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[Research note]

Organizing the Development of the High-Speed Railway Network and Measures Taken on Parallel Conventional Railways in Japan since the 1990s^{*}

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Abstract

Japan's nationwide railway network is narrow gauge (1067 mm). By contrast, the high-speed railway, which started service in 1964, is standard gauge (1435 mm). Narrow-gauge railway lines, or "conventional lines," and standard-gauge high-speed railway lines, or "Shinkansen," are independent of each other and do not connect directly or mix.

However, as railway technology has advanced and the Japanese government has expanded the high-speed railway network throughout Japan, limited sections of the Shinkansen and conventional lines now operate interconnectedly.

Deteriorating market share and labor-management relations led to the Japanese National Railways (J.N.R.), which had operated Japan's high-speed railway system, being declared bankrupt in 1987. The JR Passenger Company, which took over J.N.R.'s railroad business, also took over the management of the high-speed railways. The Japanese government established clear rules for the expansion plan of the high-speed railway network after reforming the J.N.R.

Therefore, this study briefly introduces Japan's high-speed railway network, starting with the Tōkaidō Shinkansen, the first to open, and explains measures taken for the JR conventional lines that run parallel to the high-speed railways.

Keywords: High-Speed Railway Network, Shinkansen, Parallel Conventional Railway, Projected Shinkansen, Hybrid Shinkansen

1. Introduction

Since the Tōkaidō Shinkansen began train services in 1964, Japan's high-speed railway network has been extended with the opening of six Shinkansen sections: San'yō, Tōhoku, Jōetsu, Hokuriku, Kyūshū,

^{*}This research note is based on a summary of Daisuke FUJII (2011), "Projected Shinkansen," Japan Society of Transportation Economics (ed.), *Transport Economics Handbook*, Hakutō-shobō, Tokyo, pp152-153 (Japanese) translated into English and some of the results of Daisuke FUJII (2018), "Japanese High Speed Rail "Shinkansen," Meeting at Delegation of the European Union to Japan (presentation), plus information on the Hokuriku Shinkansen and Nishikyūshū Shinkansen lines and parallel conventional line measures.

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and Hokkaidō. The improvement framework for these high-speed railways can be broadly divided into three categories. The categories are as follows:

- 1) J.N.R. makes its own management decisions and develops the Shinkansen
 - 2) Based on government policy in accordance with the act, the Japan Railway Construction Public Corporation will build the Shinkansen and have it purchased by the J.N.R.
 - 3) Based on government policy and framework in accordance with the act, the Japan Railway Construction, Transport, and Technology Agency (JRTT) will build the Shinkansen and it landed by the JR passenger companies
- This study describes the changes in the improvement framework for high-speed railways in Japan, and those that will open after 2022. In particular, measures for conventional railways parallel to high-speed railway lines that have opened since the 1990s or will open in the future are described.

A map of Japan's high-speed railway network is shown in Figure 1.



Figure 1 Japan's high-speed railway (Shinkansen) network map

Source: Created by the author based on Geospatial Information Authority of Japan map

2. Scheme for building Shinkansen lines through the 1980s

2.1. Tōkaidō and San'yō Shinkansen

The Tōkaidō Shinkansen, which opened from Tōkyō to Shin-ōsaka in 1964, and the San'yō Shinkansen, which opened from Shin-ōsaka to Hakata (Fukuoka) in 1975, were built by the Japanese National Railways (J.N.R.), which operated inter- and intra-city railways throughout Japan.

As Japan's economy grew, the conventional Tōkaidō Line, which connected the Tokyo metropolitan area¹, Nagoya area, and Kinki area² along the Pacific coast, was approaching the point where its track capacity was no longer sufficient to handle the increased inter-city passenger and freight transport between these three metropolitan areas, as well as intra-city passenger transport. In response, the J.N.R. planned a high-speed railway connecting Tōkyō, Nagoya, Kyōto, and Shin-ōsaka in 3 hours at a maximum speed of over 200 km/h (120mph), similar to the "Bullet Train Plan" that was developed just prior to World War II. The J.N.R. financed the construction of the Tōkaidō Shinkansen, which opened on October 1, 1964.

