎
	Suseo HSR			◎

※ *Crews on trains running on Gyeongbu HSR carry three types of user terminals.*

VHF (conventional lines)

Evolved railway radio comm. (VHF 150 MHz band & TRS 800 MHz band)

LTE-R: Railway radio standards based on 4G LTE Technology



TRS (high speed lines)

2. Frequency Allocation

Co-use of 700 MHz frequency bandwidth by **Integrated Public Network** (LTE-R, PS-LTE, LTE-M)

698	710	718	728	748	753	771	773	783	803 806
Broadcasting ↑ 2 CH (12 MHz)↑	Guard (8 MHz)	**Integrated Public Network ↑ (10 MHz)**	Telecommunications ↑ (20 MHz)	Guard	Broadcasting ↓ 3 CH (18 MHz)	Guard	**Integrated Public Network ↓ (10MHz)**	Telecommunications ↓ (20 MHz)	Guard

Public safety LTE networks
Major cities, public organizations, tourist attractions, rural areas, roads

LTE-R (Railway)
In service since April 2017 and to cover entire national rail network by 2025

LTE-M (Maritime)
In service since January 2021. Cover up to distance of 100 km or up to 400 km when integrated with satellite

Commercial Networks

All Four One Strategy

3. LTE-R Demonstration Test at 350 km/h

Testbed

•34.3-km section (including 4.3-km tunnel) of Honam HSR

Verified items

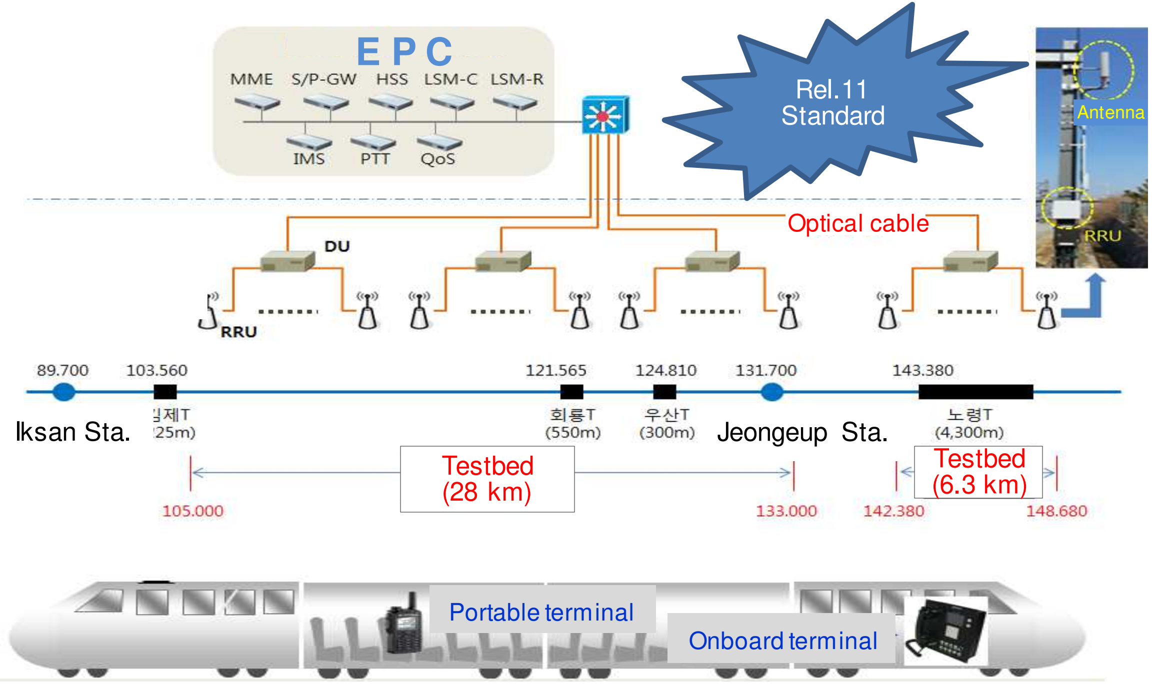
•Development of onboard terminal

•Interface with legacy radio system

•Interface between LTE-R and PS-LTE network

•Priority transmission of signaling data, etc.

Testbed configuration



4. LTE-R Demonstration Test at 420 km/h

Test type

Simulation (Demonstration test to be carried out in 2027)

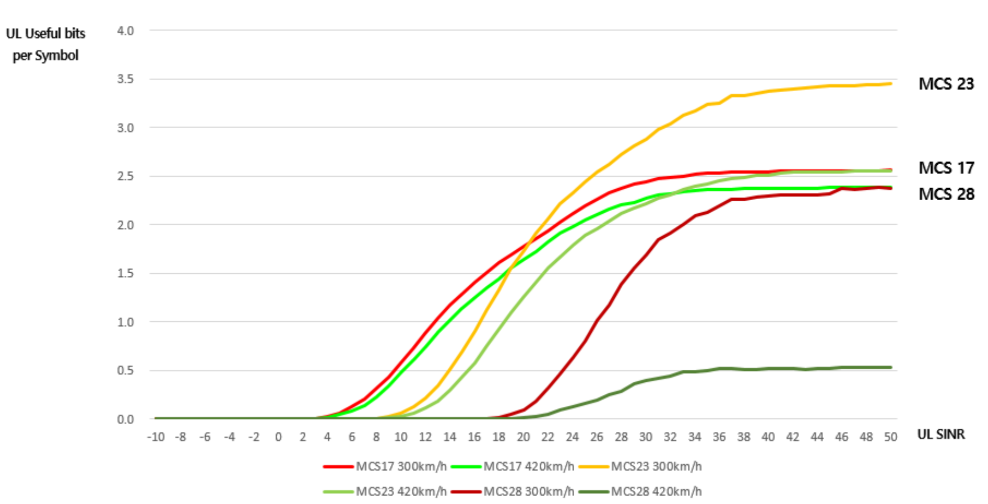
Tested items

- Data throughput (35 Mbps / 75 Mbps)
- Handover (300 ms) between cells
- Coverage rate: 98%
- Interface between LTE-R and PS-LTE network
- Signaling data receiving rate: 99.99%

Findings

Design parameter development for 420 km/h

- Gap changed between RRUs less than 1 km apart due to Doppler frequency
- Number of copy cells increased from 2 to 4 for stable handover



5. Key Features of LTE-R System

	Before LTE-R	After LTE-R
Transmission speed	TRS transmits voice and low speed data (28.8 – 523 Kbps) and cannot serve multi media transmission	**Multi media (voice, data, texts, video, etc.) transmissions possible (75 Mbps / Bandwidth 10 MHz)**
Applicable services	Terminals used are radio transceiver types mostly for voice calls and text messages 	 **Mobile terminal is a smart phone type enabling use of various applications (e.g. Safe Train Operation app)** **IoT service also possible with LTE-R** (e.g. monitoring of environment and hazards, etc.)
Operational efficiency	High dependence on foreign manufacturers impeded technological development and maintenance	**Korea has world-class LTE-R technology that facilitates safe train operations**

5. Key Features of LTE-R System

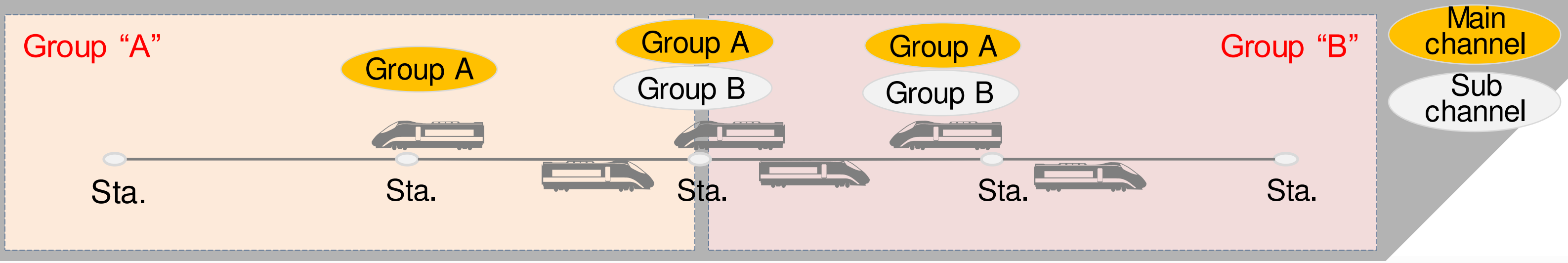
Seamless radio coverage over 350 km/h to 420 km/h

- On-site dynamic demonstration at speeds of 250/300/350 km/h
  - Downlink traffic: approx. 43 Mbps
  - Uplink traffic: approx. 20 Mbps

- Passed software simulation (speed 420 km/h)
  - Design scheme change: trackside antenna distances adjusted from 1 km to 800 m

Mission critical push to talk

- Moving trains automatically join voice talk groups from current train locations



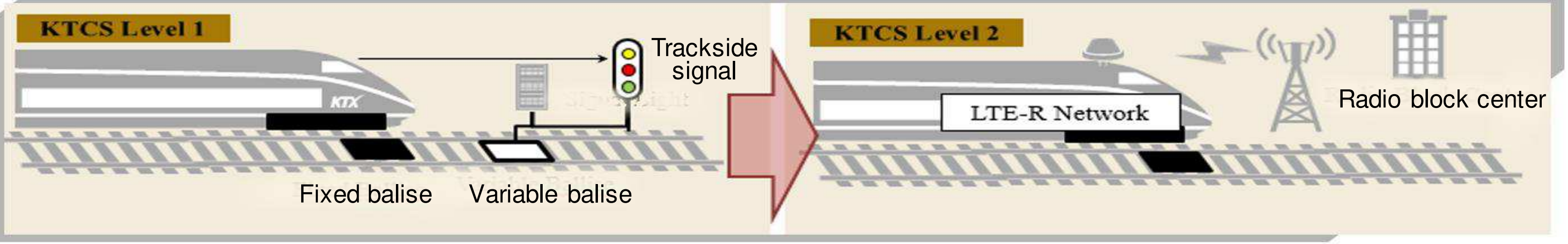
5. Key Features of LTE-R System

1:N multimedia broadcast service

- Enables immediate response to natural disasters and railway accidents
  - Specific group video communication service
  - 1:N broadcast service can monitor real-time situation and give instructions to onsite personnel via video

