

# **High-speed Railways in Japan**

## **A Short History and Current Topics**

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### **Introduction**

'High speed' in today's railway is generally understood to mean 'regular revenue-earning operation of passenger trains at more than 200 km/h', and true high-speed services in this sense began in Japan in 1964. Today, Japan's high-speed rail network slightly exceeds 2,000 km, carrying around 750,000 passengers every day without any fatal accident for nearly 40 years.

This paper presents a brief history of high-speed railways in Japan as well as current topics and future prospects. The opinions and evaluations stated in this paper are the author's personal view, and do not represent those of the Japanese governments or railway companies.

### **1. Success of Tokaido Shinkansen**

#### **1.1. Opening of the world's first high-speed railway**

In October 1964 Japanese National Railways (JNR) opened a new railway line between Tokyo and Osaka (515km). The new standard-gauge double track electrified at 25 kV, 60 Hertz was called New Tokaido Line or simply Shinkansen (new trunk line). The main intention of building this line was to relieve the overcrowded existing narrow gauge (1067mm) Tokaido line (556 km from Tokyo to Osaka), but it had many unique features compared with traditional railways.

The Shinkansen was wholly dedicated to high-speed intercity passenger trains, with no mixed traffic with slow commuter and freight trains. The maximum speed of 210 km/h was much higher than that of the existing narrow-gauge Japanese network. It even exceeded by far the European standard at that time. In those days 160 km/h was regarded as the acceptable maximum speed, as engineers

thought it impossible to keep the track in good order if trains ran faster than that every day. The JNR engineers challenged this preoccupation and successfully made a breakthrough, although intensive maintenance works were necessary at night. The rapid services with two intermediate stops made the 515-km run in 3 hours and 10 minutes, an average of 166 km/h.

### **1.2. Technical features**

To allow such high speed, sharp curves and abrupt gradients were avoided and no level crossing was permitted. All trains were of multiple-unit formation, each being composed of 12 or 16 railcars equipped with motive power. This facilitated quick turn-rounds at termini, and permitted the heavy electric components to be evenly distributed along the whole length of the train, thus reducing undesirable dynamic forces that might otherwise cause serious damage to the track. With a traction motor on each axle, a very powerful braking force was made available by switching the motor into a dynamic brake, generating electric current by the kinetic energy of the running train and absorbing it by heating a rheostat. This was important for the shinkansen, as there were more than 10 intermediate stations on the 515-km line, requiring frequent acceleration and braking.

There were no line-side signals, and a receiver on the leading car detected the pulse frequency transmitted by the track circuit on which the train was running, and the speed instruction was shown on a panel in front of the driver. If he exceeded the speed limit indicated on the panel, the brake was automatically applied.

Traffic control was centralized at the Tokyo station. In so far as trains were running on schedule, route setting (turning switching points as required) was automatically carried out as programmed. When certain trains were running late or out of sequence, the computerized traffic control system proposed a revised train schedule and executed the accordingly modified route setting.

Shinkansen was by no means a reckless adventure. Its technology was, though much advanced, a combination of proven techniques already available at that time.

### **1.3. Commercial success**

Tokaido Shinkansen served Japan's most important transport corridor, along which a half of the country's entire population lived. Shinkansen's high speed attracted customers despite a fairly expensive supplement charged on top of the normal fare, and the number of passengers grew very rapidly. The high speed also meant high productivity and high profitability, with fewer rolling stock and workforce providing a larger transport capacity and better quality of service. By the third year of operations, the revenue had exceeded the costs, including the interest and the depreciation of the initial investment.

## 2. Network expansion

### 2.1. San'yo Shinkansen

Before the opening of the Tokaido Shinkansen, a number of people criticized the project comparing the 515-km high-speed line to the Great Wall of China or the Pyramids of Egypt. After the opening, however, people's scepticism was quickly replaced with a nation-wide enthusiasm for shinkansen. Satisfied with the high performance of the Tokaido Shinkansen, JNR decided to extend the shinkansen westward from Osaka and construction works started for Osaka-Okayama section (161 km) in 1967 and for Okayama-Hakata (Fukuoka) section (393 km) in 1970. The former was opened in 1972, and the whole Osaka-Hakata section was opened in 1975.

### 2.2. Nation-wide Shinkansen Development Act of 1970

Politicians also learned that shinkansen construction could be a good vote-gathering machine, and they concentrated their efforts to draw up a master plan for a nation-wide shinkansen network.

As for road network, the National Principal Expressway Construction Act was enacted already in 1966, with a table of future expressway routes totalling 7,600 km. Politicians wanted a similar arrangement for shinkansen, and the 1970 Diet promptly passed the *Nation-wide Shinkansen Network Development Act*. As for planning and construction of future shinkansen network, the 1970 Act stipulates the following three steps.

First, the Minister of Transport decides a '*basic plan*' of future shinkansen routes. After deciding the basic plan, the Minister can order necessary investigations for future construction.

