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Policies and governance for faster and more attractive rail transportation

Examples from China, India and Japan

Fast trains are slowly but steadily becoming an increasingly popular solution to many of the challenges in the transport sector today. In the countries studied in this report – China, India and Japan – rail transportation is a policy area of great priority. With Japan and China already being world leaders in high-speed rail (HSR) implementation, India is still in its infancy. Their goal is however the same: mass transport of people and goods – further, faster and more sustainably.

growth analysis

Forum för innovation
inom transportsektorn

The Swedish Agency for Growth Policy Analysis has been commissioned by the Forum for Innovation in the Transport Sector (Forum) to conduct three studies of policies in other countries to find pathways to these solutions. Forum is a network of public and private players in the transport sector in Sweden and its most important objective is to develop common national strategies for research and innovation – strategies that will increase the competitiveness of Swedish enterprise, make transportation more efficient and reduce the sector's environmental impact, for example from carbon dioxide emissions. Read more at https://transportinnovation.se/

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Förord

Transporter av personer och gods utgör blodomloppen i den globala ekonomin och har de senaste årtiondena blivit allt viktigare, smartare och mer effektiva. Baksidan med denna utveckling är den huvudsakligen fossila energianvändningen och de växthusgasutsläpp som transporterna ger upphov till. Farliga partiklar, trängsel och buller är andra problem som dagens transportsystem förknippas med. Hållbara transportlösningar är således en prioriterad fråga, i Sverige liksom runt om i världen.

Tillväxtanalys har fått i uppdrag av Forum för innovation inom transportsektorn (Forum) att genomföra tre studier av politik i andra länder för att hitta vägar till dessa lösningar. De områden som studierna fokuserar på är: Elektrifiering av fordonsflottan (Indien, Japan, Kina och Sydkorea), Snabba och attraktiva tågtransporter (Indien, Japan och Kina) samt Alternativa bränslen (Brasilien och USA). Utgångspunkten för urvalet har varit de länder som Tillväxtanalys bevakar samt områden där det bedömts finnas intressanta lärdomar att dra för Forum i arbetet med att utveckla den svenska tranportpolitiken.

Denna rapport fokuserar på politik för snabbare och mer attraktiva tåg i Indien, Japan och Kina.

Några av de observationer som görs i rapporten är:

- Snabbare och mer attraktiva tågtransporter är ett allt mer prioriterat politiskt område i de tre studerande länderna, även om mognadsgraden varierar. Japan och Kina är världsledande medan Indien fortfarande är i startgroparna.
- Ambitionen är att förbättra transportsystemets effektivitet generellt genom att bygga bort flaskhalsar och flytta över persontrafik från de traditionella tågnätverken till snabbare och mer attraktiva alternativ. I Japan vill man också se en överflyttning från flyg till tåg, vilket inte uttalat är fallet i Kina och Indien.
- Stigande kostnader är en av huvudutmaningarna och nya finansieringsmodeller utforskas intensivt, där privata aktörer tar en allt mer framträdande roll. Fortfarande dominerar dock de statliga aktörerna, i synnerhet i Kina.

Rapporten har författats av Izumi Tanaka (Japan, koordinator), Rajeev Palakshappa (Indien) och Johanna Bark (Kina).

Martin Flack vid Tillväxtanalys kontor i Stockholm har varit projektledare.

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Stockholm, mars 2013

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Sammanfattning

Snabbtåg är på väg att bli en allt populärare lösning på många av de problem som dagens transportsektor brottas med. Utvecklingen startade i Japan på 1960-talet, men sedan dess har de flesta utvecklade ekonomier gjort stora investeringar i liknande järnvägsnät för höghastighetståg. Tempot har skruvats upp ytterligare under de senaste decennierna när Kina, Sydkorea och andra klivit in som utmanare på den globala marknaden. Såväl tekniska innovationer som förändrade institutionella förutsättningar, affärsmodeller och finansieringsmetoder har gjort detta möjligt.

I en färsk rapport från Trafikanalys[1] identifierar man tio globala trender inom sektorn för höghastighetsjärnväg, däribland:

- Höga hastigheter är inte det enda viktiga målet – det finns motstridiga trender
- Ökad kapacitet är viktigare än trafikomställning
- Det blir allt dyrare att bygga höghastighetsjärnväg, men ny teknik kan ändra detta
- Marknaden börjar bli mättad
- Utbyggnaden av höghastighetsjärnväg fortsätter trots finanskrisen
- Förutsättningarna för utvecklingen av system med höghastighetståg blir allt mer komplexa
- Tekniken håller på att globaliseras – fler aktörer på marknaden

Den rapport som sammanfattas här utgår från dessa observationer och försöker ge mer detaljerade svar på varför och hur utvecklingen av systemen för höghastighetståg har sett ut i Kina och Japan. Den försöker också visa på vilka viktiga faktorer som formar framtiden för snabbtågsutvecklingen i dessa två ledande länder samt i Indien, där utvecklingen fortfarande är i sin linda men där de höga ambitionerna kan göra landet till en betydelsefull aktör. Syftet är att belysa utmaningarna och framgångfaktorerna i den komplexa processen som det innebär att implementera och driva en höghastighetsjärnväg, med fokus på den politiska hanteringen av innovation och teknikutveckling.

Drivkrafter, visioner och mål

Historiskt sett, och än mer idag, har transportmöjligheterna för människor och gods varit en viktig faktor för ekonomisk tillväxt. Gränserna för att kunna genomföra snabbare och längre transporter utmanas ständigt. För både Japan och Kina har sammanlänkandet av större städer och ökad rörlighet hos befolkningen för att vitalisera ekonomin utgjort starka drivkrafter för att skapa ett omfattande nätverk av höghastighetsjärnväg. I Kina betraktas transportsektorns flaskhalsar som ett av de större hoten mot fortsatt ekonomisk tillväxt, och ett utbyggt järnvägsnät och snabbare tåg ses som en viktig del av lösningen. Även i Indien fokuserar man på tågtransporter, även om det enorma och relativt fattiga landet ännu har en bra bit kvar när det gäller höghastighetsjärnväg.

I Japan ska det befintliga nätet av shinkansenbanorna byggas ut och de sista installationerna planeras till mitten av 2020. I januari 2004 godkände Kinas regering planen för järnvägsutvecklingen på medellång och lång sikt, vilken innebär att 25 000 km höghastighets-

[1] *Trafikanalys rapport 2012:10, Höghastighetsjärnväg, en global utblick.*

järnväg år 2020 ska genomkorsa landet i fyra horisontella och vertikala korridorer. Även om Indien fortfarande befinner sig i startgroparna när det gäller snabbtåg, har landet som mål att bygga ut järnvägsnätet till ca 4 000 km under de kommande åren.

En ytterligare drivande faktor är höghastighetsjärnvägens betydelse för den nationella prestigen, något som varit mest märkbart inför internationella evenemang som OS och världsutställningar. I både Kina och Japan har detta varit mycket tydliga anledningar till tunga investeringar i höghastighetsjärnväg.

Utveckling och framsteg

Både Kina och Japan har kunnat bygga ut järnvägsnätet snabbt, och hittills med få tillbud. Kina har hunnit mer på kortare tid, vilket sannolikt hänger samman med regeringens starka engagemang. Kina har också den stora fördelen att genom överföring av teknik och kunskap från andra länder, såsom Japan och Frankrike, kunna ta snabba tekniksprång. Takten på implementering och för forskning och utveckling varit anmärkningsvärd, och politiken som gynnat tekniköverföring från innovationsledande aktörer har varit framgångsrik. Vad som kommer att hända i framtiden nu när Kina kommit ikapp är oklart, och inom Kina finns viss oro för att innovationstempot inte är tillräckligt högt för att man ska kunna hålla jämna steg med konkurrenterna.

För Japan är kostnaden det dominerande problemet i framtiden. Med en krympande befolkning tävlar höghastighetsjärnvägen hela tiden med andra transportlösningar, och att locka passagerare är en viktig faktor för ytterligare utveckling. De demografiska förutsättningarna bidrar också till höjda exportambitioner. Japans industri för höghastighetsjärnväg har drabbats av den ökande konkurrensen (inte enbart från Kina) och ligger avgjort på den högre prisskalan, vilket är en nackdel i detta sammanhang.

Ett unikt projekt har dock nyligen påbörjats i Japan. En privat finansierad maglevbana som sammanlänkar Tokyo och Osaka är tänkt att stå delvis klar 2027 och vara helt färdigställd 2045. Ambitionen är inte bara att förkorta restiden utan också att den nya linjen ska fungera som en extra pulsåder mellan landets två ekonomiska centrum, Tokyo och Hokkaido.

Sammanfattning av drivkrafter och hinder

Masstransport av människor och gods – längre, snabbare och mer hållbart – är det gemensamma målet för implementeringen av höghastighetsjärnväg i alla länder som studerats. Eftersom höghastighetsjärnvägen består av många tekniska element är förstås intresset stort när det gäller att gynna den inhemska industrin i både Kina och Japan. Regeringarna har en central roll som initiativtagare för design och planering av nät för höghastighetsjärnväg, men deras inblandning i finansiering, beslutsfattande och drift varierar stort mellan länderna. Den kinesiska regeringen har fortfarandet det dominerande inflytandet över järnvägsdriften, medan den japanska regeringens inflytande har minskat över tiden.

Vilka hinder finns det för fortsatt utveckling och expansion av snabba tåg? Kostnaderna kommer att vara ett hinder för expansion inom landet, och finansieringsplanen för de nya shinakansenlinjerna i Japan kommer att kräva insatser från både nationella och lokala myndigheter, dvs. skattebetalarnas pengar. På grund av detta kommer sannolikt legitimiteten för vissa av de nya linjerna att ifrågasättas. När det gäller export kanske Japans långa erfarenhet av att driva ett säkert och effektivt system inte räcker till i den globala konkurrensen. Å andra sidan kan en framgångsrik introduktion av maglevbanor medföra en betydande konkurrensfördel på längre sikt.

Kina måste fortsätta öka säkerhetsmedvetandet, både för att övertyga den inhemska opinionen och potentiella köpare utomlands. Höghastighetsjärnväg handlar om mer än snabba tåg, och olyckorna under senare år är en möjlighet för Kina att slå av på utvecklingstakten för höghastighetsjärnväg och fokusera på systemintegration och institutionella reformer. Om Kina kan återställa förtroendet för säkerhetsfrågorna kan landet bli ledande på exportmarknaden för teknik för höghastighetsjärnväg.

Summary

Fast trains are slowly but steadily becoming an increasingly popular solution to many of the challenges in the transport sector today. The development started in Japan in the 1960s but since then most advanced economies have invested heavily in rolling out similar networks of trains capable of travelling at higher speeds. The pace has accelerated in recent decades with the entry of China, South Korea and other contenders on the global market. Innovations in technologies as well as in institutional settings, business models and modes of financing have made this possible.

In a recent report from Trafikanalys[2], ten global trends in the High Speed Rail (HSR) sector have been identified, for example:

- The highest speeds are not the only important goal – conflicting trends exist
- Increased capacity is more important than modal shift
- Building High Speed Rail is becoming more expensive – but new technologies may shift the trend
- Markets are becoming saturated
- Expansion of High Speed Rail is continuing, despite the financial crisis
- The characteristics of the development of High Speed Rail systems are becoming more complex
- Technology is being globalised – more actors are present

The report summarised here us based on these observations and tries to give more detailed answers to the questions of why and how fast train systems have developed in China and Japan. It also tries to show important factors shaping the future of the fast train development in these two leading countries, as well as in India, which is still in its infancy but has great ambitions and might become an increasingly important player. The purpose is to illustrate the challenges and success factors in the complex process of establishing and operating a high speed rail system, focusing on policies for and governance of innovation and technological development.

Drivers, visions and specific targets

Historically, and even more so today, the mobility of passengers and goods has been a vital aspect of economic growth and doing so faster and over longer distances are aspects constantly being contested. For both Japan and China, connecting their major cities and increasing the mobility of their populations to vitalize business have been strong drivers to establish an extensive network of HSR. In China, the transport bottle-necks are today viewed as one of the major threats to continued economic growth – an expanded rail network and faster trains are seen as an important part of the solution. Also in India, rail transportation is very much in focus even though the huge, relatively poor country has yet to get off the ground when it comes to HSR.

[2] *Trafikanalys rapport 2012:10, Höghastighetsjärnväg, en global utblick.*

Connecting major cities and then connecting smaller or less accessible cities that are currently accessible by air are intended to be realized by means of HSR. In Japan, in addition to its already existing Shinkansen lines, the network is to be extended with the last installation due in the mid-2020s. In January 2004, the State Council of China approved the mid- and long-term railway development plan, including the ambitious HSR strategy of a railway network of four vertical and horizontal corridors throughout the country by 2020 consisting of 25,000 kilometres of dedicated HSR. Again, India's endeavour to introduce high-speed trains is still in its initial stages but the goal is to extend the network to approximately 4,000 kilometres over the coming years.

A driver that is not to be forgotten is the value of HSR in terms of national prestige, most clearly visible before international events such as the Olympic Games or the Expo. In both China and Japan this has been a very obvious reason to invest heavily in HSR.

Development and Progress

Both China and Japan have been able to roll out their networks rapidly and so far with few incidents along the way. China has done it in a much shorter time, which likely has much to do with the strong commitment from the government. China has also had the important advantage of leap-frogging countries like Japan. In any case, the speed of implementation and R&D has been remarkable and policies to benefit from tech-transfer from innovation leaders have been successful. What will happen in the future, now that China has caught up, is a different matter and there are great concerns also within China that the speed of innovation will not be high enough to keep up with its competitors.

For Japan, the cost issue will be of paramount concern in the future. With a decreasing population, HSR is in constant competition with surface and airborne transport and attracting ridership is an important issue for further development. This demographic characteristic has also called for high ambition for exports. Japan's HSR industry has suffered from gradually increasing competition (not only from China) and is definitely at the higher end of the price range, which is a challenge when competing in the global market.

A unique development has recently been initiated in Japan; a privately funded maglev line connecting Tokyo and Osaka will partially open in 2027 and be completed by 2045. The ambition is not only to shorten the travelling time but also to have the new, dedicated maglev line serve as a second artery between the country's two economic centres, Tokyo and Hokkaido.

Summary of conclusions concerning drivers and barriers

Mass transport of people and goods – further, faster and more sustainably - is the common goal for initiating implementation of HSR in all the countries studied. As HSR consists of many elements in one system, including manufactured products, the motivation to nurture domestic industry is evident in both China and Japan, though the same cannot yet be said of India. Government plays a central role as an initiator of the design and plan of the HSR network, however the extent of current involvement such as in finance, decision-making and operation differs greatly between the countries. The Chinese government still has the dominating power over railway operation while the Japanese government's involvement has decreased over time.

