Mumbai–Ahmedabad High-Speed Rail Project

Indigenous solutions opportunities for High Speed Railway applications

NATIONAL HIGH SPEED RAIL CORPORATION LTD
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)

Gujarat: 349.03 Km (8 districts)
Maharashtra: 154.76 Km (3 districts)

DNH*: 4.30 Km (1 UT)

GAUGE: Standard (1435 mm)
SPEED: 350 Km/h (Design), 320 Km/h (Operating)

* DNH: Dadra & Nagar Haveli
## SALIENT FEATURES OF MAHSR

<table>
<thead>
<tr>
<th>TRAIN OPERATION PLAN</th>
<th>Source: Feasibility Study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
<td>2023</td>
</tr>
<tr>
<td><strong>Train Configuration</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Number of Rakes</strong></td>
<td>24</td>
</tr>
<tr>
<td><strong>Number of Train Trip</strong> (per day/one-direction)</td>
<td>35</td>
</tr>
<tr>
<td><strong>Train Capacity</strong></td>
<td>750</td>
</tr>
<tr>
<td><strong>Traffic Volume</strong> (day/one direction)</td>
<td>17,900</td>
</tr>
<tr>
<td><strong>Number of Trains</strong> (per day/hour/one-direction)</td>
<td>Peak Hour: 3</td>
</tr>
<tr>
<td></td>
<td>Off peak: 2</td>
</tr>
</tbody>
</table>

Operational Control Centre: Sabarmati
Maintenance Depot/Workshop (Rolling Stock): Thane, Sabarmati
## SALIENT FEATURES OF MAHSR

### MAINTENANCE SCHEDULE

<table>
<thead>
<tr>
<th>Inspection (Period)</th>
<th>Light Maintenance</th>
<th>Heavy Maintenance</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily (48 h)</td>
<td>Regular (30 days)</td>
<td></td>
</tr>
<tr>
<td>Thane Depot</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sabarmati Depot &amp; Workshop</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Key Features:

- **Power supply**: 12 Traction substations, 2 Depot substations and 16 Distribution substations (12 Stations, 2 Depots & 2 Tunnel)
- **OHE**: 2X25 KV, Heavy Compound Catenary System
- **Annual Energy requirements**: (Trains, Stations etc) -1100 million units
- **Signalling**: DS- ATC similar to Shinkansen
- **State of the art**: High Speed Railway Training Institute at Vadodara

### Details:

- **Train Acceleration**: 0 to 320 Km/h in 310 s (distance- 18 Km)
- **Braking**:
  - Service brake - 320 to 0 Km/h in 167s (distance- 8.5 Km); Power failure detection brake - 320 to 0 Km/h in 78s (distance-3.875 Km)
- **Classes of coach**: 3 types (Standard, Business, First Class/Grand Class)
- **Fare**: Standard class 1.5 times of AC-I (about Rs3000), [fare of other classes not yet decided]
Project will have multiplier effect on the Indian economy like generating employment, creating demand for construction industries etc.

- **Job creation:** 40,000 persons during construction and 3,550 during Operation.

- **Infusion of private investment:**
  - “Make in India” of major material/equipment - Track (12 out 20 items), Civil (50 out of 52 items), Electrical/S&T (48 out of 78 items) and last 06 train sets.

- **Increase in Construction Material demand:**
  - Cement = 75 lakh MT, Steel = 21 lakh MT, Structural Steel = 1.4 lakh MT

- **Increase in Construction Machine demand:**
  - Large number of construction machines will be required in the project -
    - Excavation (50 lakh m3) - About 300 excavators required
    - Piling (25,000 Piles) - About 280 Piling Rigs required
    - Full Span Launchers – More than 20 FSLM
    - Tunneling Boring Machines
    - Electrical and S&T Equipments
To revolutionize connectivity in India, 7 new corridors are being studied for implementation of High Speed Rail.

Detailed Project Report (DPR) is being prepared by NHSRCL.