Second, the Minister of Transport decides a '*preparatory plan*' for construction, based on the above-mentioned investigation. Then the Minister can order to the construction body to submit a '*construction plan*' to start real engineering works.

Third, the Minister approves '*construction plan*' and the real construction work starts.

The constructing is usually done by the state-owned Japan Railway Construction Public Corporation (JRCC, recently reorganized as Japan Railway Construction, Transport and Technology Agency or JRJT), which was founded in 1964. In the case of Tohoku Shinkansen from Tokyo to the North, however, the construction was executed by JNR. Following the above-mentioned procedure, the Minister of Transport decided future plans step by step from 1971 to 73.

Priority was given to Tohoku Shinkansen from Tokyo to Morioka (497 km), Joetsu Shinkansen branching from Tohoku Shinkansen at Omiya to Niigata (270 km), and Narita Shinkansen from Tokyo to Narita (65 km) where a new international airport was to be built. The basic plans for these three lines were decided in January 1971, followed by their preparatory plans decided in April 1971, and the construction plans were approved between late 1971 and early 1972.

Following the top three lines, preparatory plans were decided in November 1973 for Tohoku

Shinkansen's extension to Aomori, Hokkaido Shinkansen from Honshu via Seikan undersea tunnel to Sapporo, Hokuriku Shinkansen from Tokyo to Osaka via Kanazawa, Kyushu Shinkansen from Fukuoka to Kagoshima and Nagasaki. These five lines are together called 'Seibi Shinkansen' (shinkansen in preparation), and their construction still draws much attention from politicians and local authorities.

More than ten routes (totalling 3,500 km) were given only their basic plans by November 1973. The total length of these shinkansen lines including Tokaido and San'yo Shinkansen is approximately 6,900 km.

### **2.3. Opening of Tohoku and Joetsu shinkansen**

However, just a few days after the decision of shinkansen plans, the Government was forced to announce a series of emergency measures to cope with the disastrous inflation caused by the 1973 oil crisis, and public works projects including shinkansen construction were frozen up or left on the shelf.

The construction works of the 'top three' were not cancelled, but works slowed down due to reduced budget. Narita Shinkansen was met by hostile protests of local residents, and the whole plan was abandoned later. The works of Tohoku and Joetsu Shinkansen took a long time. In 1982 both shinkansen started revenue-earning services northward from Omiya. Because of severe protests from local residents, both lines reached Tokyo's Ueno terminal in 1985. They reached Tokyo (Central) Station only in 1991.

### **2.4. Noise problems**

Shinkansen was generally welcomed by the public, but as the number of trains rose, the JNR began to face serious protests over noise in some areas where people live very close to the line. In the mid 1970s, the Government set a very strict guideline for noise protection, and the JNR had to spend an enormous amount of money in fulfilling the requirements. The noise problem prevented further improvement of speed. By the mid 1980s, however, the maximum speed has been raised gradually from 210 km/h to 220km/h between Tokyo and Osaka, 230km/h from Osaka to the West, and 240km/h from Tokyo to the North.

### **2.5. Severe road and air competition causing JNR deficits**

The Tokaido Shinkansen was a great success for JNR. The paradox was, however, that JNR began to show huge deficits as soon as the Tokaido Shinkansen started commercial services in 1964.

The JNR's deficits at the first stage came mainly from road and air competition. Car ownership started to grow rapidly from the early 1960. JNR registered its first deficit in 1969, coinciding with the opening of the Tokaido Shinkansen. Air transport also started to grow rapidly from the late

1960s, as airports were built in provinces and the people gradually became familiar with airplanes as their income level improved.

## **2.6. JNR's financial crisis**

From 1971 onward, JNR's expenditure excluding depreciation exceeded revenue. JNR made several attempts to stem the losses mainly in three directions: a) by raising fares to increase revenues; b) by reducing staff by mechanising labour-intensive operations and closure of lightly-used freight stations and rural lines, etc.; c) by seeking more financial support from public funds.

Higher fares were very unpopular. Moreover, fare hikes did not bring proportional revenue increases, as passengers shifted increasingly from trains to cars and airplanes.

JNR's workforce reduction never meant real dismissals, proceeding slowly by partial replacement of retiring employees. Nevertheless, trade unions were firmly opposed to any kind of rationalization. As labour-management relationship deteriorated, strikes were repeated every year from the late 1960s to the early 1980s.

As the result of the Government's reluctance to give cash to the railway, public grants covered only a small part of huge deficits, and most of the losses were covered by private and public loans that later accumulated enormous amount of interest.

To make things even worse, politicians forced JNR to continue a high level of investments including loss-making new lines in rural areas and expensive new shinkansen lines. Political pressures often hindered JNR from closing lightly used rural lines.