What is hindering the further development and expansion of the system? Cost will be a barrier to domestic expansion and the financing scheme for Japan's New Shinkansen lines will involve finance from both national and local governments, i.e. taxpayers' money, and

the legitimacy of some of the new lines will always be contested. Regarding export, long experience of running a safe, efficient system may fall short in the global cost competition. Additionally, successful introduction of a maglev line will bring unprecedented competitive advantage.

China needs to continue improving safety awareness, both to convince the domestic constituency and potential buyers abroad. There is much more than a fast train fleet technology in a high speed train system and the accidents in recent years were rather a good opportunity for China to slow down its high speed development of HSR and focus on system integration and institutional reform. If it can regain its trust in safety, China could continue to be one of the technology and export leaders in HSR.

1 China

1.1 Introduction

The world's biggest and most rapid growing HSR network has been built with strong political support of China's central government. This and the extraordinary role of the Ministry of Railways (MOR) constitute the main features of the ambitious HSR project. The support stems from a political ambition to reduce the infrastructural bottlenecks and to connect the country in a more efficient way.

The MOR's role is unique in its control over the whole process from import, digestion, and secondary innovation to frontier research in major parts of the HSR project in China. This has affected the formation of the market and the government created industry-driven research. The lack of pluralistic inputs could be one of the reasons why the best technology may not always be chosen.

A crash in 2011 that killed more than 40 people together with the corruption stamp of the MOR has forced the ministry to change the methods of regulation. The ministry's trustworthiness is not only important to avoid public unrest in safety issues; it is also important in the sense of debt repayment. The HSR project has in large parts been financed through debt issuance by the MOR and the ministry is facing a large debt repayment. In other words, the MOR also has to secure the value of its bonds.

The project has proven to be more expensive than expected and despite the financial support of the government doubts have been raised about the project's feasibility.

Much of the project is based on transfer of foreign technology. However, achieving indigenous HSR technology has been a major goal of Chinese state planners. The HSR project has specifically been chosen to be a symbol for the national technology development in China, both domestically but also globally in order to improve the image of China. It is therefore of politically importance that the project has the stamp of "Made in China".

Chinese HSR constructors have been able to achieve a considerable degree of self-sufficiency. They have developed indigenous capabilities to produce key parts that are adapted to the Chinese context and have also improved foreign components and design. Many would argue that China has leapfrogged other countries when digesting and improving foreign technology in high-speed rail.

Even though railways in China have made significant progress in recent years, they are still unable to meet the increasing demand for passenger and freight transport. High economic growth rates and increasing urbanization are two major causes of increased transport demand. 60% of the rural population is expected to move to urban areas by 2020.[3]

Furthermore, China's economy depends heavily upon coal and coke, metal ores, iron and steel, petroleum products, grain, fertilizers and other bulk products that have to be transported from inland China to factories and ports around the country, mainly by rail.[4] The current railway system is not able to keep up with the growth in scale and complexity of this vast production system.

[3] *Asian Development Bank, Technical Assistance, People´s Republic of China: Railway Passenger and Freight Policy Reform Study, 2005*
[4] *Ibid.*

1.2 Why fast trains? Drivers, ambitions and targets

To meet the infrastructural challenge and to solve the bottlenecks, China has embarked upon the world's biggest railway construction programme since the nineteenth century. In January 2004, the State Council approved the mid- and long-term railway development plan, including the ambitious HSR strategy. According to this strategy the railway network will by 2020 consist of four vertical and horizontal corridors throughout the country – in total 25,000 kilometres of dedicated high-speed rail with trains reaching a speed of 350 km/h. The network will connect all major cities in China and many smaller cities on the way.

Figure 1-1 Completed (red) and planned (dotted) lines

Source: Ministry of Railways

The Chinese High Speed Rail (HSR) network aims to relieve the old rails of passenger traffic and make room for goods transportation on the old tracks. The State Council has specifically pointed out that high-speed trains would help China to face the challenges for infrastructural bottlenecks in transportation in order for China to maintain its rapid development. Another reason is of course that a national fast train network would make it easier for the government to have overall control of the transport system.

The HSR project is also an example of how the Chinese government supports specific industries to show both its own citizens and other countries that China can produce more than just McDonald toys and sweatshirts, thus improving China's image as a high-tech nation.

The HSR has been identified as one of the Strategic Future Markets. HSR technology has therefore been heavily invested in by different state actors, with the explicit ambition to

"leap frog" to the global technological frontier by adopting best practice. The ultimate goal is to lead the innovation race in this sector and to export to other countries what was previously imported.

With the rapid growth of HSR in China, domestic companies have in fact emerged to challenge global multinationals. Having started either by serving the domestic market or exporting low-cost items overseas, they are now trading up and starting to compete in the higher end of the global marketplaces.

The ambitious plans need strong financial support and in 2004, total investments were estimated to be 7 trillion RMB through 2020 (in 2004 prices). This has since then been revised upwards partly due to unexpectedly high costs, but also because new resources were channelled to the HSR project through the economic stimulus programme adopted by the government in 2008. The latest projections indicate that the total investments will reach almost 19 trillion RMB (1 RMB ≈ 1 SEK) by 2020.[5]

China's railway policy makers thus face two distinct strategic challenges in order to fulfil these goals and develop a working and efficient HSR network. The first is to increase infrastructure capacity and quality. The second is to reform the railway industry into a more market-oriented industry in order to both increase the rate of innovation and curb the rapidly increasing costs. To tackle these challenges, an extensive portfolio of different policies has been put in place, which is described in this report. But first, the next section gives an overview of the different actors involved in implementing the government policies.

1.3 Main actors in the HSR-sector

Despite its rapid economic reforms, China still maintains in large a centralized, authoritarian political system where the central government makes most of the critical decisions. Consequently, China's HSR expansion is entirely managed, planned and financed by the government. It is, however, important to note that this does not mean that there is a unified and fully consolidated set of actors working towards the same goals. There are many different interests and partially diverging agendas at different levels of the administration.

The National Development and Reform Commission (NDRC) who is very powerful in shaping the general political framework in China, has set out policy principles to be adopted in the railway industry;

- Separate government administration from enterprise management.
- Introduce competition where suitable.
- Regulate industry more effectively.

The principles have been introduced as a prerequisite for sustainable construction and maintenance of the Chinese HSR network.

The ministry assigned to implement the HSR plan is the Ministry of Railways (MOR). It is a powerful ministry that lacks transparency and also has a stamp of corruption. The MOR is strongly advised to implement the principles above in order to eliminate its corruption stamp and to achieve the ambitions and targets in the HSR project. However, the MOR will set the timing for these measures; for now, the MOR has prioritised infrastructure and service development over delegation and separation of power in the railway industry. In

[5] *Powell, Bill, China´s amazing new bullet train, CNN Money, Beijing, 2009*

other words, the ministry still governs the railway and market-oriented competition is only small-scale.

Beyond the NDRC and the Ministry of Railways (MOR), China Rail - with its 18 Regional Railway Bureaus – is a third central player in the HSR innovation system. Apart from these three, the state-owned enterprises, foreign companies and the domestic research institutes are of major importance. These actors are described in some detail in the following sections.

1.3.1 Ministry of Railways (MOR)

China's railway industry was initially developed during the Qing dynasty in the 19th century. But it was not until the Communists came to power in 1949 that railway construction took off. The main aim of railway construction was to secure national territory and thus foster a strong spirit of self-sustainment and military-style management and culture within the industry.[6] This has resulted in a lack of transparency and is probably a reason why the MOR has a reputation of being one of the most corrupt ministries in China.[7]

The ministry currently rules the world's second largest rail network system and employs more than two million members of staff. The MOR is responsible for the department of national railway affairs and implements the centralized traffic control system over the state railway network. It also guides, coordinates and supervises the local and industrial railways as well as the private railway sidings. It may be worth mentioning that the government, including the MOR, has long recognized that railways must develop a market-oriented approach to railway construction, become competitive with ever-improving road and air transport, and adopt commercial management principles.[8] This has proven to be a great challenge and is little more than a vision for the moment.

Today the MOR has overall control of policy, technical standards, planning and investment, finance, and system-wide train and rolling stock dispatching. Foreign actors need to be in a joint venture to enter the railway market and state owned enterprises (SOE) are the major active companies. In other words, the MOR controls entry to the playing field, sets the rules, referees the game and manages the opposing team.

1.3.2 Regional Railway Bureaus (China Rail)

The Regional Railway Bureaus (RRB) are responsible for daily management and delivery of railway infrastructure and rail transport services. It is also their research institutes that handle the specific local HSR rail technology research and also promotes its own technology.

While the regional bureaus have been given more commercial freedom in ancillary activities and therefore been delegated research competences. The MOR still closely monitors their core function. Since the MOR has formal responsibility for governance of the 18 RRBs, the RRBs have no board of directors or other external supervisory bodies and each RRB has a railway head who reports to the MOR. The organization of all the RRBs has a similar structure and tends to mirror the functional classification that exists at the Ministry level.

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[6] *Chi, Cheryl & Javernick-Will, "Institutional effects on project arrangement: High Speed Rail in China and Taiwan", Stanford, 2010*

[7] *"China Railway Market Study", OSEC Business Network, Zürich, 2011*

[8] *China Daily (2012) China´s railway bidding opens to local markets, China Daily.cn [Web Page] URL http://www.chinadaily.com.cn/business/2012-05/21/content_15347247.htm*

1.3.3 State Owned Enterprises (SOE)

The Chinese state-owned companies completely dominate the HSR industry, especially the train construction and after-sales services. Subsidiaries to the biggest Chinese train manufacturers, the China South Locomotive & Rolling Stock Corporation (CSR) and the China North Locomotive and Rolling Stock Industry Corporation (CNR) are the main actors. The CSR and the CNR were formerly the same company but have since 2008 been separated from each other to create more competition in the industry.

The big railway groups of Chinese train producers are now under the direct supervision of the State-Owned Assets Supervision and Administration Commission (SASAC) of the State Council, which is a special commission directly under the State Council. SASAC is responsible for managing the SOEs, including appointing executives and approving any mergers or sales of stock or assets. This means that the performances of these state-owned railway groups are strictly measured by the state, and the government has created competition between them as well.

1.3.4 Research Institutes

The fact that the Chinese HSR network is built "from scratch" implies that an organic platform of research networks did not exist before the political decisions to establish an HSR network were taken in the early 1990s. However, through the efforts of the MOR a national platform for HSR technology was quickly created. The research and development of high-speed railway relies on major engineering projects, integrated innovation and re-innovation by combining digestion and absorption of foreign experience.

In order to face these technological challenges the MOR needed to break down administrative and bureaucratic barriers between departments, industries, academics and SOEs to integrate it into an overall national technology platform. The overall national strategy had the aim to serve the country as a whole, which is why local rail research institutes were established. Local research institutes and departments were also established under geographically relevant SOEs (train research) and RRBs (rail research) to serve the specific conditions for the region.[9]

1.3.5 Foreign Actors

Non-Chinese actors have to be in a joint venture (JV) with a Chinese firm to enter the Chinese railway market. Additionally, the expansion of the HSR has mostly been carried out through government procurement. This section was never sorted out when China entered the WTO, which made it easier to discriminate against foreign actors without concessions. The Chinese hegemony has not hindered some big multinationals from entering the Chinese HSR market even if they had to do it on their terms. Multinationals such as ABB and Bombardier have both won JV contracts for signalling and monitoring systems. The foreign collaboration with international multinationals and their technology transfer to China will be discussed in more detail in chapter 2.

1.3.6 Summary - HSR actor relationships

Due to the intensive and deliberate actions taken by the central government in Beijing, the Chinese HSR market has developed from a "nursing" to a "bridging" market, which means that it is new but is beginning to develop more rigid characteristics.

[9] *CSR (2012) CSR Homepage, People´s Daily: China is Entering a High-speed Railway Era. [Web Page]*

Figure 1-2 below describes the relationships between the different actors further. One can note again that private participation is limited in China, as is foreign participation. Foreign actors have been less in direct contact with the key government parties, less involved in decision-making, and have been contracted to transfer technology to Chinese parties who would, in the future, replace them.

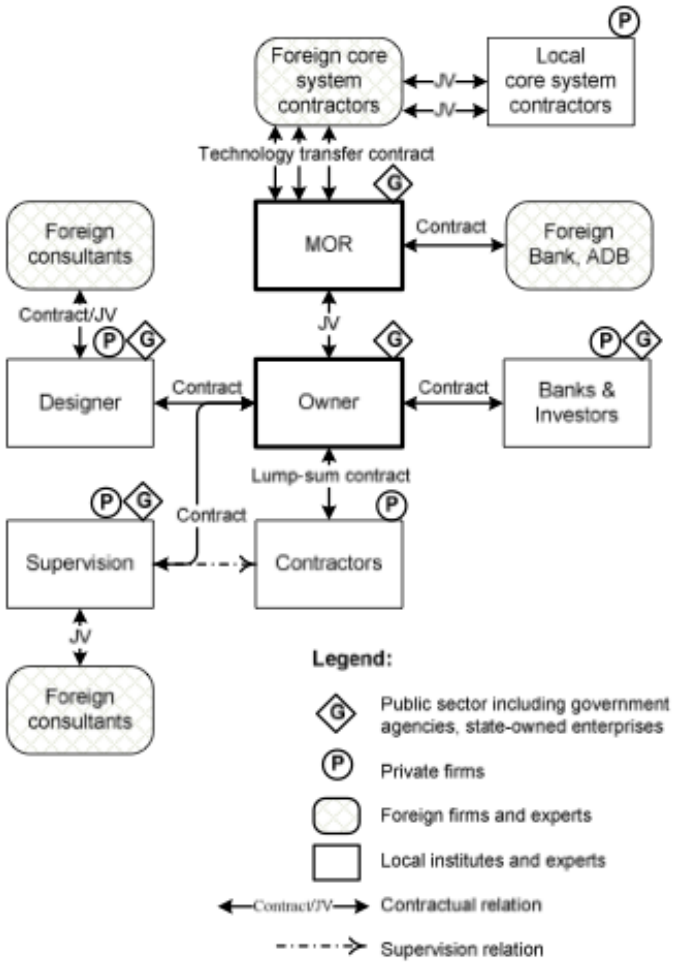

Figure 1-2 Project Arrangements HSR

Source: Chi & Will (2010)

In section 1.4 these actors, and the innovation processes they take part in, will be presented using a Technology Innovation System[10] framework. The key functions in the system will be described in order to identify the main drivers and challenges to HSR development in China, historically and in the future.