Subsequently, the J.N.R. decided to extend the Shinkansen westward from Shin-ōsaka, and the Shin-ōsaka to Hakata line opened on March 15, 1975, running parallel to the San'yō Line. Like the Tōkaidō Shinkansen, the San'yō Shinkansen was also developed by the J.N.R., which financed its own construction.

With the opening of the Tōkaidō and San'yō Shinkansen lines, the usefulness of high-speed railways was widely recognized. Because the development of a Shinkansen network throughout Japan would play a major role in land development and improve people's lives, the Japanese government enacted the Nationwide Shinkansen Railways Construction and Improvement Act in 1970, initiating the establishment of a country-wide Shinkansen network.

2.2. Tōhoku and Jōetsu Shinkansen

Under the Nationwide Shinkansen Railways Construction and Improvement Act, the Japanese government was to establish basic and development programs, and then manage construction approval, rather than basing the development of the Shinkansen network on the J.N.R.'s railway management strategy and business decisions. The Tōhoku and Jōetsu Shinkansen were constructed through this process.

In 1971, construction plans for the Tōhoku Shinkansen from Tōkyō to Morioka, Jōetsu Shinkansen from Tōkyō to Niigata, and Narita Shinkansen from Tōkyō to Narita were decided. The Tōhoku and Jōetsu Shinkansen plans were approved in 1973 and construction began.³ The Narita Shinkansen was to connect central Tokyo and the New Tokyo International Airport (Narita Airport), but construction was delayed because of strong resistance to the opening of Narita Airport.

The Tōhoku Shinkansen was constructed by J.N.R., whereas the Jōetsu Shinkansen was constructed by the Japan Railway Construction Public Corporation (now succeeded by the Japan Railway Construction, Transport, and Technology Agency (JRJT)). The Ōmiya to Morioka section of the Tōhoku Shinkansen and the Ōmiya to Niigata section of the Jōetsu Shinkansen were opened first in 1982, followed by Ueno (Tokyo) to Ōmiya in 1985, and Tōkyō to Ueno in 1991. The Tōkaidō Shinkansen and

¹ The Tokyo metropolitan area generally covers Tokyo Metropolitan, Kanagawa, Saitama, and Chiba prefectures.

² The Kinki region generally covers Kyoto, Osaka, Hyogo, and Nara prefectures.

³ Both Tōhoku and Jōetsu Shinkansen share one two-track line between Tōkyō and Ōmiya.

the Tōhoku / Jōetsu Shinkansen do not connect at Tōkyō Station.

By contrast, construction of five sections—Tōhoku (Morioka – Aomori), Hokkaidō, Hokuriku, and Kyūshū (Kagoshima/Nishikyūshū)—whose development programs were decided in 1973, was delayed because of the economic downturn in Japan, changes in the nation's social structure, and the deterioration in J.N.R.'s management. These five Shinkansen sections are referred to as the “projected Shinkansen.”

3. On Changes in Shinkansen Development as a Result of J.N.R. Reforms

3.1. J.N.R. Reforms

J.N.R., the only railway operator in Japan capable of operating a Shinkansen, posted an operating loss in FY1964, and despite efforts to improve its management, business did not improve. The Japanese government repeatedly urged the J.N.R., a public corporation, to restructure its operations. In 1986, the Japanese government decided to privatize the J.N.R. as a special company organized as a joint-stock corporation, dividing it into seven companies: six regional companies responsible for passenger railways and railway facility management, and a freight railway company that would operate freight trains from its leased railway facilities. After deliberation by the National Diet, the draft law was passed and, on April 1, 1987, 115 years of state-owned railway came to an end. Six passenger railway companies and one freight railway company were established, and J.N.R.'s railway operations were taken over by the seven JR companies. The majority of J.N.R.'s long-term debt was taken over by the Japan National Railways Settlement Corporation (Figure 2).

The J.N.R. Shinkansen lines that were in operation in 1987 were taken over by JR Central for the Tōkaidō Shinkansen, JR West for the San'yō Shinkansen, and JR East for the Tōhoku / Jōetsu Shinkansen.