Train control system based on LTE-R

- Cost down, prevent human errors



5. Key Features of LTE-R System

Railway safety

- Monitor railway assets
  - Tracks, rolling stocks, catenary
  - Trackbed, bridges/tunnels
  - Train control system for train operation

IOT (Internet of Things)

Advanced maintenance

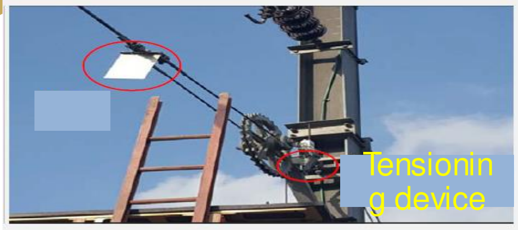
Customer service

- Technical support in maintenance
  - Accumulate error data
  - Onsite maintenance records

- Real time logistics (freight) information

Rail temperature sensor

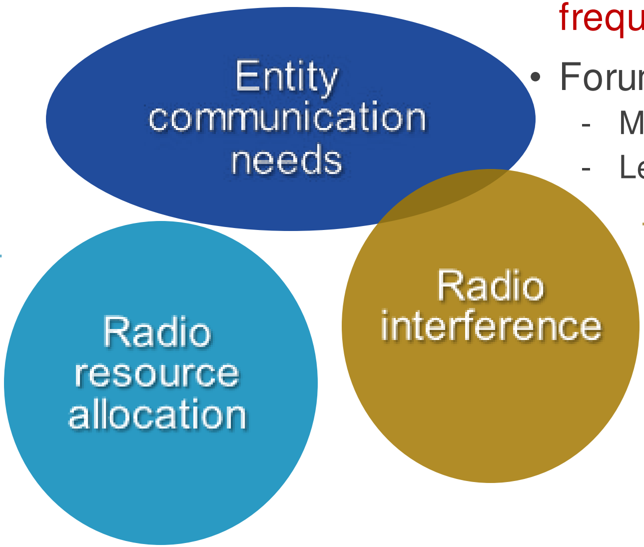
Vehicle vibration sensor



Tensor sensor

6. Challenges and Solutions

- **Normal mode** in RAN sharing area
  - LTE-R : PS-LTE = 8 : 2
- **Emergency mode** in RAN sharing area
  - LTE-R : PS-LTE = 3 : 7



- 28 entities need to share same frequency bandwidth
- Forum set up for discussions
  - Meets every quarter
  - Leads in disaster prevention training

- Radio interference caused by co-use of 700 MHz
- Optimization of field strength and tilting the antenna
- RAN sharing implemented

* RAN: Radio Access Network

7. Future Plan

LTE-R Dynamic Demonstration Test in 400Km/h HSR Train

- 400-km/h quadruple track will be completed in 2027
  - Length: 46.4-km section (34 km underground) of Gyeongbu HSR
  - Train operation frequency increase: from 190 To 380 per day
- Design parameters to be verified in simulation
  - Data throughput, distances between antennas, coverage, etc.

Implementation of IOT service, Smart Station and KTCS Level 3

- LTE-R transmits IoT data
- Smart station:
  - Total monitoring system for rail facilities
  - Systematic passenger guide service

Korea National Railway aims to build a well structured national rail network and to see to efficient management of rail infrastructures and assets.

Hanyoung Kim, Chairman & CEO
Korea National Railway

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Marrakech, 7-10 MARCH 2023

INTELLIGENT RAILWAY DISPATCHING AND COMMANDING: TECHNIQUES AND APPLICATIONS

DING, Shuxin
Associate Researcher, China Academy of Railway Sciences Corporation Limited (CARS), China
Session 5.4 Superstructure / Design

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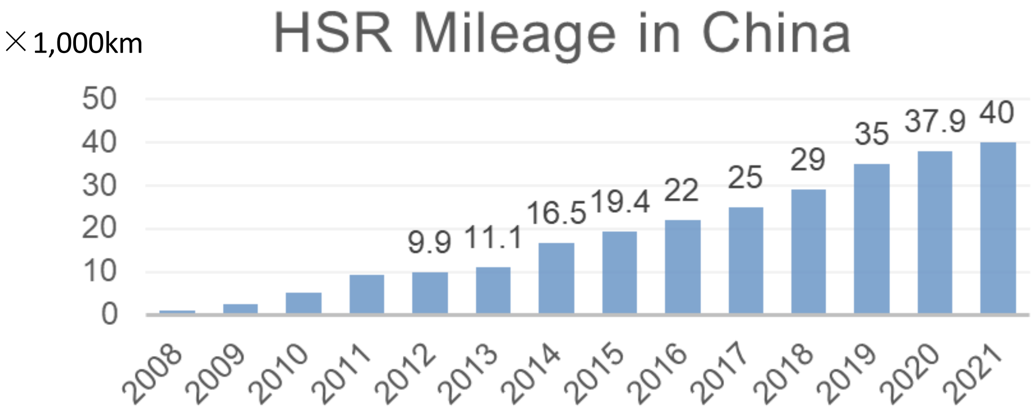
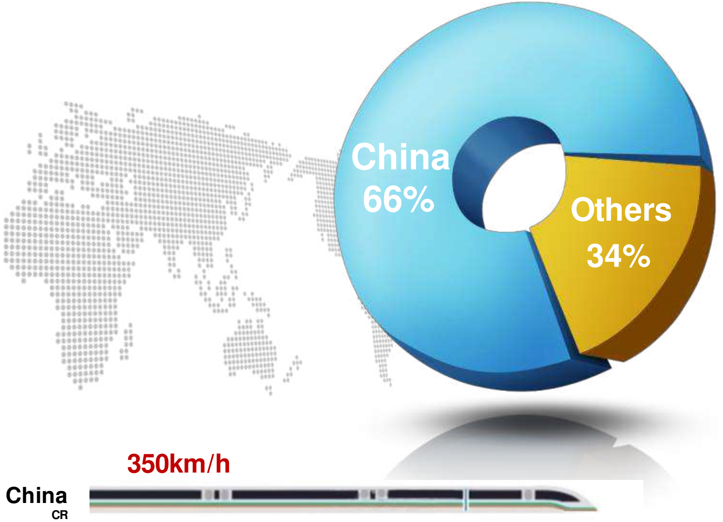
OUTLINE

China High-Speed Railway (HSR)——42000 kilometers (2022.12)

Operation as a network in China

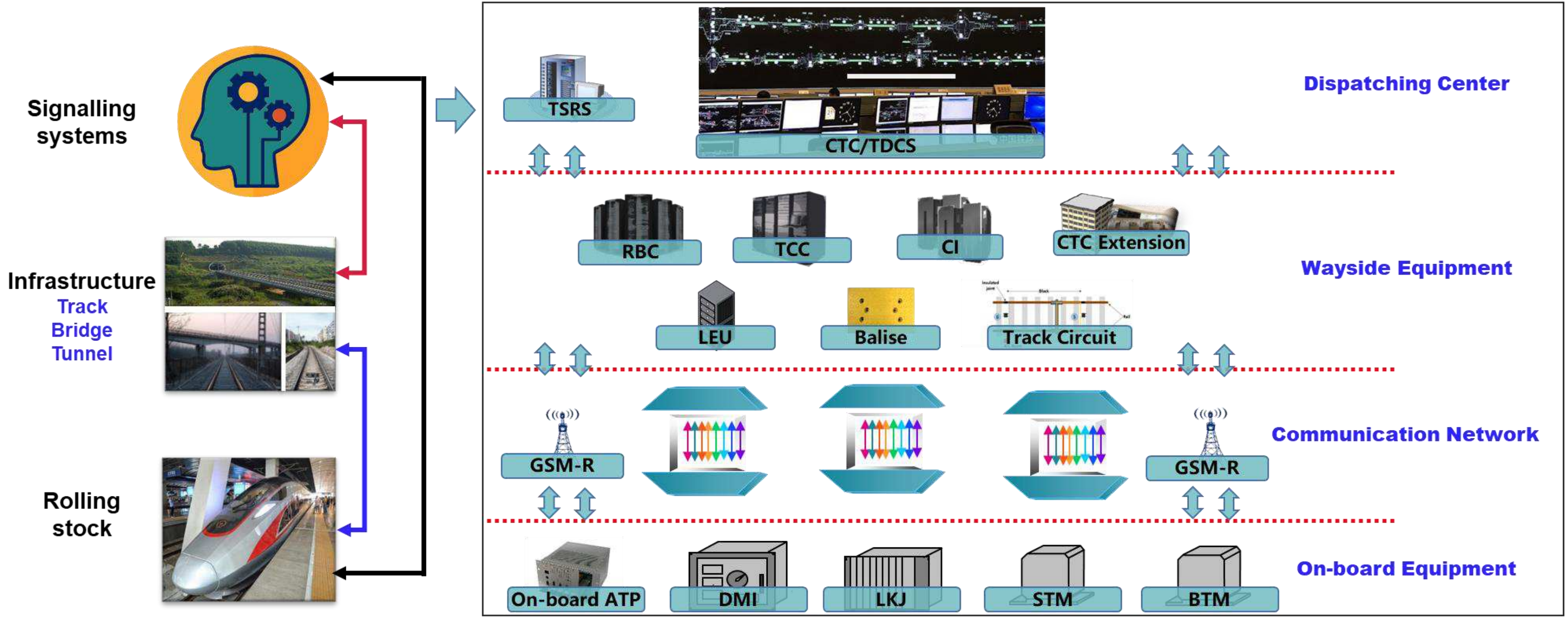




It is a great challenge to keep the HSR operate punctually

Large network size	High operation speed	High traffic density	Large amount of operation	Complex transportation organization	Diversified travel demand

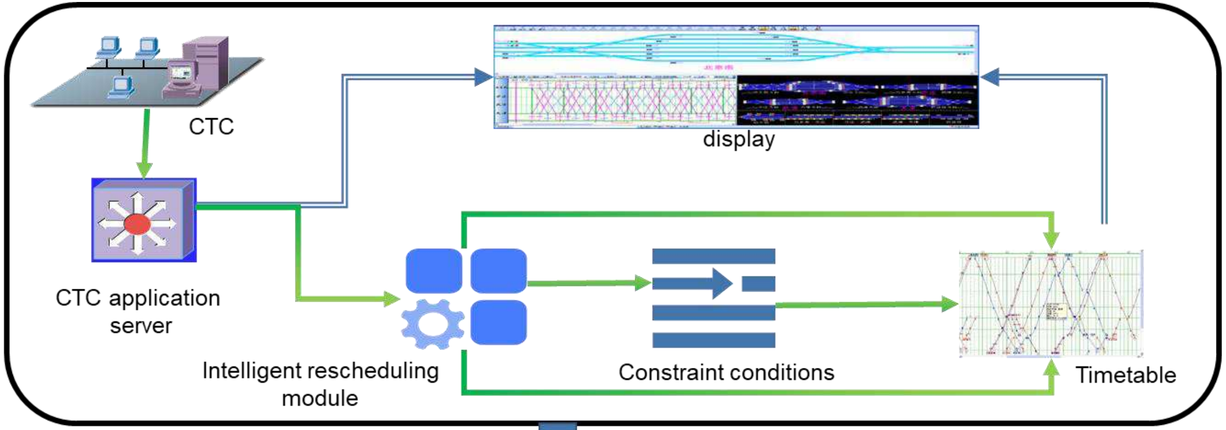
The operation of China railway depends on the cooperation of signaling systems, infrastructure and rolling stocks, and signaling systems can be divided into four levels.

