Planning and Capacity Building for High-Speed Rail Development in India: Five Key Lessons

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1. Introduction

India's urbanization rate has increased from 26% in 1991 to 35% in 2021, and it is expected to reach 41% by 2030 (World Bank 2022). In response to this, as the backbone of its growing economy, the country's infrastructure development, particularly transportation development, has been heavily emphasized. The railway sector will see an investment of $715.41 billion by 2030. Along with a series of supporting government policies, an opportunity to expand the high-speed rail (HSR) network has been presented in India. From the viewpoint of the government, HSR is an effective tool to address the surge in travel demand because of its mass transportation, high speed, and high energy efficiency (Suzuki et al. 2022). Besides, HSR projects bring about a ripple effect on the Indian economy by generating local employment opportunities, catalyzing the steel and cement sector and galvanizing Aatmanirbhar Bharat (an initiative by the Government of India to make the country self-reliant) through the indigenization of technology (National High Speed Rail Corporation Limited 2022). From the perspective of communities and individuals, HSR improves their quality of life by offering a faster and safer transportation option for work and travel.

With the aim to strengthen governance and institutional capacity in promoting HSR development, the Asian Development Bank Institute (ADBI) hosted the ADBI–World Conference on Transport Research Society Knowledge Sharing Session on Policies and Programs for Implementation of High-Speed Rail Network in Asia on 29 July 2022. The event had 85 attendees, with most of them from government agencies and academic institutes all over the world. Using the discussions as a start, this policy brief highlights five key lessons and opportunities—three for planning and two for capacity building—for equipping policy makers with the essential knowledge to unleash the full potential of HSR development in the Indian context.
2. **Overview of High-Speed Rail Development in India**

The rapid urbanization in India and its rising population and income along with its economic growth have pushed up the volume of people and goods being transported in the country. To satisfy the demand, one of the most efficient transportation options in India is high-speed rail. Since 2007–2008, budget announcements have introduced high-speed services on identified corridors at a goal speed of 300 to 350 kilometers (km) per hour. With massive work done, India finally has its first HSR project—the Mumbai–Ahmedabad High-Speed Rail (MAHSR) project (which is part of the Diamond Quadrilateral project)—confirmed, announced, and under construction. Running alongside the western dedicated freight corridor and the Delhi–Mumbai industrial corridor, this flagship project is operated and managed by Indian Railways, the statutory body under the Ministry of Railways, Government of India.

The MAHSR project, which greatly contributes to regional industrial and economic growth, has broken the record of Indian train speed. Since India’s first train connecting Mumbai and Thane was constructed in 1853 that ran at a speed of 35 km per hour, passengers of the MAHSR project will now enjoy a ten-times faster train ride running at 320 km per hour. Compared to other Asian cities, HSR development in India is still slow—HSR in the Republic of Korea reached 295 km per hour in 2004, and in the People’s Republic of China HSR reached 350 km per hour in 2008. Seeing this, besides the MAHSR, the Ministry of Railways has conducted feasibility studies on other potential HSR corridors. The identified corridors include (i) Delhi–Chandigarh–Amritsar, (ii) Chennai–Bangalore–Mysore, (iii) Delhi–Mumbai, (iv) Delhi–Kolkata, (v) Mumbai–Nagpur, and (vi) Mumbai–Chennai. Counting the MAHSR project, 6,387-kilometer-long HSR routes have been planned in India to catch up with the worldwide HSR development.

3. **Lesson 1: Planning—Formulating a Holistic and Forward-Looking HSR Planning Vision**

From an urban planning perspective, a holistic and forward-looking planning approach that takes into consideration different routes, nearby infrastructure, and future extensions, it is essential in achieving cost-effective, efficient, and sustainable HSR development in India. The following are some key elements that should be incorporated.

**Location of a Single Route and Its Stations**

An HSR corridor shall be 500 to 800 km in length spanning between two major cities. The station locations along the corridor route should be placed in accordance with space availability and economic development. While it is preferable to have the stations placed at existing intercity rail locations for better accessibility benefits and reduced infrastructure costs, this may fail to satisfy the spacing requirements and ridership demand (Roy and Maji 2019). Hence, an optimal trade-off should be made between constructing additional intermediate stations to boost overall ridership and limiting the number of stations to their minimum for faster rides.
Interoperability Among Different Routes

Interoperability is known as the flexibility of coinciding HSR corridors with the existing conventional and freight corridors. Incorporated into the technical specifications for interoperability standards, the concept has been adopted extensively for European HSR lines, as seen from the InterCity Express in Germany and the SNCF in France. In order to achieve the same, India should reference these standards to govern the interoperability among different HSR routes with the assistance of technology.

