POLICY NOTE

LESSONS FROM GLOBAL EXPERIENCES ON HIGH-SPEED RAIL IMPLEMENTATION

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Summary and Key Policy Messages

- High-speed rail (HSR) is a high-capacity, efficient, environmentally friendly inter-city transport mode that has transformed the lives of millions. However, the essential condition for its socioeconomic impacts is how effectively projects are implemented and operated.
- Learning from global HSR implementation and deriving evidence-based recommendations for the current and future generations of policymakers, practitioners, and researchers is therefore necessary.
- HSR is best understood using system-thinking principles, that is, considering the non-linear and dynamic interactions among the various technical and social components present in an HSR system.
- Stakeholder coordination during the early stages of HSR planning positively affects project implementation in terms of controlling cost/schedule overruns. Social media could also be leveraged to mobilize and gauge stakeholder engagement.
- The successful implementation of HSR projects requires a robust institutional framework delineating each stakeholder's roles, the standards used, and the coordination/conflict resolution mechanisms.
- HSR systems are shown to be capable of adapting to its users' socioeconomic needs. However, this requires a long-term commitment from the key stakeholder (operators, regulators, etc.) to facilitate continual system improvement.
- Proactive leadership from the key decision makers is essential for effective implementation and operation for HSR projects.

INTRODUCTION

Over the past 3 years, the Asian Development Bank Institute (ADBI), in collaboration with a global community of researchers and policymakers, has developed reference materials to highlight the socioeconomic impacts of investment in high-speed rail (HSR). HSR is a high-capacity, efficient, environmentally friendly inter-city transport mode that has transformed the lives of millions of passengers and non-passengers alike over the short, medium, and long term. Consequently, ADBI has also contributed a significant number of evidence-based

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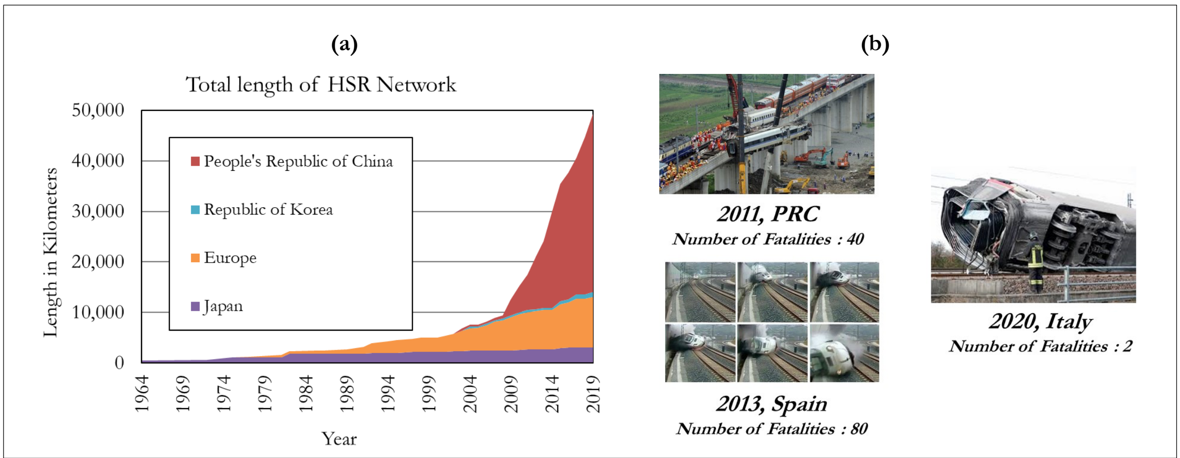
policies for improving HSR planning and project development, which policymakers have received well (Hayashi, Seetha Ram, and Bharule 2020).