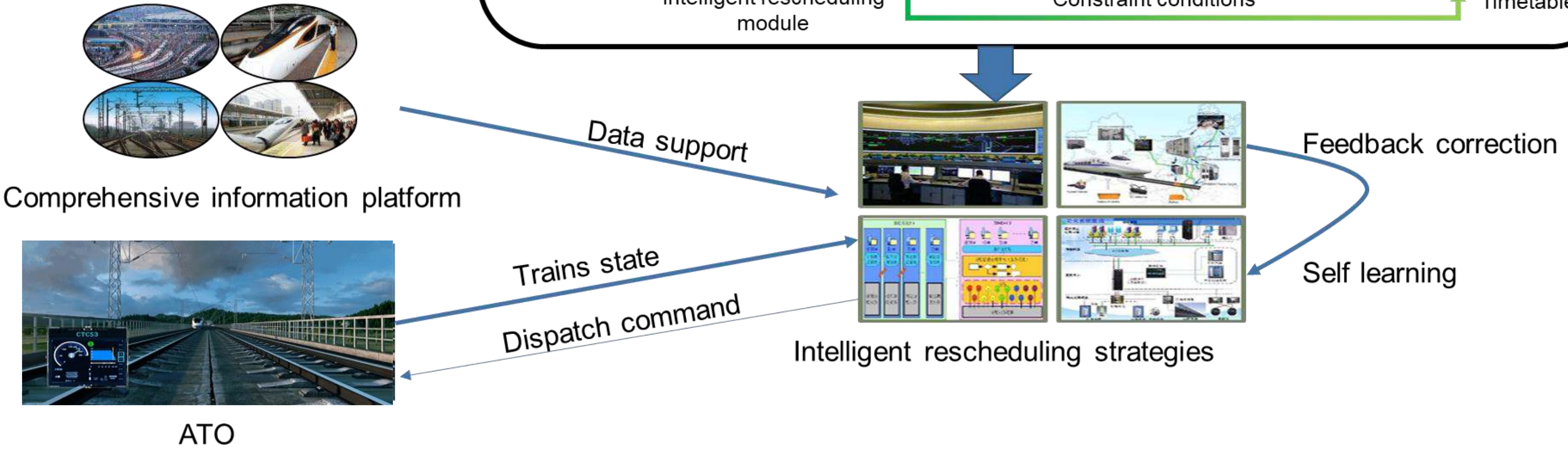


Developing an intelligent HSR dispatching and commanding system: intelligent Central Traffic Control (CTC) system

INTELLIGENT RAILWAY DISPATCHING AND COMMANDING

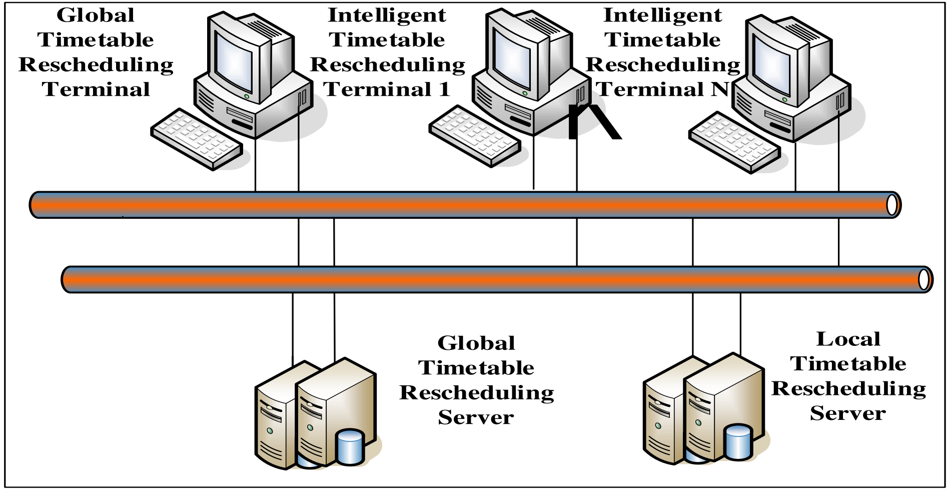
Intelligent CTC

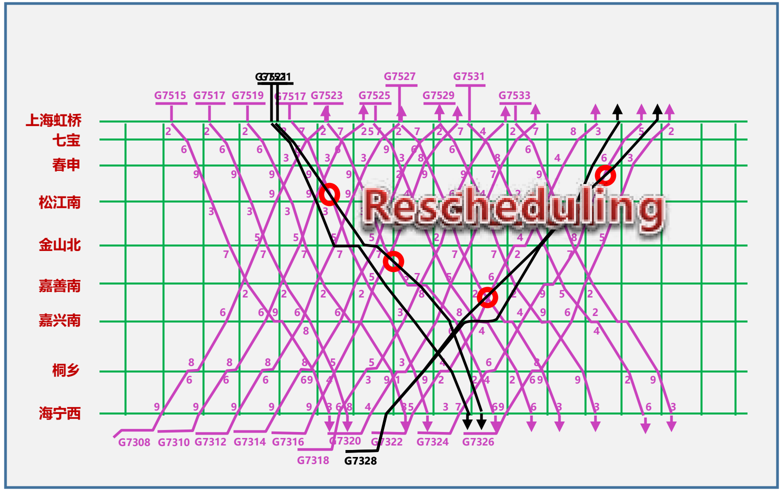




AUTOMATIC TRAIN TIMETABLE RESCHEDULING

- Intelligent rescheduling database: including train routes, minimum section running time, etc.
- Strategies: reordering is not considered
- Objectives: minimum total train delays, number of delayed trains
- Delay prediction and data exchange between different dispatching areas

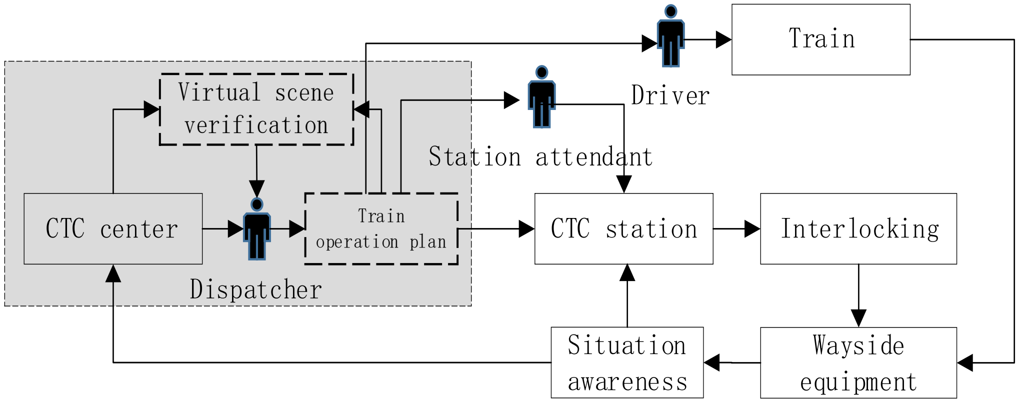




Providing an automatic and dynamic rescheduling scheme for train operation under complex railway network

STATION OPERATION SAFETY CONTROL

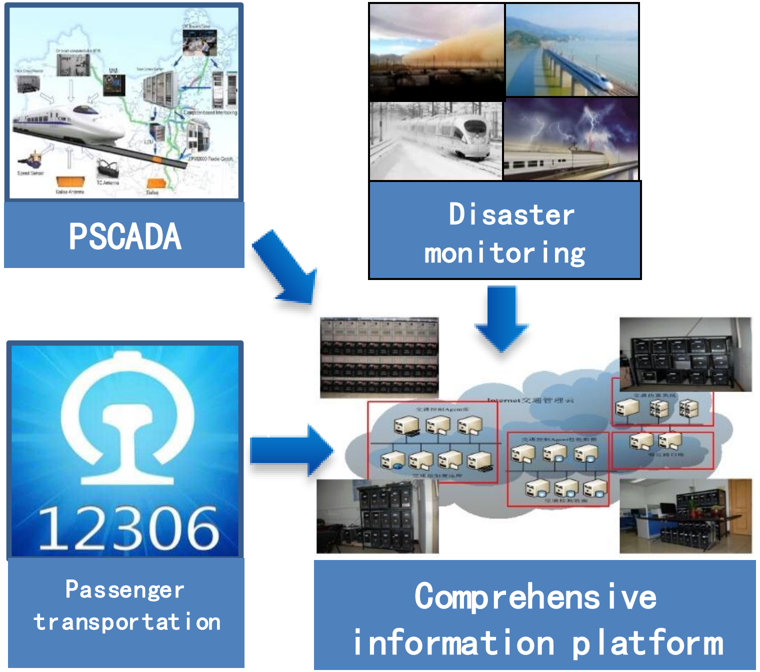
- Route safety control: alarms during dispatcher operations when the route and directions are different from the original timetable
- Station operation safety control: including water feeding, sewage suction, boarding/alighting, etc.



