MUMBAI-AHMEDABAD HIGH SPEED RAIL (MAHSR) PROJECT

Technical Seminar for IRAS Officers

Rail Bhawan, 11th Oct,2018

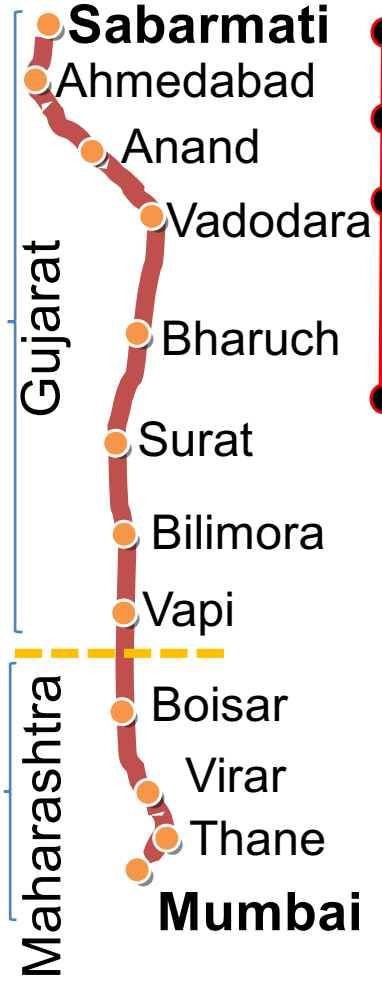
NATIONAL HIGH SPEED RAIL CORPORATION LTD
NEW DELHI

OUTLINE OF PRESENTATION

- **General Overview**
- **Technical Challenges and Solutions**
- **Key Technologies of High Speed Rail**
  - Rolling Stock
  - Systems (Signalling & Communication)
  - Overhead Equipment (OHE)
  - Special Safety Features
- **Financial aspects of the project**

GENERAL OVERVIEW OF PROJECT

Total Length: 508.09 Km



- **460.3 Km** Viaducts (**90.6%**)
- **9.22 Km** Bridges (**1.8%**)
- **25.87 Km** Tunneling (**5.1%**)
  (Longest Tunnel: 21 Km with 7 Km undersea)
- **12.9 Km** Cut/Fill (**2.5%**)

Stations: 12 (8 in Gujarat & 4 in Maharashtra)

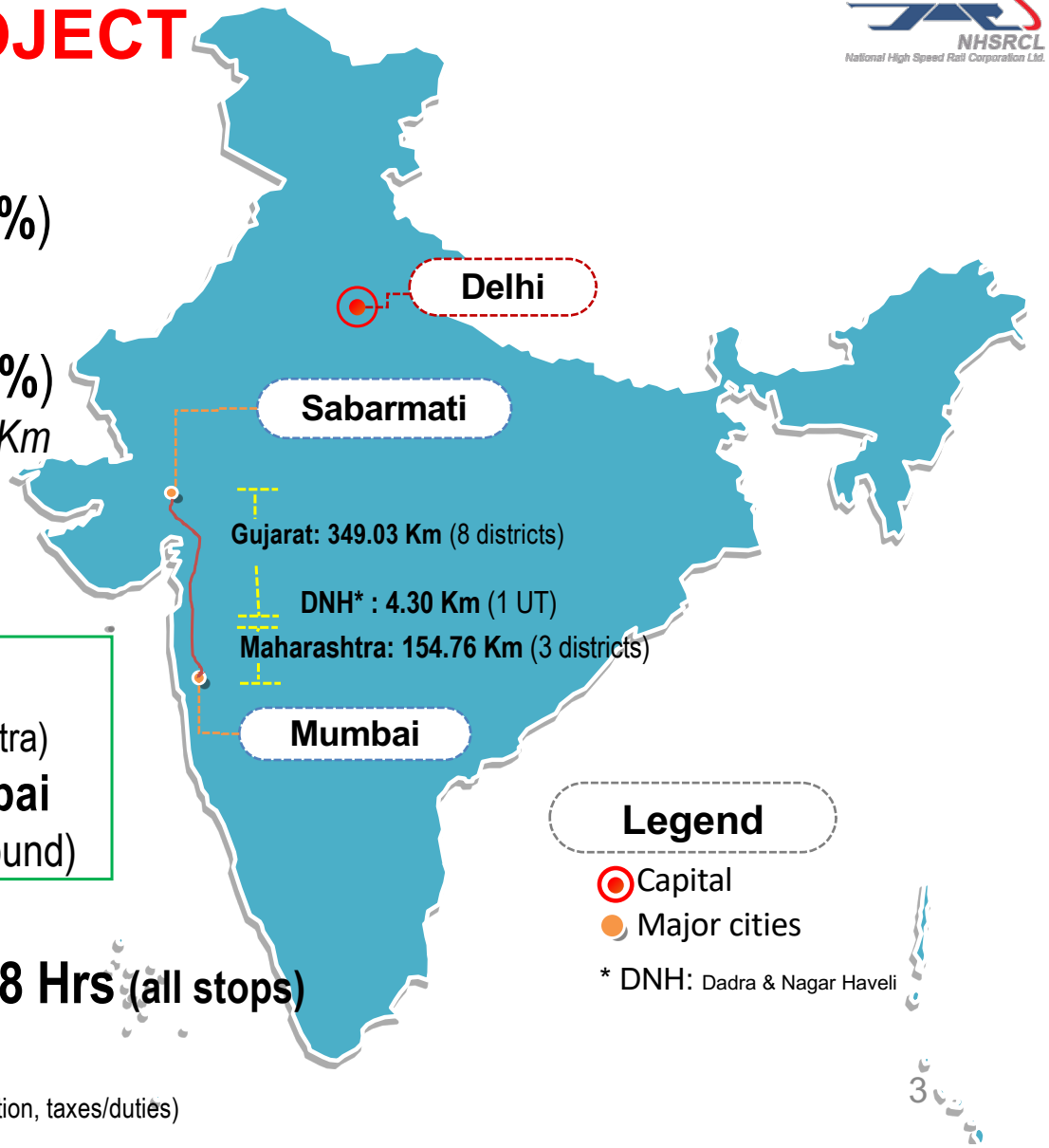
All elevated except Mumbai (underground)

Travel Time:

2.07 Hrs (limited Stops) 2.58 Hrs (all stops)

COST: 1,08000 CRORES

(including all escalation, Interest during Construction, taxes/duties)



SALIENT FEATURES OF PROJECT

Total Length	**508.09 Km** *(Maharashtra 154.76 Km, Gujarat 349.03 Km, Dadra & Nagar Haveli (UT) 4.30 Km)*
Gauge	**Standard Gauge**
Speed	Design: **350 Kmph**, Operating: 320 Kmph
Travel time	**2.07 hrs** (limited stops) , 2.58 hrs (all stops)
Stations	**12 numbers** [**Maharashtra 4 nos** *(Mumbai, Thane, Virar, Boisar),* **Gujarat 8 nos** *(Vapi, Bilimora, Surat, Bharuch, Vadodara, Anand, Ahmedabad, Sabarmati)*]. ***All elevated except Mumbai (underground).***
Alignment	**460.3 Km** *Viaducts*, **25.87 Km** *Tunneling*, **12.9 Km** *Embankment/cutting* and **9.22 Km** *Bridges*.
Longest Tunnel	**21 Km** with 7 Km under sea.
Longest Bridge	**River Vaitarna**, 1,950 m.
Estimated Completion Cost	**Rs. 1,08,000 Crores** *(including all escalation, Interest during Construction, taxes/duties)*

SALIENT FEATURES OF PROJECT

TRAIN OPERATION PLAN (Source: Feasibility Study)

		Year	2023	2033	2043	2053
Train Configuration			**10**	**10/16**	**16**	**16**
Number of Rakes			**24**	**24 +11**	**44**	**71**
Number of Trains (per day/one-direction)			**35**	**51**	**64**	**105**
Train Capacity			**750**	**750/1250**	**1250**	**1250**
Traffic Volume (day/one direction)			**17,900**	**31,700**	**56,800**	**92,900**
Number of Trains (per day/hour/one-direction)	**Peak Hour:**		**3**	**4**	**6**	**8**
	Off peak:		**2**	**3**	**3**	**6**

Operational Control Centre: **Sabarmati**

Maintenance Depot/Workshop (Rolling Stock): **Thane, Sabarmati**

TECHNICAL CHALLENGES AND SOLUTIONS

Technical Challenges and Solutions

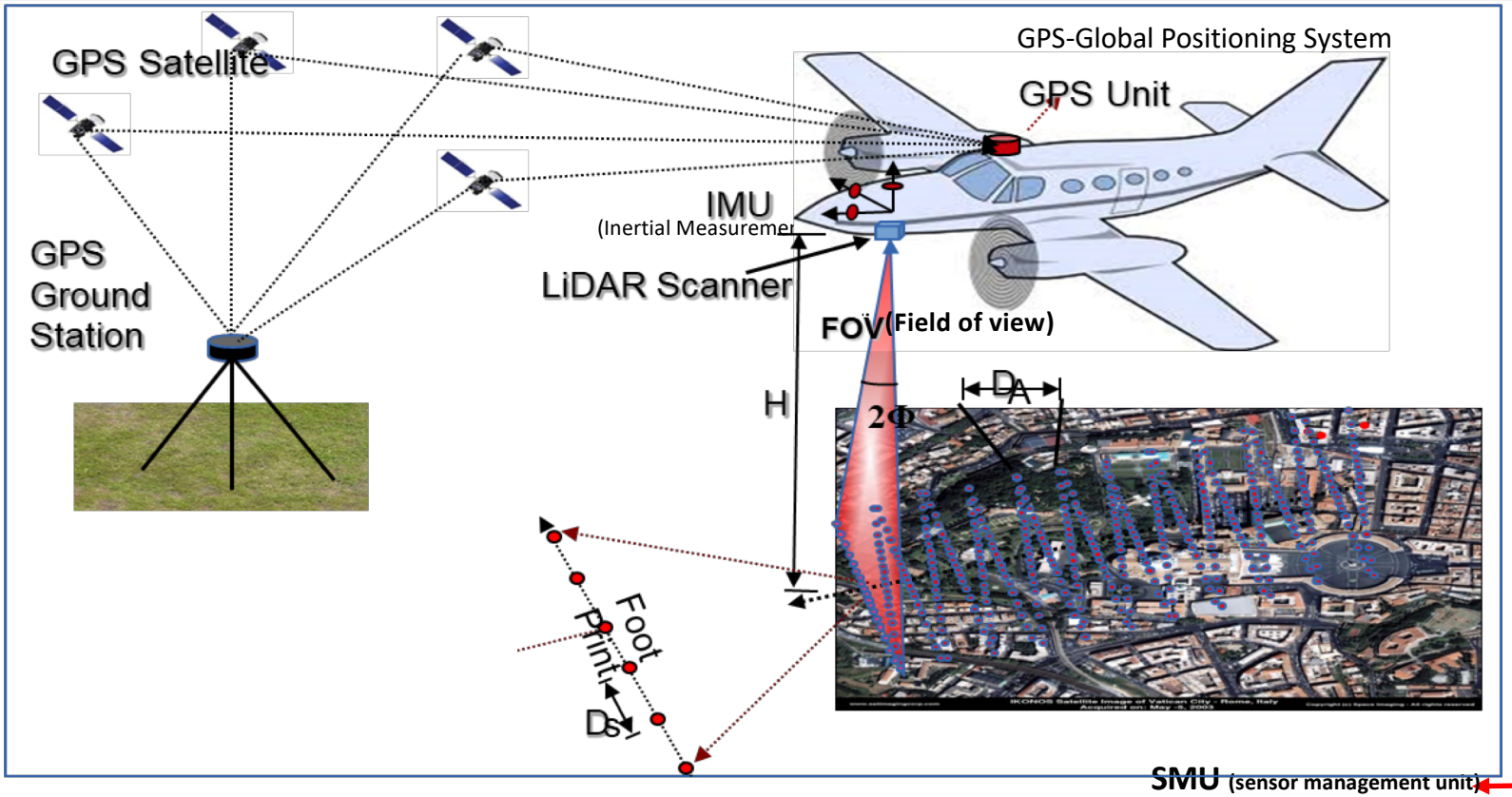
- **Mumbai-Ahmedabad High Speed Rail Project** (MAHSR) is the **first ever High Speed Rail project** in India.
- **National High Speed Rail Corporation Limited** (NHSRCL), incorporated in **2016**, is implementing this 508 KM long project.
- Project is planned to be implemented in **short time span of 6 years**.
- Project is in the initial stages of Planning , Design & Tendering, it will be followed by Construction, O & M phase.

Accurate Surveys in short time

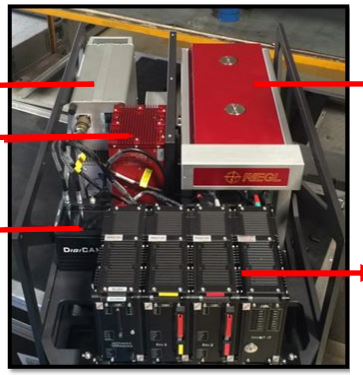
- ***Aerial Lidar Topographic Survey*** *(**LiDAR** - Light Detection and Ranging)* adopted for the **1st time** in a Railway Project in India.
- Good accuracy (100 mm) *, and survey completed in **03 months**.
- **DGPS** *(Differential Global Positioning System)* technology used to establish *horizontal control points*, and **Digital Levelling** to accurately fix the *reduced level* with respect to Mean sea level.
- LiDAR data used for design of alignment, Right Of Way, identification of project affected plots/structures etc.

***Elevation accuracy achieved in MAHSR**	**39mm**
***Positional accuracy achieved in MAHSR**	**93mm**

AERIAL LiDAR SYSTEM OVERVIEW



Aerial Lidar System



SMU (sensor management unit)

IMU (Inertial Measurement Unit)

Aerial Camera ***(Camera 100 MP)***

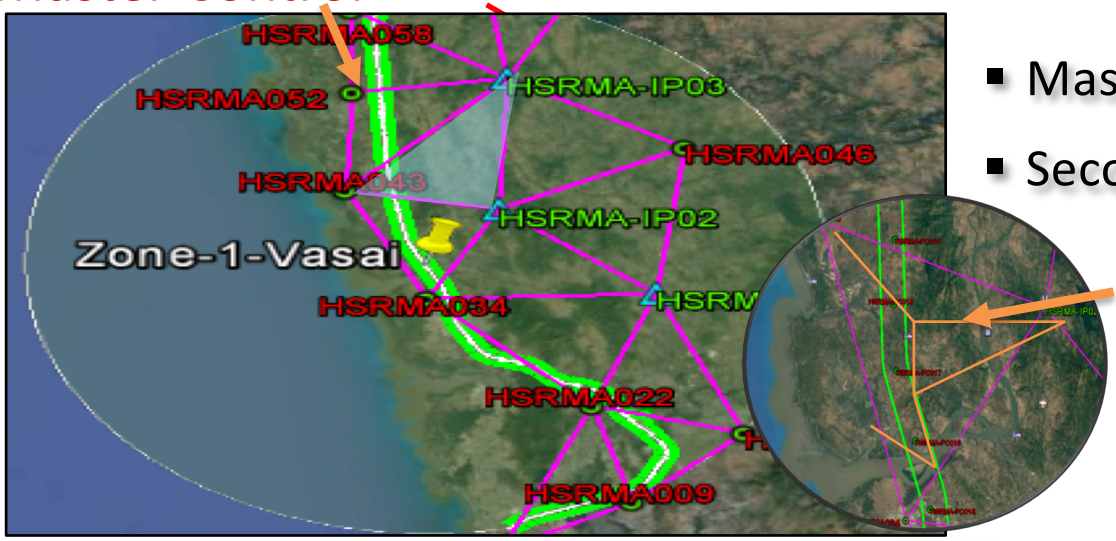
Aerial Lidar Scanner

Computer System

METHODOLOGY

The Aerial LiDAR base station locations selected from the newly established Control Points .