Compatibility of Routes with Nearby Infrastructure

To address the travel demand most efficiently, the fare range and travel time of other transport options (especially air travel) should be considered when designing the HSR network. Hence, there should be a forward-looking planning vision that projects national and regional travel demand. This can be achieved with the help of demand models. In fact, the lack of vision in the transportation network development of India was reflected in the case when the country failed to handle the pressing travel demand by taking more than 20 years to build the new Navi Mumbai Airport after the Mumbai Airport had reached its total capacity. Hence, for future HSR development, better coordination among India’s five widely-used modes of intercity travel—HSR, conventional rail, air, car, and bus—is fundamental. It is worth noting that even though many see the use of HSR as competition to air travel, the two means can be complementary to significantly benefit international travelers. Ideally, HSR routes possess direct connectivity to international airports.

Compatibility of Routes with Future Extensions

Expecting HSR to be a major transportation option in the long term, when designing new routes, possible future extensions should be considered even in the preliminary planning stage. As a case in point, the Mumbai–Pune Expressway that has been in use since 2002 is not connected to other cities further south or east, and this has greatly limited the expressway’s utilization efficiency. Regarding this, decision makers should equip themselves with a vision of how the current MAH SR project, which is situated in the west connecting the middle parts of the country, could be further expanded to the north, south, and east of India in the future.

4. Lesson 2: Planning—Exploring Public–Private Partnerships as a Funding Model

As a capital-intensive industry with a long gestation period by nature, the financing options of HSR are impossible to ignore. Although the railway sector in India has been heavily reliant on state funding and foreign loans, a shift in recent decades has been observed, especially since the Private Freight Terminal policy was launched in 2010. With the “New India New Railway” initiative in place, the private sector players, both local and foreign, have been cooperating with the government in the form of public–private partnerships (PPPs), taking up the roles of project investor, operator, and manager. Through the return-risk sharing mechanism, PPPs bring prominent benefits such as bridging funding gaps, mitigating fiscal risks, increasing technical expertise, and improving project quality. The model to finance rail development has proven its success in countries including Japan and France.

As announced in 2020, all the new HSR corridor projects will be open to PPP models. However, the PPP prospect in the sector is not without its challenges. Not only are most of the projects approved based on case-to-case viability that discourages private sector participation, but they are also subject to inconsistent and inefficient regulations resulting in delayed processes of clearances and approvals (Sitharamaraju et al. 2020). In addition, ineffective dispute resolution greatly worsens the viability of the PPP model. In light of these, in order to ensure the model’s efficacy in HSR projects, the government should actively reform its institutional and regulatory frameworks to help boost investor sentiment. Clear delegation of roles and responsibilities and fair sharing of risks and returns should be enabled and realized.

5. Lesson 3: Planning—Untapping the Potential of the Non-fare Model for Additional Revenue Streams

Non-fare revenues are defined as income from various sources, excluding passenger and freight receipts. Developing a non-fare revenue mode is beneficial to Indian HSR development from both urban planning and finance perspectives.
From the perspective of urban planning, transport-oriented development can be fostered by synergizing transportation with urban development. While HSR development leases out land surrounding the railway stations, attracting new commercial and residential construction, and stimulating construction prices, the rise in population as well as living standards in the neighborhoods can in turn boost HSR ridership.

Besides, from the perspective of urban finance, the non-fare model can help ensure the financial sustainability of the HSR operation by generating more risk-free incomes, especially during turbulent times like the pandemic era when it is difficult to guarantee steady ridership revenues. Leveraging HSR stations’ fundamental characteristics of providing wider access, more stable incomes are made from the ones produced by displaying physical and digital advertisements, setting up ATMs at stations, and selling entrance naming rights.

