Birth of The Shinkansen — A Memoir

Hideo Shima

Nearly 70 years have passed since I entered the railway industry after studying mechanical engineering at university. In those days, the steam locomotive dominated rail, and I started my career as a rolling-stock engineer designing steam locomotives.

Japan's first 3-cylinder locomotive, the C53 Class, was just being designed, based on the C52 imported from America. I was totally absorbed in wrestling with the locomotive design with senior rolling-stock engineers. The C53 was soon completed using new techniques to balance the driving wheels and new valve-gear designs. The results were excellent, and I experienced the thrill of reward for hard work for the first time in my life.

At that time, Japan was developing her own technology, thanks to the hard work of our senior engineers. To understand the actual circumstances of Japanese industry, I made it a rule to read as many domestic and foreign papers as possible. To build high-quality rolling stock, we needed good components. We were eager to encourage the growing Japanese industries and to promote national development by using domestic manufacturers to make these parts. The national railway at that time had a huge group of engineers, unrivalled except by the military. We were enthusiastic about our jobs, taking pride that we had a direct influence on national development. In response to a request from the Ministry of Commerce and Industry, we also participated in the design and fabrication of a standard automobile to promote the domestic automobile industry. These automobiles were mass-produced when World War II broke out. This experience helped the rapid growth of the Japanese automobile industry after the war.

During the war, the Japanese railway industry was in great difficulty, suffering severe damage from air raids and naval bombardment. There were serious shortages of materials but we tried to manufacture as much rolling stock of limited design and simple construction as possible, while giving a low priority to quality. Major accidents resulted from using ancient rolling stock. Many passengers were killed—they were hard days for engineers. The Hachiko Line Accident which occured soon after the war was especially terrible. Over-speeding on a down grade caused the train to derail on a curve and it went over a cliff. The wooden passenger cars, which were already worn out by overuse during the war, took a heavy toll of lives. We used the accident as the opportunity to obtain special permission and materials from the occupation forces to modify all wooden passenger cars (3000 were in use then) to a steel construction in a few years.

Soon, the time came when the Japanese National Railway (JNR) could make future plans. I started designing steam locomotives, but I always felt the limits of steam. On one hand, I wanted to build a steam locomotive with the greatest traction capacity to gain a reputation, but on the other hand, I repeatedly thought about what direction to take to pass the limits of steam, taking the features and condition of Japan into consideration. The high-capacity C62 and D62 classes were developed for express passenger trains and heavy-duty freight trains, respectively, soon after the war. They were suitable for ending the age of steam.

To clear the limits of steam, it was necessary to either introduce internal-combustion locomotives or electric locomotives. Because Japanese railways are narrow gauge with many grades and curves, there are limits on locomotive size. We concluded that increasing operating performance and achieving high-speed operation would mean using electric or diesel railcars with power distributed along the cars, namely use of distributed-power multiple-unit control systems.

Until then, JNR had only used electric railcars for urban short-distance trains in Tokyo and Osaka. I organised the replacement of locomotive-hauled middle-distance trains on the Tokaido Line with electric railcar trains. This new EMU was nicknamed "*Shonan Densha*" and was highly regarded. JNR at that time was supervised by the occupation forces who did not always agree with my ideas. JNR itself was still very passive, but I was confident that the success of the "*Shonan Densha*" demonstrated the possibility of improving service quality by introducing high-performance EMUs to long-distance trains.

I then left JNR to work for a private company, but when Mr. Shinji Sogo took office as President of JNR in 1955, he asked me to assist him as a Vice President of Engineering. I refused at first, but I discussed it with him several times and was moved by his zeal, so I decided to return to JNR.