1.4 Functional Analysis of the High Speed Rail Innovation System

When China first decided to develop a high-speed rail network, the original idea was to develop domestic technology to reach world-class standard. But the Chinese attempts to

[10] *This framework is largely influenced by Bergek et al. (2008) Analyzing the functional dynamics of technological innovation systems: A scheme of analysis, 2008, Research Policy, (37), 3, 407-429.*

create functioning HSR components failed. Much of the fundamental apparatus therefore needed to be imported. One can say that China's HSR network has mainly been built upon imported components and technology transfer of various kinds. Despite this intense import, the ambition to base the HSR on Chinese technology continued, which led China to pursue strategies of technology transfer through the "introduction-absorption-digestion-innovation" policy. This means that Chinese engineers improved and adapted the imported technology to a Chinese context. Some (mainly non-Chinese) would argue that it is just another way of copying foreign technology, while others (especially the Chinese) argue that they actually has digested it into China-specific technology.

1.4.1 Knowledge development

The HSR network project has been implemented in stages. First, China mobilized government officials, scientists, and experts in a nation-wide discussion about the feasibility, benefits and costs of high-speed rail technologies.[11] At the same time, it invested heavily in R&D of these technologies to develop in-country expertise and capability. In 2000, with the help of the government, technology imports of key components and support to construct a Chinese train were coordinated. This train, also called the Blue Arrow, could reach a speed of 200 km/h and entered into operation for commercial purposes shortly after.

In 2001, based on the experience of the Blue Arrow, the MOR began to form a development team (various companies, research institutes and universities) for a faster and more sophisticated train, with a speed of 270 km/h. However, indigenous development did not have the stability to satisfy the requirements of commercial operation. This shortcoming affected China's desire for self-sufficiency and led the country to open the railway sector to foreign participation.[12]

Foreign companies' entry to the Chinese market was still restricted and these constraints were relaxed only when the country lacked indigenous technology and capital in specific areas. This opening led China to pursue strategies of technology transfer with a policy of "introduction-absorption-digestion-innovation". Despite this external technology transfer, China still kept foreign project participants at arm's length and built up its own domestic research resources. This will be discussed in greater detail in the next section.

Import - Technology Transfers

As described in chapter one, the Chinese HSR industry is dominated by large state-controlled enterprises that have over 60 years of experience of railway construction. They had earlier overcome the geographical and geological challenges without any involvement of foreign actors. However, these large state-controlled enterprises were less successful in the most sophisticated parts of HSR and its core systems, including rolling stock, signalling, communication and electrification. In these technology sectors, China has been forced to rely heavily on foreign technology transfer.

The MOR's strong position, described above, enabled it to act as a business group and collectively bargain with foreign partners for technology. In this way, the Chinese government enjoyed superior bargaining power towards Siemens and other foreign companies to transfer their technology to China. It can be described as the MOR using a unique strategy to structure its core system deal: The MOR's state-owned enterprises represented 38

[11] *Chi, Cheryl S.F. and Javernick-Will, Amy. (2010) "Institutional effects on project arrangement: High-speed rail projects in China and Taiwan"*
[12] *Ibid.*

local train manufacturers in negotiations for 280 train-sets used in multiple projects in 2004 and 2005 with four international manufacturers: France's Alstom, Canada's Bombardier, Japan's Kawasaki, and Germany's Siemens. All of the four firms eventually agreed to meet China's three criteria: (i) transfer of the latest technology, (ii) joint design and production, and (iii) use of local brand names.

After the agreements, problems began to arise when Chinese engineers tried to adapt to the Chinese context. The first problem was to adjust foreign technology to fit China's bedding.[13] Take the rail roadbed for example. As China consists of an enormous territory with different geological regions, it is necessary to acquire the technology to handle and fill roadbeds in order to build high-speed track under such complicated geological conditions. However, the home countries of origin of the high-speed rail technology (Japan, France and Germany) did not have such complicated geological conditions during their technological development.[14] Hence, in the actual building of high-speed rail, each subsystem in high-speed rail became imperfect and needed further improvement.

Indigenous Innovation

The special geological conditions forced China to develop the technology further and to adapt it to the Chinese context. In short, the imported high-speed trains were found to be inappropriate for China's geographical conditions and have encountered many problems during their operation. For example, because of the cold weather in northeast China, electrified lines and wires would become covered in frost, prohibiting the railway's operation. As the technology needs a great deal of local knowledge for its operation in China, Chinese industry and academia were pushed to coordinate and develop local knowledge. As a result, Chinese indigenous innovation created a cold-proof HSR network running from Harbin and Dalian in the north-eastern part of China. The 921-km route, with 24 stops, is the first high-speed, high altitude rail line, and has been designed to withstand extremely cold temperatures. The Shenyang Railway Bureau put the line into operation in December 2012. The train maker, which is a subsidiary to China's major train maker, CNR, developed the cold-proof train and said that their team had solved the problem Eurostar trains once encountered, which is a major challenge for developing cold-poof trains.

Alongside China's geographical conditions, HSR construction is also a special area of future expansion pointed out by NDRC. The current five-year plan (2011-2015) specifically mentions seven "Strategic Emerging Industries", of which advanced construction is one, including HSR components. This means that the desired expansion and advancement will include massive R&D investments, and through them, the intention is that China will rapidly leapfrog to the global forefront of science and technology. In order to concretely achieve this a large number of plans and policies for S&T have been implemented.

Today the HSR project has brought together the S&T resources of 6 central enterprises, 25 universities, 11 research institutes, 51 national key laboratories and the State Engineering Research Centre. This scientific research team consists of a great many academics and professors, as well as thousands of S&T personnel.

With the help of imported technology and structural and coherent centralized management by the MOR, the coordination of HSR research has guided the innovation structure in this

[13] *Salzberg et al. (2013)"High-Speed Rail, Regional Economics, and Urban Development in China", World Bank Office, Beijing*
[14] *Ibid.*

ambitious network. The financial and political support of the central government has also helped the project to be coherent and unified.[15]

1.4.2 Influence on the direction of research

Despite heavy investment in foreign technology, the MOR kept external actors largely out of the process of influencing the market and its research direction. This can be exemplified by how foreign companies previously had a 70% market share but after the intensive technology transfer, their share fell to 15-20%.[16]

In order to apply and digest high-speed rail and train technology, the government forced local manufacturing companies (subsidiaries to CSR and CNR) to carry out research in their specific area behind high-speed rail technology. The MOR ordered a large number of research institutes to take part in basic research in the field of high-speed trains.[17] The final beneficiary of this locally driven basic train research is the domestic manufacturing companies.

Additionally, to improve the efficiency of localisation, the MOR adopted the method of gradually reducing the purchase price of high-speed trains from local companies and thus forced the companies to reduce imports of components. The specific method was as follows; when the MOR first purchased a Chinese high-speed train from the CSR, the price was 230 million RMB; the second time the price had been reduced to 160 million RMB and finally 135 million RMB at the third purchase. The localisation efficiency policy of MOR forced the factories to find domestic providers, who were finally able to deliver such new products.

1.4.3 Resource mobilization

The Chinese HSR project has essentially been funded through loans and debt issuance, as well as collaboration agreements.[18] State-owned banks and other financial institutions have shared the financing of the HSR project. The MOR has mainly contributed through debt issuance, and regional and local governments usually through the ceding of land.

Figure 1-3 below illustrates the overall financing structure. It also explains how the China National Railway Group (CNRG), on behalf of the MOR, takes control of the railway financing process for individual HSR line development. The second key element in this structure are the so-called 'financing arms', They include the China Railway Investment Co. (CRIC), which is a subsidiary of the MOR, and similar subsidiaries under the provincial government. One important function of these organizations is to issue bonds or borrow money from commercial banks and other funders of railway development, because China's Budget Law prohibits governments from doing so directly.[19]

[15] *CSR (2012) CSR Homepage, People´s Daily: China is Entering a High-speed Railway Era. [Web Page]*
[16] *Salzberg et al (2013)"High-Speed Rail, Regional Economics, and Urban Development in China", World Bank Office, Beijing*
[17] *Lui, Cheng, Chen, (2011) "Basic Research and catch-up in China´s high-speed rail industry" School of Management, Beijing*
[18] *Albate, Daniel & Beligerman. (2012) "The economics and politics of high speed rail: lessons from experiences aboard" Lexiton Books, Plymouth*
[19] *Wang, et.al (2012) "The funding of hierarchical railway development in China", Research in Transportation Economics 35 (2012) p 22-33.*

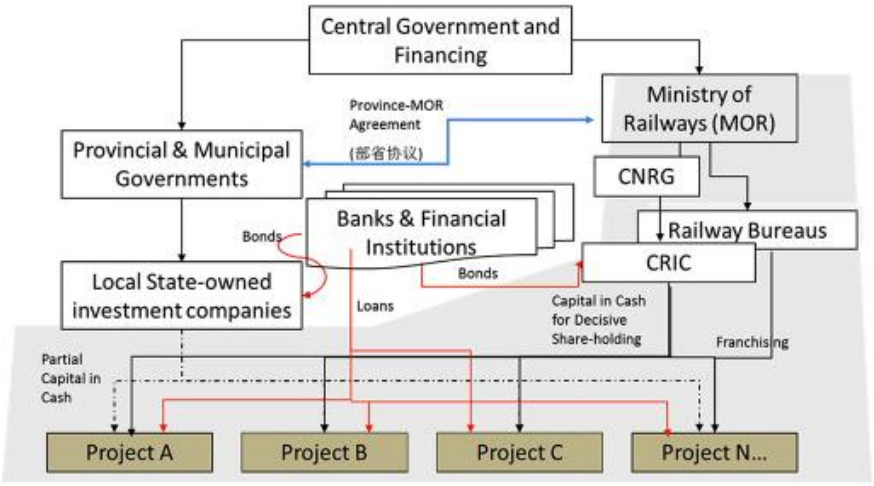

Figure 1-3 Project Funding HSR

Source: Wang et al. (2012)[20]

In other technology-digest projects conducted by other ministries, China's decentralized development gave incentives to local governments to foster growth, but it also created a competitive environment between the governmental bodies. This decentralization and competitive environment can be argued to be a positive and healthy development but it also brings some difficulties. The competition can create diverging agendas and thus disturb the coherency from the Chinese central government. But the fact that the MOR has kept the power and finances on a central level has facilitated a coherent Chinese attitude towards multinationals and also the steering wheel of the path of national research in the HSR project.

Debt-repayment

Chinese investment in HSR has been massive and the MOR currently holds a debt of more than 2 trillion RMB.[21] Given the short period of time it has taken China to develop its network this has had immediate consequences for the MOR's finances and its debt issuance. Despite its political support, the economic feasibility of the HSR project has been questioned.

How to deal with the challenge has been an issue of debate. Some voices recommend further subsidies to lower fares and boost ridership and revenues.[22] Others warn that the financing side of the existing construction and operation model is unsustainable.[23] What is of relevance in this case is that the HSR project has proven to be more expensive than expected. If the rail-backed loans cannot be fully repaid, and are based on irrelevant expectations, they may be refinanced or the banks may seize ownership of the railways.

[20] *Ibid.*
[21] *China Daily (2013) China's high speed railway boom to continue, China Daily. [Web Page]*
[22] *"China Railway Market Study", OSEC Business Network, Zürich, 2011*
[23] *Bullock, et. al (2012) "High-Speed Rail – The First Three Years: Taking the Pulse of China's Emerging Program" World Bank Office, Beijing*

Passenger Financing

The train culture is strong in China; it has been the main transportation mode for a long time, and continues to be so today due to the fact that many Chinese cannot afford to own a car or to buy expensive airplane tickets. The fast train therefor has a sort of "cultural advantage". With increasing economic wellbeing, this will however not necessarily be the case in the future, as the HSR policy makers are very well aware.

The MOR has for that reason controlled ticket pricing until now and has previously made promises to subsidise ticket prices if they increase too much (a real risk given the situation described above) and thereby affect the demand negatively. However, the MOR has recently redefined its role and announced that they will now "take a step back" in decision-making over ticket pricing. The pricing and more direct management will be transferred to a regional level handled by the RRBs. However, this delegation of power is still only on a visionary level. The tickets are subsidised and there are no sign of a market-oriented pricing yet.

Proceeds from tickets are important however, and several attempts have been made to attract more passengers. The HSR industry is actively trying to compete with air travel and use punctuality as an argument to attract their customers. The HST aims to win over the passengers with slightly lower prices and equal or better service than the airplanes. Chinese airlines see long-term competition with the HSR, particularly for China's short-haul operators.[24]

1.4.4 Legitimacy and public perception

The time-frame for the implementation of the ambitious HSR network projects has been questioned. There has been an extensive pressure from the government to speed up projects, as it would mean substantial losses for the Chinese economy if train traffic were to come to a halt. It has proven to be a key challenge to provide all the necessary inputs (material as well as skilled labour) in order to keep up the pace and in fact it has not always been possible.[25]

All sub-projects have exceeded budget but more importantly, the speed of deployment has affected the quality of the different system components highlighted by a major accident in July 2011, which resulted in the loss of 40 lives. This incident triggered a heated debate around HSR in general and brought the rapid expansion to a temporary halt. Matters were not improved when the corruption scandal of the former railway minister, Liu Zhijun, was made public.

Today, many of the projects have been successfully carried out and confidence in the Chinese HSR project seems to be improving again.[26] The expansion of the network is under way and new lines are coming into operation on a regular basis. Some would argue that this project is "too big to fail" and that the network has to be finished to reach its full capacity.[27] However, the ministry is now more cautious with the construction process and is

[24] *So, Charlotte (2013) Airlines flies into headwinds. South China Morning Post [Web Page] URL http://www.scmp.com/business/article/1154167/mainland-airlines-fly-headwinds*
[25] *Buijs, Bram. (2012) "China and the Future of New Energy Technologies, Trends in Global Competition and Innovation"*
[26] *Salzberg, Andrew, et.al (2013)"High-Speed Rail, Regional Economics, and Urban Development in China", World Bank*
[27] *Salzberg, Andrew, et al. (2013)"High-Speed Rail, Regional Economics, and Urban Development in China", World Bank*

making a special effort to inform the public that safety comes first, an issue previously questioned by many Chinese.

The legitimacy of HSR is dualistic; on the one hand it can be argued that the party and government officials are only accountable to superiors - the legitimate concerns of citizens are therefore of low relevance; on the other hand, since the powerful MOR governs most of this project this makes it important for the ministry to have public awareness and take responsibility. The MOR's lack of transparency and its history of military style management are now being called into question, especially when it comes to safety and corruption.[28] This has also in fact led to new political measures to deal with these issues, especially the former.