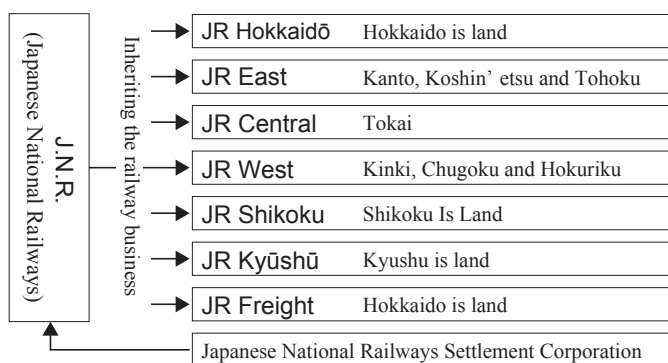


Figure 2 J.N.R. reform

3.2. Shinkansen network development after J.N.R. reform

In 1982, the Japanese government decided to freeze the development of the projected Shinkansen that had been planned in 1973, because the J.N.R. had been posting annual current account deficits in excess of 1 trillion yen since the late 1970s. However, the seven JR companies that took over the management of J.N.R. in 1987 recorded current account surpluses, partly because of the benefits of the Japanese asset price bubble. Therefore, the Japanese government formulated five conditions and a financial resource

scheme for the start of construction on the projected Shinkansen line to ensure that the JR company did not fall into the same financial trouble as the J.N.R. The five terms and conditions are as follows:

- 1) Stable financial resources had to be available
- 2) Profitability was expected
- 3) Investment effects were to be expected (cost-benefit analysis)
- 4) Consent of the JR company, the operating entity of the projected Shinkansen, was required
- 5) Consent was required from the prefectures along the parallel conventional railway line to separate its management from the JR company

The current funding scheme for the construction of the projected Shinkansen is based on a framework in which the national government pays two-thirds of the cost as public enterprises and the prefectures contribute one-third of the cost, together with “royalty fee” income from the Shinkansen lines already in operation, which is recorded as annual operating expenses.⁴

4. Development of projected Shinkansen lines

This section describes the status of the projected Shinkansen since the 1990s, and the measures taken on parallel JR conventional lines as a result of the opening of the projected Shinkansen.

4.1. Hokkaidō Shinkansen

The Hokkaidō Shinkansen is a 360-km line between Aomori and Sapporo. A 53.8 km undersea tunnel (Seikan Tunnel) between Honshu Island and Hokkaido Island opened in 1988. In 2016, the Seikan Tunnel, which had been used for conventional railways, was converted to allow Shinkansen trains to operate through it⁵, and 149 km between Shin-aomori and Shin-hakodate Hokuto opened. The Hokkaidō Shinkansen was operated by the JR Hokkaidō. The Hokkaidō Shinkansen runs directly to and from JR East’s Tōhoku Shinkansen under the name “Hayabusa,” and the journey from Tōkyō to Shin-hakodate Hokuto takes approximately four hours. The construction of the Shin-hakodate Hokuto to Sapporo section began in 2012 and is scheduled to open around 2030.

The JR conventional lines running parallel between Shin-aomori and Shin-hakodate Hokuto are JR East’s Tsugaru Line and JR Hokkaidō’s Esashi Line, respectively. Although JR East continues to operate the Tsugaru Line, the Esashi Line was spun off from JR Hokkaidō and is operated by the Dōnan Isaribi Railway, a joint company of the local government and business railway company whose shareholders include Hokkaidō Prefecture, and JR Freight operates freight trains on the Dōnan Isaribi Railway line⁶.

In addition, it has been decided that when the Hokkaidō Shinkansen line between Shin-hakodate Hokuto and Sapporo opens, JR Hokkaidō’s Hakodate Line, which is positioned as a parallel conventional

⁴ The projected Shinkansen will adopt a “separation of operator and owner” system, where train operations and ownership and management of railway facilities will be managed by different operators. In this system, JR passenger companies pay a royalty fee to JR TT to operate the trains, but JR TT owns and manages the railway facilities. However, the Railway Business Act stipulates that the JR companies, as type I railway business operators, own and manage the Shinkansen railway facilities.

⁵ In Japan, Shinkansen and conventional lines have different gauge, voltage, and current standards, and cannot interchange with each other.