At that time, JNR was suffering from a serious problem; the transport volume of the Tokaido Line (556 km) connecting Tokyo with Osaka, the centre of commerce and industry in West Japan, was increasing rapidly due to the rapid growth of the Japanese economy after the war. It was almost saturated. Finally, in autumn 1956, the whole Tokaido Line was electrified. It was transporting 24% of the total passen-

■ C53 Class 3-cylinder Locomotive
(Transportation Museum, Tokyo)

■ C62 Class *Tsubame* Express Passenger Train (Transportation Museum, Tokyo)

gers of JNR and 23% of the total freight, and the transport volume was increasing at 7.6% annually, despite the fact that it only accounted for 3% of JNR's service kilometers (20,000 km). It was clear to everyone that the transportation capacity of the existing Tokaido Line connecting Tokyo with Osaka must be doubled to meet the demand, but opinion was divided into three groups: one to construct a narrow-gauge line parallel to the existing line; another to construct a narrow-gauge line along a completely different route; and another to construct a standard-gauge line like the major railways in Europe. When Mr. Sogo took office as president, the narrow-gauge opinion was dominant. Its advocates insisted that if a standard-gauge line was constructed between Tokyo and Osaka, if construction were delayed for any reason, a line with partially-completed sections wouldn't work at all. In other words, to construct a standard-gauge line, the whole line would have to be completed at one time requiring vast construction cost, and it was not certain that the necessary funds could be raised. On the other hand, the existing Tokaido Line could be upgraded as narrow-gauge partially one section after another according to budget, and the new line would be able to use successively-completed sections.

Mr. Sogo himself had the experience of being guided by Mr. Shinpei Goto, a broad-gauge advocate, when there had been a serious dispute about reconstruction of the Japanese railways to standard-gauge at the end of the Meiji era. He had also participated in management of the South Manchurian Railways, which had operated at high speeds using standard-gauge tracks. The reconstruction of Japanese railways to standard gauge in the Meiji era was not achieved, but Mr. Sogo made up his mind that standard-gauge was indispensable to improving the capacity of the Tokaido Line and to creating a new railway that would not fall behind American and European railways.

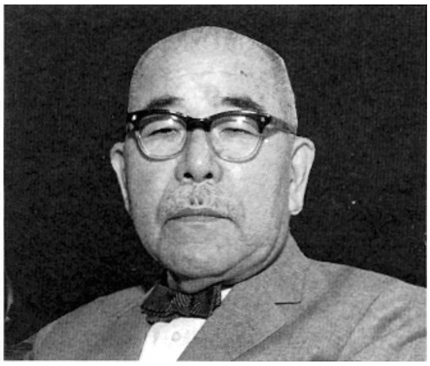
I was also thinking seriously how to meet JNR's transport needs. At that time, air and car traffic were showing remarkable growth. I thought that building a line that would soon fall behind the advancing transport world would be regrettable for the future of JNR and in meeting social expectations. I decided to build a railway that would be useful and rational for a long time into the future.

Today, passenger cars and trucks run on roads at similar speeds. However, in earlier times, cars, coaches and carts ran on roads together, and the speed of trucks dropped on hills due to underpowering, resulting in traffic congestion. Traffic flow became smoother only after truck performance had been improved so they could run as fast as cars.

Conventional railways, like roads, have different types of trains such as express trains, local trains and freight trains, running at different speeds together. Because trains run on rails, a slow train must enter a siding to vacate the main line so a faster train can pass it. It is quite hard, particularly on trunk lines with large transport volumes, to shunt trains one after another so faster trains can get ahead while observing the limits of signalling and safety systems to avoid collision.

However, major private railway companies in the Tokyo and Osaka regions considered the role allotment between railways and cars in the post-war reconstruction period. They soon abandoned freight transport and devoted themselves to high-frequency passenger transport by EMUs. They succeeding in reinforcing their transport capacity by making the most of the track capacity. This fact is worth special mention in the history of Japanese railways.

We decided to apply the same or more advanced principles to the Tokaido Line. If only express trains ran on the new line (shinkansen) while local and freight trains ran on the conventional line, unnecessary siding and waiting would be eliminated, increasing running speed and train frequency. Because the new line (shinkansen) would only run through great cities where express trains stop, and would avoid other built up areas, and because the line would exclude sharp curves, steep slopes and grade crossings, remarkably high-speed operation would be possible. On the other hand, the speed and number of services of local and freight trains on the existing line, which had long been sacrificed for the sake of express trains, could be increased. Transfer between the new lines and conventional lines would be possible at major stations producing a new "Pan-Tokaido" railway system, or an integrated railway of conventional and high-speed lines.



