Railway Modernization and Shinkansen

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Progress of Electrification and Diesel Conversion

In the late-1950s—some 10 years after World War II—Japan's economy had recovered to the pre-war level and started remarkable growth. The share of railways in the domestic transport market was still so large that the economic growth called for increased passenger and freight capacities. Heavy investment was made in the 1960s to hasten modernization of trunk lines.

Up to the war's end, the Japanese government railways (JNR after 1949) had relied on steam power, whereas private urban railways had already been electrified, and small and medium-sized local private railways were using rail-cars more-and-more. Electrification of government lines was limited to the Tokyo and Osaka areas and sections containing long tunnels. Many of the private railways nationalized during the war had been electrified lines and in 1950, JNR's electrified lines accounted for 1659 km (8%) of the total route length of 19,786 km. Most were 1500-volt DC systems.

After the war, electrification was promoted chiefly on the major trunk lines. The Tokaido Line between Tokyo and Osaka was completely electrified in 1956, followed by the Sanyo Line running to the western tip of Honshu (the main island) in 1964, the Tohoku Line running to the northern tip of Honshu in 1968, and the Kagoshima Line running to the southern tip of Kyushu in 1970. The total length of JNR's electrified sections increased from 2699 km (13%) in 1960 to 6021 km (29%) in 1970, and to 8414 km (39%) in 1980.

In addition to the 1500-volt DC system used on the Tokaido and Sanyo lines, etc., the AC system, which became common in post-war Europe, started being adopted in Japan in the late 1950s. Japan has two power frequency zones: the Tohoku Line in the east, mostly uses 50 Hz, 20 kV, while the Kagoshima Line in the west, operates on 60 Hz, 20 kV. Trunk routes running along the Sea-of-Japan coast, had to use three different electrification systems, including the 1500-volt DC system in the intermediate sections.

Moha 151-series express EMU used on the electrified Tokaido Line *(Transportation Museum)*

In addition to locomotive-hauled trains, EMUs also began operating on the electrified lines. JNR's first long-distance EMU started operation on the Tokaido Line between Tokyo and Numazu in 1950. In 1958, JNR started operating express trains with a maximum speed of 110 km/h between Tokyo and Osaka. Due to Japanese track standards, the multiple unit system with motor cars coupled to form a train, was preferred over the system using a heavy locomotive at the head of the train. From the viewpoint of terminal capacity, suburban EMUs also had the merit of dispensing with shunting of the locomotive. While major trunk lines were electrified, DMUs with underfloor diesel engines were put into operation on sub-trunk lines and secondary lines. This was made possible by the development of a power transmission system using a torque converter. A nationwide service of express trains with DMUs or EMUs was formed after JNR's first DMU made its debut in 1960.

For freight traffic on non-electrified lines, steam locomotives kept playing a substantial role through the 1960s because

JNR Rolling Stock

FY	Steam locomotives	Electric locomotives	Diesel locomotives	EMUs	DMUs	Passenger cars	Freight cars
1950	5,102	356	0	2,657	123	11,271	105,862
1960	3,974	794	218	4,534	2,227	11,412	118,729
1970	1,601	1,818	1,447	12,582	5,371	8,711	149,485
1980	5	1,856	2,109	17,696	5,038	6,176	99,562

development of high-powered diesel locomotives was slow due to the severe limitations on axle loads of the Japanese narrow-guage system. Steam locomotives did not go out of daily use until 1976 (see table).

Increasing Capacity of Trunk Lines

Before World War II, most JNR trunk lines were single track except the Tokaido and Sanyo lines which connected Tokyo with western Honshu. In addition, many lines had gradients of 1/40. These factors severely limited the capacity of trunk lines, and in the late 1950s, JNR set about double-tracking and regrading sections of its major trunk lines.

In particular, the Hokuriku Line—a part of the trunk route along the Sea-of-Japan coast—was in need of greater capacity to allow industrial development along the line. In 1962, JNR opened a new double-track line with the 13.9-km Hokuriku Tunnel (Japan's longest tunnel in those days). This, together with the AC electrification started from 1957, marked an epoch in this line's improvement.