However, a necessary condition for the benefits of HSR to accrue is its effective implementation during all stages—planning, construction, and operation and maintenance. For example, effective cost, quality, and project duration controls are necessary for rapidly scaling HSR network construction. Over the last decade, the People's Republic of China (PRC) has constructed, at unprecedented speed, more than 30,000 km of an 50,000 km HSR network (Figure 1a). Among several factors supporting such rapid HSR developments, effective project management during the construction stage has played an essential role (Martha, Bullock, and Liu 2019). Similarly, continuous efforts to make HSR a safe and reliable transport mode, thereby making it competitive among other modes, should be essential (Bugalia et al. 2019a). Among HSR countries, Japan boasts a record of zero passenger fatalities in more than 50 years, resulting from effective safety practices adopted by operating organizations (see Figure 1b) (Bugalia et al. 2020). Therefore, the upcoming ADBI activities focus on learning from the global HSR implementation experience and deriving evidence-based recommendations for the current and future generations of HSR policymakers, practitioners, and researchers. In this regard, an inaugural webinar was organized in partnership with Japan Railway Technical Services on 24 February 2021.[1] This discussion note summarizes the important messages and implications discussed in the webinar and identifies directions that need to be pursued. An overview of speakers and their presentations can also be found in Box 1 and on the ADBI website.

Figure 1a. Total Length of HSR Network among Major Operating Countries; Figure 1b. Instances of Fatal Accidents in Several HSR Operating Countries



HSR = high-speed rail, PRC = People's Republic of China.

Sources: Figure 2a: UIC 2020.
Figure 1b: Italy - https://edition.cnn.com/2020/02/06/europe/train-derailed-italy-intl/index.html (accessed 6 March 2021); Spain - https://english.elpais.com/elpais/2018/07/24/inenglish/1532418197_112660.html (accessed 6 March 2021); PRC - https://www.theguardian.com/world/2011/jul/25/chinese-rail-crash-cover-up-claims (accessed 6 March 2021).

[1] https://www.adb.org/news/events/adbi-japan-railway-technical-services-future-high-speed-rail (accessed 29 March 20210).

Box 1: Guests and Themes of their Remarks

- Haruhiko Kono, JARTS, Japan – HSR: A Complex System
- Ashwin Mahalingam, IIT Madras, India – Lessons from Vanguard's Megaprojects
- Werner Rothengatter, KIT, Germany – Project Management Lessons from European HSR Projects
- Masahi Umeda, JRTT, Japan – Slab Track Construction for the Japanese HSR
- Sudhir Misra, IIT Kanpur, India – Panel Moderator
- Yoshitsugu Hayashi, Chubu University, Japan – Resilience of HSR System for Catering to Various Demands
- Yoshihiro Kumamoto, JR East, Japan – Efforts for System Evolution by HSR Operators in Japan
- Anjum Parvez, NHSRCL, India – Project Management for Ongoing HSR Projects in India

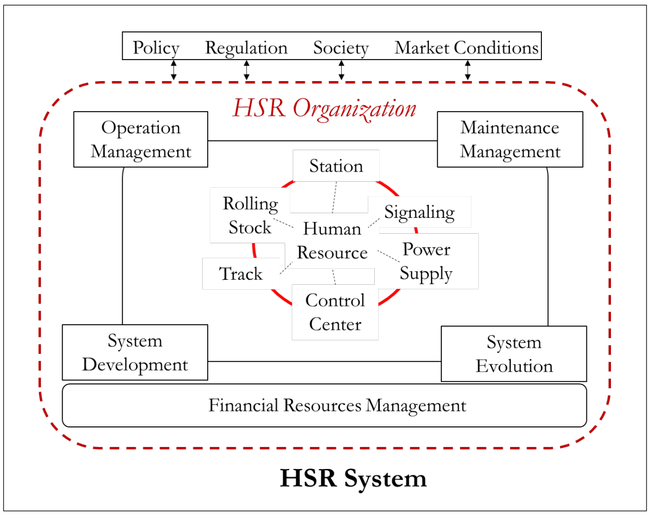
JARTS – Japan Railway Technical Service, IIT – Indian Institute of Technology, KIT – Karlsruhe Institute of Technology, JRTT - Japan Railway Construction, Transport and Technology Agency, JR East – East Japan Railway Company, NHSRCL – National High-Speed Railway Corporation Limited.

Source: Authors.