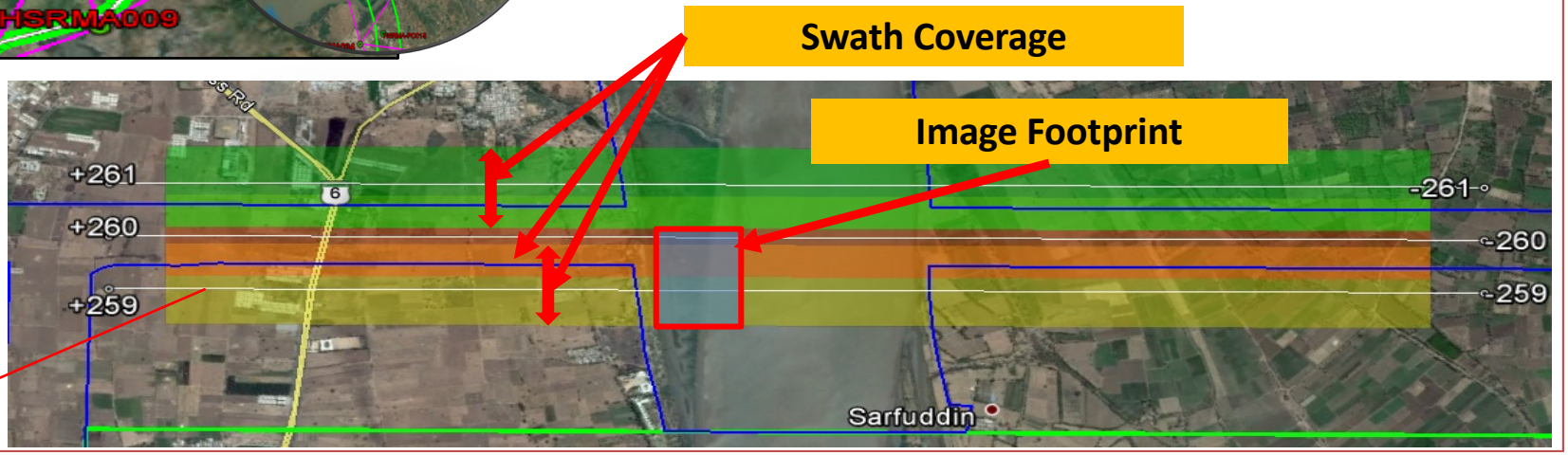
Master Control



- Master control stations: Avg. Base length 25-28 Km
- Secondary control stations: Avg. Base length 5-8 Km

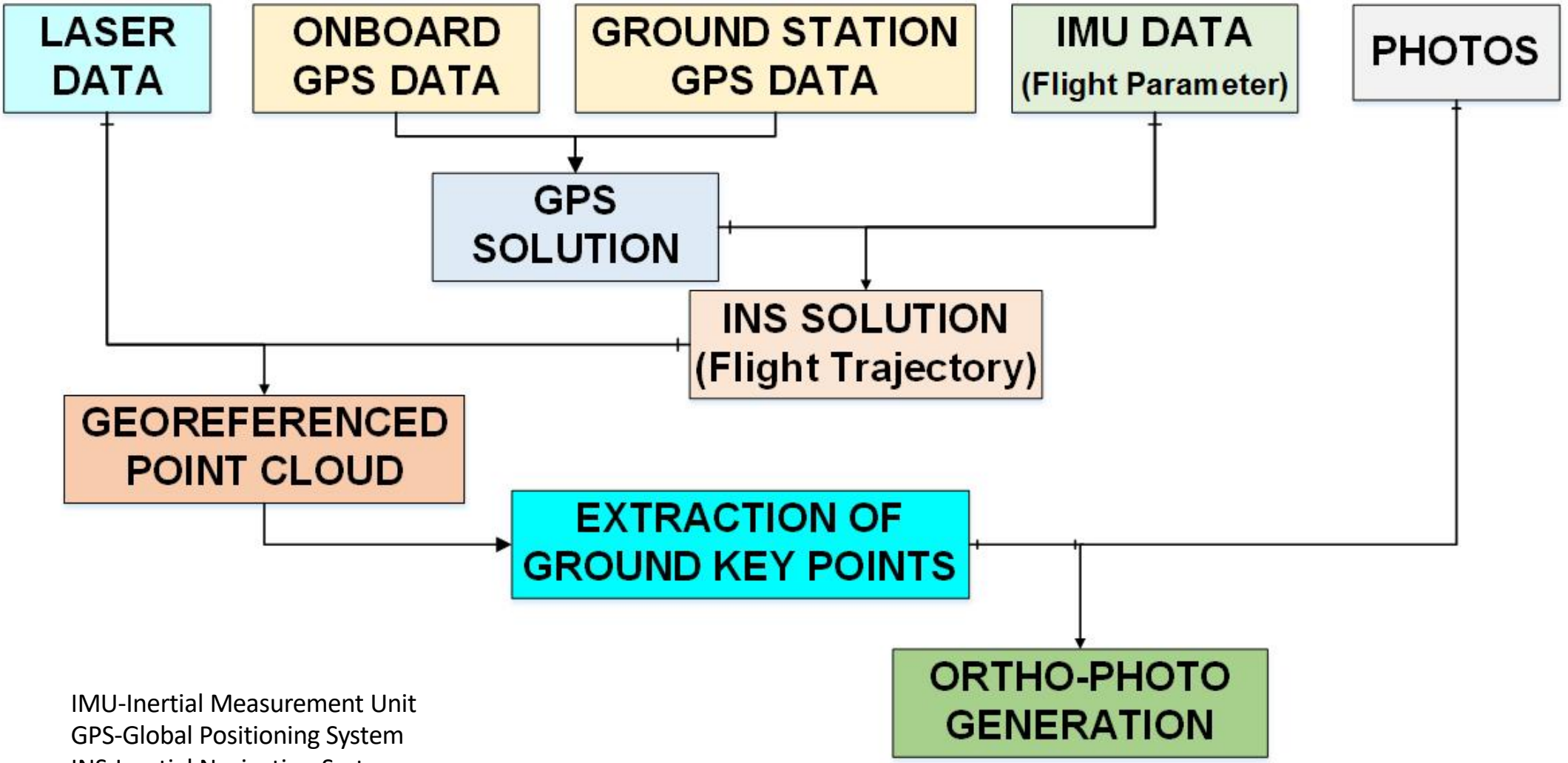
Secondary Control

Flight Plan



Flight Lines

DATA PROCESSING AND OUTPUT



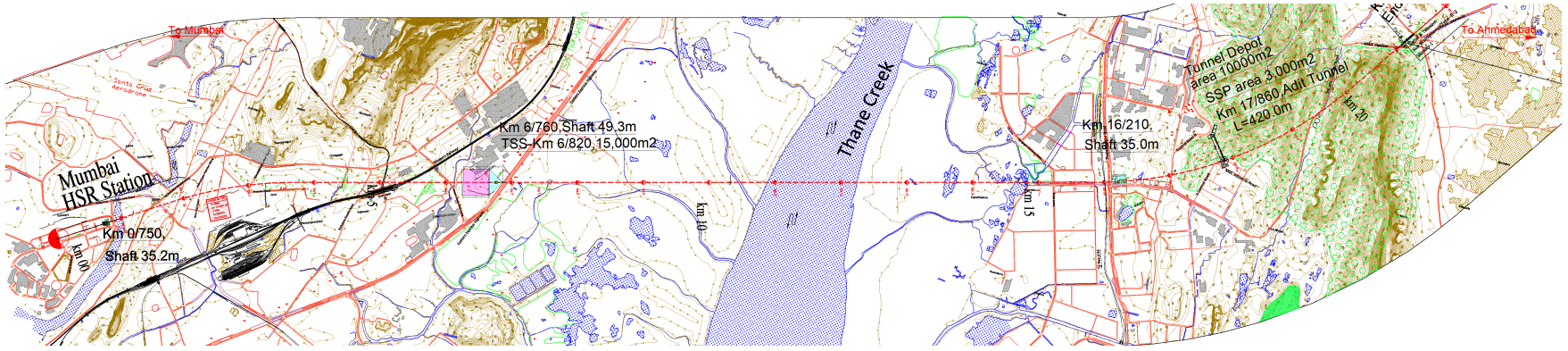
IMU-Inertial Measurement Unit
GPS-Global Positioning System
INS-Inertial Navigation System

ORTHOPHOTO FROM LiDAR

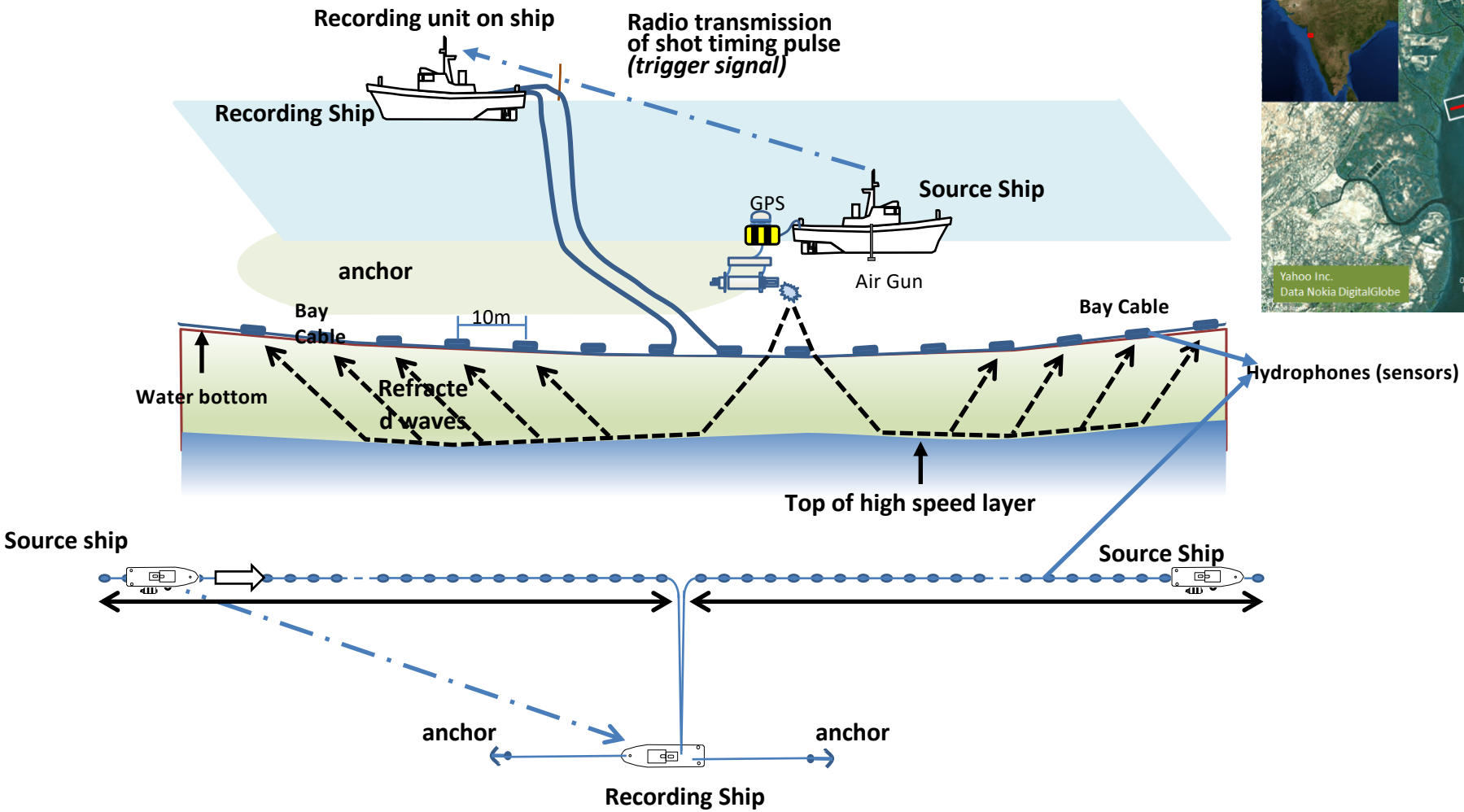
VIDEO on LiDAR Survey of MAHSR

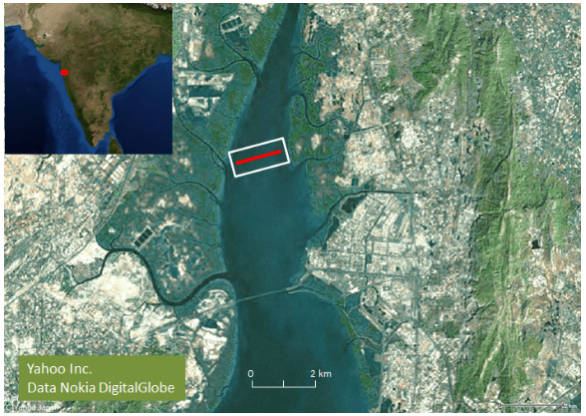
Challenges in Undersea Tunnel (Length:21 Km with 7 Km)

- **Longest** Rail transport and **1st Undersea tunnel** of India.
- **Single Tube 13.2m Φ** (outer dia)
- Alignment passes underground in *Thane creek* area avoiding disturbances in *Flamingo sanctuary* and nearby *Mangroves*.
- **Normal Borehole drilling is a source of perpetual seepage for tunnel.**
- **Underwater Static Refraction Technique adopted.**

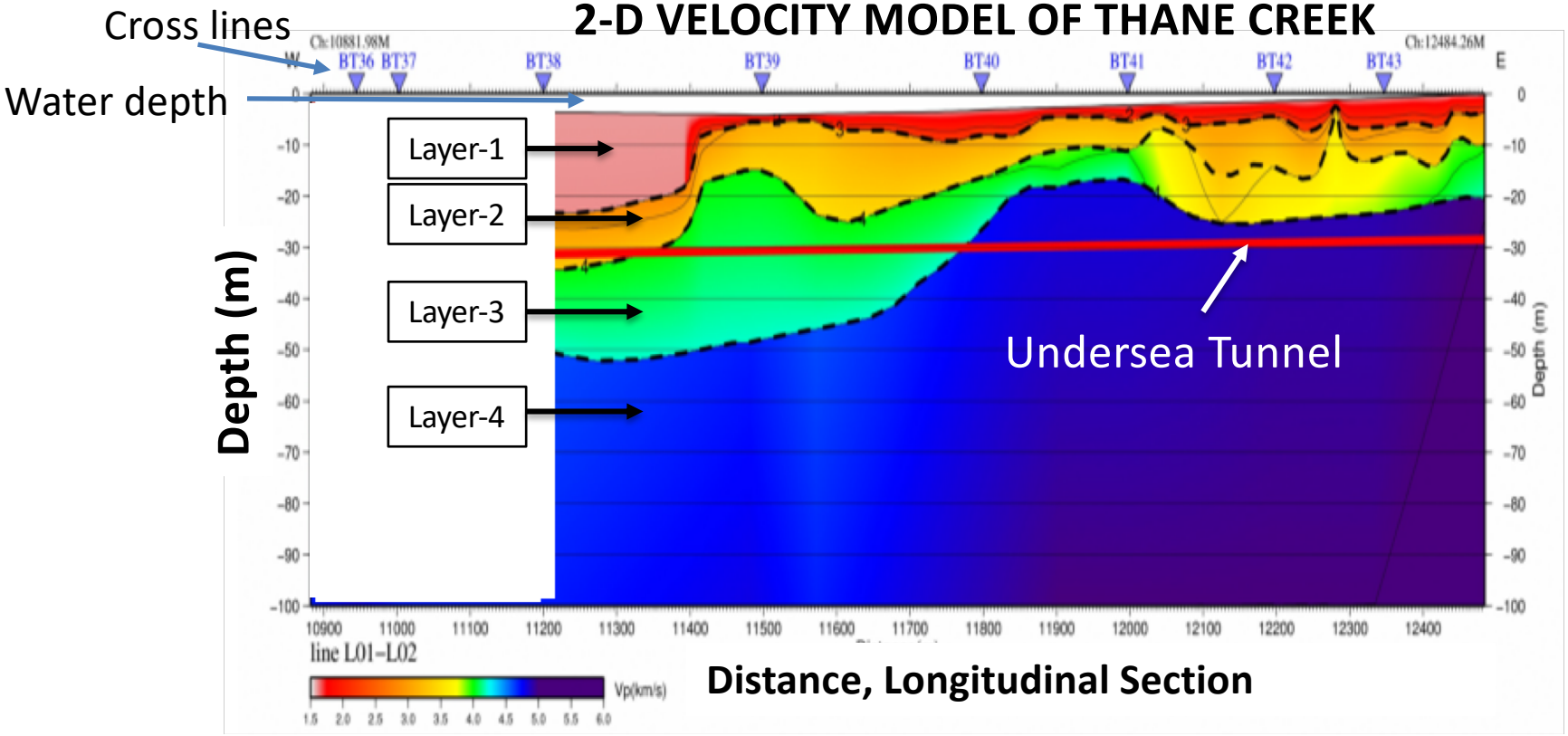


Schematic Diagram of Static Refraction Survey





2-D VELOCITY MODEL OF THANE CREEK



Layer No:	Velocity	Variation of Rock Thickness (m)		Borton's Q value	Rock Mass Rating RMR	Interpreted Lithology	Rock Mass Classification based on Q-value
	Vp (m/s)	From	To				
1	1600 to 2200	1.17	22.5	0.01 to 0.05	22 to 31	Sea sediment with highly to completely weathered basalt.	Extremely poor
2	2800 to 3500	0.94	30.64	0.20 to 1.00	40 to 50	Weathered and jointed/Fractured basalt.	Very poor
3	3300 to 4200	5.27	33.58	0.63 to 5.01	47 to 61	Slightly weathered to fresh less jointed basalt.	Fair
4	4600 to 5100	-	-	12.59 to 39.81	67 to 74	Fresh basalt.	Good