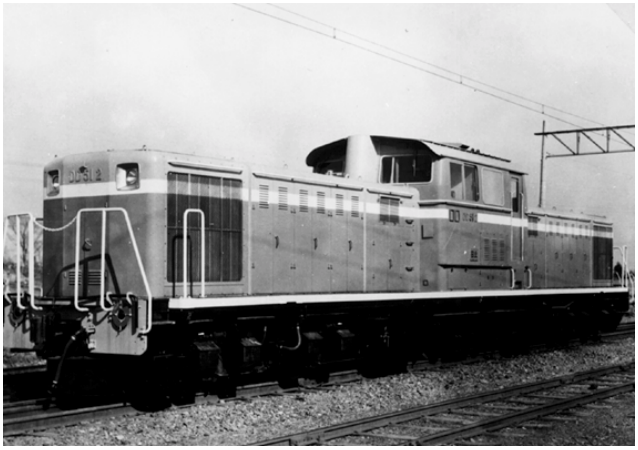
The Shinetsu Line—a trunk line crossing central Honshu—had a steep gradient of 1/15 at the Usui Pass. It was one of the few trunk lines in the world using the Abt rack-and-pinion system. The work to switch to a new line without rack-and-pinion over the steep grade was completed in 1963. The Joetsu Line, another trunk line crossing central Honshu, had two spiral loops and the Shimizu Tunnel (9.7 km, single track) to conquer the elevation. The New Shimizu Tunnel (13.5 km; single track) was built at a lower elevation than the old tunnel and the line became double-tracked in 1967 using the two tunnels.

Railway transport in northern Japan was reinforced significantly with the total electrification and double-tracking of the Tohoku Line by 1968 and the putting into operation of seven large train ferries connecting Honshu with Hokkaido in 1964–66.

The ferries were scaled-up to increase the transportation capacity and to learn the tragic lesson of the *Toya-maru*, which sank in a typhoon in 1954 (a maritime disaster, second only to the *Titanic*, claiming about 1400 lives including passengers of other sunken ferries).

Fatal rail accidents also occurred in 1962 and 1963. In both cases, EMUs collided with a derailed freight train in the Tokyo suburbs, killing 160 in the first accident and 161 in the second. After these accidents, JNR implemented extensive safety measures, including the installation of automatic train stopper devices (ATS) on all its lines.

Kiha 81-series express DMU used on Joban and Tohoku Lines *(Transportation Museum)*



DD51 Diesel locomotive—principal trunk-line loco *(Transportation Museum)*

EF63 Electric loco used exclusively on steep grade at Usui Pass *(Transportation Museum)*

Seikan Tsugaru-maru ferry *(Transportation Museum)*

Construction of Tokaido Shinkansen

The coastal plain between Tokyo and Osaka is the centre of Japanese population and industry, and demand for transport in this area was ever expanding. Scheduled flights were already in service, and a motorway was also planned between Tokyo and Osaka. The double-track Tokaido Line was reaching its capacity limit. A government panel established in 1958 discussed measures to tackle the problem, such as quadrupling the existing line, constructing a separate narrow-gauge line, and constructing a separate standard-gauge line. Eventually, the panel decided to recommend construction of a standard-gauge shinkansen. The decision was endorsed by a report of the Railway Technology Research Institute that a high-speed EMU on standard gauge could connect Tokyo and Osaka in 3 hours. Shinji Sogo, the JNR President, also strongly supported the idea.

According to the original standards, the minimum radius of curves was 2500 m, the steepest gradient was 1/50, and the top speed was 210 km/h (270 km/h today). The electrical system is 25 kV AC, 60 Hz, and the entire line is grade-separated from roads. Advanced safety systems, including cab signalling and automatic train speed control (ATC), are used.

Construction of the Tokaido Shinkansen was started in 1959 and the line was opened on 1 October 1964 in time for the Tokyo Olympic Games. For the first time in the world, the Tokaido Shinkansen routinely topped 200 km/h and demonstrated the high safety level of railways. Previously, Japanese railway technology had not been highly rated internationally, partly because of its narrow-gauge limitations. However, with the success of the Tokaido Shinkansen, it began to attract global attention.