A "SYSTEM-THINKING" FRAMEWORK FOR UNDERSTANDING HSR

HSR is best understood as a complex socio-technical system (Bugalia et al. 2019a). Thus, the interactions among the system components need to be understood simultaneously, rather than focusing on individual components alone. The technical components refer to the physical systems such as the track, the rolling stock, etc. The social components refer to the human operators, the HSR organizations, stakeholders, and the regulators. While human operators and organizational decisions govern the technical components, the larger regulatory, economic, social, and political environments in turn govern organizational decisions (Bugalia et al. 2020; Kumamoto and Bugalia 2020). A schematic of the socio-technical HSR system is given in Figure 2.

Figure 2. HSR System and Interactions to be Considered for Effective Implementation



HSR = high-speed rail.
Sources: ADBI (2019); Doi (2016).

The importance of such a system-thinking framework was emphasized by the webinar panelists repeatedly for several aspects of HSR implementation. System-thinking is also visible in the several microprocesses involved in HSR implementation. For example, the construction of the slab-track involves seamless coordination between automated processes (for construction, transport, and placement of the pre-cast slab segments), human inputs (for operating the machines and supporting the process at the intersection of several intermediate steps), and management controls (for logistic management and quality control) (See Box 1) (Umeda 2021). Therefore, understanding such a system-thinking framework is essential for stakeholders looking to implement HSR projects in the future. The webinar's main messages have been summarized for various life-stages of the HSR system, i.e., system development and system operation.

EXPERIENCES FROM HSR SYSTEM DEVELOPMENT

Typical HSRs are large-scale projects, with long service lives (approximately 50 years), and are characterized by long planning phases. Benefits and drawbacks from these projects are also uncertain, due to uncontrollable factors distributed unequally among stakeholders. Given the huge investments and wide implications, political factors also heavily influence these projects, adding to their overall complexity (Rothengatter 2019).

One commonly observed characteristic about these projects is their associated cost and time overruns during construction; however, to understand them, a system-thinking perspective is necessary. One prominent school of thought points out the concept of "optimism bias" during the planning stage, or even purposeful deception by the project promoters to push for initial approval of, as one of the contributing factors for underestimating and/or underplaying the project complexity and, therefore, in its costs and duration (Flyvbjerg 2017). On the other hand, academics also theorize that, as a project's concepts mature, several stakeholders enter its ecosystem, bringing hitherto unforeseen information and potentially some changes to the project design and contributing to the cost and time overruns (Box 2). Often these factors are beyond the control of the policymakers. Therefore, a general idea for project managers/policymakers is to recognize their potential in their **plan and develop sufficient buffers to absorb at least some of them** (Mahalingam 2021a).

Box 2: Key Messages by Professor Ashwin Mahalingam

Issues with Vanguard's Megaprojects (First of Their Kind in Complexity) and Solutions

1. Cost and time overruns are common – hence, a buffer in project planning is required.
2. Conflicts are likely to occur as robust institutions are yet to be formed – intermediaries are necessary.
3. Stakeholder management is critical throughout the project and social media is a critical tool for managing stakeholders in today's world.
4. Compared to the traditional silo-ed approach, more decentralized and collaborative planning and execution project management is necessary.
5. Leadership and commitment from the project stakeholders throughout is essential.

Source: Authors.

Moreover, the experience of cost/time overruns also highlights the importance of stakeholder engagement early in the project life-stages to reduce drastic design changes later. Research is also underway on how the current digital tools, such as social media, could be effectively leveraged for stakeholder engagement and coordination. **Social media** can allow often-marginalized stakeholders to be heard and save the project from being led by only a handful of strong stakeholders (Box 2). It also allows for easy, widespread dissemination of messages surrounding the project. Therefore, social media management is essential for successfully implementing large-scale HSR projects (Ninan et al. 2019).

On the other hand, the experience from the countries with HSR also highlights the importance of establishing a clear institutional implementation framework. Institutional frameworks refer to the "rules" governing the project implementations, which could be formal, such as standards, laws, and informal, such as the country-specific preferences or norms prevalent in the stakeholders (Box 2). Availability of a **robust institutional structure** is also known to impact project implementation performance positively by helping all the necessary stakeholders understand their responsibility and systematically seeking resolution for conflicts. A clear institutional framework supporting the development of the first HSR project in Japan was essential for its rapid implementation (Straszak 1981). By the same token, the lack of such a clear institutional structure was one of the leading causes of poor implementation of the Stuttgart-Ulm HSR project in Germany (Rothengatter 2019).