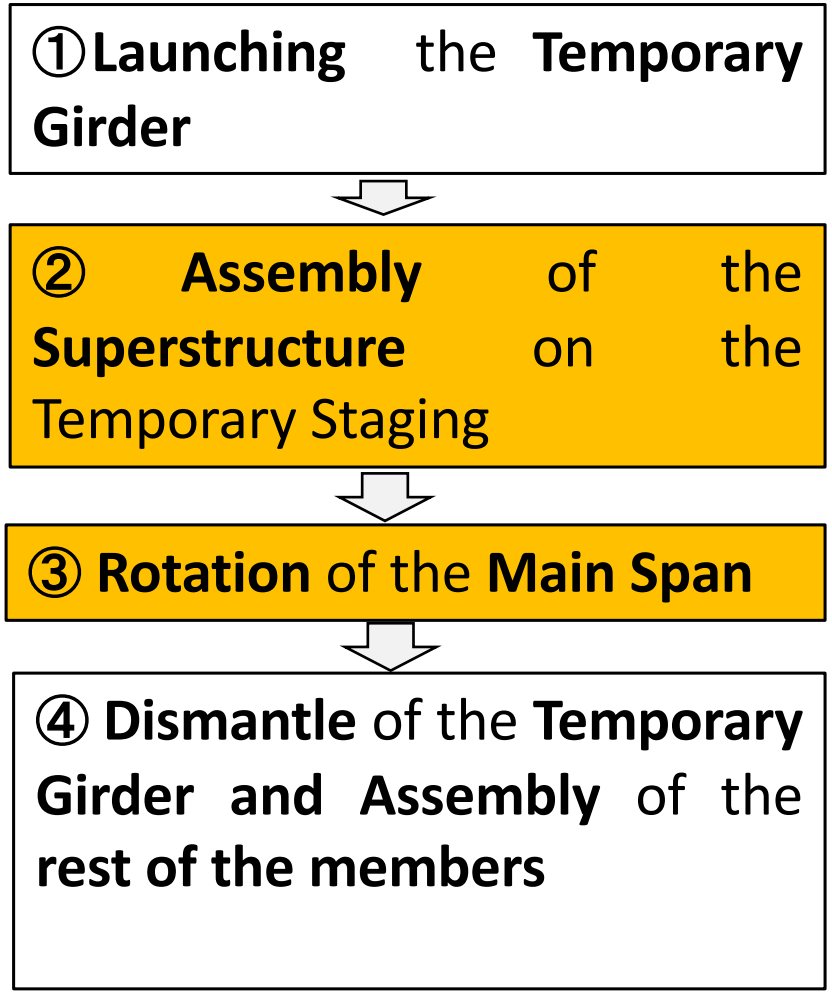
Work at Vadodara and Ahmedabad

- High Speed Rail Alignment crosses major existing Railway Stations at **Vadodara, Ahmedabad & Sabarmati**.
- **Special Bridges** planned to span over existing Railway tracks.
  - **Vadodara: 120+220+100 m** long span steel bridge
  - **Ahmedabad:** upto **120 m** long span steel bridge
- **Challenges involved,**
  - *To design long span steel bridges for stringent deflection criteria.*
  - *Work within busy existing Railway stations.*
  - *To arrange high quality steel fabrication.*

- **Innovative practice** of Project execution used in Europe, US, Japan i.e. **Construction Manager General Contractor (CMGC) adopted.**
- *In CMGC method, the contractor with sufficient experience is involved during the design phase to simultaneously examine the constructability of a particular design and also suggest innovative construction technology based on which the designer can review their design. This would help in minimizing risk during execution.*
- **As CMGC method of Project execution would be used for the first time in a Railway Project in India, its successful implementation would be a challenge.**
- It is Planned to set up **steel fabrication unit in India in JV with Japanese fabricators** to ensure high quality.

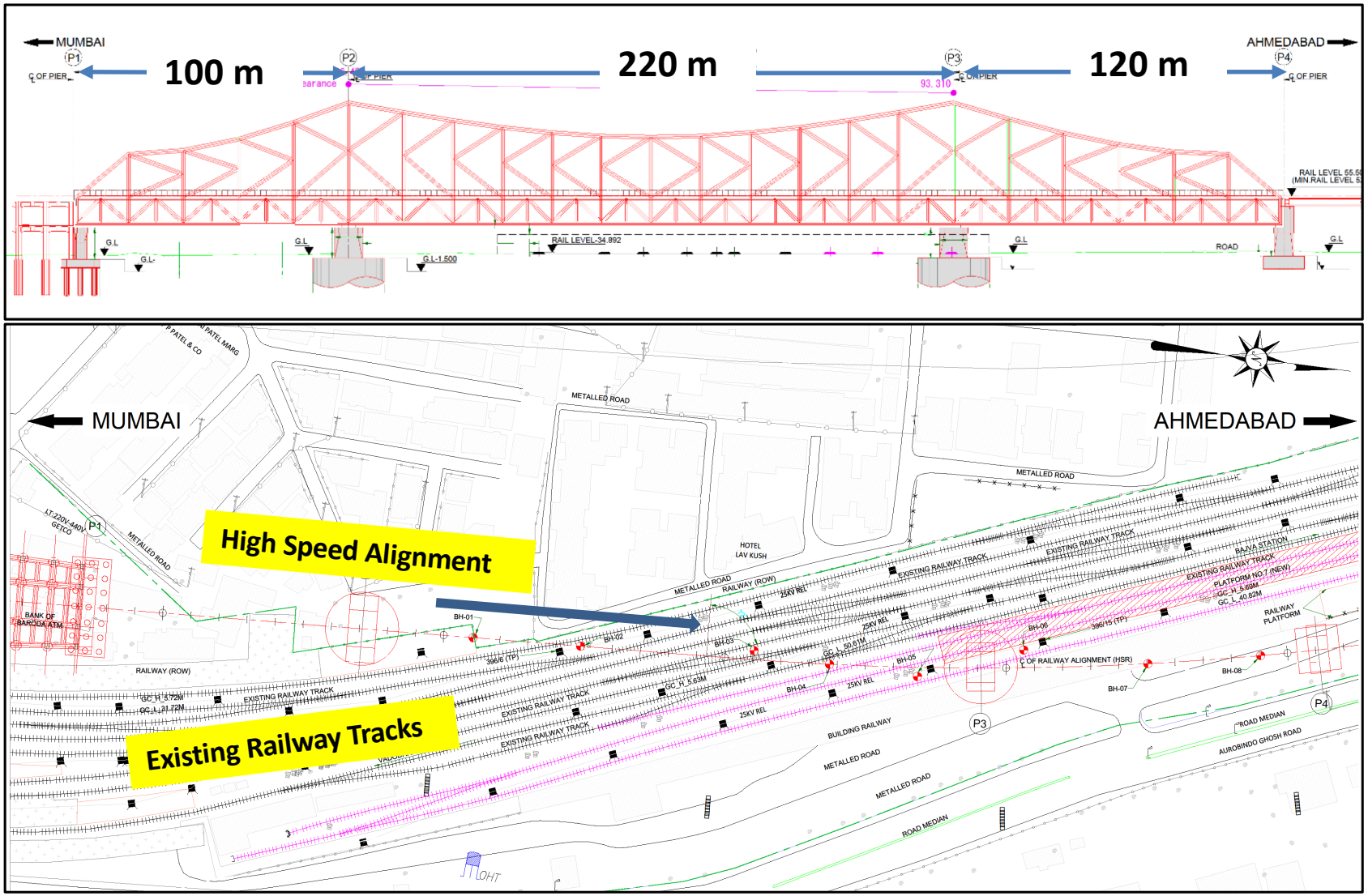
Special Bridge at Vadodara (GAD 23)

- **120+220+100 m** long span steel bridge planned to span over existing Railway tracks at **Vadodara Station**.
- **Challenges:**
  - *To work above the existing tracks*
  - *To avoid interference with permissible height of AAI*
  - *To minimize area of construction*
  - *To minimize the construction period*
- **Rotation on the Temporary Girder Method** is planned.

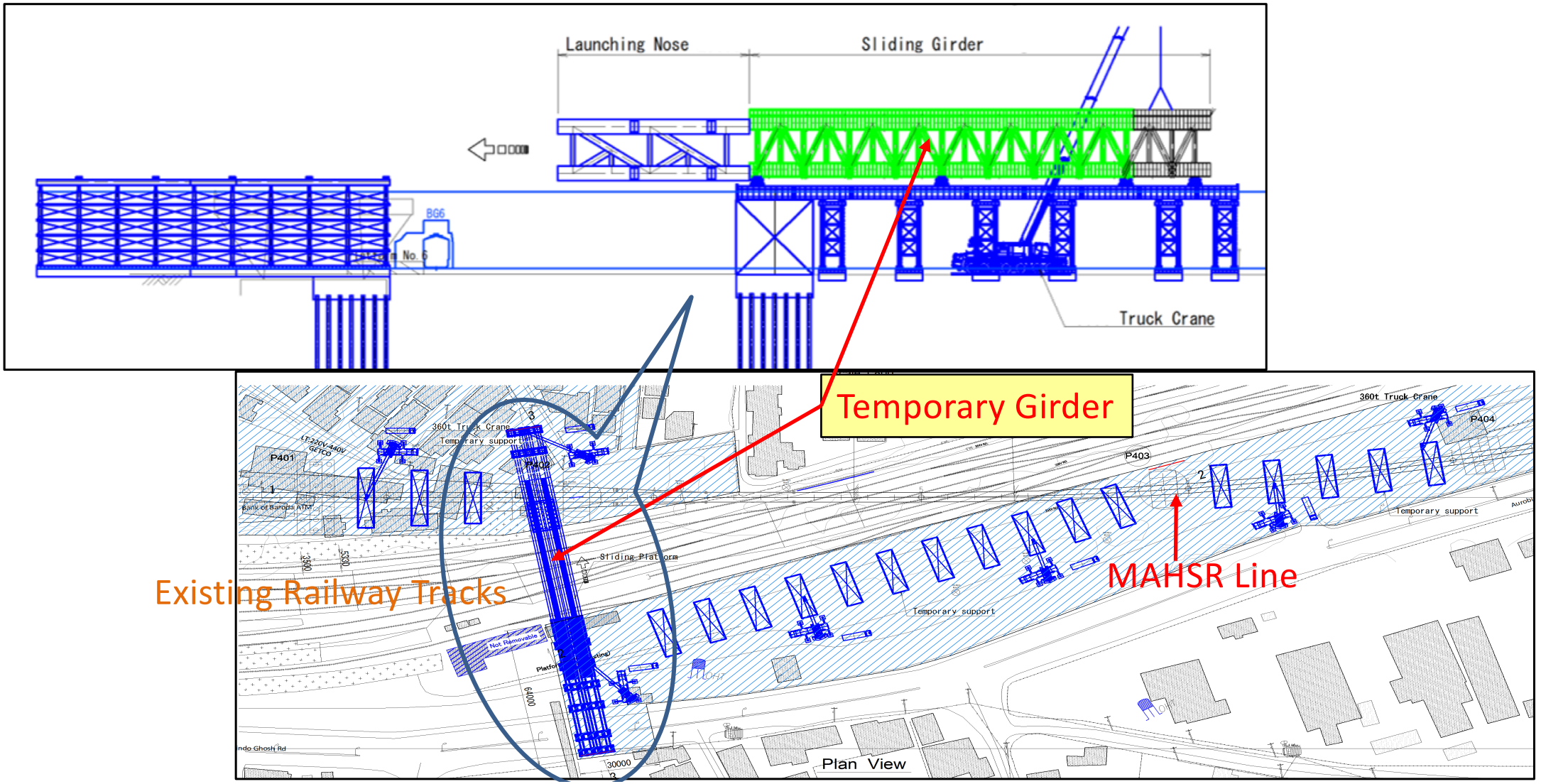


(AAI-Airport Authority of India)