From 1965, the *Hikari* trains covered the 515 km between Tokyo and Osaka in 3 hours and 10 minutes. At first, only two trains, including the stopping *Kodama* operated each hour, but the operating frequency was increased year-after-year. The Tokaido Shinkansen became the forerunner of high-speed railways worldwide, such as the French TGV. Although the construction was financed mostly by loans (partly from the International Bank for Reconstruction and Development), strong demand ensured its business success.

Inauguration of Tokaido Shinkansen on 1 September, 1964 *(Transportation Museum)*

Linking Four Main Islands

After the success of the Tokaido Shinkansen, construction of the Sanyo Shinkansen was started to extend the shinkansen to the west; it reached Hakata (Fukuoka City) in Kyushu in 1975. The planned maximum speed was 260 km/h. So the line standards were revised with a minimum radius of curves of 4000 m and a maximum gradient of 1/67. The line

Seikan Undersea Tunnel *(Japan Railway Construction Public Corporation)*

passes through many tunnels, including the New Kanmon Tunnel (18.7 km) under the strait between Honshu and Kyushu.

There was strong national opinion demanding construction of shinkansen nationwide and a new law was enacted in 1970. Construction of the Tohoku Shinkansen to Morioka and the Joetsu Shinkansen to Niigata was started based on this law. Both lines were mostly opened in 1982 (reaching Tokyo Central in 1991). The Joetsu Shinkansen running south to north crossing Honshu has many long tunnels, including the Daishimizu Tunnel (22.2 km). On this section, some trains have operated at the maximum speed of 275 km/h since 1990.

After the *Toya-maru* disaster in 1954, construction of the Seikan Tunnel under the Tsugaru strait to connect Honshu and Hokkaido was the subject of in-depth investigation. Construction was finally approved and started in 1971 with the design modified so that it could accommodate a future shinkansen. Construction of a chain of bridges accommodating road and rail (both narrow and standard gauge) to connect Honshu and Shikoku was also started.

Unlike the Tokaido route, other shinkansen running through low-density rural areas cannot be profitable, and consequently, shinkansen expansion slowed down in the 1980s. Although the Seikan Tunnel (53.9 km, double track) was opened in 1988, it only has a narrow-gauge track because the Tohoku Shinkansen still ends at Morioka. (Operation at a maximum of speed 140 km/h was started in 1991 in the tunnel.) In the same year, the bridges connecting Honshu and Shikoku were opened, but only with narrow-gauge tracks.

All four main islands of Japan were joined by rail at last, but JNR was privatized in the previous year, and the management of the new links was transferred to the separate JR companies. ■

(Transportation News)

■ **Shinji Sogo (1884-1981)**

The decision to construct a standard-gauge shinkansen at the end of the 1950s owed much to Shinji Sogo, the president of JNR. After graduating from the Faculty of Law at Tokyo Imperial University in 1909, he entered the Railway Agency and advanced through the management. While working for the Agency and the Teito Reconstruction Agency after the Great Kanto Earthquake of 1923, he was strongly influenced by Shinpei Goto (*JRTR 4*), the Agency president.

After leaving the government railways in 1926, he became a director of South Manchurian Railways. After the war, he served as Chairman of the Railway Welfare Association until he was appointed JNR president in 1955.

To improve the Tokaido Line, he insisted on adopting the standard gauge despite much opposition. His reason was that he firmly believed the international standard gauge was indispensable for radical improvement of Japanese railways. In this view, he echoed the ideals of Shinpei Goto who had called for a total change to standard gauge about 50 years earlier.

To ensure government approval for construction of the shinkansen, JNR set the original budget on the low side. As the budget shortage became clear, he resigned in 1963 to take responsibility. However, much of the credit for the Tokaido Shinkansen, which opened a new era for the world's railways, goes to him.

Yasuo Wakuda

Mr Wakuda graduated from the University of Tokyo, Faculty of Law, in 1957 and worked for the Ministry of Transport until 1984; he served as a board member of the Japan Non-Government Railways Association, and the Japan Railway Construction Public Corporation, and as president of the Japan Transport Economics Research Centre. He is currently the Executive Vice-chairman of Japan Air Charter Co. As a specialist in the history of railways, he is author of *100 Years of Japanese Private Railways through Men and Events, Private Railways of Japan-Their Networks and Fleets*, and other works.