■ Mr Shinji Sogo, President of JNR from 1955 to 1963 (Kotsu Shimbun)

■ Series 80 EMU *Shonan Densha* near Ginza, Tokyo (Transportaion Museum, Tokyo)

The middle- to long-distance EMUs with distributed power systems that I had advocated showed remarkable progress, with greatly improved running speed and excellent riding comfort, thanks to introduction of air suspension and air conditioning, thus surpassing the passenger cars hauled by locomotive. The speed increase made a day trip between Tokyo and Osaka possible. From the operational point of view, the super-express trains became able to make return trips and the economic advantages of the distributed-power system was clear. Soon, JNR had changed into one of the most prominent "EMU-oriented railways" in the world.

Based on this experience, a distributed traction system was applied to shinkansen trains. With all axles driven, it is possible to obtain the output required for high-speed operation without exceeding the limits on axle loads. In addition, stopping a train running at high speed using friction brakes such as shoe brakes or disc brakes, risks heat-damage to wheels and axles. Motorised axles solve this problem because electric braking becomes possible. Improving this to regenerative braking can achieve energy-saving economic transportation.

Thanks to the experience obtained from conventional lines, AC electrification was used for the shinkansen at what is called the West Japan commercial frequency of 25 kV/60 Hz. The problem of using the 50 Hz commercial supply in East Japan was solved by frequency conversion substations.

Thus, the shinkansen was born from pursuit of the best method to improve the capacity of the Tokaido Line. It had remarkably high performance, compared with conventional lines, but through services between conventional and shinkansen lines seemed to be not so useful because of the great difference in performance. Therefore, we abandoned through operation and decided to use standard-gauge to make the most of the advantages of the new line.

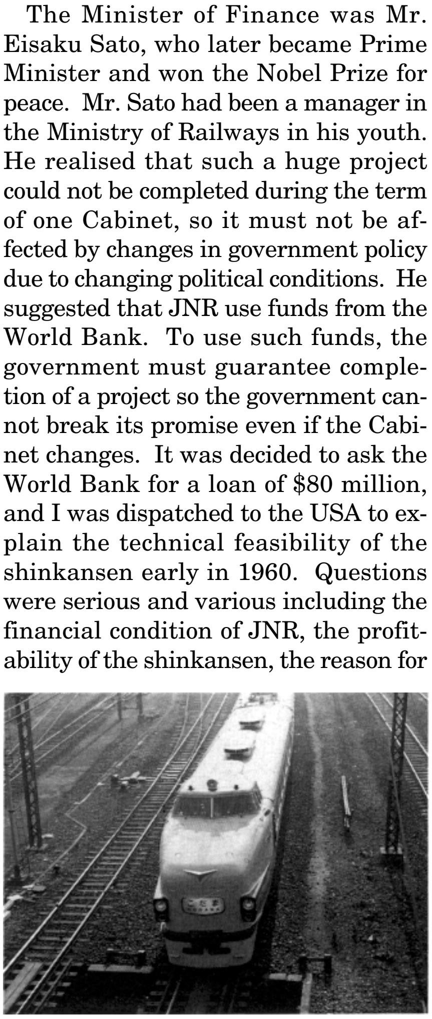
Our decision to construct shinkansen on standard-gauge resulted from the problems of through operation with conventional lines, and released JNR from old habits, making it possible to use new techniques that were impossible with conventional lines and achieving quite a new railway system.

Even if a narrow-gauge four-track line had been built from higher-priority sections, it would inevitably have to have been expanded sooner or later, and repeated partial improvements would have cost more. In addition, narrow-gauge lines would have not produced high-speed and automatic operation like the shinkansen.