Measures to Improve Safety Routines

The Wenzhou crash in 2011 pressed the Chinese government to rethink the whole high-speed rail project. The Chinese train manufacturer CNR temporarily stopped production of all trains and the government decided to implement several new security measures. A system with regular inspections of high-speed railways, including new projects, is being developed.

One could argue that the crash had wider repercussions than the high-speed rail expansion strategy itself, the perceived disregard for safety standards and the insistence on pursuing an ambitious and costly showcase project led to strong domestic criticism.[29] Observers naturally also questioned whether the extremely rapid push to develop the domestic high-speed rail industry might have led to mistakes when adopting the technology.

The accident was not a one-off event; already before to the accident some of the train services on the newly opened line between Beijing and Shanghai suffered from delays and technical failures. However, the Wenzhou accident did not stop the development of high-speed rail in China, even though the massive and rapid pace of the expansion has been slowed down and the construction approach is not as aggressive as was previously the case. The ministry seems have more patience and allows the manufacturers of the trains to take more time when testing the trains.

However, the future plan for the network is still very ambitious; the present 7,000 km of high-speed railway will be expanded to 25,000 km in only three years. Dealing with safety concerns and the public's perception will be a key issue for this plan to succeed.

1.5 Main observations and conclusions

The Chinese high-speed network is today the world's largest and will continue to expand until 2020. The main driver is the current infrastructural bottlenecks that need to be resolved and high-speed rail has been held up as one of the most important solutions. The HSR network is strongly supported, politically and finically, by the central government.

[28] *Economic Times (2011) China´s high speed rail projects on hold due to crash crunch [Web Page] URL http://articles.economictimes.indiatimes.com/2011-10-27/news/30328478_1_railway-projects-high-speed-railway-freight-lines*

[29] *Syed, Saira (2011) The Price of high-speed ambitions, BBC News. [Web Page] URL http://www.bbc.co.uk/news/business-14321131*

1.5.1 Strong central planning – blessing or curse?

One can see a clear pattern in the Chinese HSR innovation system that the MOR is highly active on most levels. The restriction on private actors and lack of pluralism can be seen as an affirmation of this, which causes weaknesses in the innovation system. Some would argue that it affects the quality of the railway network and its components on the whole. However, having one ruling ministry can also be argued to have been the strongest asset of the HSR project. In order to create this massive network, stability and relative coherence has been vital. It can be argued that the ministry's building the world's biggest HSR network in only a short period of time would be difficult to accomplish in any other governmental structure.

When bargaining and transferring technology, the MOR's powerful role can again be argued to be beneficial for the development of the Chinese HSR network. In many other technology-digest projects conducted by weaker ministries, China's decentralized development pattern gave incentives for local governments to foster growth, but it also created intra-governmental competition and diverging agendas. Such competition generally undermined the state's ability to leverage China's big market in bargaining with the powerful multinationals for example.

The future ambition is however to build the network largely on "indigenous innovation" and the Chinese HSR technology is intended to become world-leading. Historically this has not been the case; the technology and system integration have simply been too complex. China has been forced to import foreign technology on a large scale and gradually open up to foreign actors. Faced with this reality, China has pursued a strategy of technology transfer with a policy of "introduction-absorption-digestion-innovation" – in short this means to digest the foreign technology and adapt it to Chinese circumstances.

Driving technological development and pushing the technological frontier is an entirely different thing to adopting available best practice technologies. Only time will tell if the Chinese innovation system will be able to undergo the necessary transformation in order to succeed in this field when the "leap-frog" potential has been drained.

1.5.2 Challenges require sector transformation

The ministry assigned to implement the HSR plan is the Ministry of Railways, MOR. It is a powerful ministry that lacks transparency and it also has a stamp of corruption. From an economic perspective is it reasonable to reform the industry as it may be difficult to convince external investors in new rail entities that their rights will be protected and the MOR's and China Railways' obligations fairly administrated if they control entry to the playing field, set the rules, referee the game and manage the opposing team.

Transforming the railway industry requires policy and institutional analysis that would deliver good public and corporate governance of state-railway entities, while maintaining implementation effectiveness and financial viability for the long-term railway development programme. Liberalization and international integration have already been pin-pointed by state actors such as the NDRC as important factors in this process, but it remains to be seen how these visions will be realised.

In other words, the Chinese railway industry is facing a great political and organizational challenge.

1.5.3 A matter of national concern – is the HSR-project too big to fail?

Political and financial support has been essential to this project in the past and will continue to be so. The difficulties are mounting and there is no "silver bullet" or quick fix to address all of them at the same time – many different things need to be addressed at once.

It is however of great political importance that the Chinese HSR network succeeds and the financial support are still strong, despite high costs and bumps along the way. The political and economic stakes are high; some would argue that it must be finished whatever the cost. The economic argument is of course there – the HSR network would reduce shipping costs and make new locations attractive for business, creating conditions for jobs and economic growth in the poorer parts of China. It is also a matter of national prestige, which is perhaps a more important driver in China than in many other countries.

In conclusion, China's HSR network has been built with strong political support of the government. This and the extraordinary role of the Ministry of Railways constitute the main features of the world's biggest HSR project. The specific challenges and success factors are summarized below.

1.5.4 Potential Success Factors & Challenges for China

Challenges:

- The lack of transparency hollows out the credibility of the Ministry of Railways.
- In order to develop a more diverse and pluralist railway industry based on market principles, institutional reforms are urgently needed.
- The project has turned out to be more expensive than expected and doubts have been raised as to whether it really is a feasible project.
- The Wenzhou accident has held back China's hopes for exporting HSR technology. Major projects for exporting to the United States and Europe have been put on hold.

Potential Success Factors:

- The success of effectively transferring best available technology has been absolutely critical to the progress made so far.
- If handled correctly, the MOR's lack of transparency and "ruling" over the industry could also have their advantages. The MOR's top-down management provides gives it the muscle needed for big project.
- The HSR project is considered to be one of China's most important projects to improve their position as an innovative country. Its completion and the expected success of the network have strong support from the government.
- Accessing the old train system was a source of much frustration. Rising incomes have not only spurred people to travel more but also raised the demand for higher standards of service and convenience that the HSR trains can offer.

2 India

2.1 Introduction

India has one of the world's most extensive rail networks, comprising over 100,000 km of track and 65,000 stations. It is the largest network in Asia and the second largest under single management. The multi-gauge network carries over 25 million people daily and occupies both social and economic importance in the government.

Railways are lauded for their potential for high passenger and cargo utilisation and energy efficiency when compared to other modes of transport. Freight traffic currently accounts for about 70% of Indian Railways' revenue and cross-subsidises the loss-making passenger business.[30,31] However, factors such as under-investment in infrastructure and inadequate facilities has seen a shift from rail freight transport to road.

Created in 2008 by the then railways minister Mamata Banerjee, the Railways Vision 2020 document highlights the need for greater logistical and technological improvement across the railway sector. The document sought to address four strategic national goals: Inclusive development, both geographical and social; Strengthening national integration; Large-scale generation of productive employment, and Environmental sustainability.

The Vision document also calls for higher speeds on Indian railways, by increasing the speeds of existing railway rolling stock on current tracks (through investments including tracks, bridges, and signalling) and the development of High Speed Rail corridors.

Although High Speed Rail (HSR) has been thought about since the 1980s, it is only since the Vision 2020 document and the identification of six high-speed corridors for further investigation that it has begun to develop traction. For the purposes of the following discussion, High Speed Rail, unless otherwise specified, refers to speeds in the range of 300-350 km/h in dedicated corridors.

2.2 The Need for Speed: Infrastructure Improvement needs and India's High Speed Rail Aspirations

India's rail network has been hamstrung by under-investment and has lost freight transport share to other potentially less energy-efficient and environmentally friendly modes such as road transportation. India has also witnessed substantial growth in air travel, attracting business travellers and individuals with growing disposable income. It is estimated that the Chinese railways network (which along with Russia is of comparable size and scale) is nearly twice as efficient.

Indian Railways understands the need to increase investment to improve supporting infrastructure (including station facilities, catering and ancillary services), railway network improvement and increased quality of carriages. Although speeds are intended to be in the range of 100-120 km/h on faster services (such as the Rajdhani and Duronto trains), the actual speeds are much lower. Also, as freight and passenger trains share the same tracks rail traffic is often limited by the slowest traffic.

[30] *Planning Commission Doc, volume 1*

[31] *For the period 2011 – 12 Freight revenue was 677,436 Crore and passenger revenue 282,464 Crore. Source: Indian Railways Facts and Figures 2011-12 http://www.indianrailways.gov.in/railwayboard/view_section.jsp?lang=0&id=0,1,304,366,554,1275*

Table 2-1 Slow going – average train speeds

Type of Train	Broad Gauge (Avg km/h)	Metre Gauge (Avg km/h)
Mail/Express	50.3	30.2
Ordinary Passenger	36.2	25.1
Goods	25.0	14.1

Source: Government of India Press Information Bureau, www.pib.nic.in

In 2012, the then railways minister Dinesh Trivedi constituted an Expert Group to produce recommendations for 'Modernisation of Indian Railways'. The group considered a number of strategies to increase efficiency and quality of rail operations. The report also focuses on 15 key areas related to Tracks, Signalling, Stations and Terminals, Public Private Partnerships (PPP), Land, Dedicated Freight Corridors, Information and Communication Technology, Indigenous Development, Safety, Funding, Human Resources and Organization.[32] The report estimates that 560,000 Crore (USD 106 billion) would be required over the next five years to implement changes. This is a daunting amount for a ministry bogged down by lack of investment and populist decision-making, which, for example, in the past has limited the ability to increase passenger fares

Innovative approaches will be required to access necessary funds to support changes. The report highlights opportunities to generate funds from both internal sources of revenue such as increased ridership and freight volumes, through to greater involvement of the private sector. To date, private sector investment in the railways has been limited, and will need to increase substantially to begin to improve infrastructure. Private investment mobilisation in the Eleventh 5-Year Plan (2007-12) is likely to be in the vicinity of 4% of plan estimates. This is far less than the share of private capital in other sectors like ports – 80%, telecom 82%, electricity 44%, airports 64% and roads 16%.[33] There are mixed opinions about the role of the private sector in HSR, with some evidence that there is limited PPP activity in overseas HSR.[34] But from statements made in the press and from the government's overall approach to enhancement of the railways, Public Private Partnerships will play a major role in meeting India's High Speed Rail aspirations.

Along with high speed rail, dedicated freight corridors will be of importance to the government's ambition for rail to contribute 1.5-2% to GDP through greater efficiency. Freight and passenger traffic currently run on the same tracks, hindering the top speed of trains running on the track. To begin to alleviate this problem, the Indian government has announced two dedicated freight corridors – one each on the east and west coasts of the country. The western dedicated freight corridor is attracting interest from Japan and substantial funding is being provided by the Japan International Cooperation Agency (JICA).

2.2.1 Six planned corridors, no ground broken

Six corridors have been identified for technical studies of their potential as high-speed passenger rail corridors. It is envisaged that the tracks would be built in elevated corridors

[32] *Expert Group on Modernization of Rail, Government of India, 2012*
[33] *Expert Group on Modernization of rail, 2012*
[34] *http://www.indianexpress.com/news/plan-panel-launch-highspeed-rail-on-delhiagra-corridor/1057671/0*

to reduce environmental and livelihood impacts, and will be built on a Public Private Partnership (PPP) basis. Recent reports suggest that the Pune–Mumbai–Ahmedabad corridor will be the first to be given the go-ahead, although there is some preference for a small demonstration line to also be considered.

Table 2-2 Status of planned HSR Corridors[35]

High Speed Corridor	Status
Delhi-Chandigarh-Amritsar (450 km)	Re-tendered for pre-feasibility study
Pune-Mumbai-Ahmedabad (650 km)	The final report submitted by the consultants has been accepted by the Ministry of Railways. The construction cost is estimated to be Rs. 49,076 crore and the cost of rolling stock Rs. 6,783 crore (both in 2009 prices). The Internal Rate of Return (IRR) comes to 11.42%. Consultants: Systra, Italffer and RITES Limited
Hyderabad-Dornakal-Vijayawada-Chennai (664 km)	The Japan External Trade Organisation (JETRO) and Oriental Consultancy along with Parsons Brinckerhoff India
Howrah-Haldia (135 km)	The consultants have submitted a final report to the ministry and it is now being studied. Consultants: ENECO, PROINTEC, Ayesa
Chennai-Bangalore-Coimbatore-Ernakulum (850 Km)	Consultants yet to be appointed
Delhi-Agra-Lucknow-Varanasi-Patna (991 km)	The consultants have submitted a final report to the ministry and it is now being studied. Consultants: Mott MacDonald

States such as Karnataka and Kerala have also expressed an interest in developing high speed rail links. Kerala is currently the most advanced, having established a High Speed Rail Corporation and carrying out detailed due diligence on the Mangalore–Trivandrum line outlined below.