⁶ Japanese Shinkansen trains cannot operate freight trains. However, only in the section of the Seikan Tunnel are Shinkansen and conventional railways used together, with standard gauge Shinkansen and narrow-gauge freight trains in operation. Thus, the maximum speed of Shinkansen trains is limited to 160 km/h (100mph).

line, between Oshamambe and Otaru, will be discontinued because of low passenger demand.

4.2. Tōhoku Shinkansen

The Tōkyō-Morioka section of the Tōhoku Shinkansen opened between 1982 and 1991 (see 2.2). Between Morioka and Shin-aomori, 97 km between Morioka and Hachinohe opened in 2002 and 82 km between Hachinohe and Shin-aomori opened in 2010. This section is operated by JR East.

The conventional line running parallel to this Shinkansen is the JR East Tōhoku Line. The Tōhoku Line south of Morioka continues to be operated by JR East, but the Tōhoku Line north of Morioka was separated from JR East. The IGR Iwate Galaxy Railway, a third-sector railway company in which Iwate Prefecture is a major shareholder, took over from Morioka to Metoki. Between Metoki and Aomori, train operations and ownership and management of railway facilities are separated. Train operations are handled by the Aomori Railway, which is a major shareholder of Aomori Prefecture, and railway facility ownership and management are handled by Aomori Prefecture. In addition, this conventional line is an important section for freight trains connecting Hokkaido Island to various parts of Honshu Island. JR Freight operates freight trains in both sections as a type II railway operator.

4.3. Hokuriku Shinkansen

The earliest section of the projected Shinkansen line to open was the 117-km Hokuriku Shinkansen (called Nagano Shinkansen) between Takasaki and Nagano. This section opened in October 1997 and contributed to the transportation of spectators to the 1998 Winter Olympics (Nagano 1998) held in February 1998. However, it has been noted that the Tōkyō - Nagano area has become a one-day trip zone that has had the effect of decreasing hotel demand.

In April 2015, a 228 km section between Nagano and Kanazawa opened. Although JR East is the primary operator of the Takasaki - Jōetsumyōkō section and JR West is the primary operator of the Jōetsumyōkō - Kanazawa section, JR West's drivers are in charge of the Nagano - Jōetsumyōkō section, effectively taking charge of train operations. Shinkansen "Kagayaki" and "Hakutaka" operate directly between Tōkyō and Kanazawa. The construction of the projected Shinkansen is in its final stages, so that the Kanazawa - Tsuruga (Fukui prefecture) extension will open around 2024.

The conventional lines in this Shinkansen section are the JR East's Shin'etsu Line and JR West's Hokuriku Line. In the five prefectures of Nagano, Niigata, Toyama, Ishikawa, and Fukui, railway management was separated from JR East and JR West on a prefecture-by-prefecture basis and is being handled by railway companies through joint public-private sector funding: Shinano Railway, Echigo Tokimeki Railway, Ainokaze Toyama Railway, IR Ishikawa Railway, and Hapiline Fukui. Figure 3 illustrates the operating segments.

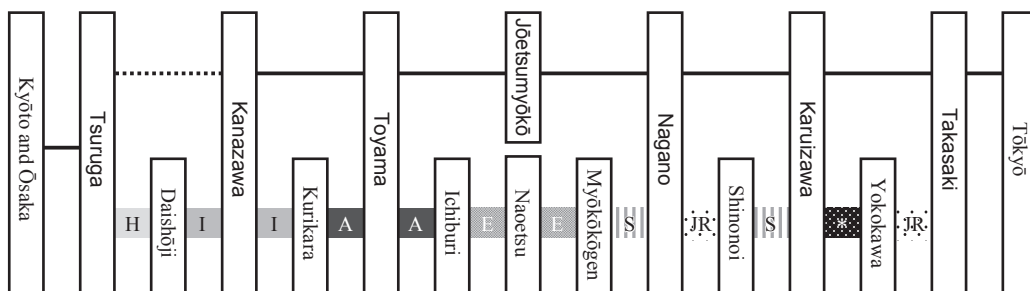


Figure 3 Conventional line operating segments of Hokuriku Shinkansen

Hapiline Fukui, IR Ishikawa Railway, Ainokaze Toyama Railway, Echigo Tokimeki Railway, Shinano Railway, and JR East. * The Shin'etsu Line between Yokokawa and Karuizawa was discontinued at the same time as the Hokuriku Shinkansen began operations because of the steep gradient of the section.