Ensuring a safe and efficient train operation in railway dispatching at station through monitoring and early warning

COMPREHENSIVE INFORMATION PLATFORM

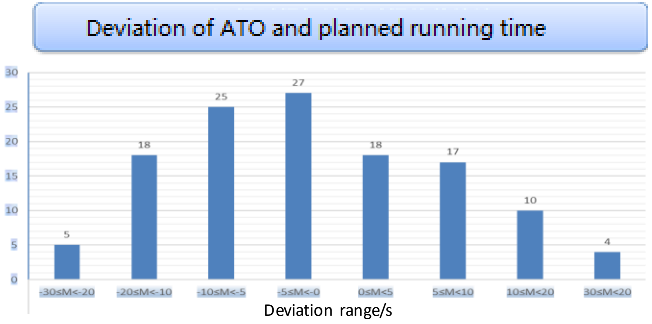
- Comprehensive management of traffic data: provide data maintenance management for bridge and tunnel, evacuation point, station, etc.
- Process setup and query: setting and query of train arrival/departure process and fault handling
- Information sharing: data sharing with passenger transportation system, power supply system (PSCADA), construction management system, and disaster prevention system

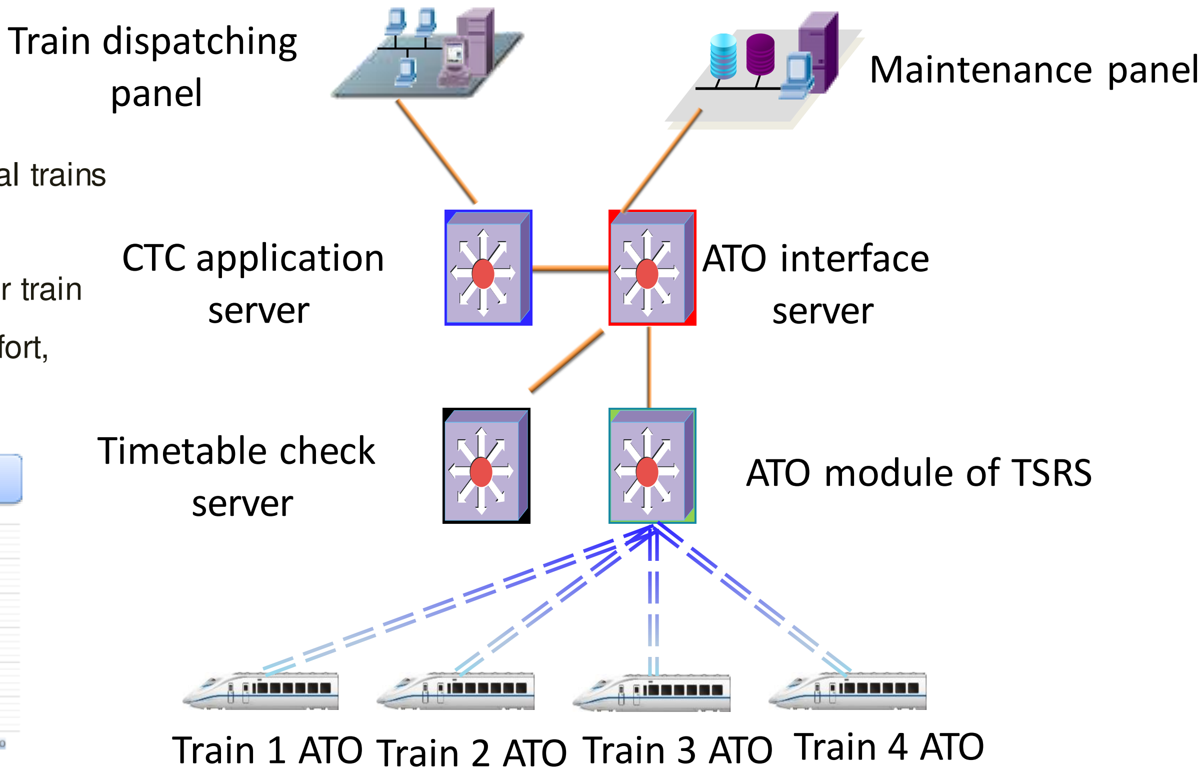


Verify the sharing and interaction of environment information for railway dispatching and train control

INTERFACE FOR AUTOMATIC TRAIN OPERATION (ATO)

- Provide train arrival/departure time of several trains to ATO module
- ATO generates optimal running trajectory for train control to meet requirements of safety, comfort, energy saving and punctuality

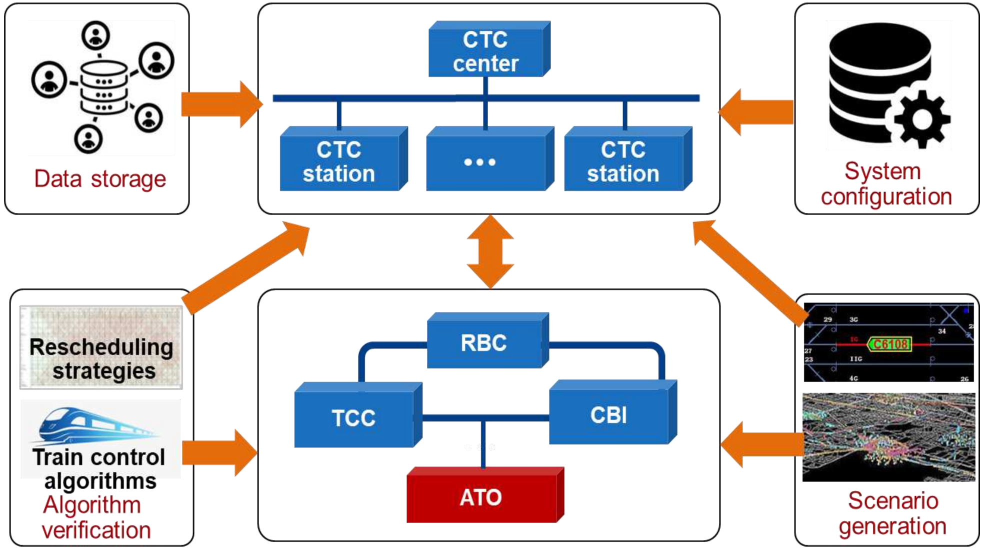




Ensuring an more precise running time between stations compared with manual driving

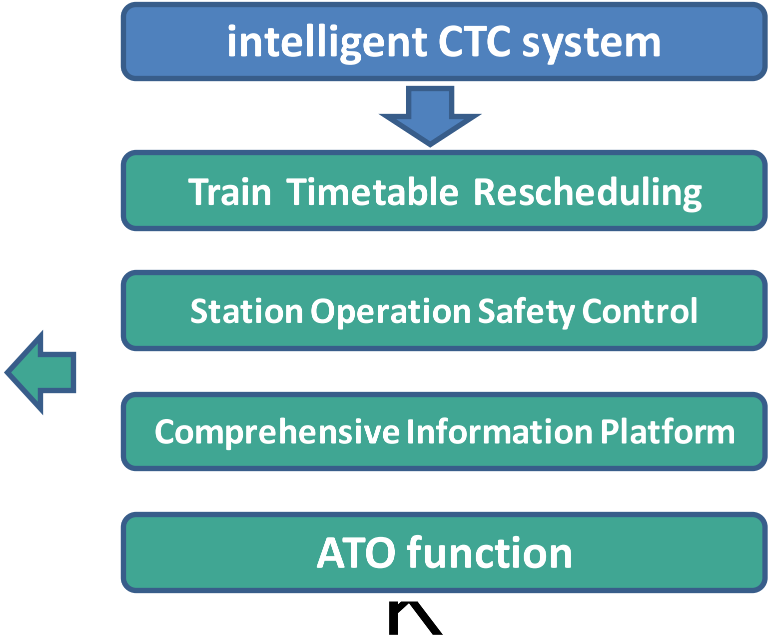
COMPREHENSIVE SIMULATION FOR TRAIN OPERATION

- Actual CTC system software, all CTC functions are supported
- Simulation of all systems connected with CTC interfaces, including computer-based interlocking (CBI), train control center (TCC), Radio Block Center (RBC), GSM-R, etc.
- Train simulation: adding single or multiple trains running in sections
- Generate disruptions and provide emergency scenarios for railway dispatchers



Providing rescheduling strategy verification, operation practice, and emergency scenario for dispatchers

- **The Beijing-Zhangjiakou high-speed railway** is considered a crucial and vital link between all three venue clusters for the Beijing 2022 Olympic Winter Games.
- The intelligent dispatching techniques have been applied at the line, which have provided the **intelligent transportation service** for passengers.



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Marrakech, 7-10 MARCH 2023

Introduction to IRS 60683
Design of a high speed railway -- Interface

Yongzheng, ZHOU
Senior Engineer, China Railway Economic and Planning Research Institute, China
Session4-5.4 Superstructure / Design

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1. Background and Working Process of IRS60683

Design of a High Speed Railway series IRSs:

- IRS60680 *Infrastructure*
- IRS60681 *Communication and Signalling*
- IRS60682 *Energy*
- IRS60683 *Interface*

High-speed IRS programme of UIC Intercity and High-Speed Committee (ICHSC).