[35] *PIB Press release, www.pib.nic.in*

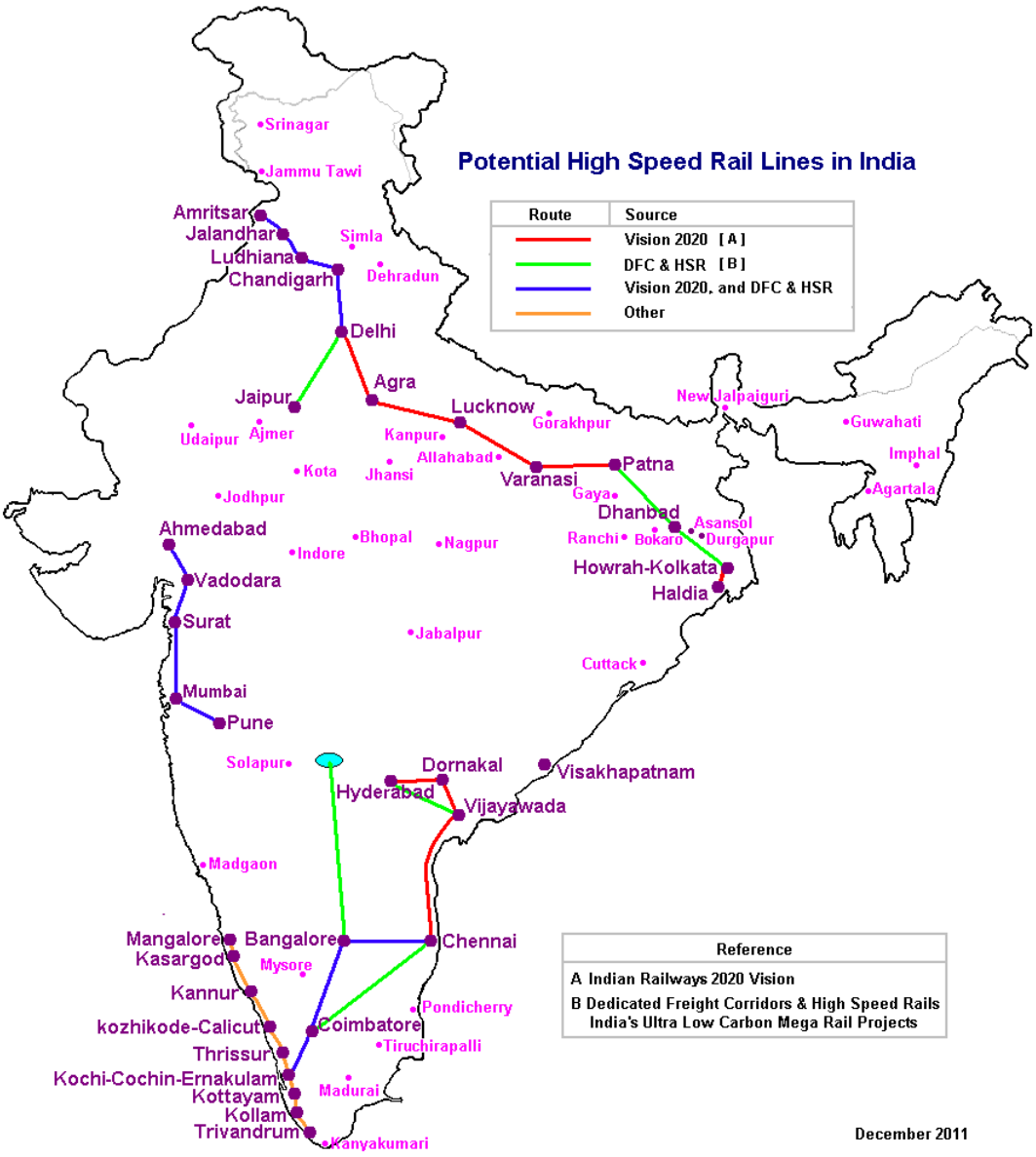

Figure 2-1 Potential High Speed Rail Corridors

Source: www.scrapercity.com

2.3 Main Actors and Networks

2.3.1 The role of the state in High Speed Rail development in India

The Ministry of Railways is a politically important body and often prone to populist decision-making[36]. For example, a fare increase in early 2013 was the first across-the-board increase in 10 years. Decisions are taken at central government level, which can often lead to delays in decision-making and frustration amongst states vying to upgrade rail services.

[36] *http://indiatoday.intoday.in/story/stricter-rail-budget-by-upa-manmohan-singh-to-combat-economic-crisis/1/238107.html*

The HSR Corridor projects have largely been planned around economic potential, with coverage across states. Stakeholders spoken to noted there might also be some political bias in the selection of routes for studies.

2.3.2 Central Government

The Ministry of Railways (MoR, see Figure 2 on the next page) is a large, complex body, supported by the Railways Board. The Board is split into 17 zones, but decision-making is largely centralised with little autonomy amongst the states and no split between executive and administrative powers. Political backing plays a significant role in railways and the successful implementation of HSR plans will be no different.

The Expert Group on Rail Modernisation calls for a number of changes, but also echoes broader calls for changes in the way railways operate. This change in mind-set will be important for the development of HSR, especially as the costs involved will mean that more participative approaches will be necessary.

Operationally activities are broken down into units, and a number of public sector undertakings (PSUs) have also been established to carry out railway work. It is expected that these undertakings, which are similar to state-owned enterprises in other countries, provide financial returns to the government.

Key undertakings as they pertain to HSR

1. Rail India Technical & Economic Services Limited (RITES): A Government of India undertaking, RITES acts as consultants and project managers on major rail projects. RITES is involved in the pre-feasibility study of the Pune–Mumbai–Ahmedabad line in collaboration with Systra, a French Consultancy firm.

2. Indian Railway Construction (IRCON) International Limited: A turnkey construction and consultancy company (formed under the Ministry of Railways in 1974) with a focus on railway and highway construction.

3. Indian Railway Finance Corporation Limited (IRFC): A dedicated financing arm of the Ministry of Railways and raises funds from the market to part-finance government activities as outlined in the government's 5-year planning cycle.

4. Rail Vikas Nigam Ltd. (RVNL): A Special Purpose Vehicle created to undertake project development, mobilization of financial resources and implement projects pertaining to strengthening of the Golden Quadrilateral[37] and Port Connectivity.

[37] *The golden quadrilateral is a large scale highways project that connects Delhi, Mumbai, Chennai and Kolkata.*

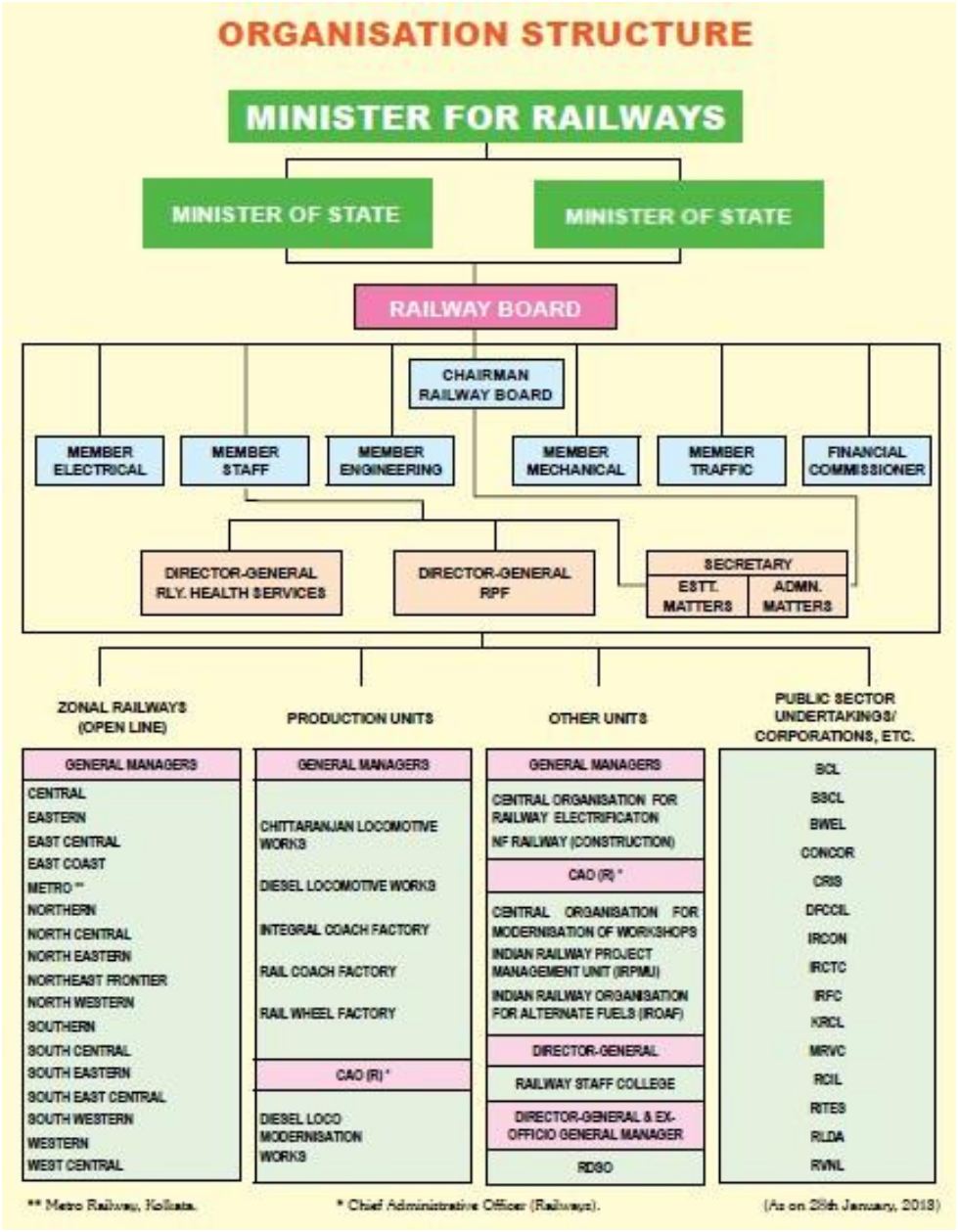

Figure 2-2 Railways Ministry – Organisation Structure

Source: www.indianrailways.gov.in

2.3.3 Overarching bodies for HSR development are developing, but are they developing fast enough?

The Ministry of Railways also established the High Speed Rail Corporation of India Ltd (HSRC) as a subsidiary of RVNL with the intention of dealing exclusively with high speed rail corridor projects. It will handle tendering, pre-feasibility studies, award contracts and execute the projects. At this early stage of the HSRC it is difficult to access information on its activities and progress.

It is also hoped that a High Speed Rail Authority will soon be finalised. The draft of the National High Speed Rail Authority Bill has been sent to the Law Ministry, the Urban

Development Ministry, the Environment Ministry, the Finance Ministry and the Planning Commission for their views. The HSRA will be responsible for overseeing the implementation of High Speed Rail Corridor projects. At the time of writing the HSRA has yet to come into existence, and stakeholders spoken to were hopeful that it would be established in 2013-14, but were by no means certain.[38]

2.3.4 State governments are important partners, but there is a lack of autonomy

A need for land acquisition and potential relocation of people means state and central governments will require transparent and open communication in the development of HSR Corridors. Also, it is expected that there will be greater interaction between central government and states as innovative partnerships are developed to overcome implementation hurdles and funding gaps. States considering HSR connectivity in addition to the central government's plans include:

Kerala: an HSR from Thiruvananthapuram to Mangalore in Karnataka. This route has been approved in principle by the central government, though there are no funds available to support implementation. The Kerala High Speed Rail Corporation is currently having difficulty finding funders for this ambitious project which they envisage will run under a PPP model. The managers of the project are keen to engage with overseas agencies with experience of innovative funding models for such projects.

Maharashtra: Mumbai to Nagpur apart from the Pune-Mumbai-Ahmedabad corridor.

Tamil Nadu: has envisaged an HSR corridor connecting Chennai, Coimbatore, Madurai and Kanya Kumari in 'Vision Tamil Nadu 2023', released this year.[39]

Karnataka: wants an HSR from Bangalore to Mysore (which it has put on hold while the central HSR program develops) and also from Bangalore to Belgaum and Gulbarga.

It is important that there is appropriate communication between state and central government level actors as interest in HSR grows. There will be a need for information and experience sharing as projects are implemented.

Box: Overseas governments are keen to play a role in India's HSR aspirations

High-Speed Rail is still in its infancy in India, but countries with experience are pushing to be involved in the development of the sector. Numerous of memoranda of understanding (MOU) are currently being developed to foster cooperation on HSR. This cooperation includes France, Japan, Spain, China and Austria. Although a number of MOUs are general in nature, outlining a desire to cooperate on knowledge exchange, it is a signal of intent to become involved in India's HSR market. On the other hand, an MOU does not necessarily guarantee active involvement in a particular sector.

[38] *Japanese consortium to study Hyderabad-Chennai high speed rail corridor project, http://www.thehindubusinessline.com/industry-and-economy/logistics/article2697564.ece*
[39] *http://www.tn.gov.in/spc/pdfs/TN_Vision_2023.pdf, page 25*

1.1.1 Other Main Actors

Given that HSR is very much at the planning stage, non-government actors operating in the space are primarily consultants helping to develop pre-feasibility reports. International consultancies are bringing in experts to help with studies; this includes Parsons Brinckerhoff, Mott Macdonald, Systra and the Japan International Cooperation Agency.

As the HSR corridors develop it is expected that overseas technology companies (including carriage manufacturers) will begin to enter the market. This will include companies such as the French SNCF promoting their TGV solution and the Japanese Shinkansen.

In section 2.4 these actors, and the innovation processes they take part in, will be presented using a Technology Innovation System[40] framework. The key functions in the system will be described in order to identify the main drivers and challenges to HSR-development in India, historically and in the future.

2.4 Functional Pattern of High Speed Rail in India

2.4.1 Development, direction and diffusion of knowledge

A wealth of railway experience exists but does not extend to HSR which is a relatively new area. Knowledge development will initially be through collaborative approaches to project development and execution, largely under PPP models. As illustrated, a number of international organisations have been involved in pre-feasibility studies, often with international experts sharing knowledge with local staff.

There is growing support for one corridor to act as a pilot, with knowledge developed helping further spur activity around the country. Pune–Mumbai–Ahmedabad is the preferred route at present, with the support of Gujarat Chief Minister Narendra Modi. However, the Planning Commission has also recently suggested that a smaller 200-km stretch of the Delhi Agra–Varanasi corridor should be implemented as a demonstration. Such an approach has been particularly successful in the metro rail industry where the successful deployment of the Metro in Delhi, has paved the way for confidence that such transportation solutions (and large-scale infrastructure projects) can be successfully implemented. Metro construction is currently under way in a number of countries around the world.

Collaboration has also been developing at a government level with a number of MOUs being signed (as illustrated earlier). These relationships also have a bearing on the direction the market will take with leaning towards particular technologies being based on the country of origin and source of funding. India points to the success of HSR in Japan as a key example of the potential economic benefits of a shift towards HSR. The direction of knowledge diffusion may in part be directed by the source of knowledge, e.g. a lean towards French or Japanese technologies. Trade-tied finance is also prevalent in such large infrastructure projects. For example, in the development of Delhi–Mumbai dedicated freight corridors there has been significant investment from Japan, with requisite involvement of Japanese companies. This could also be expected in the development of High Speed Rail corridors.

[40] *This framework is largely influenced by Bergek et. al. (2008) Analyzing the functional dynamics of technological innovation systems: A scheme of analysis, 2008, Research Policy, (37), 3, 407-429.*

Knowledge Development and R&D are at early stages

There is confidence amongst stakeholders that, given specific HSR domain guidance by experts, there is sufficient civil engineering experience to undertake HSR projects. HSR domain knowledge especially rolling stock and signalling technology experience and expertise is currently lacking. These skill requirements are quite different to the existing skill base and will require overseas experience to be shared locally.

Recently there have been local discussions and conferences covering HSR and the opportunities for collaboration. This has included a side event at the recent Delhi Sustainable Development Seminar (DSDS), organised by the Energy Resources Institute (TERI) in collaboration with the Institute for Policy Studies in Japan. The Institute of Railways Electrical Engineers (IREE) also recently held a two-day conference to discuss technical aspects of HSR in India.