<table>
<thead>
<tr>
<th>SN</th>
<th>HSR Corridor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Delhi-Varanasi (865km)</td>
</tr>
<tr>
<td>2</td>
<td>Mumbai-Nagpur (753km)</td>
</tr>
<tr>
<td>3</td>
<td>Delhi-Ahmedabad (886km)</td>
</tr>
<tr>
<td>4</td>
<td>Chennai-Mysore (435km)</td>
</tr>
<tr>
<td>5</td>
<td>Delhi-Amritsar (459km)</td>
</tr>
<tr>
<td>6</td>
<td>Mumbai-Hyderabad (711km)</td>
</tr>
<tr>
<td>7</td>
<td>Varanasi-Howrah (760km)</td>
</tr>
</tbody>
</table>
HIGHLIGHTS OF MAHSR PROJECT

- LiDAR- Aerial Survey Method (1\textsuperscript{st} time in a Railway Project)
- Undersea Tunnel & use of Static Refraction Tomography
- Elevated Corridor
- Controlling Tunnel Boom effect (Train nose, Tunnel Hood)
- Improved Bogies Technology
  - Pressurized car body and Double skin hollow Aluminum car body
  - Noise Mitigation
  - Pantograph
  - Special Lurch Control System
- Continuous Automatic Train Control (DS-ATC) System
  - Digital Audio Frequency Track Circuit (DAFTC)
  - Track to Train Transmission
  - Fall-back System
- Disaster Management System
LiDAR- Aerial Survey Method (Topographical Survey)

- 500 Km topographical survey within **short time** of 3 months.
- Aerial survey technique of LiDAR (*Light Detection and Ranging*) used.
- 1st time in a Railway project in India.
- Good accuracy achieved (<100 mm).

**LiDAR data used to develop:**
- Digital Surface Model (DSM)
- Digital Elevation Model (DEM)
- Digital Terrain Model (DTM)
- Topo maps, Orthophoto photo
AERIAL LiDAR SYSTEM OVERVIEW

- GPS Satellite
- GPS Ground Station
- LiDAR Scanner
- IMU (Inertial Measurement Unit)
- GPS-Global Positioning System
- Field of view (FOV)
- SMU (sensor management unit)
- IMU (Inertial Measurement Unit)
- Aerial Camera (Camera 100 MP)
- Computer System
- Aerial Lidar System
21 Km undersea tunnel planned in Thane creek to avoid disturbances in Flamingo sanctuary and nearby Mangroves.

“Underwater Static Refraction Tomography” sub-surface investigation adopted.

Done by Kawasaki Geological Engineering Co. Ltd, Japan.
90% alignment is on viaduct (460 Km viaduct).
Conventional methods of superstructure construction are slow.

Full Span Launching Method (FLSM) of superstructure launching is planned.
CONTROLLING TUNNEL BOOM EFFECT (Train nose, Tunnel Hood)

- **Sound Pressure wave-Tunnel Boom effect**
  - High speed train (Speed > 200 Km/h) entering a tunnel, generates sound pressure wave. Pressure wave travels at extremely high speed through tunnel.
  - At tunnel exit, a loud noise like Sonic Boom is generated due to micro pressure waves (Tunnel Boom effect).

- **To Control Tunnel boom:**
  - Aerodynamic shaped train nose (Bio-mimicked from duckbill).
  - Slotted baffle structures at Tunnel Portal (Tunnel Hood).
**IMPROVED BOGIES TECHNOLOGY**

- **Pressurized car body**
  - To avoid discomfort to passengers due to drop in pressure inside the passenger cabin in tunnel, Car body is pressurized.
  - Complete car body is made air tight and Pressure inside the car is kept above the atmospheric pressure.

- **Double skin hollow Aluminum car body**
  - Car body is kept light weight
  - Double skin hollow Aluminum extrusions with truss section used.
**Noise Mitigation**

- Bogies are completely covered to reduce noise from rail contacts.
- Pantographs are fitted with sound insulators on both sides.
**Pantograph**

- For reducing pantograph noise:
  - Use of only one pantograph per trainset.
  - Low noise pantograph with a cantilevered main arm used.
  - Pantograph noise insulation panel provided.