The system-thinking framework also explains another essential dimension for managing large projects, i.e., Project/Risk Management. Given the complexity of the typical HSR project, not all possible futures can be estimated with reasonable accuracy. Therefore, traditional project management, which is essentially deterministic in nature, is relatively static and linear and has its limitations. In other words, in such an approach, the work is divided into several parts, each of which works in isolation to achieve its objectives. However, the large-scale HSR project's complexity demands a **dynamic and non-linear perspective on project/risk management**, enabling flexible interaction among several stakeholders to manage issues dynamically as and when they begin to unravel (Bugalia et al. 2020; Rothengatter 2019).

Box 3: Case of Stuttgart-Ulm HSR station by Professor Werner Rothengatter

Project Brief: Stuttgart21 is an underground railway station on the Stuttgart-Ulm HSR line in Germany. The project was technically complex: construction of the main underground station, and two underground stations at the airport having access link to both regional and urban public transport, occurred while the existing freight station was being replaced, with this area utilized for a land-use project. Because of this, the project also involved several important stakeholders, including the national, regional and city governments, railway and the airport operators, as well as the European Union project governances for co-financing. Beginning from its announcement in 1994, the project has long been marred by institutional conflicts resulting in huge cost overruns (EUR5.1 billion in 2009 to EUR12.3 billion now estimated) and time overruns (As of 2019, the start of operation is expected in late 2025). The main causes of such poor performance are:

1. Lack of in-depth analysis of needs, designs, cost-benefits, and alternatives in the early planning phase.
2. Lack of governance structure and allocation of responsibilities among stakeholders.
3. No risk and insufficient change management.
4. Lowest bidder selection, leading to supplementary claims and interruptions of work.
5. Conflicts, missing mediation, stakeholder participation and cooperation.

Source: Authors.

In principle, the effective planning framework, robust institutional structure, and multi-disciplinary management framework provide the necessary support to manage a project's complexities; however, these human-dominated systems also require effective leadership from the key decision-makers. Leadership can help assure the team's motivation, ensure inclusivity of and transparency towards the stakeholders, and enable trust among the stakeholders to ensure meeting project commitments (Mahalingam 2021b). Lack of such leadership can often hamper project progress when conflicts among stakeholders are not addressed expeditiously, as seen in the German HSR case (see Box 3).

EXPERIENCES FROM SYSTEM OPERATION AND SYSTEM EVOLUTION

The inaugural webinar pointed out the **HSR system's resilience** and the efforts required to achieve this during the operation stage. The industrial ecology of the first-ever HSR line globally, the Tokyo–Osaka HSR corridor (inaugurated in 1964), has changed dramatically in the last 55 years of its operation. However, the HSR has been successful in consistently offering competitive services and is still highly relevant. In 1964, approximately 46% of the industry on the Tokyo–Osaka corridor belonged to the Tertiary Sector, 42% to the Secondary sector, and 13% to the Primary sector. Even then, the Tokyo–Osaka HSR line was an immediate success in attracting passengers at a rate higher than that anticipated in the initial design stage. Now, even under the significantly different industrial ecology (1% Primary, 12% Secondary, 75% Tertiary, as per 2010 figures), the Tokyo–Osaka HSR line continues to dominate the inter-city passenger market in the corridor, with only moderate competition from other transport modes such as highways, etc. Such trends highlight the HSR system's ability to be resilient in the long term. The same is also expected to be achieved in Japan when society continues to face aging and declining populations.[2]

On the other hand, a prominent HSR operator's perspective presented in the webinar provided insights on the efforts required to achieve such a resilient HSR system. The essential strategy for the Japanese HSR operators has been to provide utmost priority to the customer's (passenger) requirements in terms of providing safe and reliable services. An increase in network length, utilizing state-of-the-art technology to improve operating speeds continuously while maintaining impeccable records on safety and service reliability are some of the significant steps taken to maintain HSR's competitiveness. Moreover, to support such advancements, a competent team of **human resources** at the operator and the organizational level is also necessary (Mukoyama and Bugalia 2020). Once again, leadership from the top management is an essential requirement to sustain the efforts for continuous system improvement (Bugalia et al. 2019a, 2019b).