Item set-up	Initial draft	Draft versions and comments review	Final draft version	Committee final review and endorse
2018.03	2020.06	2020.06-2021.08	2021.09	2021.12

2. Main Content of IRS60683

- Foreword
- Executive summary
- Field of application
- Abbreviations and symbols
- Concepts, terms and definitions

General Part

1- Introduction

2- Interface concept, basic design requirements and main interfaces

3- Interfaces between track and earthworks/bridges/tunnels

4- Interfaces between infrastructures and communications / signalling systems

5- Interfaces between infrastructures and energy system

6- Interfaces between communications/signalling systems and energy system

7- Interfaces for rolling stock

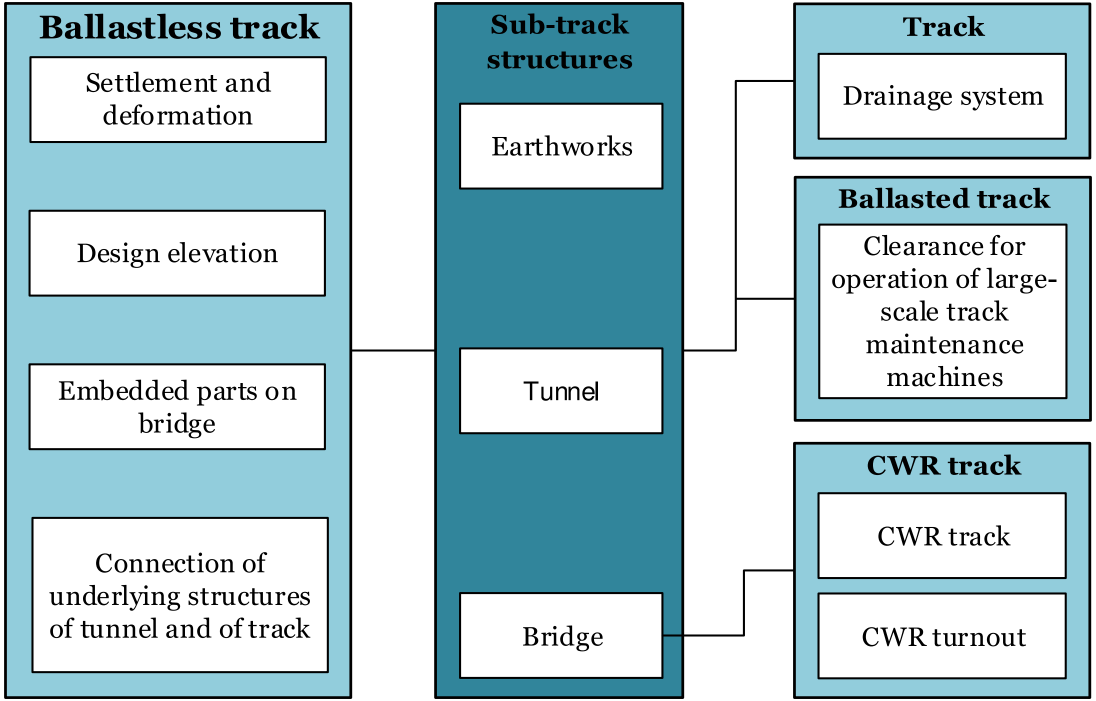
8- Interface between high-speed railway system and non-railway systems

9- Transit Oriented Development (TOD)