Source: Created by the author

4.4. Kyūshū Shinkansen

The Kagoshima route of the Kyūshū Shinkansen, commonly referred to as the “Kyūshū Shinkansen,” opened in March 2004 between Shin-yatsushiro and Kagoshima-chūō on the southwest side of Kyushu Island and began integrated operation with conventional limited express trains. The Hakata (Fukuoka City) - Shin-yatsushiro route opened in March 2011, and the “Mizuho” and “Sakura” trains operate directly from Shin-ōsaka to Kagoshima-chūō on the San'yō Shinkansen.

The Kyūshū Shinkansen parallel conventional line is JR Kyūshū's Kagoshima Line. The southern part of the line between Yatsushiro and Sendai was spun off from JR Kyūshū, and the Hisatsu Orange Railway took over the management of the line. JR Kyūshū operates trains between Hakata and Yatsushiro, and between Sendai and Kagoshima-chūō, without separation.

4.5. Nishikyūshū Shinkansen

The Nishikyūshū Route of the Kyūshū Shinkansen runs from Shin-tosu on the Kyūshū Shinkansen to Nagasaki. It was also known as the “Nagasaki Shinkansen,” but it was decided to call it the “Nishikyūshū Shinkansen.” The section between Takeo-onsen and Nagasaki was opened on September 23, 2022. The Shinkansen operates between Hakata (Fukuoka City) and Takeo-onsen in unison, by connecting a limited number of express trains and passengers can change trains on the same platform at Takeo-onsen Station in a short time. It has not been decided where the Shinkansen route will be laid between Shin-tosu and Takeo-onsen. Therefore, for more than 10 years, Hakata - Nagasaki will have to transfer between the Shinkansen “Kamome” and the conventional line-limited express. There was a plan to run a variable-gauge train (or free-gauge train) directly between Hakata and Nagasaki, but the variable-gauge train was abandoned because it did not pass the final safety inspection.

The conventional line parallel to the Nishikyūshū Shinkansen is JR Kyūshū's Nagasaki Line. The original plan was to separate the railway business from JR Kyūshū, between Hizen-yamaguchi⁷ and

⁷ Hizen-yamaguchi Station was renamed Kōhoku Station on the day the Nishikyūshū Shinkansen opened.

Isahaya. However, the residents along the conventional line route opposed this plan. Therefore, Saga Prefecture, Nagasaki Prefecture, and JR Kyūshū held repeated discussions and decided to adopt a vertical separation system that separated the operation of trains from the ownership and management of track facilities. Under this system, JR Kyūshū is responsible for train operations (type II railway operator), whereas a general incorporated foundation jointly established by Saga and Nagasaki prefectures is responsible for the ownership and management of track facilities (type III railway operator). In principle, the management of parallel conventional lines should be separated from the JR companies, but for the first time the management of the Shinkansen section will not be separated from JR.

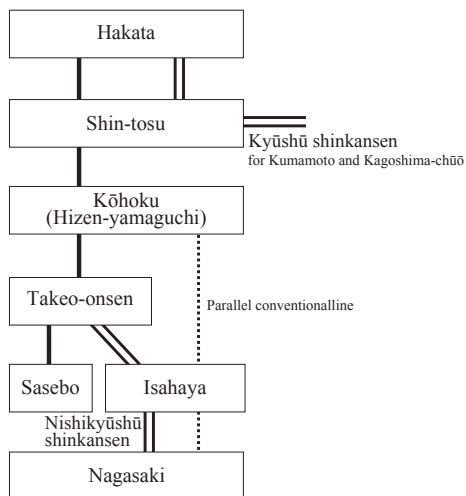


Figure 4 Nishikyūshū Shinkansen

Source: Created by the author

4.6. Chūō Shinkansen

The Chūō Shinkansen is a Japanese maglev line under construction between Tōkyō and Nagoya with plans for extension to Ōsaka. The line is expected to connect Tōkyō and Nagoya in 40 min and eventually Tōkyō and Ōsaka in 67 min, running at a maximum speed of 505 km/h (314 mph). The Chūō Shinkansen is also known as the linear Chūō Shinkansen.