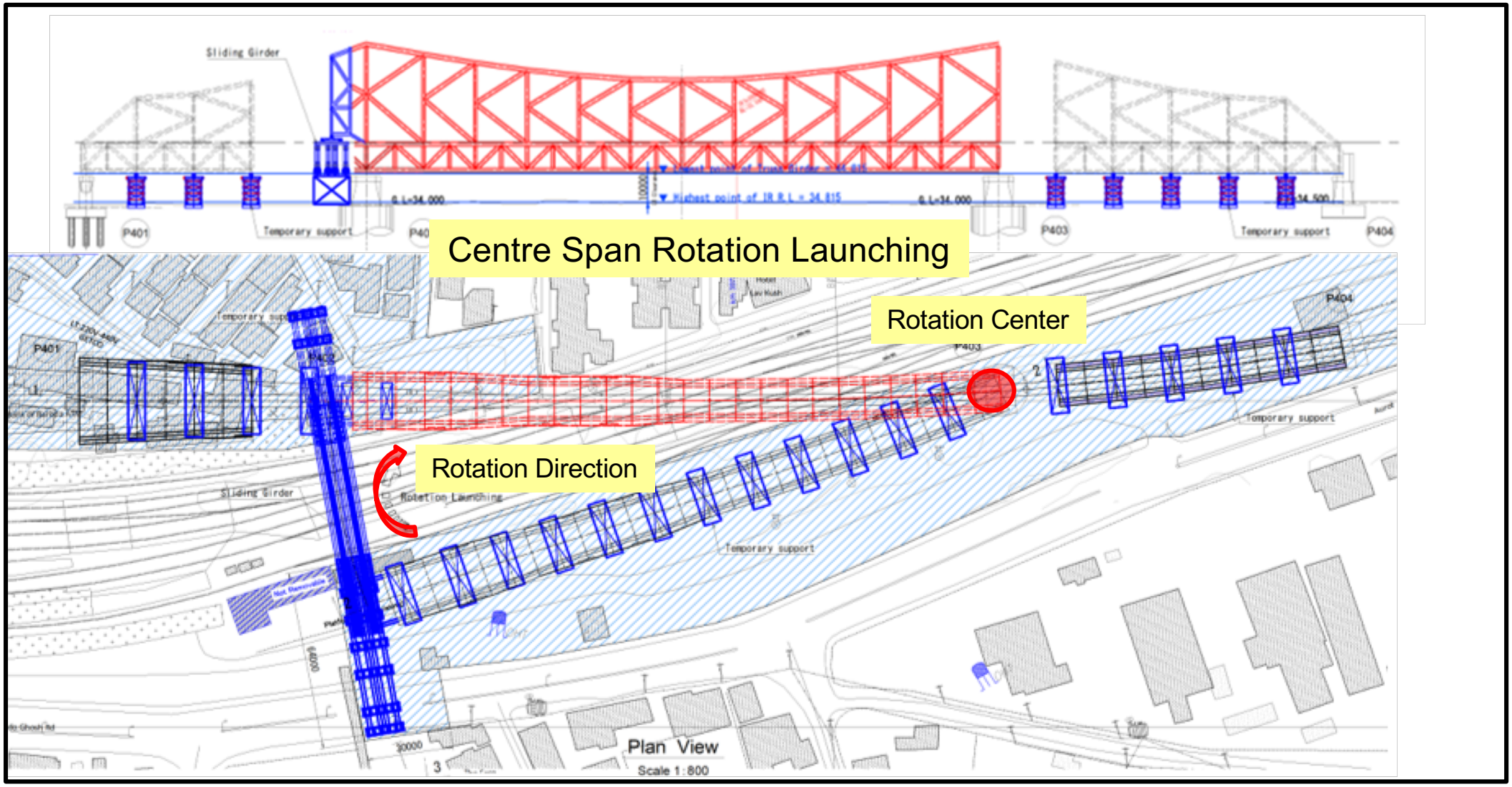
GAD 23: General Arrangement of Bridge



Step① Launching Temporary Girder



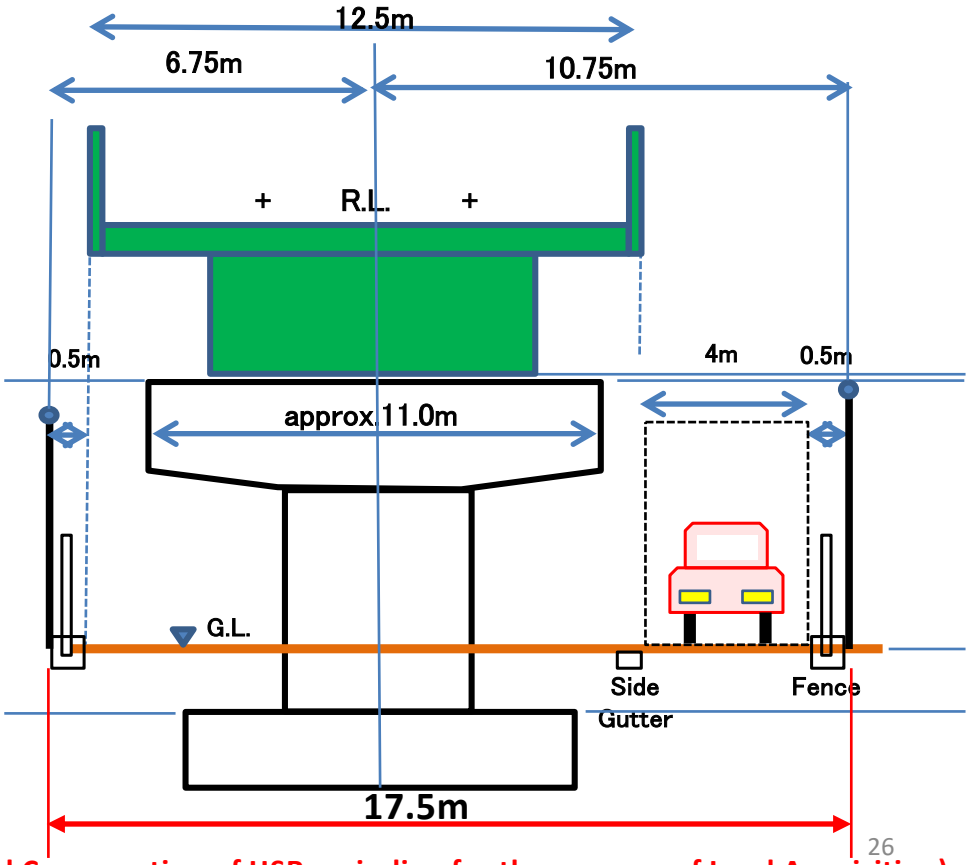
Step③ Rotation of the Main Span



Minimizing land Acquisition in order to save time

More than 90% of the alignment has been changed to **Viaduct structures** although the **feasibility report** had **proposed** more than **60%** on **embankment.** This

- **Reduces** requirement of land (**17.5 m** width **against 36 m**)
- Ensures **no obstruction** to natural flow of waters
- **Provides crossing** at all places, sufficient clearance of 5.5m (highest for roads) is available over existing road network
- Greatly **improves safety and security perception** against external interference



(Typical Cross-section of HSR main-line for the purpose of Land Acquisition)

KEY TECHNOLOGIES OF HIGH SPEED RAIL

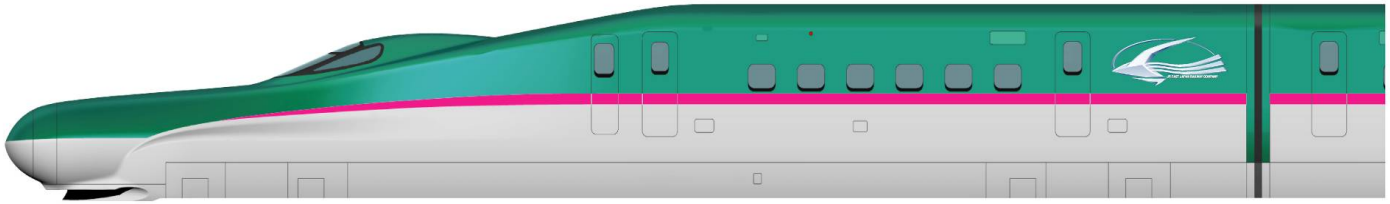
NHSRCL
National High Speed Rail Corporation Ltd.

ROLLING STOCK

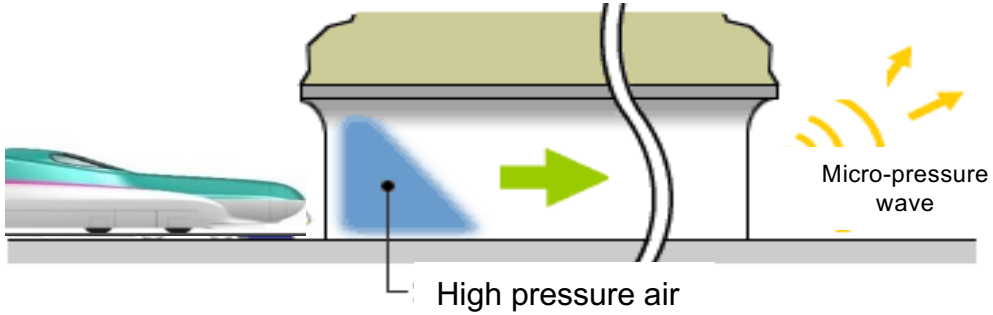
Achieving High Speed

Aerodynamic Design

- For high speeds, air drag is to be minimized.
- Aerodynamically designed Car body with long nose to reduce drag

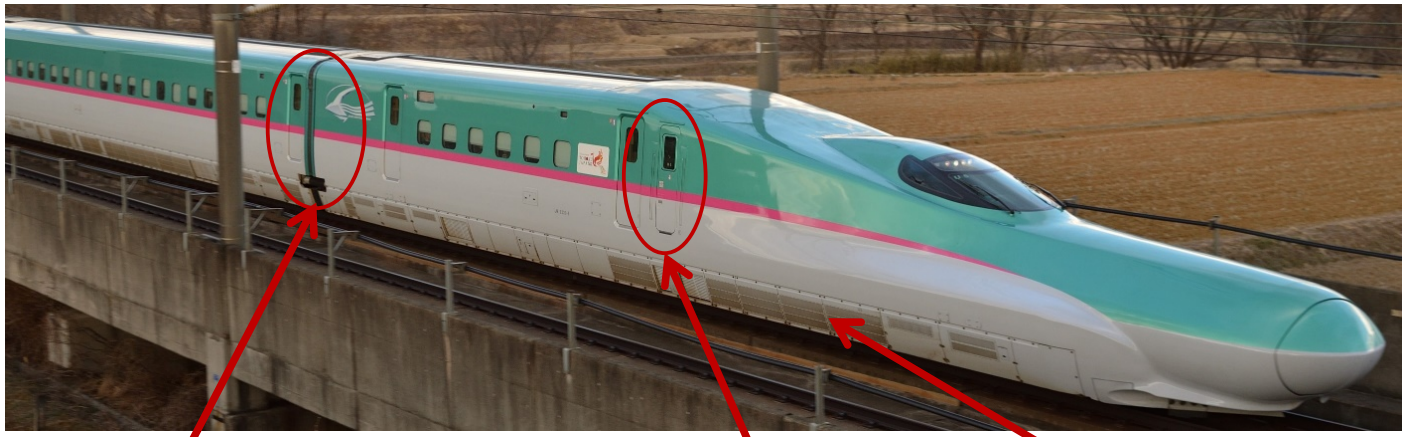


When high speed train exits a tunnel, a blasting sound is generated due to micro pressure waves. To reduce this micro pressure, the front car is designed with a nose section.



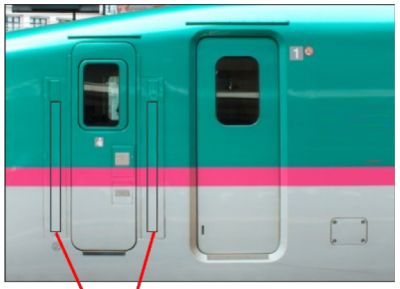
Achieving high speed

○ Reducing Air Drag



Fairings fitted all around the gaps between cars

Side and Bottom covers for Bogies and other underframe mounted equipment



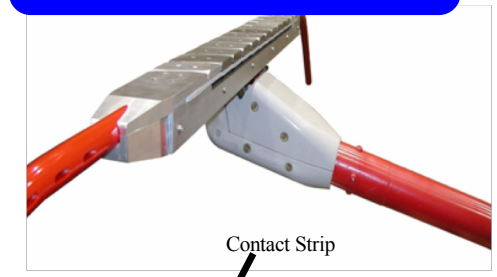
Open : Low speed

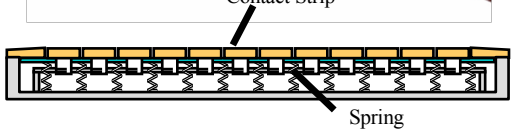
Close : High speed

○ Pantograph

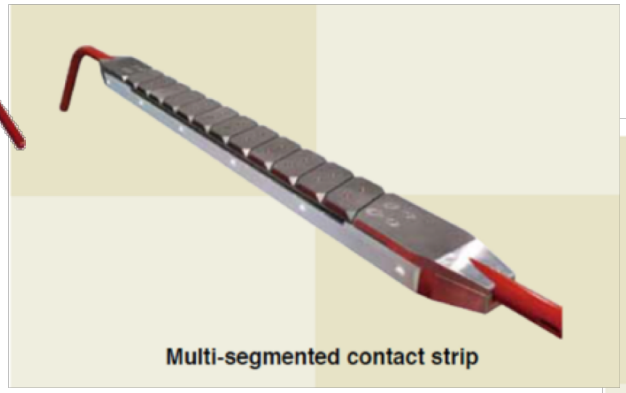
- Single arm to generate even less noise than other existing pantographs.
- Multi-segmented contact strip ensures stable power collection even at a running speed of 320 km/h.

Stable Current Collection

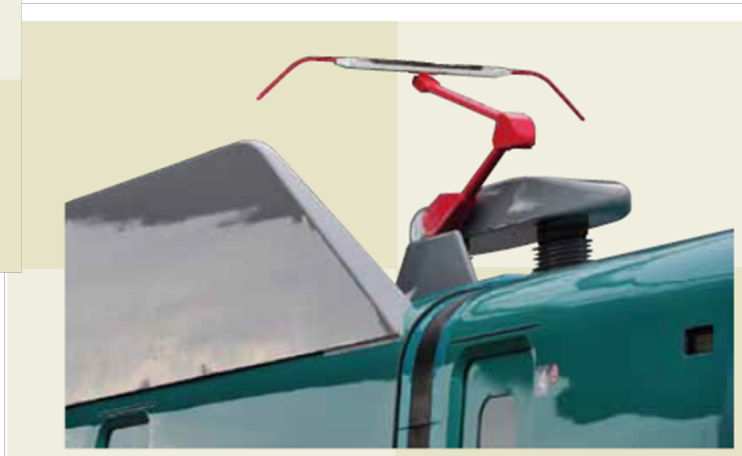




Multi-divided Contact Strip



Multi-segmented contact strip



Low-noise pantograph and noise reduction plate

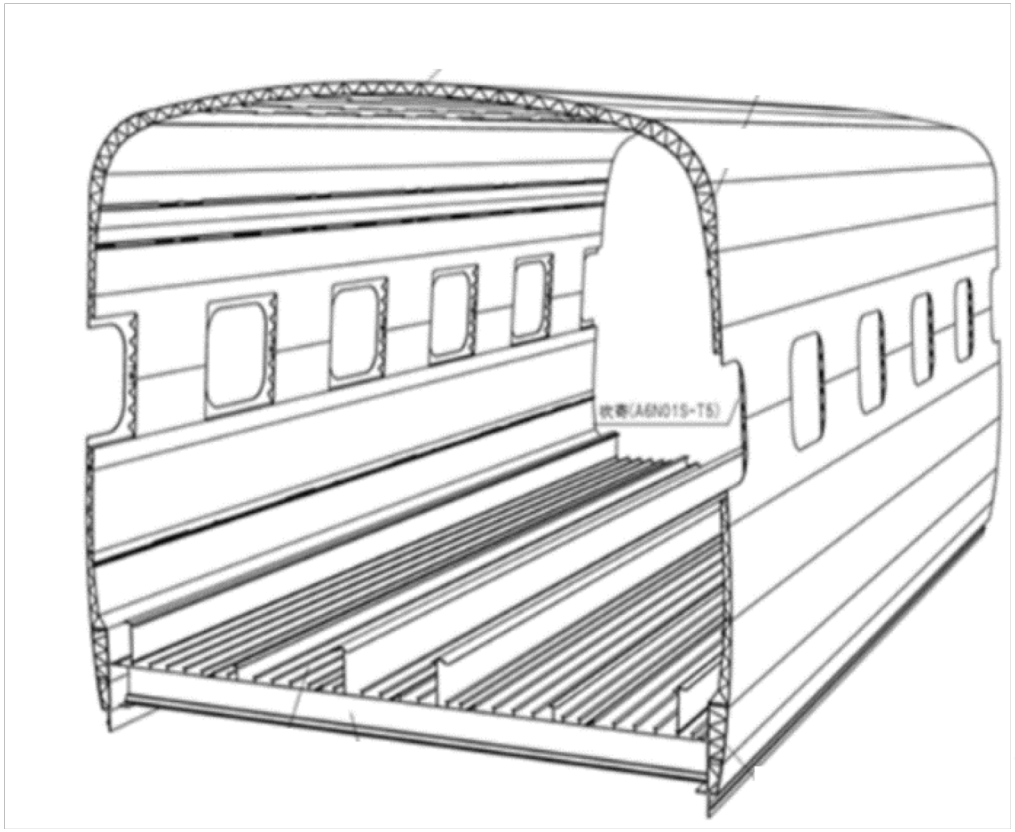
Passenger Comfort

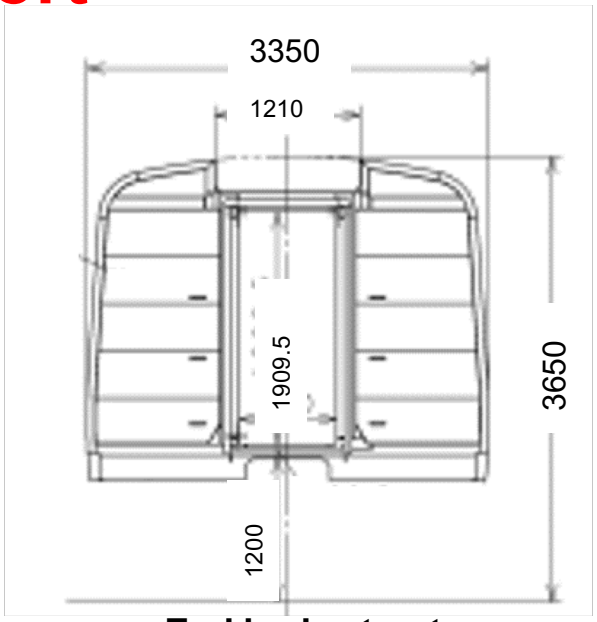
Avoiding Ear Pressure in tunnels

- The car body is pressurized to avoid discomfort to passengers due to drop in pressure inside the passenger cabin in tunnel.
- To achieve this complete car body is made air tight and a pressure inside the car is kept above the atmospheric pressure.