10- Interfaces for earthing system

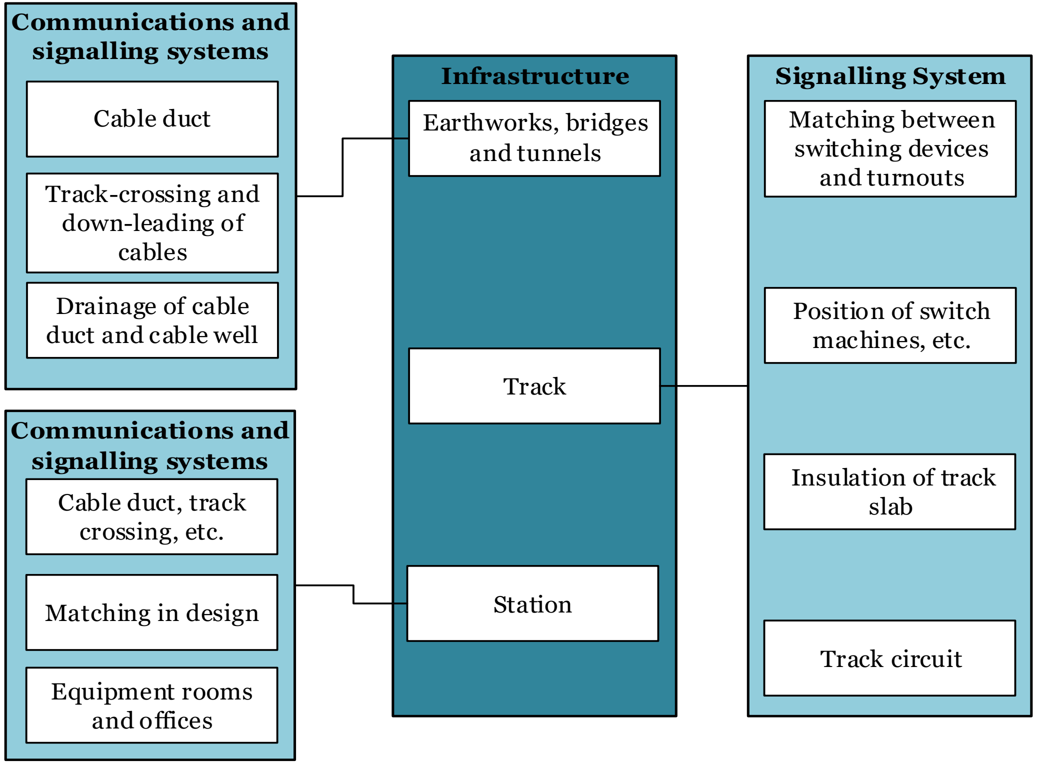
2. Main Content of IRS60683

2.1. Interfaces between track and earthworks/bridges/tunnels



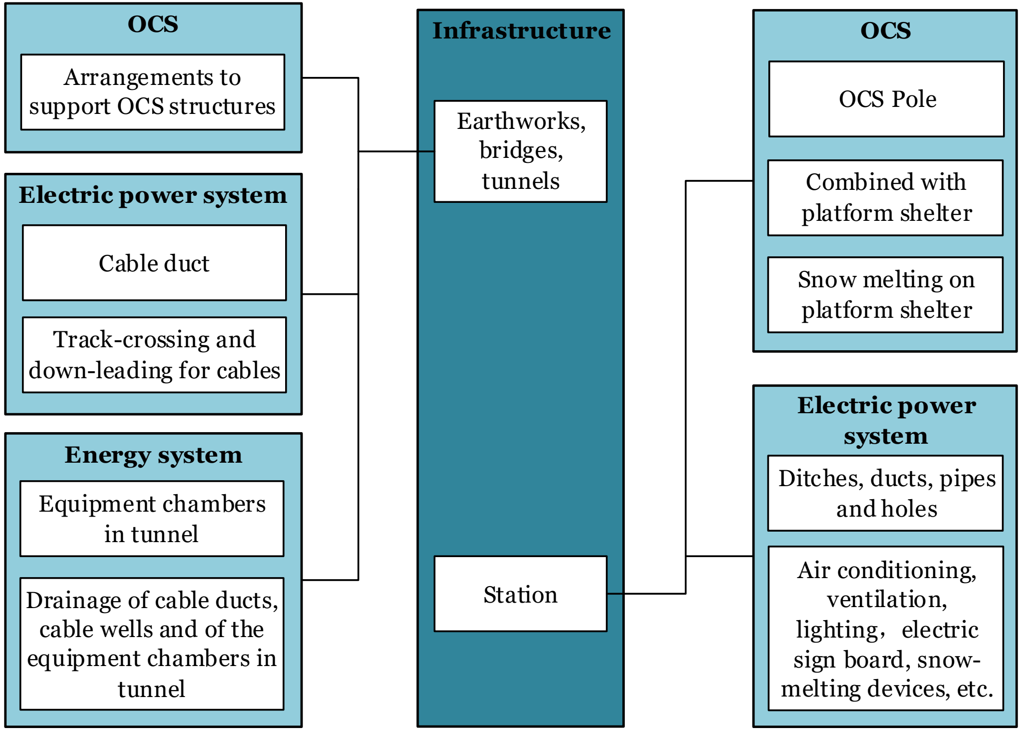
2 Main Content of IRS60683

2.2. Interfaces between infrastructures and communications/signalling systems



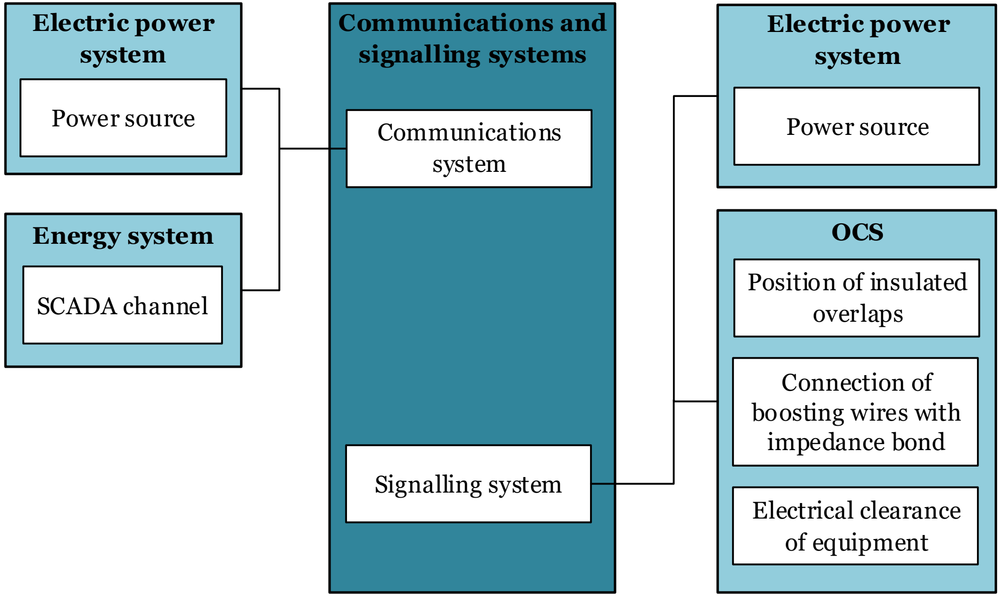
2. Main Content of IRS60683

2.3. Interfaces between infrastructures and energy system



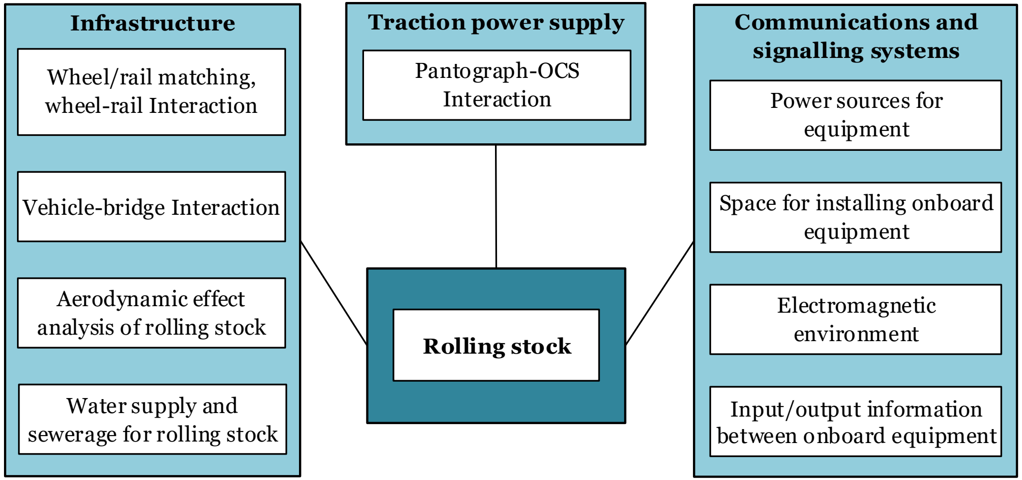
2. Main Content of IRS60683

2.4. Interfaces between communications/signalling systems and energy system



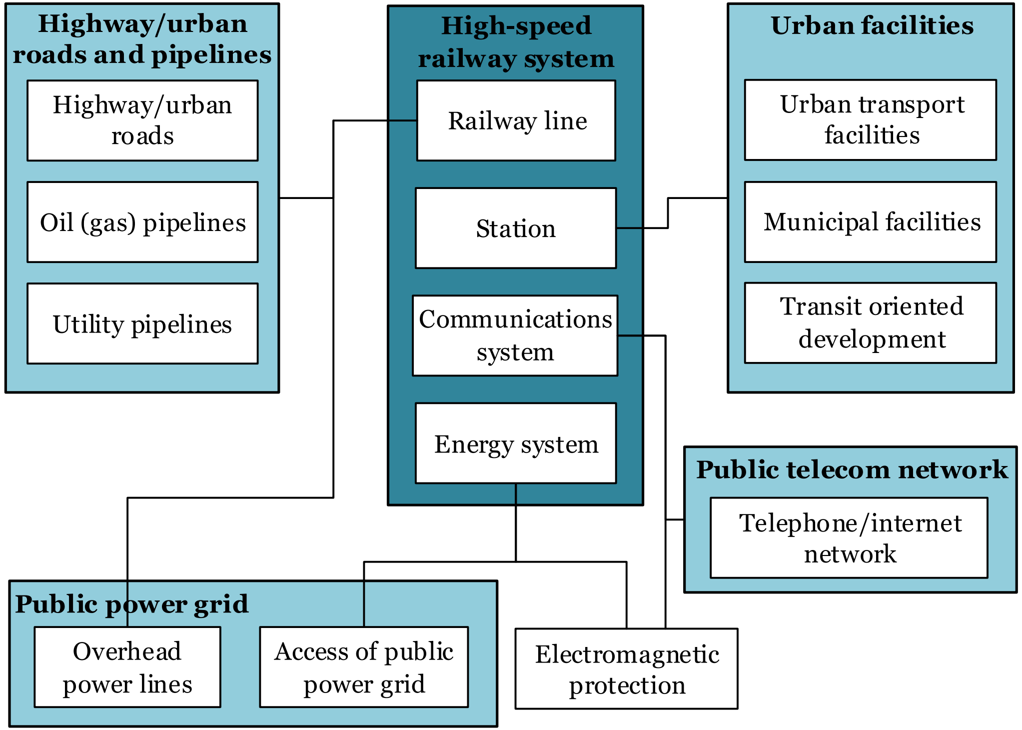
2. Main Content of IRS60683

2.5. Interfaces for rolling stocks



2. Main Content of IRS60683

2.6. Interfaces between high-speed railway and non-railway systems



2.Main Content of IRS60683

2.7. Transit Oriented Development (TOD)

- ❖ Concept
- ❖ Basic requirements
- ❖ TOD design of high-speed railway

High efficiency | Convenience | Comfort | Profitability

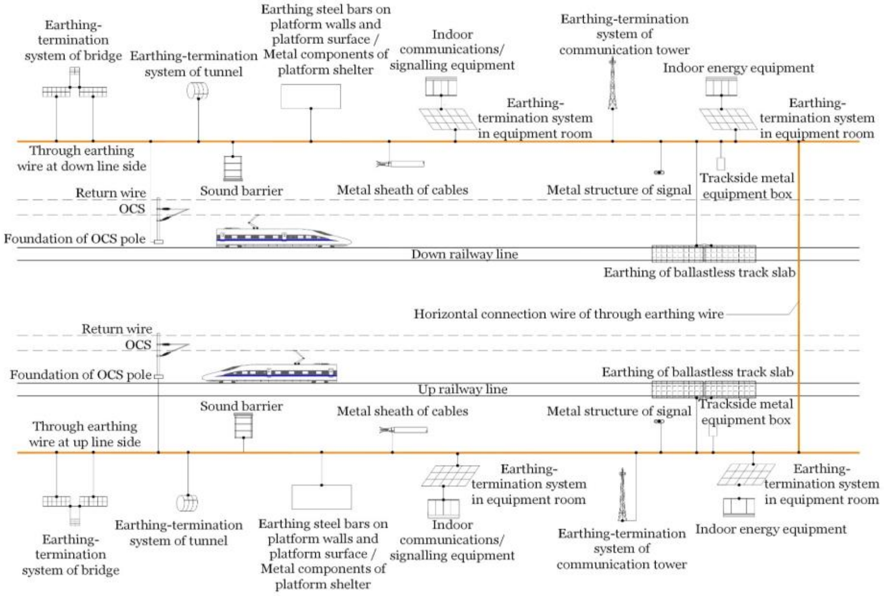
Complex functions: integrating hub functions, city functions, and commercial and entertainment functions.

Diversified spaces: integrating concourse spaces, public spaces, landmark buildings, and leisure spaces.

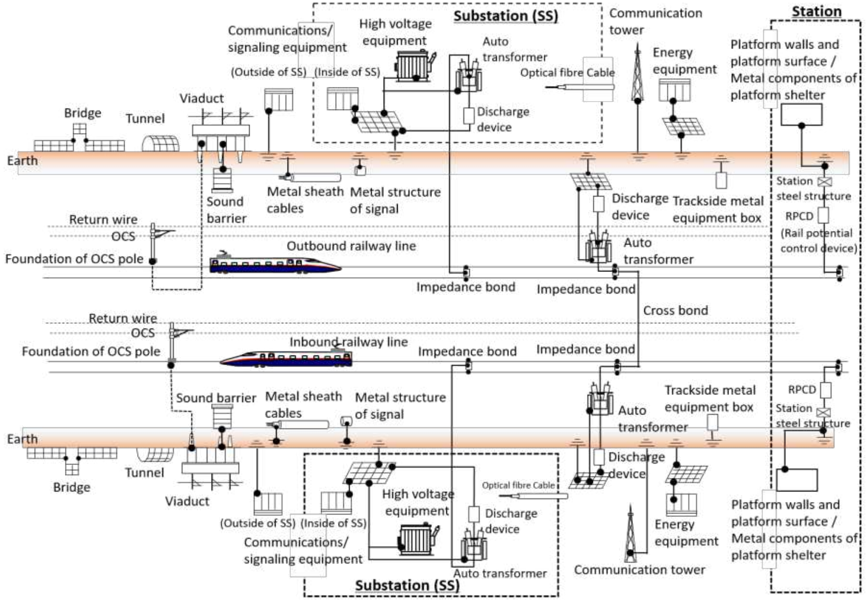
Structural extension: the extension from the transportation center to the urban spaces, ecological corridors and public spaces.

2. Main Content of IRS60683

2.8. Interfaces for earthing system



Schematic diagram of railway integrated earthing system



Schematic diagram of railway individual earthing system

THANK YOU

Contact me: 404168542@QQ.com

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Marrakech, 7-10 MARCH 2023

INDUSTRIAL ENGINEERING
CASE OF THE RAILWAY DOMAIN
DESIGN, REALIZATION AND OPERATION
CATENARY LINE INSTALLATIONS
FOR HIGH SPEEDS

Brahim BENCHELHA
MECHANICAL ENGINEER
SCHOOL OF MINES OF DOUAI FRANCE SESSION 1999
prof,benchelha@gmail,com
Session5.4 Superstructure / Design

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INTRODUCTION

The technological progress made in several countries, particularly in the railway field, falls within the scope of industrial engineering.
The most recent and common definition of engineering is:
Engineering is all essentially intellectual services aimed at optimizing an investment of whatever nature, during its design, construction, commissioning and operation.

Currently, throughout the world, the design of high-speed lines is on the agenda of many countries. The role of these lines in economic development no longer needs to be demonstrated,
Only fifteen kilometers separate Europe from Africa at the Strait of Gibraltar, the realization of this link as well as the realization of a Moroccan high-speed network constitute a beautiful dream.
.
I would consider dividing the Catenary engineering process into two types of adaptive and new design in order to have a progressive approach that treats each type on a separate part.

As a result, I am participating in this high-speed UIC congress with this presentation by which I address an original and very important subject that I defended as my dissertation at the Ecole des Mines de Douai in France on 29 October 1999,

Key Words : Enginneering- Technological- Catenary- Speed- Constraint- Process- Damage- Maintenance
Mots clés : Ingénierie - Technologique - Caténaire - Vitesse - Contrainte - Procédé - Avarie - Maintenance.