In 2010 the Ministry of Railways signed an MOU with IIT Kharagpur to create the Centre for Railway Research. Research areas cover Heavy Haul Technology, Advanced Maintenance and Operation, Advanced Materials and Manufacturing, and High Speed Rail - though in this context it is focused on increasing train speeds rather than looking at High Speed Rail Corridors. No specific HSR R&D programmes have been announced as yet. The Research, Design and Standards Organisation is the premier government railways research institution but at present lacks a mandate to look at high speed rail.

2.4.2 Developing a market for HSR (Entrepreneurial Experimentation and Market Formation)

The market for HSR is at a formative stage. There is a desire for HSR to come in, but there is a lack of clarity as to when implementation can realistically begin. From recent press reports it seems that the most likely starting point for HSR will be the Mumbai – Ahmedabad HSR Corridor. This has been backed by statements from Gujarat's Chief Minister, calling for the upcoming budget to carve out specific budgetary support to fulfil HSR aspirations. Unfortunately there were no specific statements about High Speed Rail in the railway budget on 26 February. It is fair to say there is some interest in developing HSR, but there is no clarity as to how to accelerate the process. As mentioned earlier, there are some calls for a demonstration leg between Delhi and Agra, which may add further delays to decision making.

Given the large investment requirements there is limited scope for small-scale entrepreneurial activity. However, given the scale of rail investment requirements the railways are becoming increasingly open about the need to think of innovative ways of improving infrastructure. This will include great involvement from state governments, private sector players and multilateral and bilateral agencies (such as the Asian Development Bank and the Japan International Cooperation Agency)

Along with byzantine decision-making processes there are two key barriers to the development of HSR: land acquisition and finance. To overcome the financing difficulties there has been a shift towards PPPs in the railway area. The government has broadened its scope of potential partners and identifies some of these potential partners as:

- State governments
- Local bodies
- Beneficiary industries
- Ports
- Large import and export companies
- Infrastructure and logistics providers
- Foreign direct investors (After clearance by the Foreign Investment Promotion Board)

Several models for engagement have also been published to help facilitate private sector participation and build confidence in the railways. Depending on the model chosen there will be varying levels of involvement on the part of the railways in finance structuring, land acquisition and operations. This guidance will be beneficial to HSR players as it lends weighting to the need for multiple stakeholders' participation in railway development.

Example Models potentially relevant to HSR include:[41]

Non-Government Railway Model: It envisages financial participation of the project proponent in the development and creation of rail infrastructure for providing first/last mile connectivity under an agreement with the MoR either on its own or as a joint venture with infrastructure financing and development institutions. Funds will be fully mobilised by the project proponent etc. without any participation by the railways.

SPV Model for operationally necessary/bankable sanctioned railway projects: Project development will be done by Indian Railways or its PSU through consulting firms to establish project cost, land requirement, project design and other project component requirements, and project bankability. IR will perform the financial structuring of the project to make it bankable, including identification of risks and mitigation measures.

Railway Projects on Build Operate Transfer awarded through competitive bidding: Project development, preparation of Detailed Project Report (DPR), establishing financial viability & bankability will be done by the MoR/Zonal Railway by engaging credible consultants and the project will be sanctioned as a railway project following the applicable procedure of appraisal/approval of PPP projects.

Manufacturing capabilities exist for rolling stock, but HSR manufacturing is some way off. Railways would like to see domestic manufacturing develop over time, but it is recognised that technology will need to be imported and manufacturing capability developed in the longer term. Currently there is no clear road map how this capability may develop for High Speed Rail. A number of manufacturing units exist in the country for standard rolling stock, but planning for HSR rolling stock is not yet under discussion.

2.4.3 Building support and ridership will be important, but it isn't a straight shift from air to rail

Rail holds a unique place in India's history and is an important part of the fabric of the nation. This means that decisions are often not able to be made solely on economic param-

[41] *Participative models for rail-connectivity and capacity augmentation projects, 10 December 2012, www.indianrailways.gov.in*

eters as social implications are given significant weight in decision-making. For a period cheap air fares and higher disposable incomes had prompted a boost in air travel. This is plateauing as the air travel industry faces numerous challenges including high fuel prices, increased development costs and increased security checks at airports causing delays and inconvenience to passengers.

India's dependence on imported fuels, along with environmental concerns are beginning to be factored into discussions on High Speed Rail. From a consumer perspective convenience and cost will be paramount, but the environmental benefits of railways need to be communicated in a planned manner to support a broader shift to high-speed services.

Environmental impact assessments (EIA) will be required as part of infrastructure development. Elements of the KHSRC EIA process include:[42]

- Land environment (physiography, geology and minerals, soils, seismicity)
- Water environment (water resources, water uses)
- Air Environment (air quality)
- Noise/vibration environment (noise/vibration levels)
- Ecological environment (flora and fauna) and
- Socio-economic environment (demography, socio-economics, etc.)

The potential ecological and social impact is also substantial if the planning process is not inclusive. This will require strong community engagement, robust environmental impact assessments and clear communication.

Currently there is no clear pathway for legitimation of High Speed Rail. A common refrain when mentioning HSR is that the country should focus on good speed on existing tracks. HSR will be competing financially and politically against the needs for more general improvement and systemic change within railways.

In many countries HSR is seen as a viable alternative to air travel, but in India although the aim would be to shift air and road demand to rail, there is a recognition that pricing will need to be at a point where HSR travel is accessible to a broad set of the population.[43]

2.4.4 Resources – financing HSR projects

Since 1924-1925 the railways' finances have been separated from general revenue and a distinct 'Railway Budget' has been presented to Parliament, usually two days before the general budget.

The railway budget announced on 26 February contains no specific mention of HSR. This reinforces the need for private sector inflows, but also highlights the fact that HSR is one several priorities for the Ministry of Railways. It is estimated that the Pune–Mumbai–Ahmedabad line will require in the vicinity of 65,000 crore (approx. USD 12.3 billion), which is nearly the same amount as the entire railway budget. HSR will continue to compete for scarce financial resources as India seeks to overhaul its railways.

[42] *www.khsrcl.gov.in*

[43] *Mumbai-Ahmedabad high-speed link may cost more than Railway's annual Plan, http://www.thehindubusinessline.com/industry-and-economy/logistics/mumbaiahmedabad-highspeed-link-may-cost-more-than-railways-annual-plan/article4369429.ece, 1 February 2013*

2.5 Conclusions

There is no overarching policy to develop High Speed Rail, but it is hoped that greater coordination and momentum will develop through the implementation of the High Speed Rail Authority (HSRA). Such an autonomous planning body is required to take a strategic view of the requirements of HSR and understand where best to begin implementation and how the best lessons from the implementation should be shared.

The High Speed Rail market is at a formative stage in India with no specific ecosystem to support it. There is some confidence, given the significant experience in rail-related civil works, that there is an opportunity for the requisite skill base to develop quickly once implementation begins. Given the financing requirements it will be necessary for government to take a collaborative approach to developing HSR projects, primarily through Public Private Partnership models.

HSR in India will need to develop in parallel with overall improvements required across the rail network and needs to be shown as a viable alternative to air travel. For the first series of corridors there will be a need for transfer of skills and knowledge from overseas technology providers. There will need to be considerable guidance from government through implementation to ensure that the role of Rail in India as a unifying and common good, accessible to millions of people, continues.

3 Japan

3.1 Introduction

Japan is a land of railways. From the first tracks laid in October 1872, a network expanded throughout the country. Today the railway system is responsible for approximately 30% of national passenger transport.

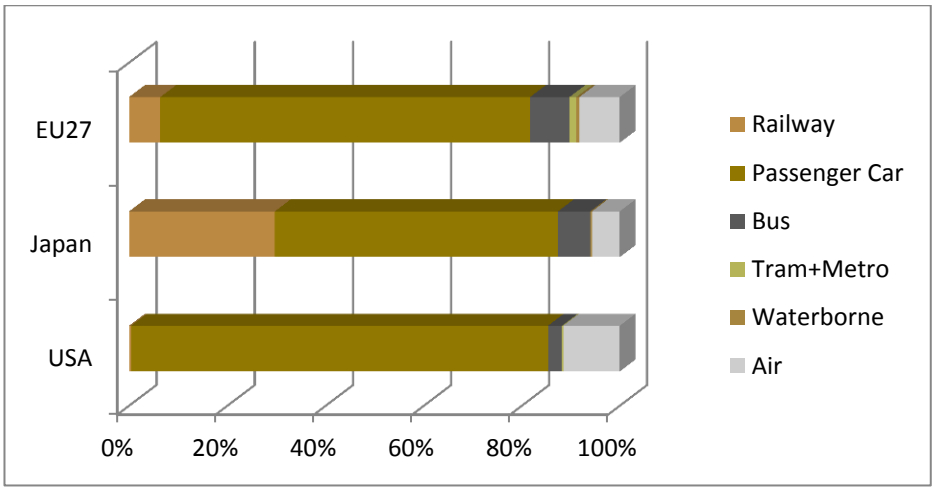

Figure 3-1 Split of Passenger Transport 2009

** Tram and Metro included in Railway for Japan*

Source: http://ec.europa.eu/transport/facts-fundings/statistics/doc/2011/pocketbook2011.pdf

The two largest cities in Japan, Tokyo and Osaka, were connected by approximately 500 kilometres of railway track in July 1899, one of the first major steps towards the development of railways in Japan.

The early days of railway development in Japan owe much to the British. For this reason, "narrow" gauge track of 1,067 millimetres was used in the first installation of rail tracks, as seen in British colonies around the same time. The discussions to match the gauge to the international standard of 1,435 millimetres have come up numerous times, but it was not until 1964 when the Tokaido Shinkansen (super-express or bullet train) was inaugurated, the gauge standard in Japan was changed to 1435 millimetres.[44] To this day, most previously nationally owned lines are narrow-gauge track (1034mm) and gauge conversion is required to connect high-speed railway or Shinkansen line to conventional lines.

3.1.1 Inter-regional transport and high-speed railway – Shinkansen

The six independent Japan Railways (JR) companies, which succeeded the trunk lines, new trunk lines (Shinkansen) and the regional lines from Japan National Rail (JNR), play an important role in passenger transportation throughout Japan. However, there are some larger private railway operators who own and operate inter-regional transport. For example, there are three operators, viz. Kintetsu, Tobu and Meitetsu, operating 508, 463 and 442

[44] *Imashiro, M. (March 1995). Japanese Railway History. Retrived from Nationalisation of Railways and Dispute over Reconstruction to Standard Gauge: http://www.jrtr.net/jrtr04/pdf/history.pdf*

kilometres, respectively.[45] Also within JR, there are different categories of inter-regional express. In this document, the category known as super-express or Shinkansen operated by the JRs will be focused[46].

Current Shinkansen network

The concept of high speed train between t Tokyo and Osaka, connecting the two major cities in the eastern and western parts of Japan, first appeared in the 1930s. Planning was interrupted by World War II but resumed in 1959. The 1964 Olympic Games were one of the strong drivers in development of the first line, the Tokaido Shinkansen. It began operating in 1964 with a speed of 200 km/h, when the average speed of high speed trains in Europe was approximately 160 km/h. Shinkansen operation continued to expand and the total service coverage is currently approximately 2,500 kilometres on enclosed dedicated lines, with total fleet of approximately 4000 and maximum speed of 320 km/h.

When services began, it came as a surprise to the world, for Japan was thought to be a latecomer in high speed train development. Success of Tokaido Shinkansen has led to national enthusiasm to establish other Shinkansen lines and in 1973 the Nationwide Shinkansen Railway Development Law came into force. At present there are six Shinkansen lines (two are mini-Shinkansen) operating in Japan.

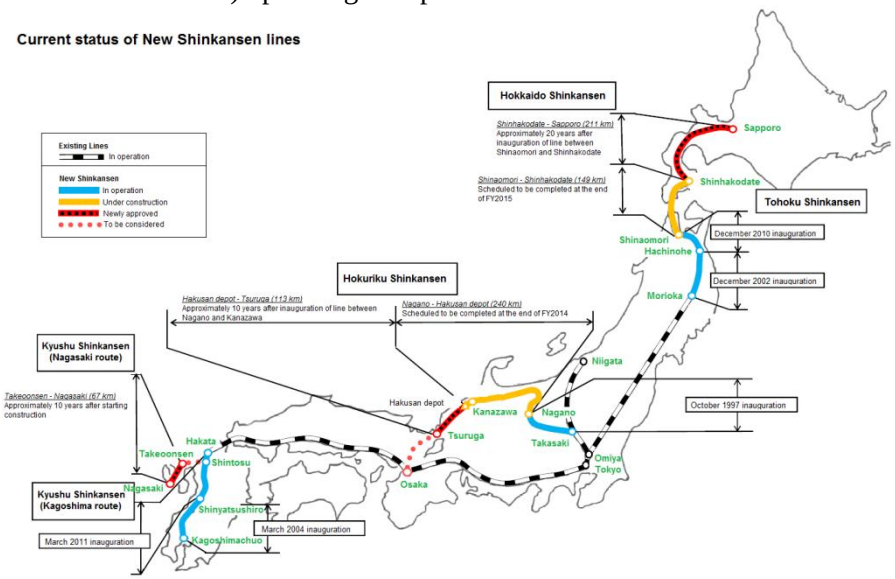

Figure 3-1 Current status of New Shinkansen lines

**Note. Chuou Shinkansen, a planned maglev Shinkansen line, is not considered a New Shinkansen by the Nationwide Shinkansen Railway Development Law*

Source: translated by the author based on http://www.mlit.go.jp/common/000224502.pdf (in Japanese)

3.2 Why fast trains? Drivers, ambitions and targets

Olympic Games held in 1964 was one of the strong drivers in development of the first Shinkansen line, the Tokaido Shinkansen in 1964, with a speed of 200 km/h. The line complemented a conventional line that already connected the two economic centres of

[45] *Weekly Diamond. (August 4, 2012). JR vs Private Companies (in Japanese, tentative translation). Weekly Diamond, ss. 26-69*

[46] *Kumagai, (2011) Development of Shinkansen System as a Business Model (in Japanese, tentative translation). RRR Vol.68 No.3, 2-5*

Japan, Tokyo and Osaka. The success of the Tokaido Shinkansen has led to national enthusiasm to establish other Shinkansen lines to mobilize its population between regions.

The railways' competitiveness against car and airborne traffic peaks in the travelling distance range of 500-750 kilometres.