After deliberating such points, in December 1958, the Cabinet decided to construct a separate new trunk standard-gauge line along the Tokaido Line with a construction period of 5 years and construction costs of ¥ 194.8 billion connecting Tokyo with Osaka in about 3 hours.

We were most anxious about financial difficulties in raising sufficient construction funds which would suspend construction. We had many experiences. Once the decision was made to construct a standard-gauge trunk line separate from the conventional line, it was necessary to have government backing from influential politicians. President Sogo took great pains about this.

The Minister of Finance was Mr. Eisaku Sato, who later became Prime Minister and won the Nobel Prize for peace. Mr. Sato had been a manager in the Ministry of Railways in his youth. He realised that such a huge project could not be completed during the term of one Cabinet, so it must not be affected by changes in government policy due to changing political conditions. He suggested that JNR use funds from the World Bank. To use such funds, the government must guarantee completion of a project so the government cannot break its promise even if the Cabinet changes. It was decided to ask the World Bank for a loan of $80 million, and I was dispatched to the USA to explain the technical feasibility of the shinkansen early in 1960. Questions were serious and various including the financial condition of JNR, the profitability of the shinkansen, the reason for

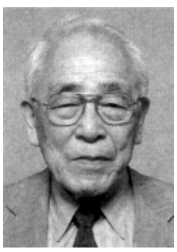


■ Narrow Gauge Super Express Kodama (Transportation Museum, Tokyo) using standard-gauge, the necessity for foreign funding, etc. One World Bank criterion excluded experimental techniques from loans. I persuaded the World Bank that shinkansen techniques included no experimental factor but was an integration of proven advanced technologies achieved under the slogan "Safety First".

It was a supreme priority to open the shinkansen before October 1964, when the Tokyo Olympic Games were to be held. Because part of the land had already been secured before the war, construction progressed quickly. However, the budget approved by the government was cut due to political considerations, and the shortage became clear as construction progressed. It was a serious political problem. In the end, the budget was increased twice to 380 billion yen. Assuming responsibility for this matter, President Sogo resigned just before the completion of the shinkansen. I also left with him. Therefore, Mr. Sogo, who conceived the shinkansen and myself, who helped design it, did not attend the opening ceremony.

I clearly remember explaining my idea to Mr. Louis Armand, President of the French National Railways when he visited Japan. At that time I was pondering over the shinkansen plan. Despite a long technical career, Mr. Armand was a human leader. Although he managed the French National Railways under German occupation during the war, he also guided the French Resistance. After the war, he was appointed President of the French National Railways, as well as Chairman of Euratom (the European Atomic Energy Commission) and Secretary General of UIC (The International Union of Railways). He was also a member of the Academie Francaise. It was wonderful to hear such a great man understand and agree with my idea to develop a high-standard, high-speed, passenger railway. I believe that Mr. Fernand Nouvion who developed high-speed electric cars under Mr. Armand as well as Mr. Bernand De Fongalland, who promoted the Paris-Lyons TGV, understood our idea too. Although Mr. Armand died in 1971, the engineers of the French National Railways who had studied under him built the wonderful TGV. At the news of the TGV completion, I could not help blessing their success and sent a letter of hearty congratulations to my old friends in France. ■

■ Series 0 Shinkansen Train near Ginza (*cf. previous page*)



Hideo Shima

Mr Shima was born in 1901 and studied at the University of Tokyo before he joined the railways in 1926. He became Director General of Rolling Stock Department in 1948. He left JNR once in 1951, but in 1955, he was appointed Vice President/Engineering by Mr Shinji Sogo, then President of JNR. He left JNR again in 1963 with Mr Sogo, without seeing the birth of their brainchild, the shinkansen. He became President of the National Space Development Agency in 1969, where he led Japan's space development programme until 1977. As one of the most prominent engineers in post-war Japan, he has been awarded various prizes and honours, including the Elmar A Sperry Prize by the American Society of Mechanical Engineers, and the James Watt Gold Medal by the British Institute of Mechanical Engineers.