HSR operations resilience has been demonstrated even in the ongoing COVID-19 situation, where systems globally are facing an unprecedented decline in passengers. Even then, HSR operators are effectively leveraging the system to recover as much as possible. For example, a few HSR operators in Japan conducted comprehensive trials to transport fresh goods using the network. The strategy, if successful, could be a first step towards the long-term overhaul of passenger-dominated HSR services to mixed passenger and freight services and adding a new dimension to revenue generation. On the other hand, considering the increasing usage of bicycles due to the pandemic, HSR operators in Germany have started to make special arrangements for allowing them on board, therefore paving a path for further integration with other transport modes. Such trends highlight that a relatively long-term commitment is required from the key stakeholders to ensure resilience; hence the need to ensure HSR operations' sustainability and integrating user-needs.

[2] Professor Hayashi's presentation at https://www.adb.org/news/events/adbi-japan-railway-technical-services-future-high-speed-rail (accessed 29 March 2021).

THE WAY FORWARD

Some of the System Development and System Operation lessons discussed in the inaugural webinar have already been incorporated into the upcoming HSR projects (See Box 4). However, for the countries planning to implement HSR, answers to the following two questions remain critical: how can the transition from the conventional railway lines to HSR lines be enabled? Moreover, how can long-term sustainability for the HSR projects be achieved? Both the questions are complex and have multiple dimensions, and can be better answered only from a system-thinking perspective.

Box 4: Experience from an Upcoming HSR Project in India

Drawing on the lessons learned from HSR implementation around the world as well as from the several mega projects in India, the Mumbai-Ahmedabad HSR implementation agency has adopted several strategies during system development. Understanding the complexity of the project-management issues, the company has started to leverage the digital project management tools, where the real-time progress information is shared transparently across decision-makers. Such tools also enable efficient approvals, etc., in a time-efficient manner. By utilizing such tools, the decision-makers are able to devote more time to planning and controlling the project rather than just gathering information to base the decision on.

Further, realizing the importance of stakeholder engagement/coordination for land acquisition, the implementation agency is committed to establishing long-term trust with the people affected in the process. Specific activities include on-time payment, high compensation rates, creation of skill-development programs for the people affected, etc. Such trust-building activities have allowed the agency to acquire land expeditiously. However, land acquisition continues to be a challenge for large infrastructure projects across the world and is an area where more context-specific solutions are needed.

Source: Authors.

It is also important that HSR planning and implementation is done within a broader framework of sustainability. Needless to say that the variety of sustainability aspects thus discussed could also seem to put contradictory demands for the system, and how efficiently the trade-offs among these systems be managed should also be understood to adopt the HSR to the country-specific context. A more specific but not exhaustive list of questions that still need to be addressed is given below.

Technology (Development, Operation, and Maintenance)

1. How different is the HSR technical system compared to the conventional railway system, and what technical advancements need to be transitioned to the HSR system?

2. What are the most effective strategies for transferring the know-how when importing a technical system such as HSR?

3. For the HSR recipient countries, how should the technical standards and regulations be set considering the long-term (self-reliant development) and short-term implications (successful project implementation)?

Human Resources

4. How are training requirements different for an HSR system compared to a conventional railway system?

5. What factors affect the sustainability of organizational knowledge and Human-resource training in an organization, and what are the best strategies to achieve so?

Organization

6. What are the characteristics, in terms of interaction with technology and human resources, for organizations successful in constructing and operating HSR projects?

7. How do the regulatory and socio-economic environments of a country affect the HSR organization's performance?

Regulation

8. How should the regulatory and institutional factors evolve to manage the modern-day complex HSR systems successfully?

9. How should HSR projects' impacts be evaluated across different domains, such as the impact on industry ecology, land use, employment, and education, among others?

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