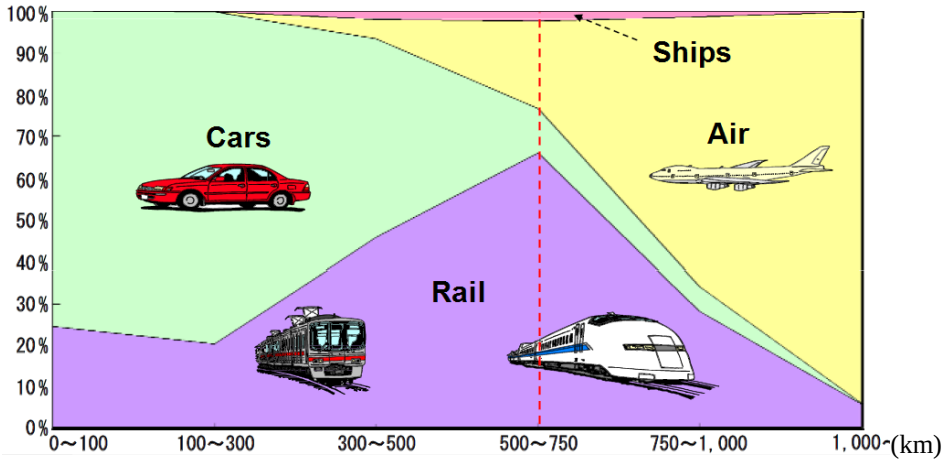

Figure 3-2 Split of passenger transportation

Source: Ministry of Land, Infrastructure, Transportation and Tourism, 2011[47]

[47] *Japan's Contribution towards Establishment of a Sustainable Society. in Ministry of the Environment, White Paper on the Environment (p. 147).*

Box: Tokaido Shinkansen Line

The Tokaido Shinkansen Line, which connects the two mega-cities of Tokyo and Osaka, 552.6 kilometres apart in 2 hours and 25 minutes, is the oldest, the most used and the most profitable line of the 2,500-kilometre Shinkansen network in Japan. 333 trains are operated daily with a maximum of ten trains operating per hour. Each train has 1,323 seats and daily and yearly passenger ridership is 391,000 and 143 million, respectively. Average delay is 0.6 minutes per train, including delays due to uncontrollable causes such as natural disasters. Its minimum curve radius of 2,500 m is much smaller than the new lines which have a radius of 4,000 m, due to the technology limitation of weaving through metropolitan areas in the early days of infrastructure construction. For this reason, the top speed of the Tokai Shinkansen is only 270 km/h, compared to 320 km/h elsewhere in Japan.[48]

The cost of constructing the Tokaido Shinkansen was estimated to be approximately 200 billion yen and was approved by the Diet. It was raised in the form of a government loan, railway bonds and a low-interest loan of USD 80 million from the World Bank, as one of the 31 projects funded in Japan. However, the estimate was deliberately understated and the actual figures almost doubled to 400 billion yen.

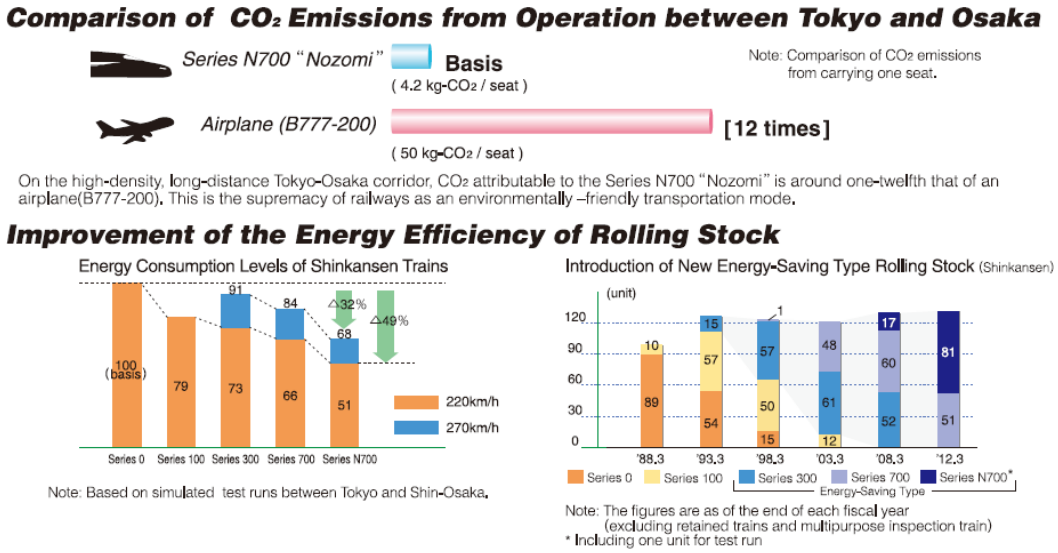

Figure 3-3 Comparison of environmental performance

Source: JR Tokai, 2012[49]

[48] *JR Tokai. (2012). Retrieved from Data Book 2012: http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2012.pdf March 5, 2013*

[49] *Ibid.*

3.2.1 Nationwide Shinkansen Railway Development Law and "New Shinkansen" lines

Established in 1973, the Nationwide Shinkansen Railway Development Law aims to construct new Shinkansen lines to improve economic activities and vitalize local communities it serves by laying a grid of high-speed railway. The law defines the "New Shinkansen" lines and ways to realize their installation. Five new lines/routes were indicated in the law. At the time when the Nationwide Shinkansen Railway Development Law was under consideration, two lines were already in operation (the Tokaido and Sanyo Shinkansen) and three were under construction (the Tohoku, Jouetsu and Narita Shinkansen). To differentiate these from the five new lines/routes, the term "New Shinkansen Line" is utilized.

Among the New Shinkansen Lines, Tohoku Shinkansen is completed and others are partially completed as of March 2011. By the agreement on new Shinkansen lines by the government and the governing parties in December 2011, there are five sections on three lines under consideration[50].

Table 3-1 Status of new Shinkansen not yet in operation

Start Point	End Point	Line	Length	Status
Nagano	Kanazawa	Hokuriku	240km	To start operation by March 2015
Shin Aomori	Shin Hakodate	Hokkaido	149km	To start operation by March 2016
Shin Hakodate	Sapporo	Hokkaido	211km	Construction plan approved in June 2012
Kanazawa	Tsuruga	Hokuriku	113km	Construction plan approved in June 2012
Takeo Onsen	Nagasaki	Kyushu	66km	Construction plan approved in June 2012

For all the New Shinkansen Lines, the subsidiary agency of the Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) called the Japan Railway Construction, Transport and Technology Agency (JRTT) constructs, owns and leases out the railway system to JR. The details of this scheme will be explained in a later section. The total budget for the construction of New Shinkansen Lines is estimated to be 8.9 trillion yen (approximately SEK 590 billion). The financing of the construction will be mentioned in a later section[51].

3.2.2 The Chuou Shinkansen – a maglev train

In addition to Shinkansen lines to be constructed identified as "New Shinkansen Lines", the Nationwide Shinkansen Railway Development Law also states the vision for the construction of the Chuou Shinkansen. Unlike the rest of the lines planned for construction with both national and local public funding, this line is to be constructed solely by JR Central with their own funding. The line will connect Tokyo and Osaka, taking a different route to the existing Tokaido–Shinkansen Line and as stated in the plan announced on May 2011, it will be a superconducting maglev system with a maximum speed of 505 km/h.

[50] *Ministry of Land, Infrastructure, Transportation and Tourism. (March, 11, 2011). Export of Japanese HSR (tentative translation). Retrived from http://pari.u-tokyo.ac.jp/event/policy_discussion/pari110610_rail.pdf March 5, 2013*

[51] *Weekly Diamond, 2012 (August 4, 2012). JR vs Private Companies (in Japanese, tentative translation). Weekly Diamond, ss. 26-69*

Travelling time between the cities 550 kilometres apart will be shortened by 1 hour and 18 minutes to 1 hour 7 minutes. The total budget for the construction of the Chuou Shinkansen Line is estimated to be 9 trillion yen (approximately SEK 600 billion). JR Central has announced that it will finance the project completely on its own. This is a result of JR Central wishing to remain independent of the political influence in the process of construction which will possibly delay development. Additionally, should JR Central depend on public funding for construction, it will have to pay rent to the government agency that owns the infrastructure. The rent increases as profits increase, leaving less incentive to promote ridership.

Table 3-2 Progress of the Chuo Shinkansen Project

November 1973	The Minister* decided the Basic Plan
February 1990	The Minister instructed topographical and geological survey
December 2007	Decision to promote the Chuo Shinkansen project using the Superconducting Maglev system made by JR Central. Also announced the construction cost to be borne by the company.
October 2008	Topographical and geological survey reported to the Minister
February 2010	The Minister consulted the Transportation Policy Council of the MLIT regarding the designation of an operator and constructor
May 2011	The Minister designated JR Central as the operator and constructor of the Chuo Shinkansen between Tokyo and Osaka based on the recommendation of the Transport Policy Council
	The Minister determined the Development Plan and instructed JR Central to construct the Chuo Shinkansen
June-September 2011	Announced the approximate route and location of the stations in the "Report for Environmental Consideration at the Planning Phase" (Between Tokyo and Nagoya)
November 2011	Agreement was reached between JR Central and host municipalities of the stations in-between to collaborate on construction of the stations, while JR Central bears the cost

**The Minister stands for the Minister of Land, Infrastructure, Transport and Tourism (the Minister of Transport in 1973 and 1990)*

3.2.3 Export

The railway sector is highlighted in both the New Growth Strategy 2010 and the Strategy for Rebirth of Japan 2011 as a prospective growth sector for exports. The Japanese system is highly regarded for its long experience of running punctual and safe system, but it is also said to be high in cost and lacking in the ability to provide attractive comprehensive plans including operation.

In April 2010, the Vietnamese government announced its cabinet decision to select the Japanese Shinkansen technology for its high-speed railway project connecting Hanoi and Ho Chi Minh City. In 2012, the Japanese and Indian governments agreed to hold talks on adopting Japan’s Shinkansen system for a high-speed rail project on a 680-kilometer route

linking Pune, Mumbai and Ahmedabad[52]. These two agreements are the first since the tender for Taiwan HSR.

3.3 Main actors

3.3.1 Nationalization and Privatization

At the dawn of railway history in Japan, the government took direct control as a railway system operator but in 1880 privately-owned railway operation was permitted. The success of regional lines brought many private actors into the business of railway operation. Over time, including experiencing several wars, the structure of railway service providers in the country underwent many changes.

Nationalization

In 1906, the first successful attempt was made to nationalize privately owned railway systems after the government came to realize the importance of having full control over the railway system throughout the country in wartimes. 17 private railway companies were bought by the government in two years, while other companies only operating intra-regional transport were exempted from government purchase. After the "merger" by the government, the Japanese Government Railways operated a 1,750-kilometer railway system, covering 90% of the service provided in Japan. Though the name and the status of the organization changed from the state-owned and operated Japanese Government Railways to a public corporation called Japan National Railway (JNR) in 1949. Tis publicly owned railway operator giant existed until privatization in 1987[53]. Due to the lack of other means of transportation, in 1950 JNR represented 92% and 52% of passenger and freight transport, respectively[54].

Privatization

Until the mid-1960s, JNR continued to record profit but the productivity of the organization became questionable. Though the introduction of the Shinkansen in 1964 surprised the world, in the same year the first deficit was recorded. JNR's financial hardship could have been avoided if Shinkansen construction had been limited to the lucrative section between Tokyo and Osaka. However, the interests of factions within JNR favouring extension of Shinkansen services to other areas coincided with the interests of politicians, and the Shinkansen was extended to the Sanyo region (between Osaka and Fukuoka).[55] High fares and competition with road and airborne traffic caused a diversion of passengers from JNR. In spite of the increasing deficit, JNR continued to make huge investments in infrastructure and the deficit grew to 25 trillion yen (approximately SEK 1.7 trillion) immediately before privatization[56].

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[52] *Asahi Shimbun, (November 21, 2012). India looks to adopt Shinkansen technologies.*
[53] *Imashiro, M. (March 1995). Japanese Railway History. Retrived from Nationalisation of Railways and Dispute over Reconstruction to Standard Gauge: http://www.jrtr.net/jrtr04/pdf/history.pdf ; Imashiro, M. (January 1997). Hämtat från Dawn of the Japanese Nation Railways: ttp://www.jrtr.net/jrtr10/pdf/history.pdf*
[54] *Imashiro, M. (March 1995). Japanese Railway History. Retrived from Nationalisation of Railways and Dispute over Reconstruction to Standard Gauge: http://www.jrtr.net/jrtr04/pdf/history.pdf*
[55] *Kakumoto, R. (u.d.). Transportation Investment and Japan's Experience. Japan Railway & Transport Review No. 11, 4-12.*
[56] *Imashiro, M. (September 1997). Retrived from Changes in Japan's Transportation Market and JNR Privatization: http://www.jrtr.net/jrtr13/pdf/his_13.pdf, March 5, 2013*

In 1987, JNR was privatized into six independent passenger railway companies, the JRs and a freight company, JR Freight.

Figure 3-4 JR Companies

Source: Wikipedia

Upon privatization, difficulties in maintaining profit in JRs Hokkaido, Shikoku and Kyushu located outside of the main island of Honshu were indicated, and a 1.3 trillion yen (approximately SEK 800 billion) Management Stabilization Fund (MSF) was formed to adjust profits between the newly created companies. The JNR Settlement Corporation (NJRSC) was also established to liquidate the old JNR debts by selling unused land and to find jobs for employee surplus to the JR operation4.

3.3.2 Government - Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

The MLIT is the government entity responsible for the Nationwide Shinkansen Railway Development Law and for policy measures to design, plan, coordinate and approve projects related to the Shinkansen lines, including promotion of exports. It provides funding through the Japan Railway Construction, Transport and Technology Agency (JRTT) to support construction of new lines.

3.3.3 Japan Railway Construction, Transport and Technology Agency (JRTT)

The JRTT reports to the Minister of Land, Infrastructure, Transportation and Tourism and is the body responsible for construction and ownership of the new Shinkansen lines as identified in the Nationwide Shinkansen Railway Development Law.