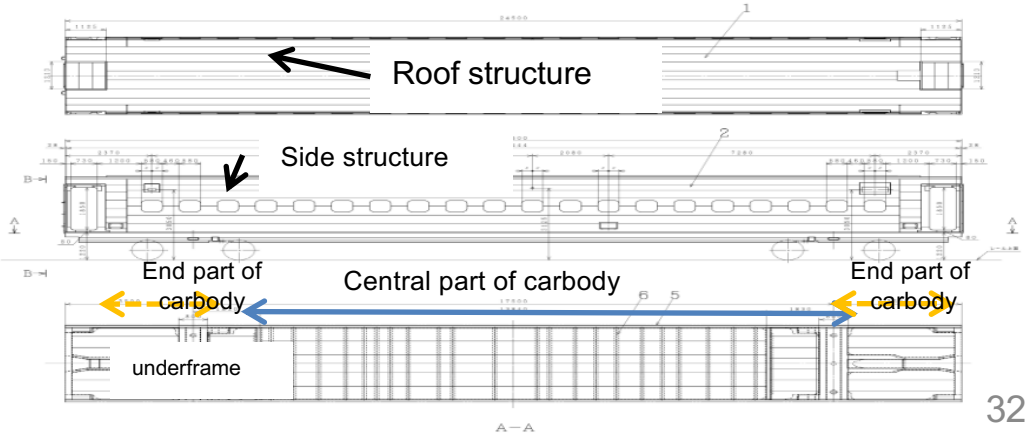
Passenger comfort

Double skin hollow Aluminum extrusions with truss section



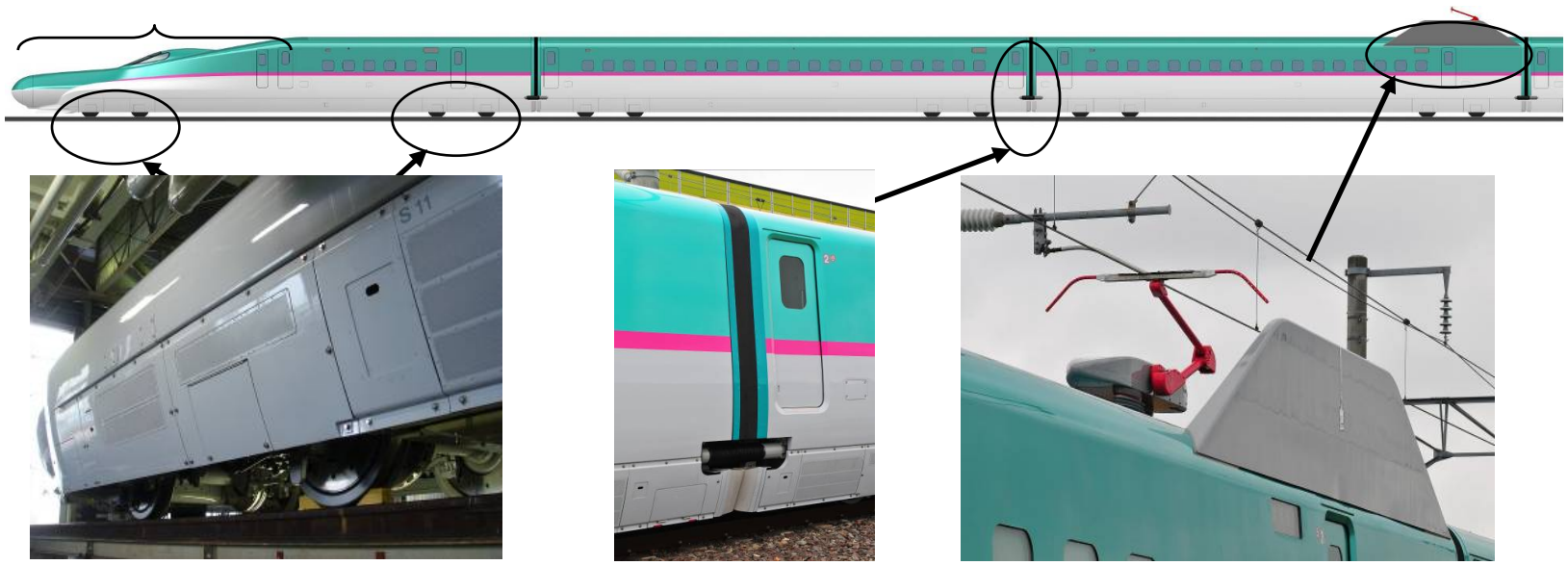


End body structure



Passenger comfort

○ Noise Mitigation



Bogie covers Sound-absorbing construction

Fairing (Smooth covers) between cars

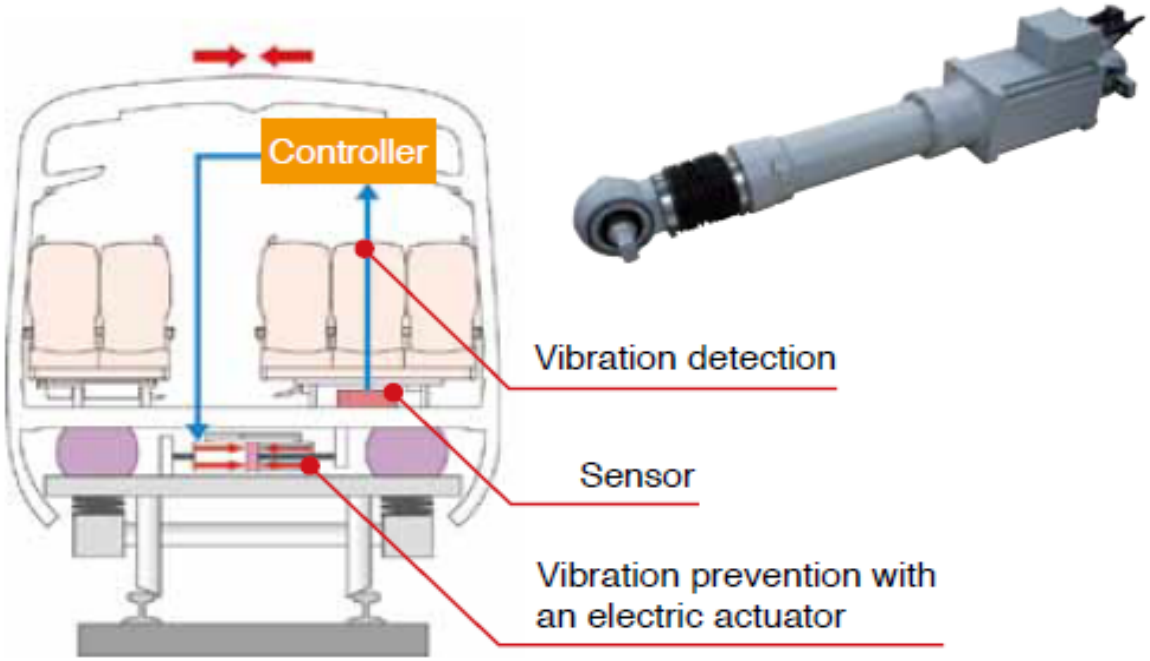
Pantograph noise insulation panel

Passenger Comfort

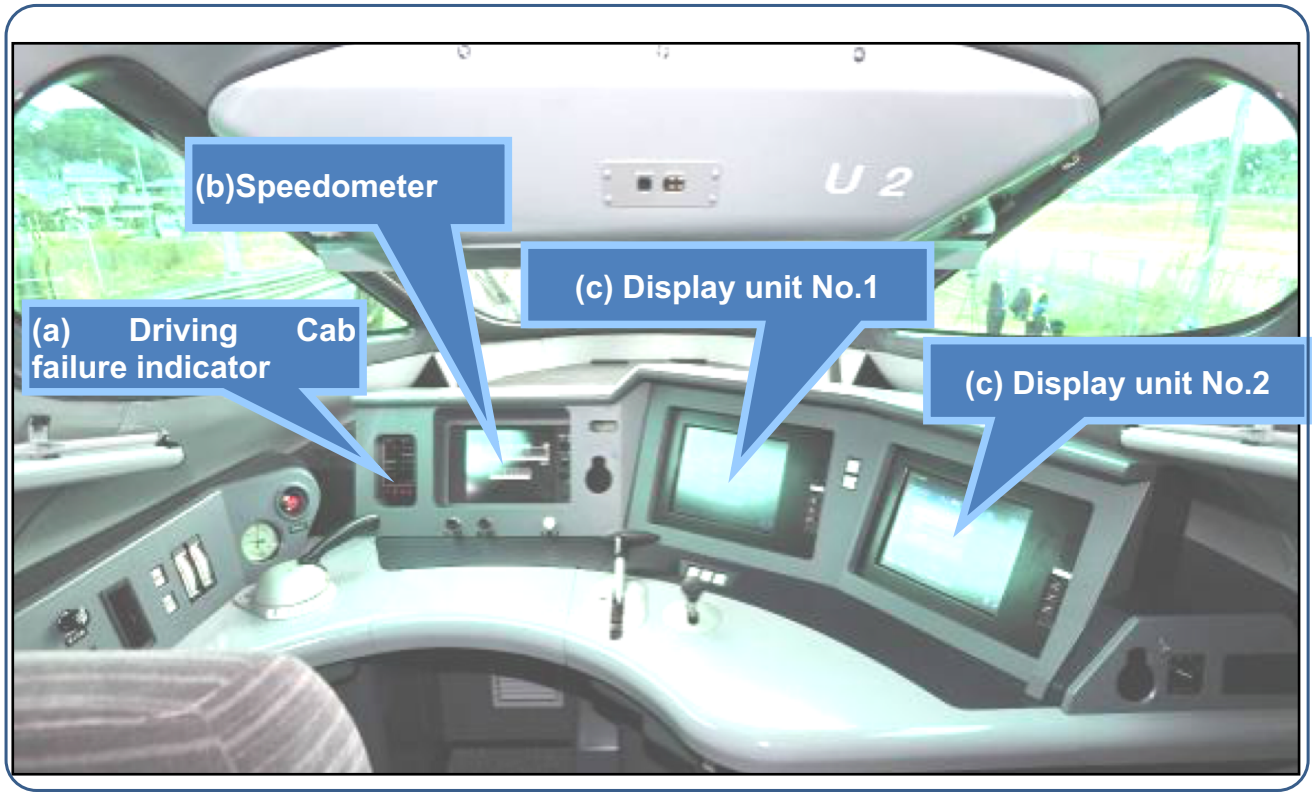
Special Lurch Control System

- Intelligent control system that detects car body swaying and then reduces lateral vibrations.

Full-active suspension system and electric actuator



Driver Support



(a)Driving Cab failure indicator is illuminated, in case of major failures.
(b)Signal from DS-ATC and Train Radio are indicated on speedometer.
(c)Failure Indication on driver display unit

Extraordinary Performance

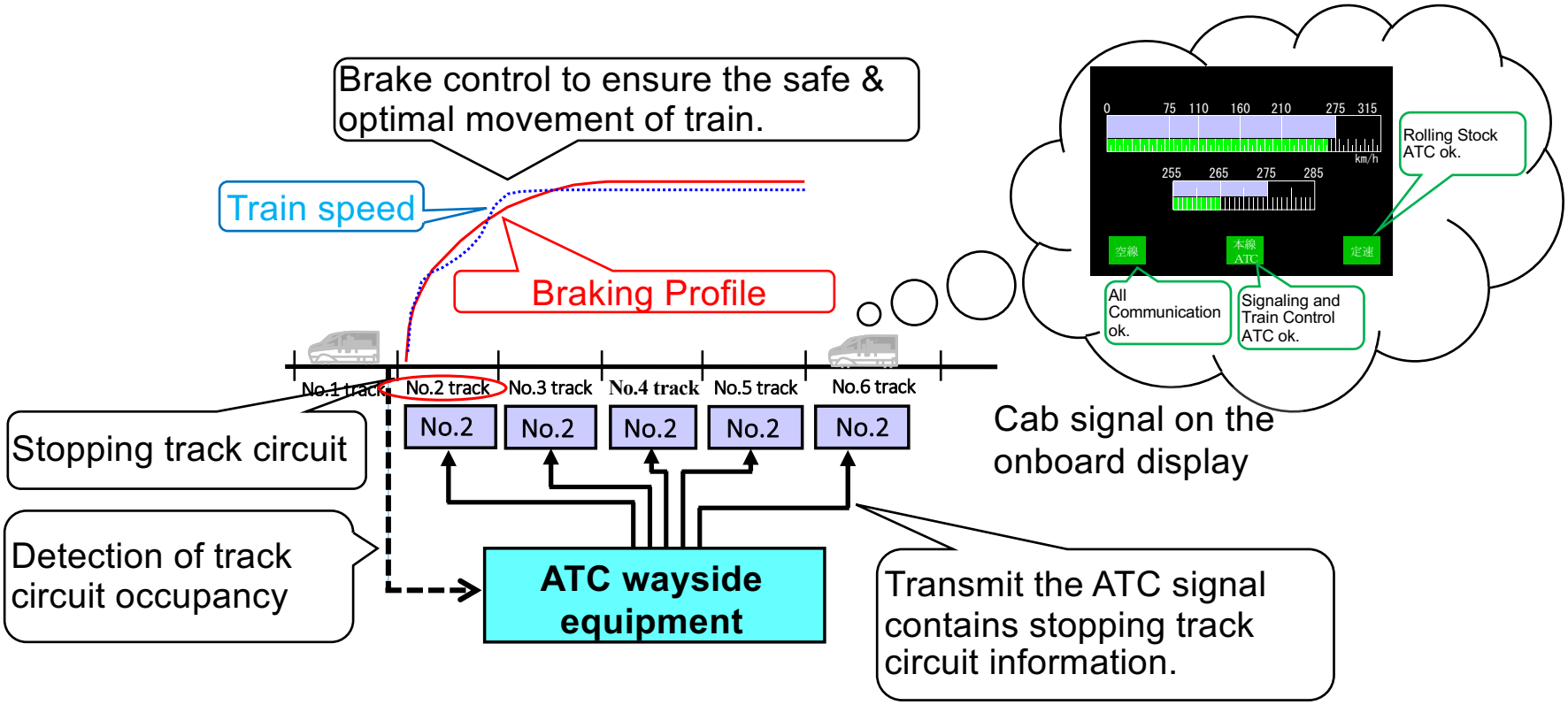
- **Accelerates from standstill to 320 Kmph in 310 s running 18 Km**
- **Service Brakes** bring the train running at 320 Kmph to halt **in 167 s (less than 3 minutes) running 8.5 Km**
- **Power failure detection brakes** bring the train running at 320 Kmph to halt **in 78 s running 3875 m**

SYSTEMS (Signalling & Communication)

Signalling System (Continuous Automatic Train Control)

- **Objectives:**
  - Optimal utilisation of infrastructure for maximising train operation frequency,
  - Safe and Punctual Running of Trains.
  - Avoidance of collision and other accidents, by automatic train control and braking.
  - **Last mile to ensure complete safety in train operation.**
- **Major Components:**
  - Coded Digital Audio Frequency Track Circuit (DAFTC).
  - Built In Intelligence in Track Circuits to Adjust its voltage automatically for better reliability.
  - Heavy duty Point Machine, with first time swing nose operation in India.
  - Safety ensured in Fall-back System through Leaky Coaxial Cable.
  - Remote monitoring of Signalling Equipment – Status of all equipments is monitored on real time basis.