1-INDUSTRIAL ENGINEERING

1-1-engineering of railway industrial units by 2EI

Example of a unit Installed from 2011 at the LGV Kenitra works base
Case 1 of Sateba concrete sleeper unit installed on Tangier LGV
Case 2 of KRC Geismar LRS unit installed on LGV Tanger-Kenitra

1-2-railway engineering of catenary lines

the inauguration in 1927 of the first catenary line between CASABLANCA and KHOURIBGA designed for a speed between 80 to 100km/h

The Evolution of Innovation technology of the facilities catenaries has not ceased to progress to answer
to the requirements of our country,
By a catenary carried or partially suspended or
Fully regularized, ²

Engineering missions and industrial design

ADVISE THE INVESTOR At the stage of:
- Decision
- Identification
- Programming
- Feasibility

DESIGN The project to be carried out
- Design study
- Execution project

CONTROL The quality of the Project implementation
- Design compliance
- Respect of costs
- Respect of deadlines

REALIZE The project
- Conduct of works
- Supply of equipment

TO ASSIST INVESTMENT
- Reception of equipment
- Staff training
- Getting started
- Choice of maintenance policy

the Sateba unit

the KRC unit

2-ADAPTIVE DESIGN OF EXISTING CATENARY FOR HIGH SPEEDS

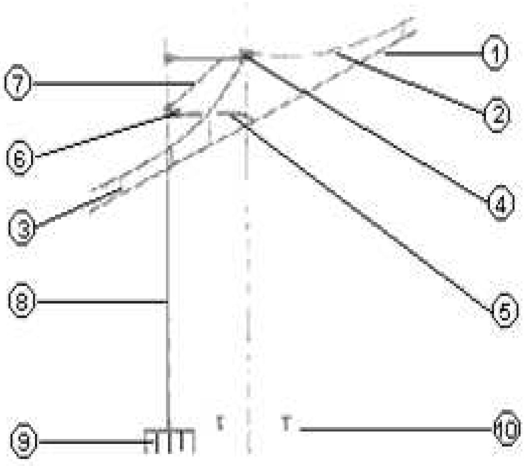
2-1: IMPROVEMENTS TO TECHNOLOGICAL PRINCIPLES

2-1-1: Critical analysis of the partially and fully regulated catenary:

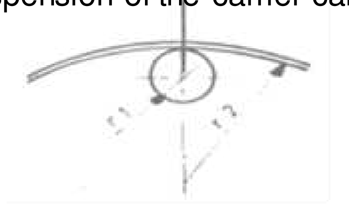
The critical analysis of the technological principles of the types of installations requires the examination of the following points:

- The constitution of the catenary
- The suspension of the catenary
- Regularization of the catenary
- Other special points

Constitution of the catenary



Suspension of the carrier cable



Hertz formulas

$$P_{MAX} = 0{,}62\sqrt[3]{\frac{N\ell^2}{\alpha^2}} \quad avec\ \ell = \frac{1}{2}\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$$

$$\alpha = \frac{1}{2}\left(\frac{1}{E_1}+\frac{1}{E_2}\right)$$

2-1-2 Supporting calculations for catenary conductors:

A carrying cable stretched between 2 supports takes the form of a chain. To simplify the calculations, we will assimilate this catenary to a parabola.

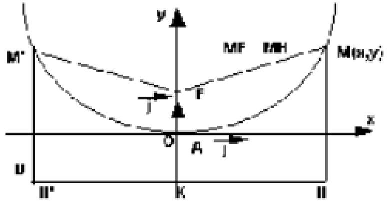
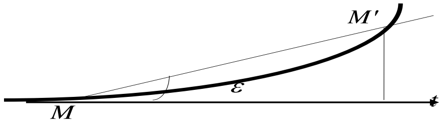


Figure: Parable

Calculation of the length of a parable arc (p)

An arc MM and its rope MM'

are two infinitely small equivalents,



The length of the parabola arc (p) is:

$$OM = s = \frac{1}{2p} X\sqrt{X^2+p^2} + \frac{p}{2}\ln\frac{X+\sqrt{X^2+p^2}}{p}$$

- reduced equation of the parable

In the orthonormed benchmark $(o,\vec{i},\vec{j})$, the reduced equation of the parable is $x^2 = 2Py$

- Approached length of the Arc-OM

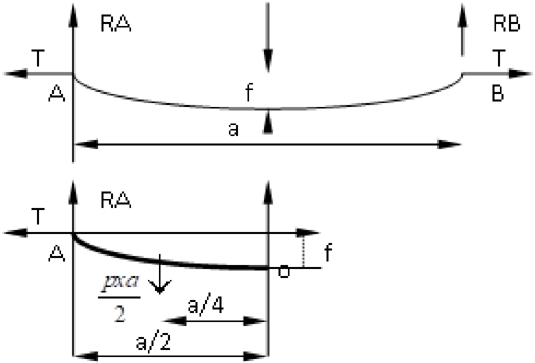
Let us seek the limited development of the function of the length Arc de la parable (P) using Mac-Laurin's formula.

$$f(x) = f(o) + xf'(o) + \frac{x^2}{2!}f''(o) + \dots \frac{x^n}{n!}f^n(0) + x^n\sum(x)$$

Limited development $= f(x) = x + \frac{3x^3}{12p^2} - \frac{x^3}{12p} = x + \frac{2x^3}{12p^2}$

therefore the approximated formula of the arc is equal to: $OM = f(x) = x + \frac{x^3}{6p^2}$

Important formula for the next catenary calculations.



$$L = a + \frac{a^3p^2}{24T^2}$$

so we have $f = \frac{pa^2}{8T}$ et $y = \frac{x^2}{2p_1}$

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2-1-3 ANALYSIS OF THE PANTOGRAPH - CATENARY INTERACTION

The circulation speeds of electric trains are limited by the phenomenon of pantograph-catenary interaction.

Because, the contact force (Fc) is determined by the following formula:

$$Fc = Fs \pm Mt \cdot m^2 y$$

$$Mt = m_A + m_c$$

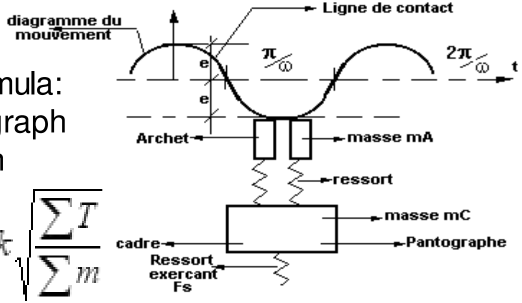
Fs: the static force of the pantograph

Mt: total mass of the pantograph

the speed of the wave train is equal to: $V = \sqrt{\frac{T}{m}}$

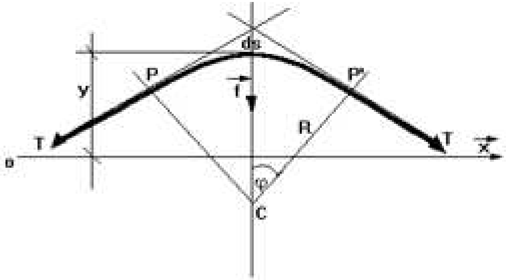
$$Vcr = 3{,}6k\sqrt{\frac{\sum T}{\sum m}}$$

Dynamic behavior of the pantograph



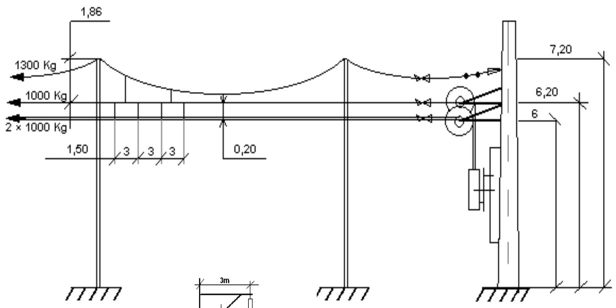
Pantograph in contact with the catenary

Dynamic behavior of a conductor



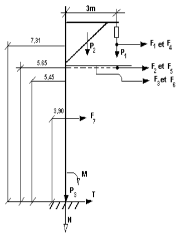
2-1-4: COMPARATIVE STUDY OF TECHNOLOGICAL PRINCIPLES

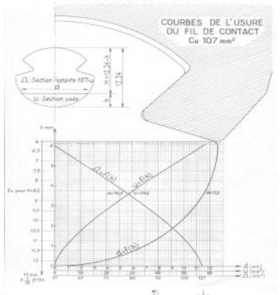
The elements	Partially regularized catenary		Fully catenary regularized		
To	Scope	Suspended	Scope		Suspended
compare			carrier 94 mm²	carrier 153 mm²	
Suspension					
- Support	rigid	soft	rigid	rigid	soft
- Pressure (Hertz	big	weak	big	very tall	weak
-Y Or V	without or V(m)	pendulum	V	Y or V	pendulum



2-1-5: RECOMMENDATIONS AND RECOMMENDED REMEDIES

Items to modify	Catenary scope	catenary suspended
1) Regularization of the mechanical tension of the conductors	It is not possible to compensate the carrying cable, the consoles being fixed hence the non-uniform elasticity, therefore it is recommended to use an auxiliary wire to increase the sum of the tensions and to make the elasticity uniform.	





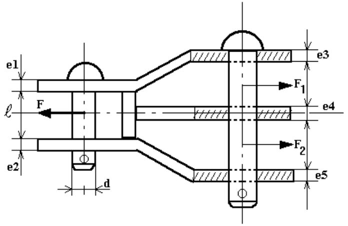
2-2: IMPROVEMENT OF EQUIPMENT AND MATERIALS

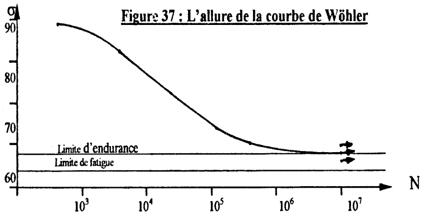
2-2-1: Analysis, calculations and verification of the mechanical behavior of equipment.

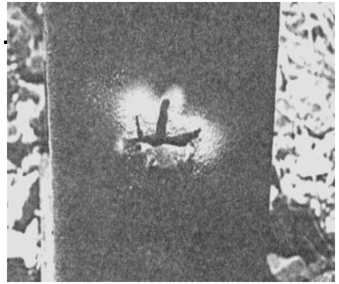
2-2-2: Analysis of the causes of non-conformity and expertise of mechanical damage by FMEA.

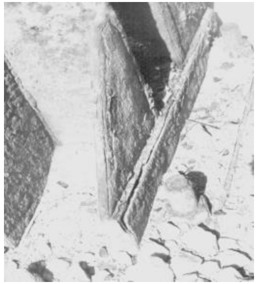
2-2-3: Analysis of tribological damage: wire wear, matting, fatigue and parts corrosion.

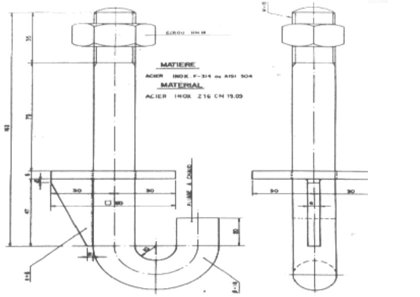
2-2-4: Recommendations and recommended remedies.