Despite the New Innovative Non-Fare Revenue Ideas Scheme coming into force in 2018, which set an ambitious goal of generating ₹15,000 crore in 10 years, the bureaucracy and ambiguity embedded in the initiative have hindered the potential of the model to be fully unleashed. In view of this, two policy modifications are suggested to increase non-fare revenues. First, while the general managers of all 17 zones are granted independent execution power overseeing the advertisement projects in their own zone, a single window system will be established to handle on-demand projects. Second, practicing a hybrid revenue-sharing model where the advertising revenues are comprised of a fixed minimum guarantee and a percentage of the revenue over the benchmarked value, the model shall be unified across all 17 zones.

6. Lesson 4: Capacity Building—Strengthening Innovation Capacity

As an engine of growth, innovation capacity is a prerequisite for promoting sustainable HSR development in India. On 22 January 2019, a High-Speed Rail Innovation Centre Trust was registered to strengthen wider circulation of innovative ideas surrounding HSR development through providing access to data, information, studies, and resources that are available, acting as a “sounding board” for new ideas, and serving as a bridge between university research students and the HSR projects. Through collaborating with educational institutes, research facilities, and laboratories, the following are three specific tools suggested for further stimulating HSR innovation capacity.

- Establishing research and development (R&D) wings
- Offering project-oriented internships
- Connecting government, industry, and academia

Research and Development Wings

R&D wings actively spearhead research projects to identify the best practices and develop new and improved designs. There are currently five projects identified for further R&D in India: (i) Design for Reinforced Earth Retailing Wall & Retailed Earth Abutments for HSR and Railway Applications; (ii) Development of Indigenous Simulation Model for Design Validation of Power Supply; (iii) Development of Indigenous Simulation Model for Design Validation of Overhead Equipment Pantograph Interaction; (iv) Study on Fire Safety and Fire- retardant Materials for HSR Applications; and (v) Detailed Study on Cement Asphalt Mortar for HSR Track. These projects are expected to significantly contribute to delivering cost-effective and efficient HSR solutions. With more HSR R&D wings covering experimental, operational, and market research, more applicable knowledge conducive to development can be produced.

Project-Oriented Internships

Exposing interns to first-hand empirical work experiences in the field of HSR under the guidance of experienced supervisors, internship programs can help cultivate next-generation talents in fields such as research, engineering, and project management. From the perspective of the interns, they can gain practical knowledge of HSR planning, design, operation, and maintenance. From the perspective of the railway company, bringing in young passionate talented persons and offering them a working environment that facilitates the exchange of ideas is also conducive to generating innovative and indigenous insights. With its very first internship scheme “Bullet Train” launched in 2021, the country can keep housing more programs by partnering with universities and schools in the future.
Connection between Government, Industry, and Academia

A stronger connection between government, industry, and academia enables comparative advantage and synergy creation that benefit HSR development. Indeed, industry and academic research inputs in HSR are complementary to each other given their different approaches and emphases when it comes to R&D. Industry practitioners, on the one hand, often focus research on their past operation and management experiences—they explore what has worked in the past and try their best to replicate the success. Academic researchers, on the other hand, usually look closer into the opportunities, challenges, and patterns seen in the industry—they analyze why something would work and try their best to provide a solution to bring maximum outcome in the future. With the analytical power of academia combining their work with the industry that possesses the essential data and information, HSR knowledge can be formed from different perspectives. On top of that, since the research on the essential working transport demand models requires data sharing from multiple government agencies, a better connection between government and academia can also enable more informed decision making and comprehensive planning and implementation for Indian HSR development. Most importantly, while the research approach adopted by academic institutions allows original ideas to be generated in a more unconstrained way, it is not uncommon for them to face the problem of lack of funds. With closer liaisons among government, industry, and academia in coordinating research funds, knowledge on future HSR development can be more effectively transferred and utilized.

7. Lesson 5: Capacity Building—Transferring Technologies from Other Countries and Indigenizing Them

Since HSR is a complex mechanical-electrical system that integrates multi-interdisciplinary and large-scale technologies, as an emerging industry in India, extensive technology transfer from foreign countries would significantly contribute to its growth. To cite an example, the innovative Aerial Lidar Topographic Survey with DGPS technology was used for the first time in India as an essential element of the MAHSR project. Seeing this, the National High Speed Rail Corporation Limited, a special purpose vehicle with equity participation of the Ministry of Railways and two state governments—the Government of Gujarat and the Government of Maharashtra, was set up in 2013 with the main objective to manage the MAHSR project. In this project, India will introduce cutting-edge Shinkansen technology to its railway design and construction together with 15 other countries.

