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

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

## TRAIN OPERATION PLAN
(Source: Feasibility Study)

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

**Operational Control Centre:** Sabarmati  
**Maintenance Depot/Workshop (Rolling Stock):** Thane, Sabarmati
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.

<table>
<thead>
<tr>
<th><em>Elevation accuracy achieved in MAHSR</em></th>
<th>39mm</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Positional accuracy achieved in MAHSR</em></td>
<td>93mm</td>
</tr>
</tbody>
</table>
METHODOLOGY

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

- Master control stations: Avg. Base length 25-28 Km
- Secondary control stations: Avg. Base length 5-8 Km
DATA PROCESSING AND OUTPUT

1. LASER DATA
2. ONBOARD GPS DATA
3. GROUND STATION GPS DATA
4. IMU DATA (Flight Parameter)
5. PHOTOS

- GPS SOLUTION
- INS SOLUTION (Flight Trajectory)
- GEOREFERENCED POINT CLOUD
- EXTRACTION OF GROUND KEY POINTS
- ORTHO-PHOTO GENERATION

IMU-Inertial Measurement Unit
GPS-Global Positioning System
INS-Inertial Navigation System
VIDEO on LiDAR Survey of MAHSR

Laser sensor is flown over the corridor on a helicopter
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

- Recording Ship
- Source Ship
- Recording unit on ship
- Radio transmission of shot timing pulse (trigger signal)
- Top of high speed layer
- Water bottom
- Refracted waves
- Bay Cable
- Air Gun
- GPS
- Bay
- Cable
- Hydrophones (sensors)
- Anchor
### 2-D VELOCITY MODEL OF THANE CREEK

#### Distance, Longitudinal Section

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

100 m  220 m  120 m

Existing Railway Tracks

High Speed Alignment

Existing Railway Tracks
Step 1: Launching Temporary Girder

Existing Railway Tracks

Temporary Girder

MAHSR Line
Step③ Rotation of the Main Span

Centre Span Rotation Launching
Rotation Center
Rotation Direction
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

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.
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

End part of carbody
Central part of carbody
End part of carbody

Roof structure

Side structure

Double skin hollow Aluminum extrusions with truss section
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.

![Diagram of Full-active suspension system and electric actuator](image-url)
(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 Km/h in 310 s running 18 Km
- **Service Brakes** bring the train running at 320 Km/h to halt in 167 s (less than 3 minutes) running 8.5 Km
- **Power failure detection brakes** bring the train running at 320 Km/h to halt in 78 s running 3875 m
KEY TECHNOLOGIES OF HIGH SPEED RAIL

SYSTEMS (Signalling & Communication)
Signalling System (Continuous Automatic Train Control)

• Objectives:
  o Optimal utilisation of infrastructure for maximising train operation frequency,
  o Safe and Punctual Running of Trains.
  o Avoidance of collision and other accidents, by automatic train control and braking.
  o Last mile to ensure complete safety in train operation.

• Major Components:
  o Coded Digital Audio Frequency Track Circuit (DAFTC).
  o Built In Intelligence in Track Circuits to Adjust its voltage automatically for better reliability.
  o Heavy duty Point Machine, with first time swing nose operation in India.
  o Safety ensured in Fall-back System through Leaky Coaxial Cable.
  o Remote monitoring of Signalling Equipment – Status of all equipments is monitored on real time basis.
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.
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.
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.
OVERHEAD EQUIPMENT (OHE)
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)

Instantaneous blackout
(300ms)

Track circuit
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

- Messenger wire:
  - St180mm² (Tension=24.5kN)
  - Encumbrance = 1,500mm
- Dropper wire interval = 10m
- Span = 50m
- Auxiliary messenger wire
  - PH150mm² (Tension=9.8kN)
- Hanger length = 150mm
- Hanger interval = 5m
- Connector
- Contact wire
  - GTSN170mm² (Tension=15.6kN)
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**
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

When the seismometer detects a primary wave

Power shutdown

Emergency brakes

Detects P wave

Substation

Primary wave

Secondary wave

Epicenter
Early Earthquake Detection System
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.**
Continuous Rail temperature monitoring at web of Rail by rail thermometer, 5 locations 100 km apart
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.
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.
• Sabarmati
Stations

- Anand/Nadiad
• Vapi
THANK YOU