3 : NEW DESIGN OF FUTURE HIGH-SPEED CATENARY LINES

3-1: BASIC ENGINEERING: TECHNOLOGICAL PRINCIPLES.

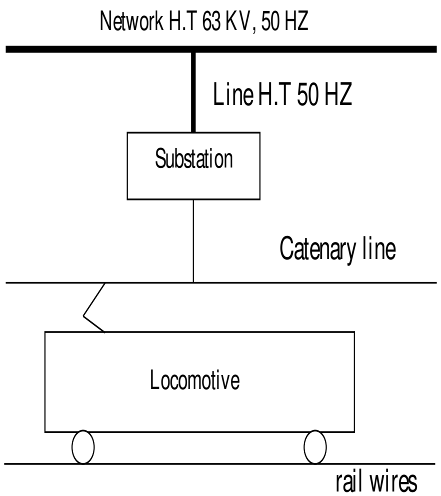
3-1-1- Study of conductors:

Catenary lines must have the best electrical, mechanical and geometric qualities.

The 25 KV single-phase power supply system is opted for in order to achieve interoperability in accordance with the European standard (pr EN 50 xxx of 08/09/99) of the European Committee for Electrotechnical Standardization (CENELEC).

La grande train circulation speed is equal to 300 km/h

feeding diagram

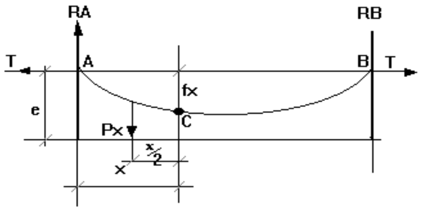


Wave propagation velocity $VP = 3{,}6\sqrt{\dfrac{\sum T \rightarrow en\ Kg}{\sum m \rightarrow en\ Kg.\sec^2/m}}$

from where VP = 474 Km/h

- Arrow at any point of the staff.

Boom carrier



$$\sum M_C = 0$$

$$\sum M_C = Tfx + Px\frac{x}{2} - R_A x = 0$$

$$Tfx = Pa\frac{x}{2} - \frac{Px^2}{2} = \frac{Px}{2}(a-x)$$

$$P = \frac{P}{2T}x(a-x)\ \ comme\ f = \frac{a^2 P}{8T}$$

(The arrow equation is demonstrated in paragraph 2-1-2)

from where $\dfrac{P}{2T} = \dfrac{4f}{a^2}$ $\quad donc \quad$ $f(x) = \dfrac{4fx}{a^2}(a-x)$

3-1-2: PRINCIPLE OF COMMON TRACK EQUIPMENT:

Conductors	Carrying cable	contact wire	Earth wire and fixed point	Cable Pendulums
Nature	Bronze 98,65 Cu	hard copper 98,8 % Cu	Galvanized steel	In bronze
Section mm²	94,13	150	60,93	12
Diameter mm²	12,6	14,5	10	4
Mass Kg/m	0,88	1,334	0,487	
Composition	37 strands 1,8 mm	Flat Grooved Wire	7 × 3,3mm	Strands 0,53 à 0,63 mm
breakdown tension	5640	5400	7920	
Coefficient of expansion	18×10^{-6}	17×10^{-6}	13×10^{-6}	
Elongation coefficient	78×10^{-6}	91×10^{-6}		
Operating tension in Kg	1800	2200	400	

- ***Conductors Choice Goal:***

We have four key goals.

The mechanical tension of conductors must be very high.

The service life of the contact wire must be very long.

The main role of the carrier is to support the load of the catenary.

The main role of the contact wire is to ensure current collection.

3-2: DETAIL ENGINEERING:

3 - 2 - 1: DETAIL STUDIES.

3-2-1-1: studies, choice and applications of materials,

3-2-1-2: studies and calculations of columns of equal stress, and presumed frames.

3-2-1-3: studies, calculations of the massifs and determination of the central core.

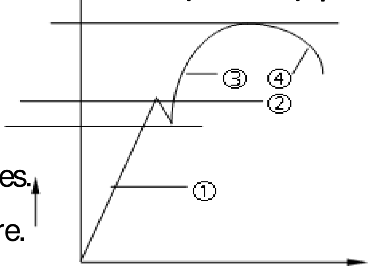
3-2-1-4: studies of separate mechanical compensators.

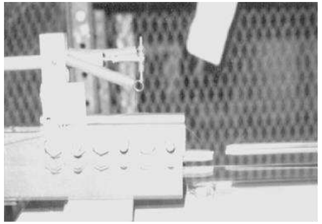
3-2-1-5: studies and calculations of catenary parts subjected to buckling.

3-2-1-6: studies and calculations of the bending of curved catenary parts.

3-2-1-7: studies and calculations of catenary cables to the curvature constraint.

Curve (hook) pull

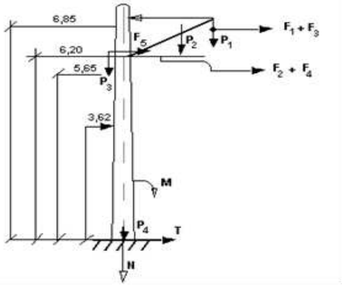




standard tests U.I.C.

$$\sigma_t = \frac{Mf.v}{I_D} + \frac{P}{S}$$

$$\frac{(P+N)a}{2(M+T_h)} \geq 1,3$$

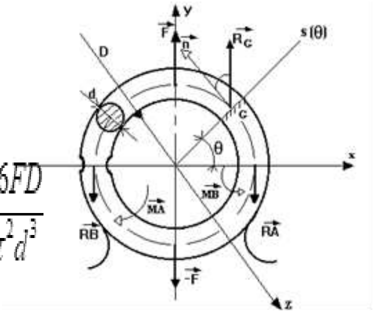


$$\Delta L = 4\,\alpha\,L\,(\theta_2 - \theta_1)$$

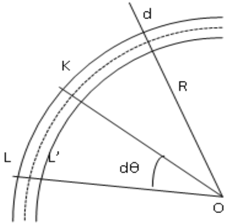
Euler's critical load:

$$P_c = \frac{\pi^2 EI}{L^2}$$

$$\frac{\pi}{2} \quad \sigma_R \max = \frac{16FD}{\pi^2 d^3}$$



$$\sigma_t = \frac{T}{S} + \frac{Ed}{D}$$



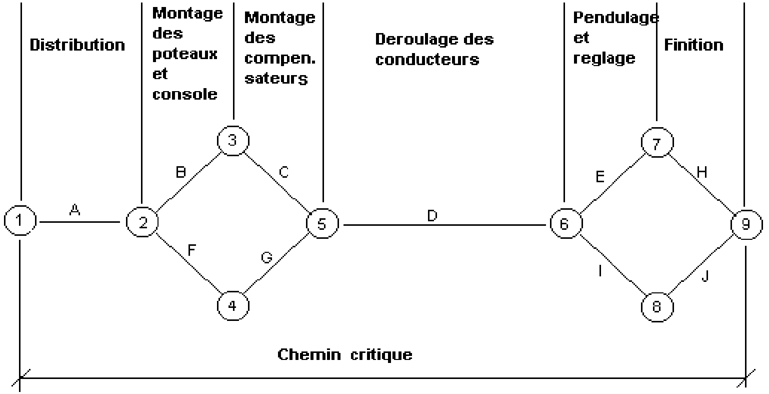
3 - 2 - 2: REALIZATION:

3-2-2-1: conducting the picketing study.
3-2-2-2: studies of the main construction processes for catenary parts.
3-2-2-3: procurement and development of a standard technical specificatior
3-2-2-4: assembly methodology and conductive creep resorption study.

3 - 2 - 3: OPERATION:

3-2-3-1: organization of catenary maintenance.
3-2-3-2: development of a maintenance guide.

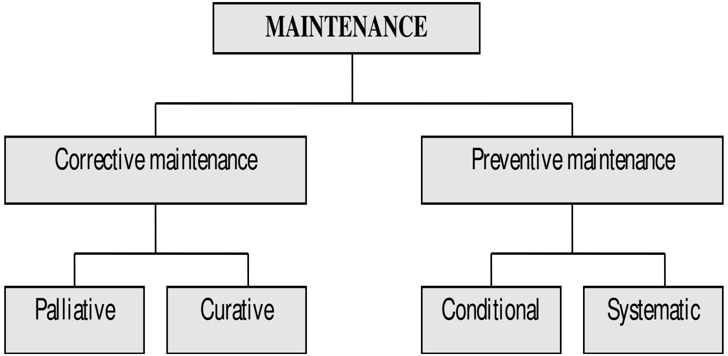
Réseau PERT



- **Type of creep:**
- There are several types of creep in this case we have a so-called logarithmic creep:
- θ << θ fusion according to the observed experimental law
- $\varepsilon_t = \varepsilon_0 + A \log(\beta t+1)$ $\quad v = \dfrac{d\varepsilon}{dt}$
- creep speed

steadily decreases over time.

The different types of maintenance.



CONCLUSION

- The importance of this thesis lies in the fact that it allowed me to exploit my strengths, my know-how and my scientific and technological knowledge that I have built up over more than twenty years in the field of railway industry.

- **Summary**: Engineering and technological development are two concepts that are closely linked, in other words the trajectory of the increase in rail speed passes through engineering, therefore either through adaptive design or through new design.
- The adaptive design of existing catenary line installations for high speeds allowed me to assess the current state and to begin the study of "speed" wave propagation, therefore, I recommended recommendations and remedies to increase the speed of electric trains between 180 and 260 km/h, designed for limited speeds between 120 and 160 km/h.
- The new design of the future catenary line installations for high speeds offered me the possibility of meeting the requirements of high speed thanks to the basic and detail engineering and offered me the possibility of using the new system of 25 KV single-phase power supply in order to achieve interoperability in accordance with European standard (pr EN 50 xxx of 08/09/99) of the European Committee for Electrotechnical Standardization (CENELEC). The recommended high speed for future catenary lines is 300 km/h.

- **Perspectives**: The increase in speed on a railway line requires the improvement and innovation of all the equipment and materials which are linked to the catenary installations.

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THANK YOU

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