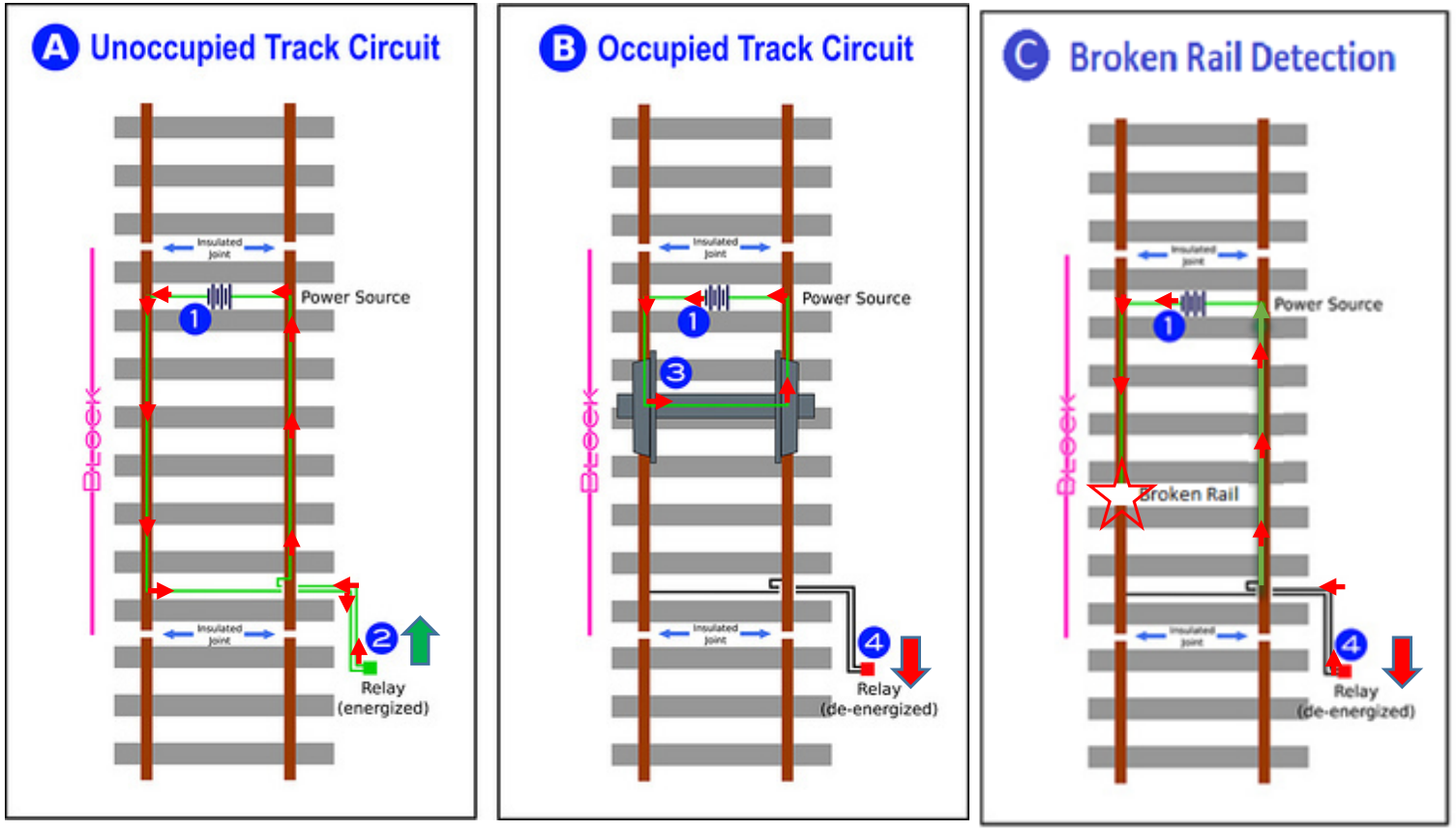
Over View - Continuous Automatic Train Control



CATC shall control train speed according to the brake profile which takes into account, **safe distance from train ahead, speed restrictions due to alignment** profiles (e.g. curve, gradient, and turnout etc.). ATC signal contains stopping track circuit and TSR information.

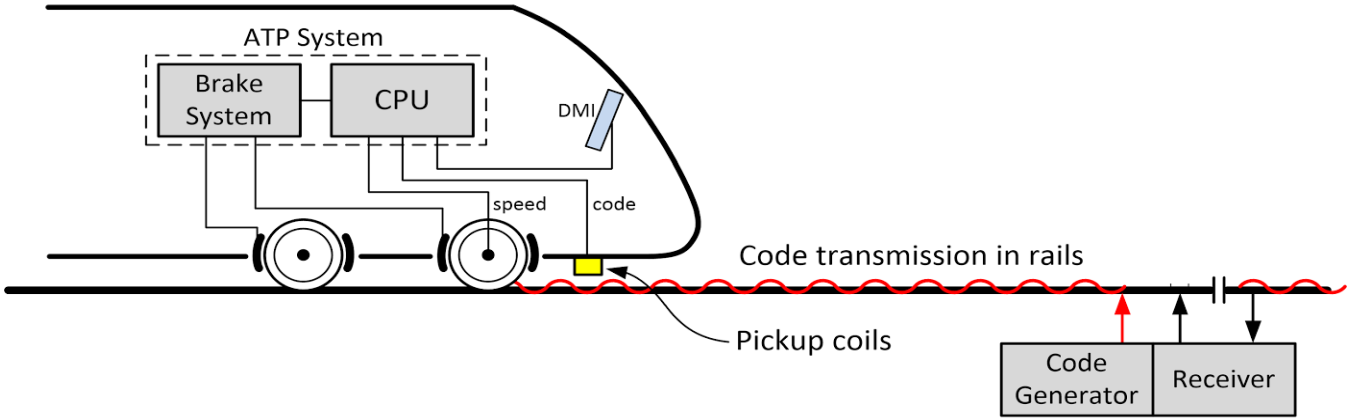
Major Component - Track Circuit

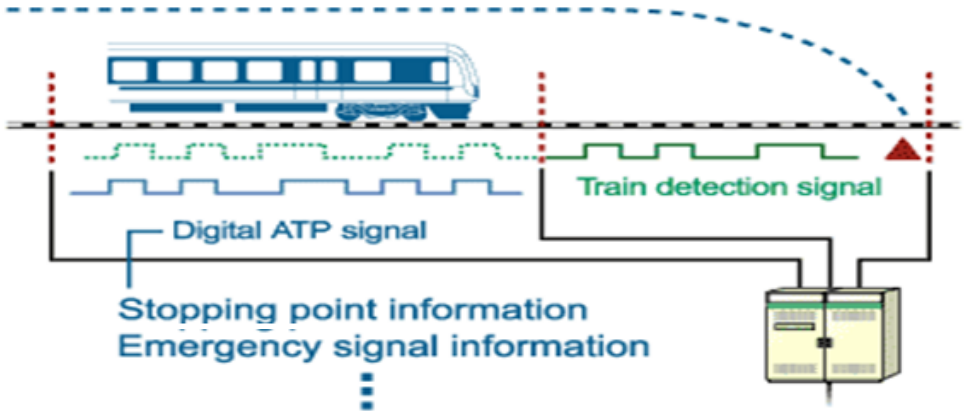
It Detects Train on Track by diversion of current through train axle.
Helps in identifying Broken rail



Track to Train Transmission

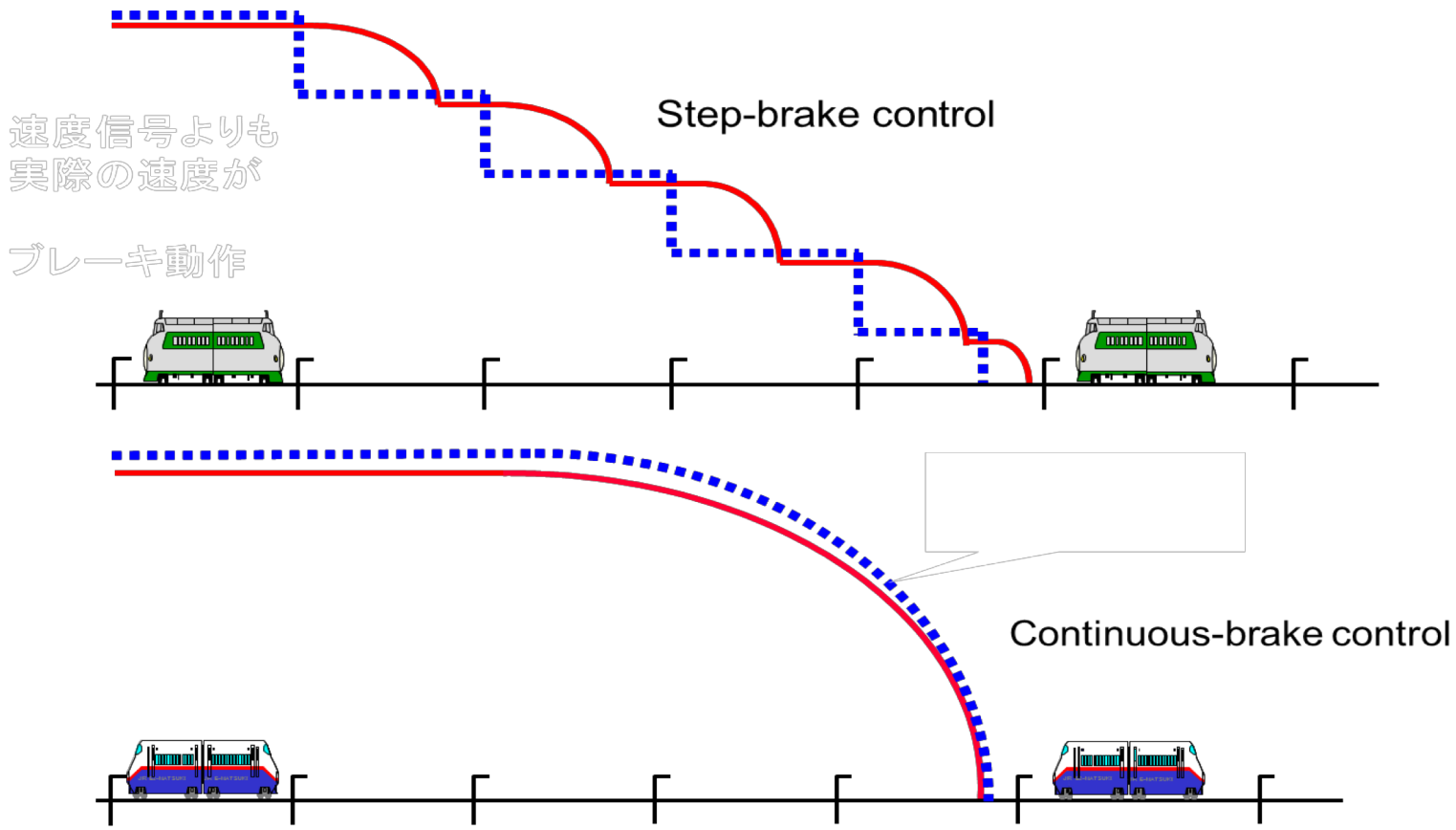
- Once the train occupies railway track, the rails transmit coded messages to the train about maximum speed it can run, as well as apply brakes if any unsafe situation is detected.



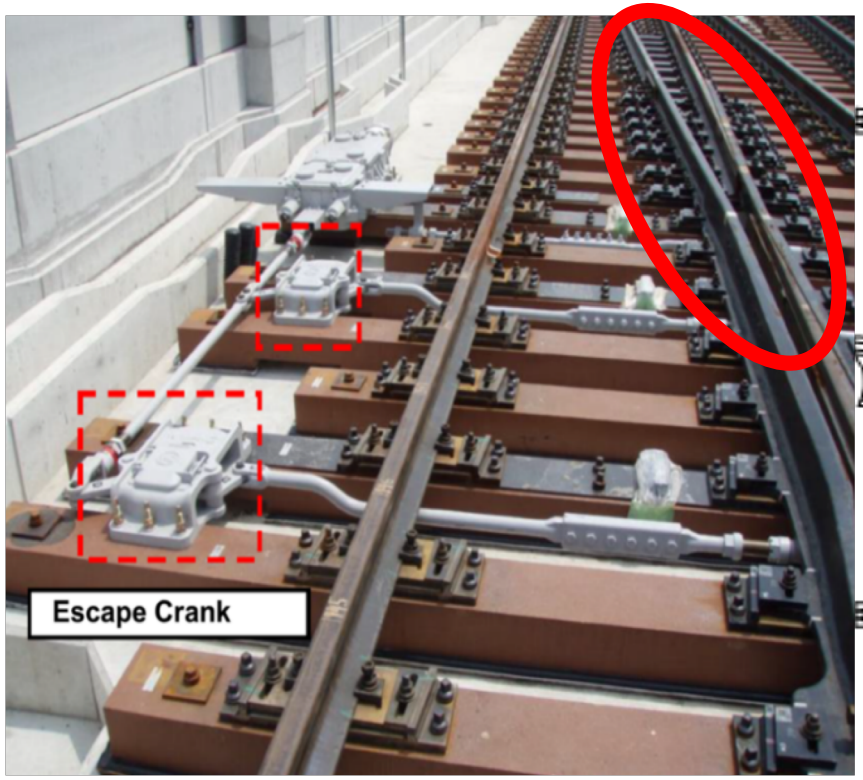


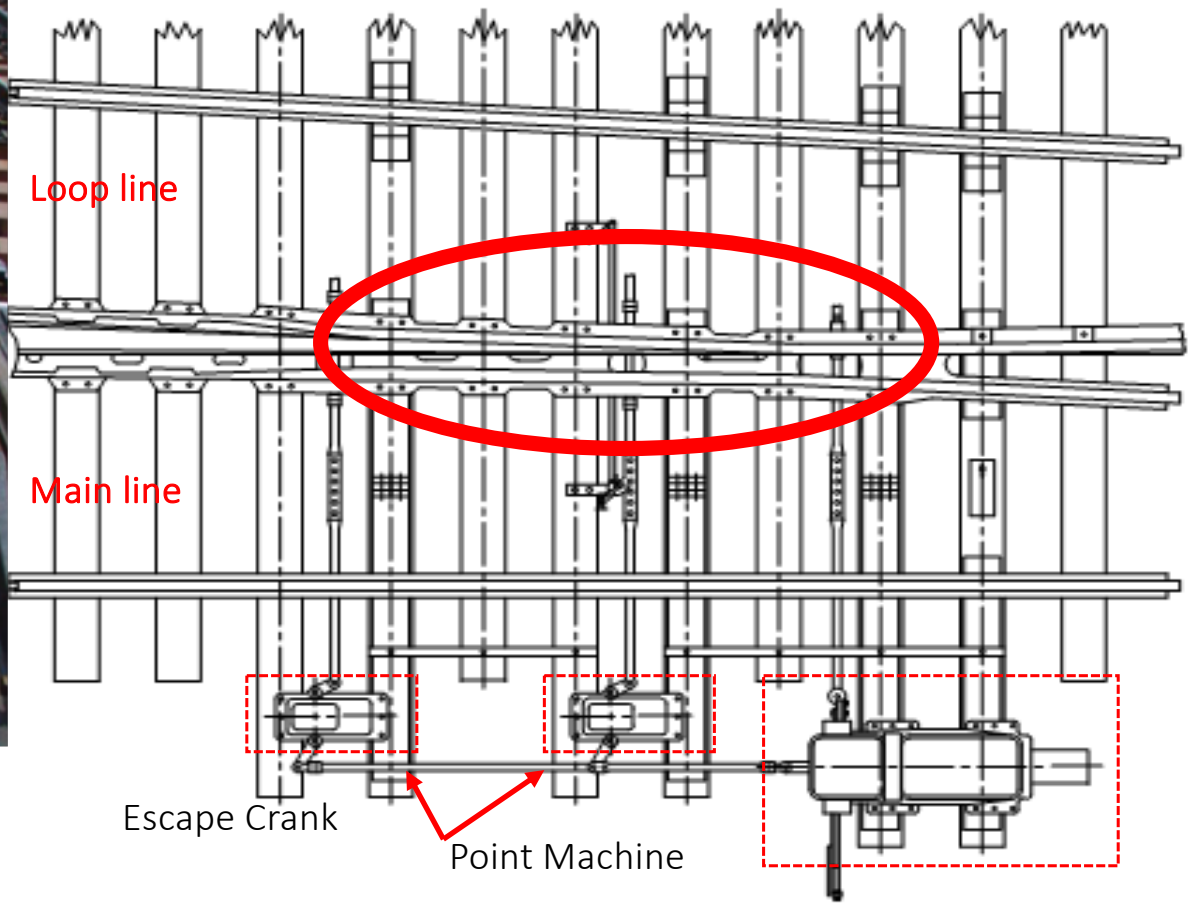
Salient Features of Digital ATC

The continuous brake control eliminates the time loss and enables the train to brake smoothly, which improves the riding comfort.