- Multi-segmented slider having fractionated contact strips for better current collection.

**Special Lurch Control System**

- Intelligent control system provided.
- Detects car body swaying and then reduces lateral vibrations.
CONTINUOUS AUTOMATIC TRAIN CONTROL SYSTEM

- Digital Automatic Train Control System for Shinkansen (DS-ATC) used.

**Objective:**
- Optimal utilization of infrastructure for maximizing train operation frequency.
- Safe & Punctual Running of Trains.
- Avoidance of collision and other emergencies by automatic train control and braking.

**Major features of DS-ATC system :**
- Coded Digital Audio Frequency Track Circuit (DAFTC).
- Track to Train Transmission.
- Fall-back System through Leaky Coaxial Cable.
- Heavy duty Point Machine with swing nose (1st time in India).
- Cable Gas pressure Monitoring System.
• **Track to Train Transmission**

  o 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.

• **Fall-back System**

  o Based on - Leaky Coaxial cable based radio system.
  
  o In case of the failure of main system, the system switches over to transmit the safety information through Leaky Coaxial Cable ensuring complete safety.
Continuous monitoring and control of train speeds through comprehensive Disaster Management System.

- **Earthquakes**: Seismometer - 22 nos along track & 06 nos in 3 most vulnerable Seismic Zone.
- **Rail Temperature**: 5 sensors at locations where rail temperature is expected to be maximum.
- **Wind Pressure**: 14 anemometers at locations where strong winds are expected.
- **Rain**: 6 rain gauges at vulnerable locations
Indigenous solutions opportunities for HSR applications

- **NHSRCL has taken steps towards self-reliance through development of indigenous capabilities & cost-effective solutions.**
  - Several materials, equipment, assemblies have been jointly identified by Japan & India to promote ‘Make in India’.

- **NHSRCL has created **High Speed Rail Innovation Centre Trust**
  - To undertake research, development in relevant fields of HSR technology by leveraging Indian technical capabilities.
  - Advisory Council includes persons of eminence from Industry, academia and research institutes both from India and abroad e.g. IITs, University of Tokyo, RTRI/Japan.

- **Many projects have been identified for Research & Development:**
  - Application Software based systems for automatic yard movement.
  - Development of Indigenous Simulation Model of Traction Power Supply and design validation of OHE Pantograph interaction.
  - Design of Reinforced Earth (RE) Retaining wall & RE Abutments for HSR/Railways
  - Detailed Study on Cement Asphalt Mortar (CAM) for High Speed Railway Track.
  - Optimization of HSR Viaduct design.
  - Fire safety and fire retardant materials for HSR applications
Indigenous solutions opportunities for HSR applications

- Many items have been identified which have potential for indigenization and is presented here to arouse the interest of technical institutions, potential manufacturers:
  - Liner Plate for Shinso pile,
  - Damper Stopper as seismic restrainer,
  - Geo-synthetics for RE wall,
  - Cement Asphalt Mortar,
  - Rail Turn-over prevention device,
  - Embedded Inserts (Tie plugs),
  - Double skin hollow Aluminum car body for coaches,
  - Contact Wire, masts for Over Head Equipment (OHE).

- Institutes/Firms developing indigenous solution would have opportunities in:
  - HSR projects (present & future; in India & abroad).
  - Big & growing Indian Railways, Metro Railways opportunities.

- Technical Institutes & firms are welcome to contribute to self reliance.
# LINER PLATE FOR SHINSO PILE (Piling in busy Railway area- Shinso Piles)

- At some location alignment runs close to existing track.
- No space for accommodating pile cap or spread footing.
- **Shinso Pile Method** is proposed.
  - Does not need big pile driver machine.
  - used in Japan, not common in India.