The construction procedures for the Chūō Shinkansen are being implemented under the framework of the Nationwide Shinkansen Railways Construction and Improvement Act, which was approved by the government in May 2011. A project cost of over 9 trillion yen will be financed by JR Central itself, using government fiscal investment funds and loans. The initial plan was to start commercial service in 2027, but construction work has been suspended and the start date remains uncertain. This is because the Chūō Shinkansen is positioned as an alternative route and the bypass express route for the Tōkaidō Shinkansen is located along the Pacific coast and passes through areas where huge earthquakes such as the Tōkai and Tōnankai earthquakes are predicted to occur. The construction of the Shinkansen is being promoted away from the coast to allow a round trip between Tōkyō, Nagoya, and Ōsaka in the event of a severe disaster.

The Chūō Shinkansen line runs from Shinagawa (Tōkyō) to Nagoya and generally corresponds to the parallel conventional lines of the JR East's and JR Central's Chūō Line. However, even after the Chūō Shinkansen begins operating, the Chūō Line will not be separated from the JR companies as a parallel conventional line, and JR East and JR Central will continue to operate the railway business.

4.7. About direct limited express trains between Shinkansen and conventional lines

There are limited express trains that run directly from Tōkyō to Yamagata/Shinjō and to Akita via the Tōhoku Shinkansen operated by JR East. These are the “hybrid Shinkansen.” The Yamagata Shinkansen has been modified to change the duration of the Ōu Line, a conventional line between Fukushima and Yamagata/Shinjō, so that the Shinkansen trains can pass directly through. The Yamagata Shinkansen, “Tsubasa,” is operated in conjunction with the Tōhoku Shinkansen, “Yamabiko,” from Tōkyō to Fukushima, and as a conventional line express from Fukushima to Yamagata/Shinjō. In addition, the Akita Shinkansen has undergone construction to change the gauge of the Tazawako and Ōu Lines, conventional lines between Morioka and Akita, to allow Shinkansen trains to pass directly through them, just as the Yamagata Shinkansen does. The Akita Shinkansen, “Komachi,” will be connected to the Tōhoku Shinkansen, “Hayabusa,” from Tōkyō to Morioka and will operate directly between Tōkyō and Akita.

These two Shinkansen trains are also called “mini Shinkansen” because their car standards are smaller than those of the Tōkaidō and Tōhoku Shinkansen, and they are also called “hybrid Shinkansen” because they can use both Shinkansen and conventional lines.

The conventional line sections of these two Shinkansen lines, Fukushima - Shinjō and Morioka - Akita, are not legally Shinkansen lines and are not subject to the Nationwide Shinkansen Railways Construction and Improvement Act or the Special Measures Act on Punishment of Acts Endangering Safe Operation of Shinkansen Railways⁸. In addition, there are no parallel conventional railways in these sections as conventional railways are converted to Shinkansen.

5. Conclusion

Japan's nationwide railway network can be broadly divided into two systems: Shinkansen and conventional lines, which are independent of each other. This is because the Shinkansen is not only a high-speed railway but also has different gauge and safety systems.

The Tōkaidō Shinkansen and San'yō Shinkansen were built as high-speed intercity railways to increase transportation capacity in response to the growing demand for intercity passenger transport. For other Shinkansen lines, the Japanese government has taken the initiative to promote the development of the Shinkansen network, despite the limited need to increase capacity. Therefore, once these Shinkansen lines begin operating, there will be no need to operate inter-city express services on conventional lines. Thus, JR passenger companies have decided to separate management of conventional lines to avoid managing two double-track railways.

None of the future parallel conventional railway companies will have much demand, making it difficult for them to operate sustainably.

⁸ This act provides for special exceptions to the Railway Operation Act regarding the punishment of acts that interfere with the safe operation of Shinkansen trains because of their ability to run at high speeds.

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