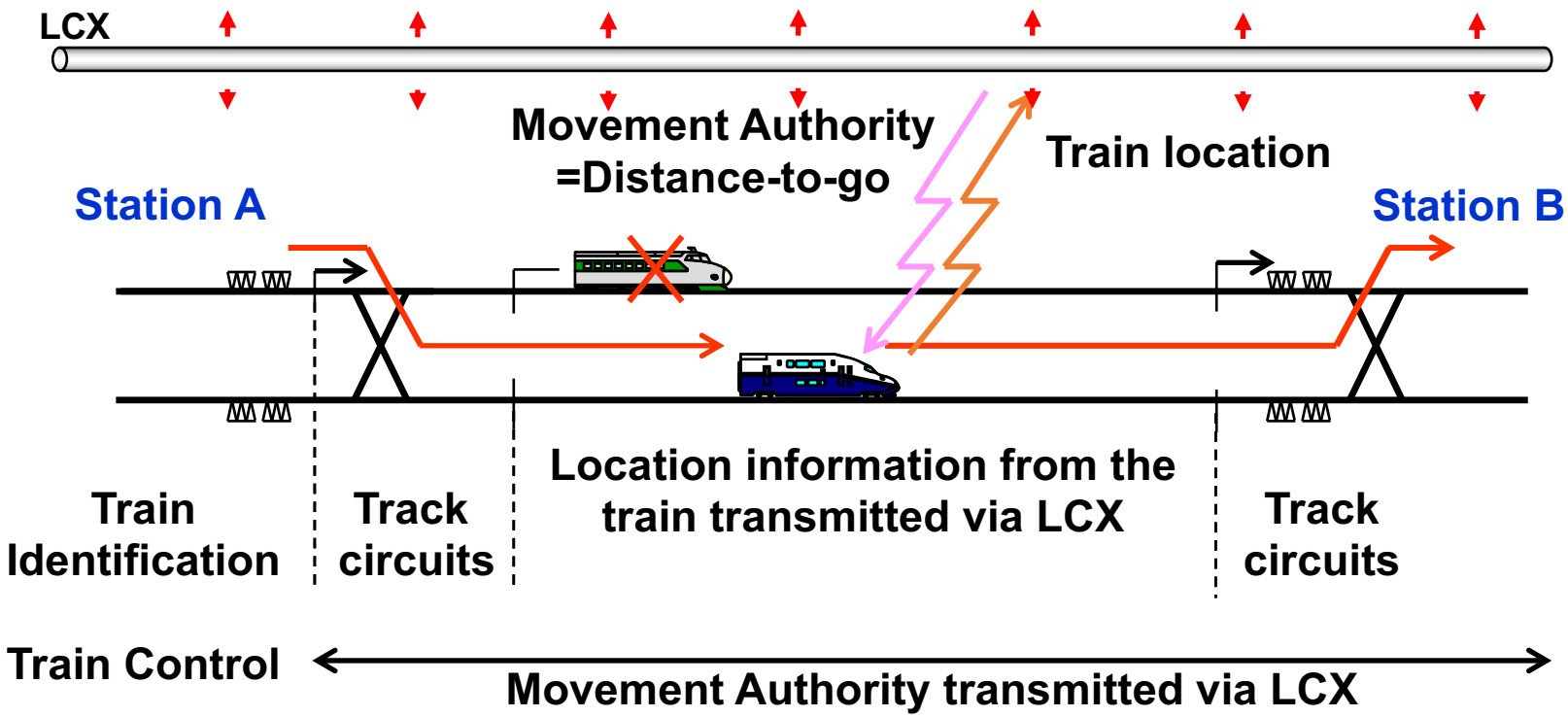
Point Machine at Swing Nose





Swing (moving) nose adopted for crossing.

Fall-back System
(In case of Main System Failure)



In case of the failure of main system, the system switches over to transmit the safety information through Leaky Coaxial Cable ensuring complete safety

Salient Features of Signalling & Telecommunication System

- Use of **Gas-Filled cables**, first time in India, for better reliability and safety through *Cable Gas pressure Monitoring System*.

Benefits of this system are,

1. **Quick detection of cable crack or breakage.**
2. **Moisture resistance.**

- Reliable and proven **Leaky Coaxial cable** based radio system.

KEY TECHNOLOGIES OF HIGH SPEED RAIL

OVERHEAD EQUIPMENT (OHE)

Changeover switches (Automatic Switched Neutral section)

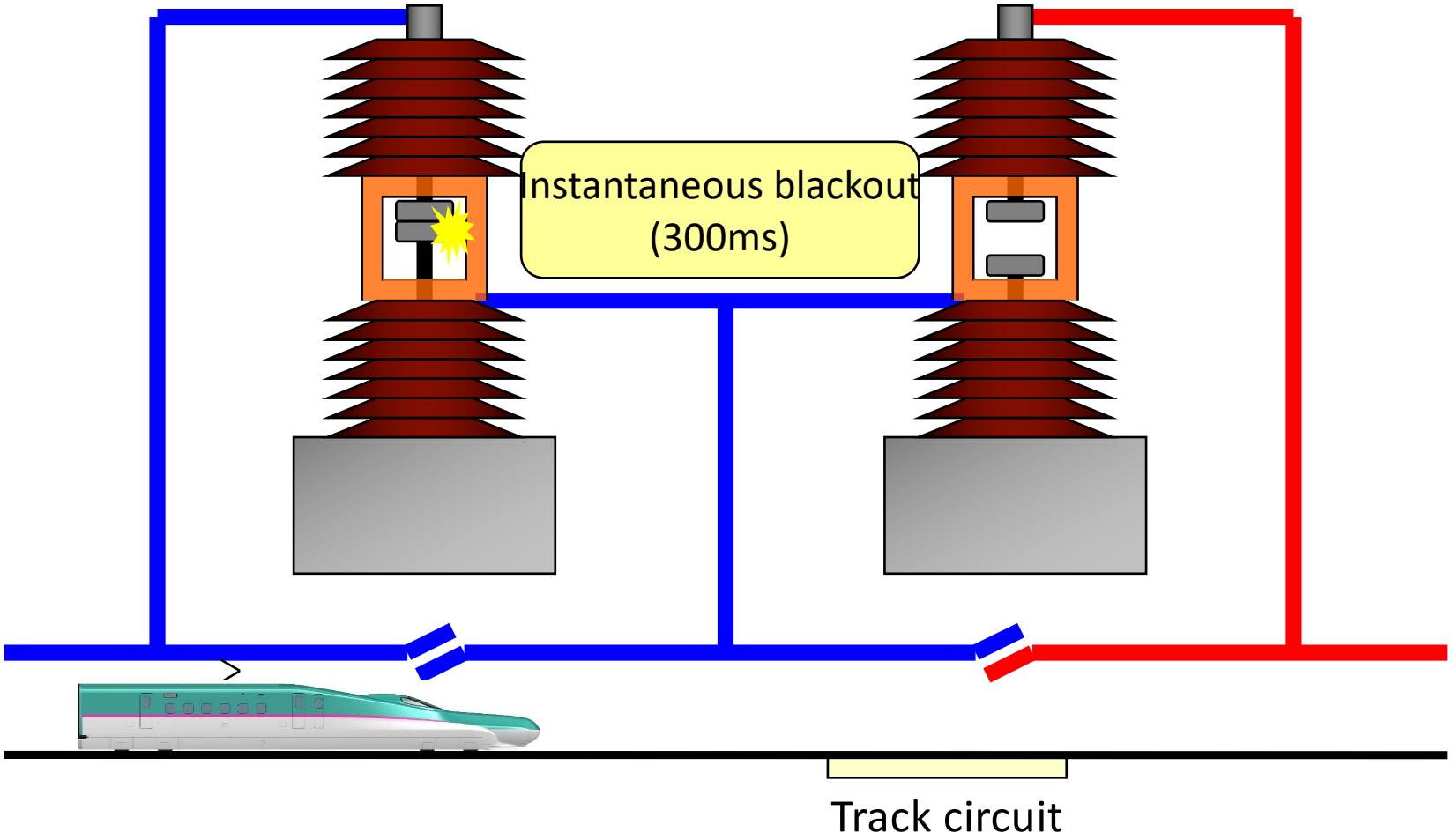
- Phases of the electrical voltage fed by adjacent sub stations are different

- On Indian Railways/Metro, the driver of the train has to **manually switch ON/OFF** the onboard circuit breaker whenever there is a change in phase of OHE (approx. **every 20-25 Km**). This is **cumbersome and not feasible in HSR**.

- In **HSR,** driver does not take any action, **the train position is detected by Track circuit** which **activates circuit breakers installed on TSS/SP (wayside)**.

- Animation explains the process.

Changeover switches
(Automatic switched Neutral section)

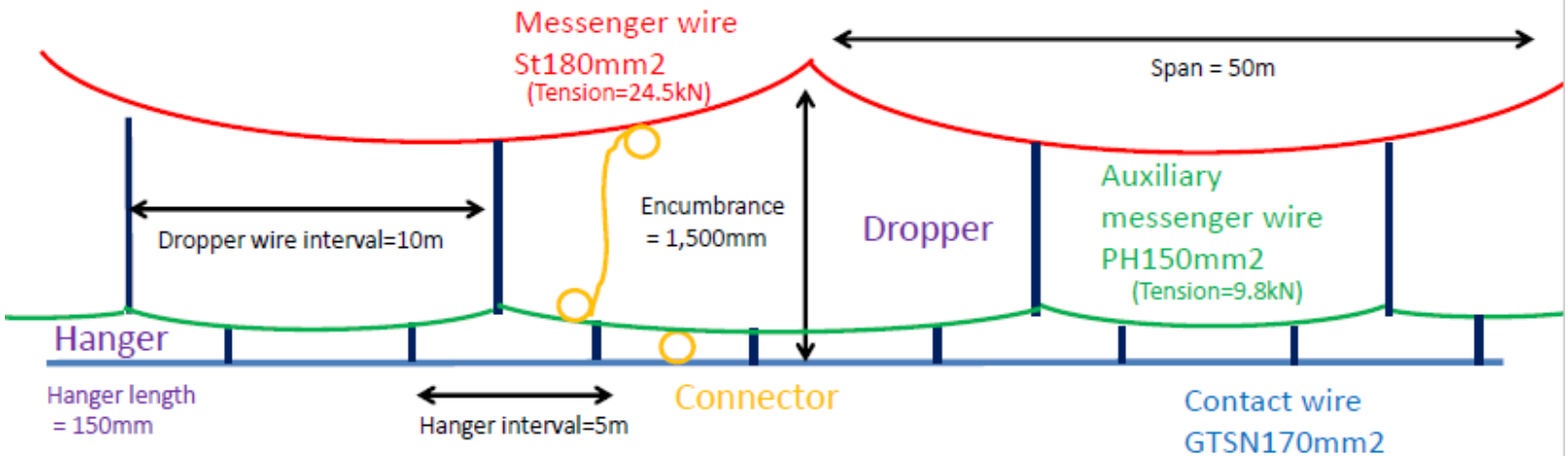


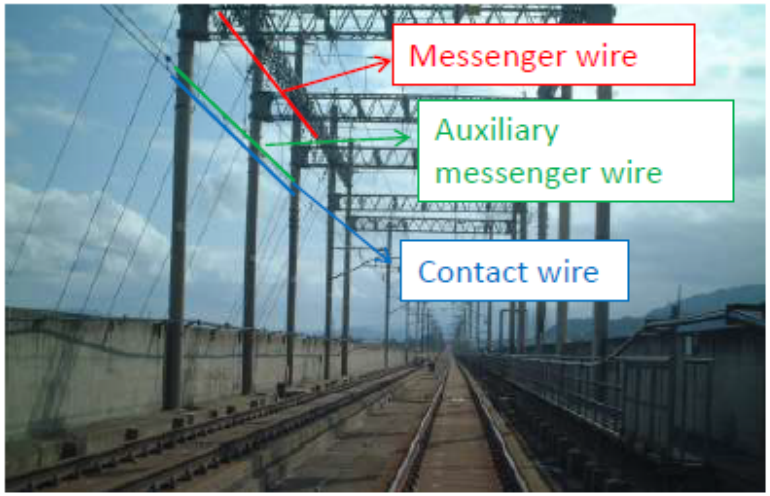
Heavy Compound OHE for higher currents and high speed

- **Bigger sizes of conductors** because of higher current *(e.g. Contact wire: IR-107 Sq.mm, Metro-150 Sq.mm, HSR-170 Sq.mm)*
- **Three conductors** (in HSR) instead of (two in IR, Metro) in Heavy Compound OHE system.
- **Higher tension** of OHE wires to ensure proper contact at high speed.
- **Conductor material are light weight alloys** (Copper-Tin contact wire) with better mechanical strength.

Heavy Compound OHE for higher currents and high speed

Schematic of compound catenary overhead line





SPECIAL SAFETY FEATURES

Special Safety Features

- Comprehensive **Disaster Management System** for Safety.
- Monitoring of **earthquakes** and **automatic stoppage** of trains on detection of primary waves.
- Continuous monitoring and **control of train speeds** for,
  - **Rail temperature**
  - **Wind pressure**
  - **Rain**

Special Safety Features

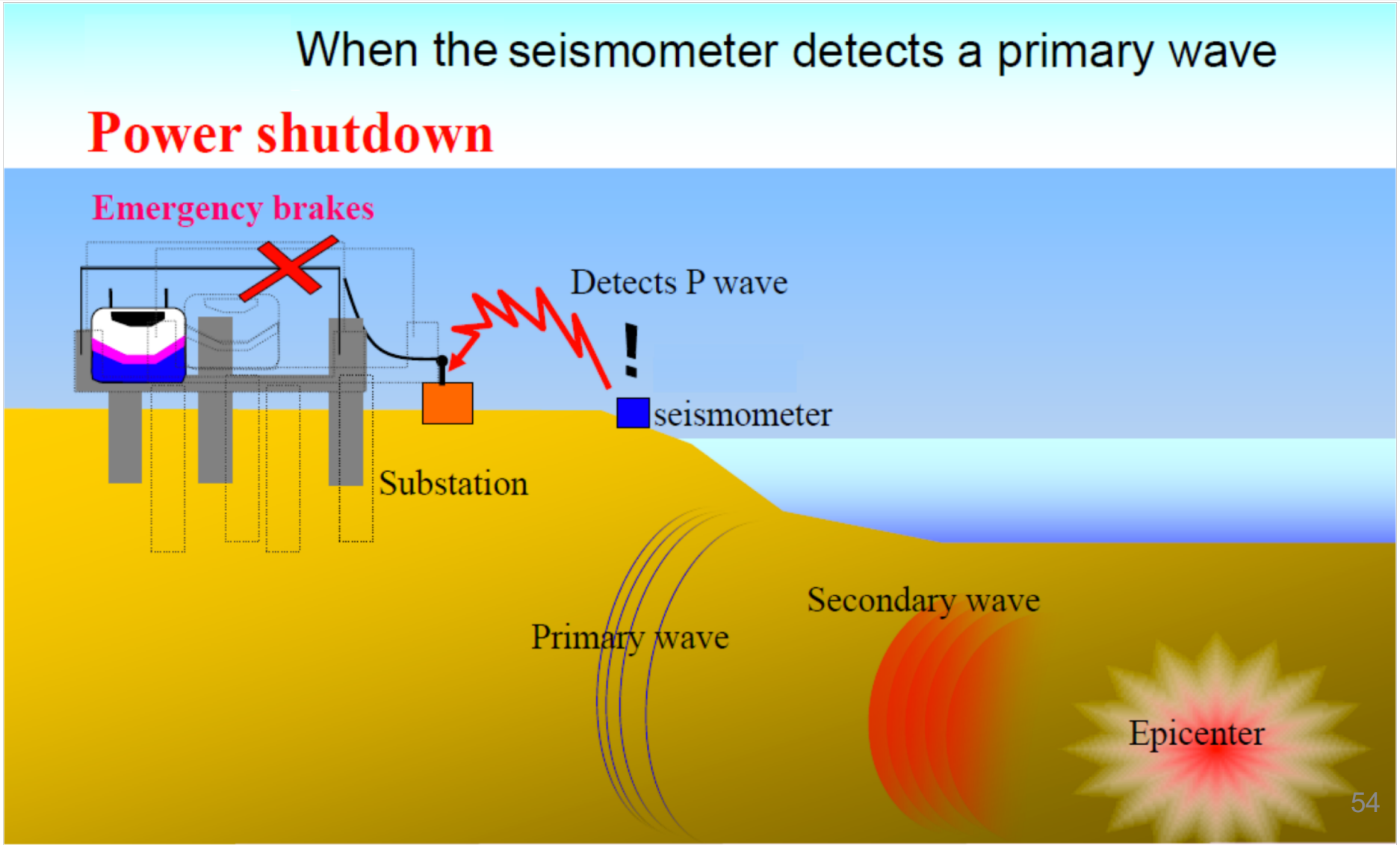
- **Early Earth Quake Detection System:**

- **Early Earthquake Detection System** to prevent any possible accident of train due to earthquake.