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**Scope of research and development**:

- To Develop the Liner Plate Indigenously in collaboration with Industry & Research Institutes.
DAMPER STOPPER AS SEISMIC RESTRAINER

- Damper stopper used in bridges to distribute Seismic forces to adjacent Piers.
  - are provided at the intermediate supports of continuous bridge.

Scope of research and development:

# To Develop the materials of Damper Stopper indigenously.
The Reinforced Earth (RE) wall up to 11m height and RE Abutment for more than 13 m has been used in Shinkansen.

*Used in Highways in India, however, they are not used in Railways.*

**Advantages of Reinforced Earth Structures:** Reduction in Land requirement, Provide better earthquake resistance structure, Cost effective compared to viaduct

**RE Wall General Arrangement:**
- Rigid face wall - with in-situ concrete better connection with stabilised reinforced soil.
- Geo-synthetic - extensible type (metallic geo-grids are not used).

On MAHSR these structures are planned to be used. *Designs are being carried out as per Japanese Railway Design Standard. Specific software is used for analysis, which is in Japanese, language.*

**Scope of research and development:**

# To develop design methods & specifications to suit Indian conditions and available reinforcement materials in collaboration with Industries & Universities in India, abroad (especially Japan).
CEMENT ASPHALT MORTAR (CAM)

- CA Mortar is a filler material (thickness ~ 50-100mm) between track slab & RC track bed.
  - **Purpose**: important roles like supporting, level adjustment, load transfer, vibration absorption, shock insulation, etc.
  - **CAM Composition**: High early strength cement, sand, asphalt emulsion & polymer emulsion (for flowing ability) and admixtures, Aluminium in powder, Anti forming agent, Air Entrainment (AE) agent, water.
  - Emulsion materials are planned to be imported from Japan.

Scope of research and development:

# To study functional & structural requirements and finalize design criteria to;
  - develop CA Mortar material suitable for Indian environmental conditions based on available chemical, cement, industrial resources.
  - develop alternative material, which can fulfill, structural & functional requirements in collaboration with Industry & Research Institutes.
RAIL TURNOVER PREVENTION DEVICE

- Rail turnover prevention device prevent rail turnover by resisting the impacted wheel loads.

Scope of research and development:

# To develop Rail Turnover Prevention device in India for MAHSR and/or for Future HSR Projects.
EMBEDDED INSERTS (TIE PLUGS)

- Tie Plugs are used in rail Fastener of Track Slab, Rail Turn over Prevention Device, for track slab handling.

  - **Types:** Type A [for Rail Fasteners], Type B [for Rail Turn over prevention device], Type C [for Track Slab lifting].

- **Made of:** Inside-Steel, Outside-Polymide (Type A)

Scope of research and development:

# To develop embedded inserts in India for MAHSR / Future HSR Projects
### DOUBLE SKIN HOLLOW ALUMINUM CAR BODY and ROLLING STOCK EQUIPMENT

- Double skin hollow Aluminum extrusions with truss section used in Rolling Stock body.

- Some Japanese Companies in India are manufacturing equipment for Metro Projects in India.

<table>
<thead>
<tr>
<th>SN</th>
<th>Item</th>
<th>Manufacturers in India</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traction Converters, Traction Motor, Transformer</td>
<td>Toshiba India, MELCO India</td>
</tr>
<tr>
<td>4</td>
<td>Brake Controller, Auxiliary Power Unit, HVAC</td>
<td>MELCO India</td>
</tr>
</tbody>
</table>

# Scope of research and development:

- Capability of manufacturing 25 m long hollow Aluminum extrusion, facility of Aluminum welding (Friction Stir/MIG) needs to be developed in India.
- Possibility for manufacturing of the equipment for HSR requirements in India through Collaborative research of Industry & Institutes.
## CONTACT WIRE FOR OVER HEAD EQUIPMENT (OHE)