Originating in Japan, Shinkansen technology is known for its safe and speedy services. Not only do the current Japanese shinkansen trains allow rides to run at speeds of up to 320 km per hour (210 km per hour when they first operated in 1964), but they also have proven their high safety standards with no passenger fatalities occurring since 1964. By adopting the E5 series of the technology, the MAHSR project permits a maximum operating speed of 320 km per hour over its 508-kilometer railway sections. Compared to the country’s maximum operating speed of 160 km per hour in 2015 (Gatimaan Express), the transfer of technology has doubled train speeds in India.

The technology sharing in the MAHSR project is embedded in the “Make in India” initiative as part of a wider set of nation-building initiatives launched in 2014. Besides introducing a suitable policy framework for the transfer of technology, the initiative also emphasizes the importance of setting up joint ventures for local technology manufacturing and mobilizing India’s private sector investment in manufacturing the technology. To implement the initiative, sub-group meetings, workshops, and taskforce meetings are held regularly and frequently with extensive participation from Indian and Japanese government representatives, railway providers, firms, investors, and bilateral organizations to facilitate the planning and execution of project details (Table 1). The items that have been identified for “Make in India” include track slabs, auto and distribution transformers, fiber optic cables, substation switchgears, and overhead equipment poles (Hayashi, Rothengatter, and Seetharam 2021).

With this initiative in mind, the indigenization of HSR in India as Japan once achieved (Box 1), can be realized in three steps:

(i) Learning

In this initial stage, blueprints and methodology behind the technology creation are shared with India. Indian railway engineers, manufacturers, and workers are exposed to an integrated
learning environment to develop a thorough understanding of the technology with the help of R&D wings and customized training programs. Regarding this, a High-Speed Railway Training Institute campus has been established in Vadodara accompanying the

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<tr>
<th>Type of Meeting</th>
<th>Meeting Details</th>
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<tr>
<td>Sub-Group Meetings</td>
<td>Four key sub-groups, Track, Civil, Electrical &amp; S&amp;T, and Rolling Stock hold meetings to identify the potential items to be made in India. The meetings are attended by senior representatives from the Ministry of Railways, Department of Industrial Policy and Promotion, Japanese Embassy, National High Speed Rail Corporation Ltd, Japan Railway East, Japan External Trade Organization, and the Confederation of Indian Industry, among others.</td>
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<tr>
<td>Workshops</td>
<td>Regular day-long workshops are held to engage existing partners and potential investors and interested firms. They are usually followed by business-to-business meetings and discussions for closer interactions between Japanese and Indian companies. All participants of sub-group meetings also attend these workshops.</td>
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<tr>
<td>Task Force Meetings</td>
<td>Held by the Department of Industrial Policy and Promotion, task force meetings review the progress of sub-group meetings and workshops and finalize action plans that have been agreed. Representatives of sub-group meetings and workshops also attend these task force meetings.</td>
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Box 1: Japan Railways Development: Technology Transfer and Indigenization

Japan, having one of the most advanced rail systems around the globe, also experienced a similar development phase of railway development where it indigenized the technology after borrowing it from foreign countries. Under the supervision of an Englishman, Edmund Morel, the first railway in Japan launched in 1872 connecting Yokohama to Shinagawa, was fueled by Welsh coal and operated by British drivers. During the Meiji Restoration (1868–1912), Japan sent specific scientific and technological knowledge to the West, translated Western research work into Japanese, and reformed the education system by referencing the styles of Western universities. Even before the British took up the leadership roles, Japanese engineers and managers assumed full control of the railway network.

In 1926, Japan started developing its automatic couplers on freight wagons indigenously. This came in advance to similar moves in Europe. Through the process of adopting, adapting, and indigenizing borrowed technology, Japan produced its original and world-class railway technology without assistance from foreign countries or the ability of its engineers and scientists to speak foreign languages.

Source: Smith (2003).

(iii) Transformation

In this final stage, incremental upgradation of the originally transferred technology is demonstrated. By collaborating with academia, key decision makers and players are expected to formulate a contextual understanding of why certain HSR technology can be transferred, which HSR technology can be transferred that benefits India the most, and how the transferred HSR technology can be further utilized in the most efficient way. This transforms the Indian HSR development in the long term.
References


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