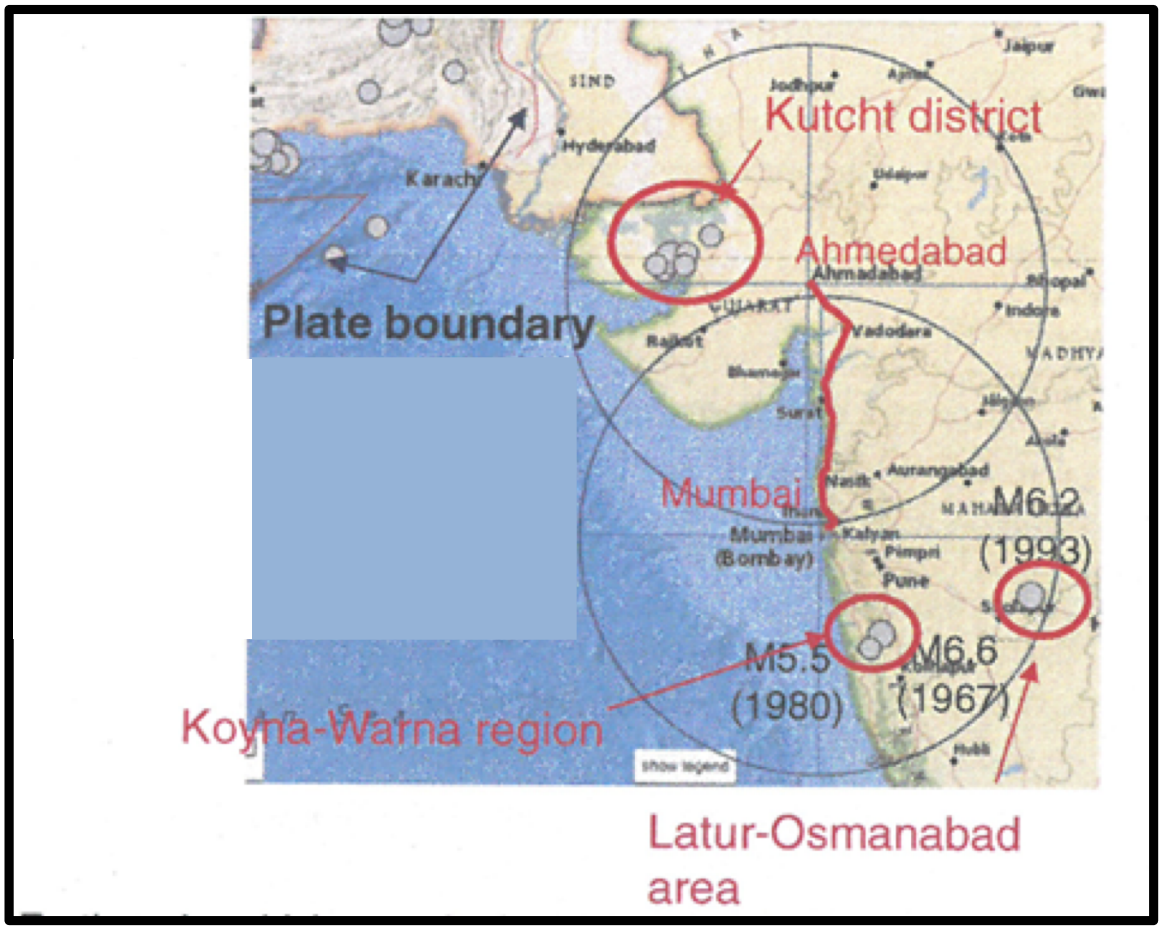
- **Seismometer installation: 22 nos along track** and **06 nos** in **3 most vulnerable Seismic Zone** (Kutch, Koyna-Warna region and Latur-Osmanabad).

- Seismometer will detect the **Primary waves** of earthquake and cause immediate **shutdown of power supply** (at threshold value of earthquake) thereby stopping the train.

Early Earthquake Detection System



Early Earthquake Detection System



[Location of seismometer]

Wayside seismometers are installed at each SP and SS, except for SP 11.

Special Safety Features

- **Rail Temperature Monitoring:**

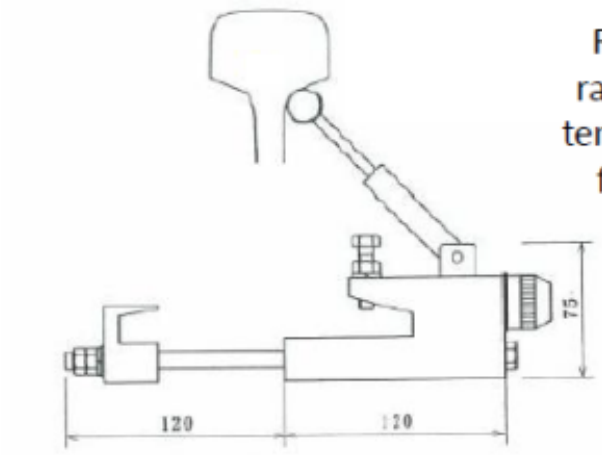
  - Rail temperature monitored through **Rail temperature sensors**.

  - **Sensor Installation: 05 sensors** *at locations where rail temperature is expected to be maximum*. Monitors rail temperature continuously (**-5 degrees to 70 degrees** (C)).

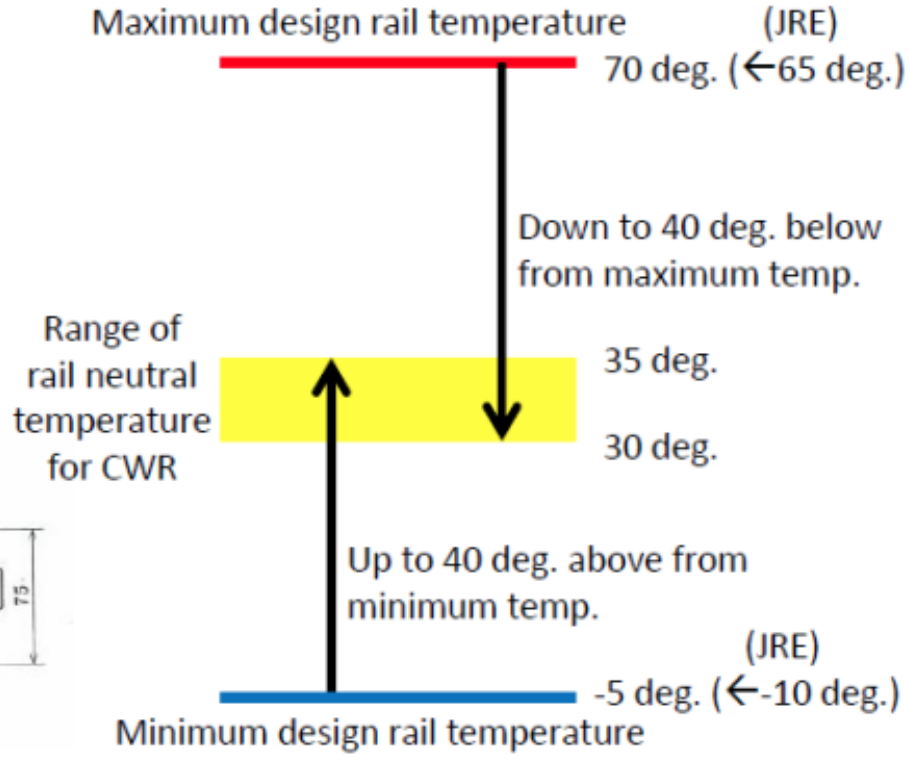
  - In case of *abnormal increase* in *rail temperature* beyond the threshold level, there shall be **alarm in Operation Control centre (OCC)** and accordingly **train speed be regulated**.

RAIL TEMPERATURE MONITORING

Continuous Rail temperature monitoring at web of Rail by rail thermometer, 5 locations 100 km apart



Example of Rail Temperature Sensor installed on Rail



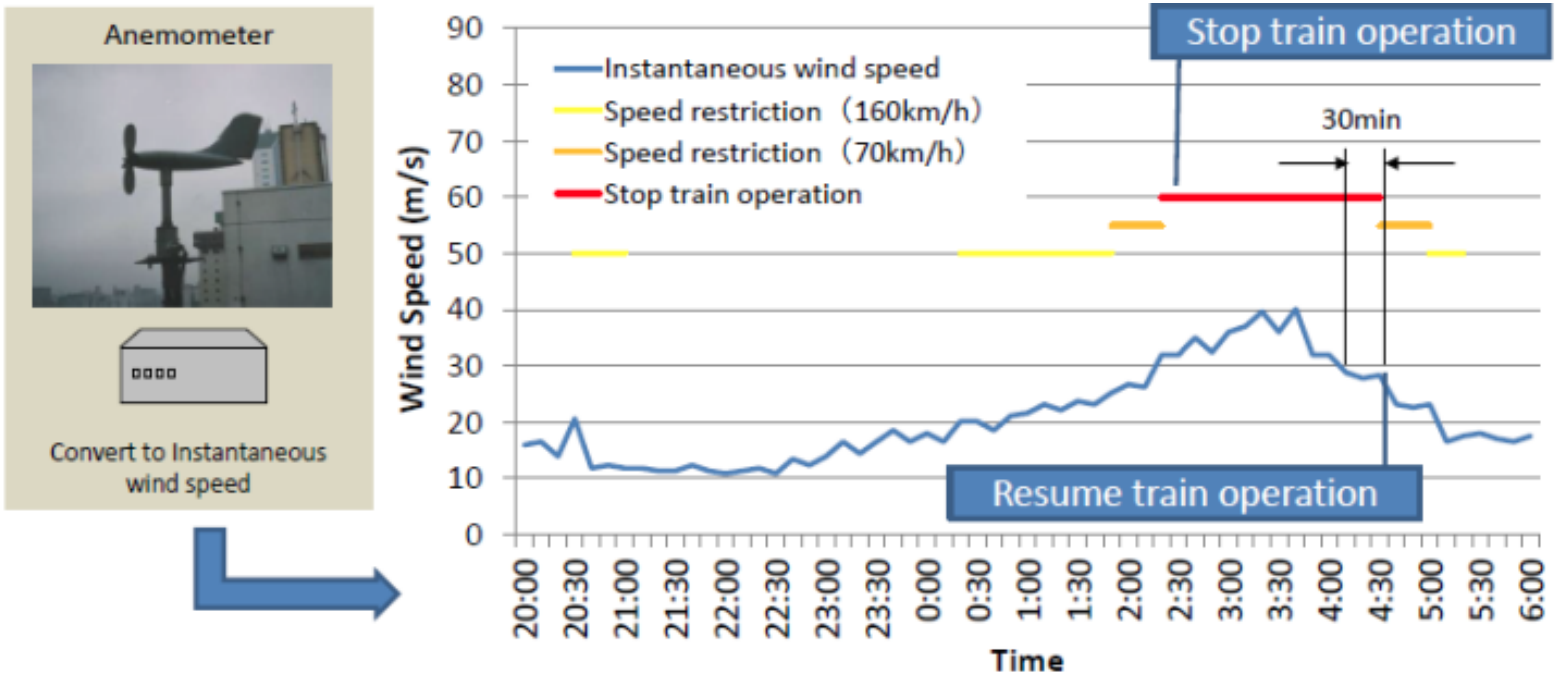
Range of Rail Neutral Temperature for CWR

Special Safety Features

- **Wind Monitoring:**

  - Continuous monitoring of the wind speed.
  - **Anemometers: 14 nos** at locations where strong winds are expected.
  - For wind speed increasing **beyond 30 m/s** (108 Kmph), there shall be **alarm in Operation Control centre** (OCC), so that **train can be stopped**.
  - For wind speed **less than 30 m/s** (108 Kmph), the **train operation regulation shall be fixed**.

Wind Monitoring



Threshold value for train operation regulation against strong wind is determined based on critical wind speed of overturning of rolling stock and design wind velocity for calculation for deviation of contact wire.

[Location of anemometer]

The locations where strong wind tend to blow are chosen based on the report of RTRI (simulation, field survey and etc.). 8 out of 14 location that are chosen are around river.

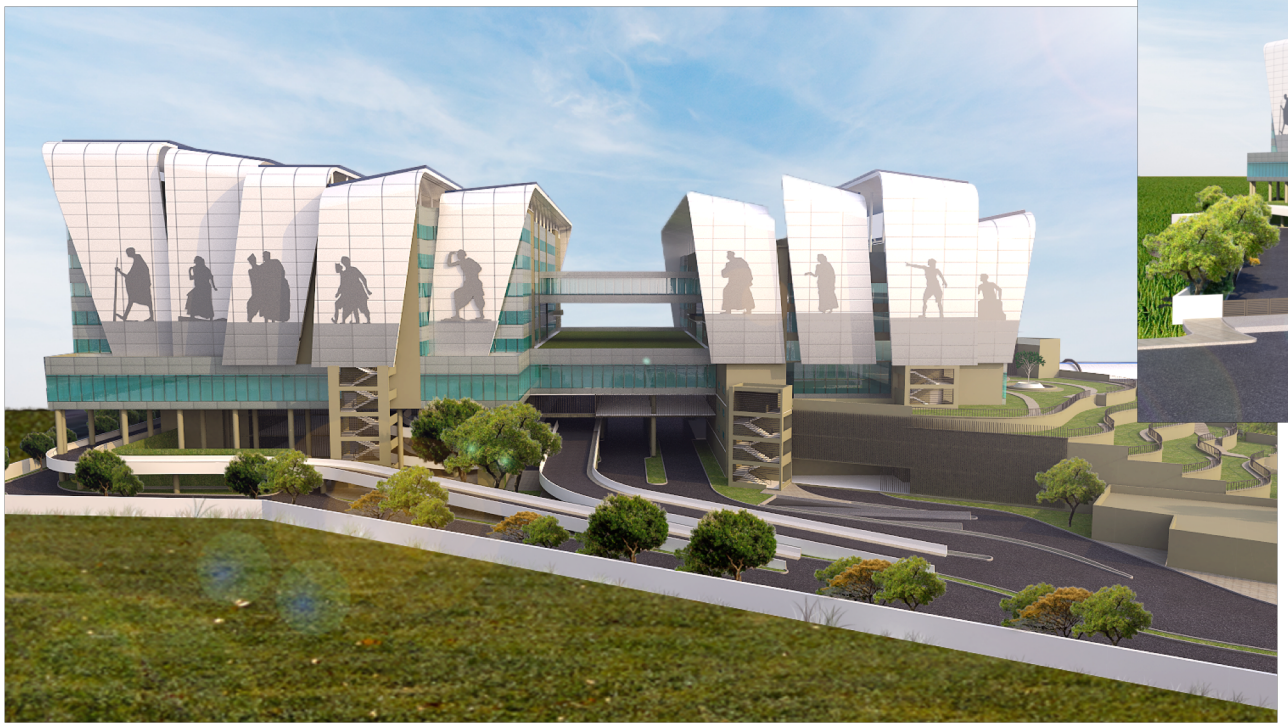
Special Safety Features

- **Rain Monitoring:**

- To prevent any accident due to heavy rain.
- **Rain gauges: 6 nos** at vulnerable location.
- Continuously measures the rainfall and compiles the data of 1-Hr as well as 24-Hr rainfall.
- ***Based on rainfall record, threshold value for the train operation regulation shall be fixed.***

Stations

- Sabarmati



Stations

- Anand/Nadiad

Stations

- Vapi

THANK YOU