### Comparison of contact wire for IR/DFC/MAHSR:

<table>
<thead>
<tr>
<th>Properties</th>
<th>IR</th>
<th>DFC</th>
<th>MAHSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Speed (Kmph)</td>
<td>160</td>
<td>120</td>
<td>320</td>
</tr>
<tr>
<td>Material</td>
<td>Electrolytic Copper</td>
<td>Copper Silver alloy</td>
<td>Copper Tin Alloy</td>
</tr>
<tr>
<td>Area (mm$^2$)</td>
<td>107</td>
<td>150</td>
<td>170</td>
</tr>
<tr>
<td>Tension (KN)</td>
<td>10</td>
<td>10</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Scope of research and development:

# Indigenous development of Copper Alloy for future Projects through Collaborative research (Industry & Institutes).
**MASTS FOR OVER HEAD EQUIPMENT (OHE)**

- Mast supports the OHE with cantilever assembly.

<table>
<thead>
<tr>
<th>Type of Mast</th>
<th>IR / Metro / DFCC</th>
<th>MAHSR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>▪ BFB (Broad Flanged Beam)</td>
<td>▪ Circular Mast</td>
</tr>
<tr>
<td></td>
<td>▪ RSJ (Rolled Steel Joist)</td>
<td>(Rolled Steel)</td>
</tr>
<tr>
<td></td>
<td>▪ K&amp;B type (fabricated)</td>
<td>▪ Fabricated mast</td>
</tr>
<tr>
<td></td>
<td>▪ Portal</td>
<td></td>
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</tbody>
</table>

APPLICATION SOFTWARE BASED SYSTEMS FOR AUTOMATIC YARD MOVEMENT

- To control and provide automatic, efficient, systematic, and safe movement of trains in the yard for best utilization of available rakes and crew.
- Indigenous software models would save resources [*money & time (in case of modifications)]* and help in further design improvements under Indian conditions economically.

Challenges:
- Integration of the software with communication system of Rolling Stock and OCC for data exchange.
- Course correction in the event of sudden breakdown.
- Adjustment in the rake movement in case of yard track, signal and OHE maintenance.

Scope of research and development:

# An application software flexible to integrate with other modules and capable of exchanging information in real time can be developed in India through Collaborative research of Industry & Institutes.
Presently all simulations studies for OHE system design for Railway projects in India (Metro, DFC, MAHSR), are carried out abroad.

- Power Supply Simulation (for Substation spacing and sizing, etc)
- Simulation of Pantograph & OHE interaction (for OHE geometry & design, etc)

**Source Code / “know-how” / “know-why” remains with agencies. Any modifications/changes/re-design, takes up more time and cost.**

**Objective:**
- To develop Indigenous simulation software models.
- Enabling techno-economic study under Indian ambient conditions for Substation spacing and sizing, OHE geometry & design.

**Scope of research and development:**

# Simulation software models can be developed using indigenous software skills through collaboration of Railway domain experts, academia personal, software experts etc for future HSR, Metro, Railway projects.
MAHSR is being designed based on Japanese Standards.

Many new corridors have been planned by GOI.

Presently, there are no Indian Standards for HSR.

It is pertinent to prepare a set of Guidelines to be followed for HSR in India with an intent to Standardize and Optimize the Viaduct Design.

### Scope of research and development:

- Studying the Design Parameters for Viaduct Design used in Japan, China, Taiwan and other HSR’s in the World and finalise the parameters & methods suiting Indian Conditions, available materials etc and prepare guidelines for HSR in India.
FIRE SAFETY AND FIRE RETARDANT MATERIALS FOR HSR APPLICATIONS

Fire in Trains is a cause of concern.

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<tbody>
<tr>
<td>Accidents</td>
<td>9</td>
<td>31</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Casualties</td>
<td>16</td>
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<td>41</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>7</td>
<td>40</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Coach furnishing materials, seat upholstery are a major factor for fires.

There is need to establish specification of all the components of the seat, identifying sources for developing the same indigenously and establishing the supply chain.

Scope of research and development:

Area for R & D:

- Minimise the possibility of ignition and limit the spread of fire.
- Minimise effect on passengers - heat, smoke and toxic gases.
- Development of Testing and Research facilities for Materials.
THANK YOU