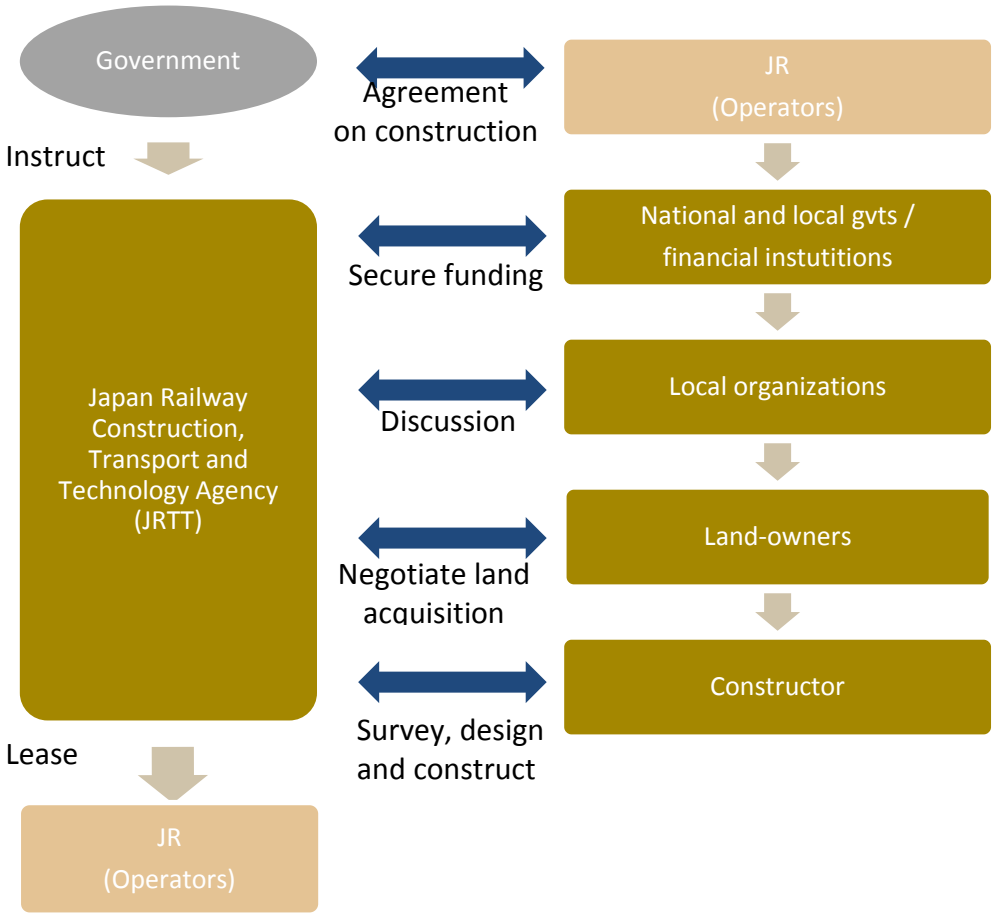

Figure 3-5: Relationship between the JRTT and other high-speed train actors

3.3.4 Shinkansen operators - the JRs

All JRs except for JR Shikoku are or will become operators of Shinkansen. For the New Shinkansen Lines, including those already in operation and those to be constructed in the future, the JRs are responsible for operation and maintenance of the infrastructure.

For the non-New Shinkansen lines, i.e. Tokaido, Sanyo, Tohoku (between Tokyo and Morioka), Jouetsu, Shinkansen lines, in operation before the privatization of Japan National Railway in 1987, a similar scheme of leasing was implemented upon privatization. A scheme was suggested such that the JRTT owns the infrastructure and the JR East, West and Central rents the infrastructure from the JRTT. However in 1991, in anticipation of taking the companies public in the future, the operators JR East, West and Central purchased the infrastructure with a 60-year loan.

3.3.5 JR Central

In addition to being one of the JRs operating existing Shinkansen lines, JR Central is unique. The company will be constructing a new line, the Chuou Line, with their own funding. Its economy is supported by the Tokaido Shinkansen, which is the most profitable Shinkansen of the existing lines.

3.3.6 Private operators and local public corporation

Technically speaking since 1987, all passenger rail services including the six JRs have been privately owned and operated. However, JRs are often differentiated from the other privately owned companies. From 1880, when first allowed to enter the market as A railway operator, private investment has played an important role in the development of the railway system in Japan. There are currently 71 private railway operators, with some handling inter-regional transport.

There are 17 local public enterprises running railway systems, including subway and light rail transit (LRT) systems, throughout Japan. As the name suggests, these public corporations are mainly responsible for operating local railway systems.

3.3.7 Manufacturers, consulting firms and consortia of companies

Compared to the "big three" railway manufacture/service providing companies, Bombardier, Siemens and Alstom, their Japanese counterparts have much smaller turn-over. With the anticipated decrease in the domestic market, railway manufacture/service providing companies in Japan have an eye to expanding their market abroad. Japanese companies currently form a consortium per project with the participation of various (and sometimes competing) manufacturers under the leadership of railway operators. However, this form of project management has proven to be disadvantageous to other international competitors who form alliances of consulting firms, railway manufacturers/service-providing companies and the government at the early stage of procurement calls. To meet the challenges from international competitors, "Team Japan" is beginning to take shape with the support of the government[57].

In section 3.4 these actors, and the innovation processes they take part in, will be presented using a Technology Innovation System[58] framework. The key functions in the system will be described in order to identify the main drivers and challenges to HSR development in Japan, historically and in the future.

3.4 Functional Analysis of the High Speed Rail Innovation System

3.4.1 Knowledge development

Before the privatization of Japan National Railway in 1987, R&D in Shinkansen technology was centrally conducted at the former Railway Technical Research Institute (RTRI) which was incorporated in 1986. RTRI still exists, but HSR R&D is conducted in the R&D centre/section of each of the JRs operating Shinkansen lines. In Japan, high speed rail is expected to be able to maximize its speed to 400 km/h, but this is not thought to be optimal from the point of view of investment in safety measures, maintenance and operation cost and energy consumption.[59] The maglev train under development by JR Central, is aiming for 500 km/h in operation.

[57] *Weekly Diamond. (August 4, 2012). JR vs Private Companies (in Japanese, tentative translation). Weekly Diamond, ss. 26-69.*
[58] *This framework is largely influenced by Bergek et al. (2008) Analyzing the functional dynamics of technological innovation systems: A scheme of analysis, 2008, Research Policy, (37), 3, 407-429.*
[59] *Kumagai, N. (2011). Development of Shinkansen System as a Business Model (in Japanese, tentative translation). RRR Vol.68 No.3, 2-5.*

Earthquake safety has always been on the agenda for Japanese R&D in HSR, and the disaster in March 2011 has strengthened the need for further research in the field. None of the 27 Shinkansen in commercial operation in JR East serving the disaster-stricken area derailed (four wheels of a test train derailed) and no casualties were caused by the damage to the infrastructure.[60]

3.4.2 Resource mobilization

In this section, financing of the currently pending New Shinkansen Lines will be introduced. As noted in the earlier section, a government entity the Japan Railway Construction, Transport and Technology Agency, is responsible for the construction of the infrastructure. The funding for the construction comes from national and local governments and from leasing of the infrastructure to the operators, the JRs. The current funding scheme, effective as of 1996, calls for the national and local governments to cover two thirds and one third, respectively, of the budget minus the rent fee. Originally, the rent paid by the operators was allocated for repayment of the Nagano Shinkansen's[61] debt and to subsidize operations of conventional lines running parallel to New Shinkansen Lines. However, the law was changed in 2011 such that the rent fee is to be allocated to the construction of the New Shinkansen. Rent fees vary depending on the number of passengers. The change in the financing scheme is said to be in accordance with the interests of politicians from regions to be served by the New Shinkansen Lines. The MLIT will acquire additional funding to accelerate construction of the new lines, while JR bears no additional cost. In fiscal year 2012, the rent fee was only 15% of the total budget, 85% coming from either national or local taxes[62].

Measures to promote existing railways running parallel to high speed rail

"Existing Conventional Line" is defined as a conventional line existing in parallel to the anticipated New Shinkansen. To ease the burden on JR to operate both the New Shinkansen and the conventional line running parallel and to take into account the passenger needs served by such conventional lines (often intra-region transportation), upon agreement by all local municipalities (both prefectural and city/town/village governments), the existing conventional line is to be separated from JR. Often the separated conventional line is operated as a public corporation. Both the national government and JR are to aid the promotion of ridership on the existing lines. Both national and local government provide policy packages to exempt License Registration Tax and Property Acquisition Tax and provide a 50% reduction in City Planning Tax and Fixed Asset Tax for 20 years.

In addition to tax exemption and reduction, both the national and local governments provide subsidies for promotion measures taken by regional railway service providers. These measures are not only for the existing conventional lines running parallel to the New Shinkansen, but all railway operators serving regional needs are eligible.

[60] *Shinkansen in the disaster stricken areas is not running along the shoreline and was not affected by tsunami.*
[61] *Special government loan was allocated for construction of Nagano Shinkansen to realize early construction of the line in time for Nagano Winter Olympics in 1998.*
[62] *Weekly Diamond. (August 4, 2012). JR vs Private Companies (in Japanese, tentative translation). Weekly Diamond, ss. 26-69*

JR, which will be operating a New Shinkansen in parallel to the existing conventional line provides support by dispatching personnel to the separated entity, providing special transit tickets and conducting tourism campaign together[63].

3.4.3 Legitimacy and public perception

Introduction and expansion of new lines have always been a political issue. Politicians representing regions yet to have accessibility to HSR have advocated the need vigorously in the political arena and sometimes used their political power to change the route or decide on the locations of stations. As mentioned in the previous section, most of the financing for new lines is covered by public funding and with the already existing phenomenal national debt and much reconstruction needs to be done in the disaster-stricken areas of north-eastern Japan, the legitimacy of further extension of the lines is somewhat questionable. There are analyses that show benefits and increased economic activities in the regions the Shinkansen lines are extended to. Cost-benefit analyses were also conducted before the five New Shinkansen Lines were approved in December 2011. However, in the current study, the legitimacy of such analyses was not able to be conducted due to time restrictions. In spite of Shinkansen giving some impression of being a political tool and unjustified use of tax money, the general perception of Shinkansen by the public is generally good and it competes well with other means of transportation.[64]

Rail vs. air

An analysis by the Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) states that a travel distance of 500-700 kilometres is when rail is chosen most as passengers' choice of transport mode (see section 3.2). Diversification of transportation in itself is a good phenomenon, providing passengers with more choice in different price ranges encouraging and stimulating usage for both business and leisure. However, the full-scale introduction of low-cost carriers (LCC) in Japan in 2012 may set off unsustainable competitive price cuts, as seen in other sectors such as the food service and home appliance industries. No thorough analysis has been found of how introduction of LCC has affected the high-speed railways so far, but effects on both HSR and long-distance night bus services are anticipated[65].

Attractiveness of rail

Traditionally, railway operators have promoted rail over airborne traffic by emphasising the punctuality of the system. Most of the Shinkansen lines also offer a few carriages allowing seating without reservation at a lower price, allowing passengers to make last minute changes to their travelling schedule making it especially popular with business people who often experience changes in their schedule.

In an internet survey asking for passengers' preference between use of Shinkansen and LCC, conducted immediately before the inauguration of LCCs in Japan, the second most popular reason for choosing rail over LCC (after dislike for procedures at the airport) was

[63] *Ministry of Land, Infrastructure, Transportation and Tourism. (u.d.). Retrived from About the New Shinkansen Lines (in Japanese, tentative translation): http://www.mlit.go.jp/tetudo/tetudo_fr1_000041.html March 5 2013*

[64] *Business Media Makoto. (May 16, 2012). Retrived from Why Shinkansen Wins Against Flying (in Japanese, tentative translation): http://bizmakoto.jp/makoto/articles/1205/16/news004.html March 5, 2013*

[65] *Diamon. (March 10, 2012). Shinkansen cannot surive without a price cut? (in Japanese, tentative translation). Retrived from Diamond Online: http://diamond.jp/articles/-/16622 March 5, 2013*

simply that passengers like the Shinkansen, illustrating the well-rooted train culture in the Japanese society[66].

JR fares have not gone up since privatization in 1987, except to integrate introduction and changes in the rate of consumption tax in 1989 and 1997. JRs are responsible for the maintenance of the infrastructure and significant discounts or discount schemes for Shinkansen tickets in addition to discounts provided for group tickets and internet reservation may be difficult to apply.

JR has been cooperating with tour companies to promote the use of Shinkansen as part of a package tour with transportation and accommodation. A significant discount is provided for the use of specific Shinkansens stopping at more stations and running more slowly or at off-peak times. This is a conscious effort on the part of JR to divert ridership to less popular trains[67].

3.5 Main observations and conclusions

Since its inauguration in 1964, Shinkansen has been proven and is well-trusted as a punctual, safe and reliable mean of transportation in Japan and has contributed to increased mobilization of the population. The infrastructure of most of the existing lines were financed and originally operated by governmental entities but the expansion is being conducted with joint funding by national and local governments. Analyses have been made that support the economic benefit of the regions served, such as attraction of new businesses and the environmental impact of a modal switch from automobile transportation. However, the legitimacy of continued funding in similar matters and allocating leasing income for further expansion is in question in the current recession and decreasing population when government spending is limited. JR Tokai deciding to construct a maglev line solely on its own expense proves that the current government-led system is inefficient and unattractive to an operator of a lucrative line. On the other hand, other Shinkansen are seeking government support as the profitability of their lines is than that of the JR Tokai. A sustainable and politically independent funding scheme and thorough cost-benefit analysis is a challenge to further expansion of the network. Japan is looking for the Shinkansen to be one of its growth engines as an export product and this endeavour faces strong international competition. Overcoming the barrier of high cost and promoting the value added of the system are key to increasing exports.

3.5.1 Potential Success Factors & Challenges for Japan

Success Factors:

- Extensive R&D in realizing punctuality, safety, light weight and energy efficiency.
- "Safety first" philosophy in development and operation, which gained trust domestically as a reliable source of public transportation and internationally as an added value.
- Existence of a profitable Tokaido Shinkansen Line, which allowed JR Central to finance new technology, a maglev line, on its own.

[66] *Lifenet Seimei. (February 27, 2012). Survey about LCC (in Japanese, tentative translation). Retrived from http://www.lifenet-seimei.co.jp/newsrelease/2012/3734.html#anchor3 March 5, 2013*

[67] *For example, Tokaido Shinkansen Lines consists of three different types of operations; Nozomi only stopping at major stations, Hikari stopping at a few additional stations and Kodama making stops at every station.*

Challenges:

- Finance challenges - most (85% in 2012, for example) of the funding for New Shinkansen Lines (the Chuou Shinkansen maglev not included) comes from national and local taxes. Should such a burden be placed on future generations?
- Decreasing population, not much left of the plan for expansion, and a need to increase share of the international market.
- It has been over 40 years since the enactment of the Nationwide Shinkansen Railway Development Law. Re-evaluation of the role of New Shinkansen Lines is needed.
- International standardization led by European entities.

www.growthanalysis.se

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