## **2.7. Shinkansen's financial merits and demerits**

As previously mentioned, the Tokaido Shinkansen started to register profits from the third year, covering depreciation and interests of the initial investment. The narrow-gauge Tokaido Main Line suffered from losses caused by reduced traffic volume, but the profit from shinkansen could cover the loss of the conventional line.

In the case of San'yo route, however, the shinkansen's profit was never sufficient to cover the losses from the narrow-gauge line.

Tohoku and Joetsu Shinkansen suffered from higher and construction costs as well as smaller traffic volume compared with Tokaido and San'yo routes. Together with the unprofitable parallel narrow-gauge lines, the losses from the Tohoku and Joetsu routes exceeded by far the profits from Tokaido and San'yo routes.

Unlike road construction, there was clear funding arrangement for shinkansen construction. The only available funds for shinkansen construction were therefore private and government loans, which also accumulated interests to an enormous burden for JNR.

## **2.8. Lack of overall policy coordination**

Despite the deepening financial crisis of JNR, the government's policy lacked coherence and coordination between different government departments. The Government worked out the so-called 'Comprehensive National Land Development Plan' for several times. Transport infrastructure development programmes were mentioned every time, but these were always based on a mixture of wishes from different ministries. As a result, demand forecast tended to be optimistic, justifying political pressures for investment in all kinds of transport infrastructure.

The Ministry of Transport tried in 1978 to establish a special financial arrangement for 'land public transport development' by creating a new tax on private cars and trucks. This attempt failed, because of the road lobby's firm opposition, and the reluctance of the Ministry of Construction (in charge of road construction and maintenance) and the Ministry of Finance. Comprehensive transport policy of this kind was never discussed since then. In 2001, the Transport and Construction ministries were merged into a huge new department called Ministry of Land, Infrastructure and Transport, but there is little sign of reducing sectionalism between the road and railway camps.

## **2.9. Last days of JNR**

Since JNR fell into the red in 1964, the Government and JNR announced six consecutive rehabilitation plans, but all of them failed. In these plans, future demand was always overestimated, and a high level of investment was continued despite the disastrous financial performance. However, the shinkansen projects at the preparatory stage were finally suspended in 1982.

In 1985, a specially established government committee (composed of business leaders, men of learning and experience, and government officials) concluded that JNR should be split into six regional passenger railways and one national freight system, and all of these new railway companies should be privatised. The Government accepted this conclusion, and quickly prepared necessary legislation to close JNR's 38-year-long history on 31 March 1987. The majority of people welcomed this conclusion.

The proposed radical reform was the inevitable consequence of many failures made in the previous decades by the government, politicians, JNR managers, trade union leaders, the media, etc. In short, Japanese people failed to adapt JNR to the changing transport market. Nobody understood the real significance of the growth of motor and air transport, which deprived the railway of its monopoly in the market. People continued to think that JNR is an unsinkable battleship, and they continued to demand something that JNR could no longer afford.

### **3. 1987 JNR Reform and Its Consequences**

#### **3.1. Outline of the JNR reform**

On 1 April 1987, JNR's railway operation was taken over by six passenger railway companies and one national rail freight company. Each of smaller islands of Hokkaido, Shikoku and Kyushu has one passenger company (JR Hokkaido, JR Shikoku and JR Kyushu), and Honshu was divided into three (the Tokyo-based JR East, Nagoya-based JR Central and Osaka-based JR West).

To assure a sound financial basis to the new railway companies, JNR Settlement Corporation (JNRSC) was founded as a government-owned liquidation company, which took over a greater part of JNR's long-term debts, surplus railway land such as disused freight terminals and marshalling yards, and redundant workforce.

Three passenger companies on the main island of Honshu were expected to be profitable due to dense urban operations and frequent intercity services, but other three companies on the smaller islands of Hokkaido, Shikoku and Kyushu were not able to make money. The Government therefore created the so-called 'Management Stability Fund' to cover their losses. These three passenger companies and freight company did not take over any long-term debts from JNR, while three passenger company on Honshu Island took over a substantial amount of debts in accordance with their assets.

Freight trains run mostly on passenger companies' tracks. Track access charge is set low and only covers marginal costs.

The workforce was reduced from 280 thousand to 200 thousand.

All the new railway companies took the form of joint-stock company, but all shares were held by the JNRSC at the first stage.

All the existing shinkansen lines were to be run by the three Honshu companies: Tokaido by JR Central, San'yō by JR West, and Tohoku as well as Joetsu by JR East.

#### **3.2. Short-lived Shinkansen Holding Corporation**

Because of the differences in profitability between the four existing shinkansen lines, the government-owned Shinkansen Holding Corporation (SHC) was founded to hold shinkansen infrastructure. Track usage fees were calculated based on the replacement value (not the book value) and traffic volume of each line. The revenue of the SHC was mainly used to repay historical debts accumulated by shinkansen construction.

There were several problems with this arrangement. First, the conditions of transferring shinkansen assets to the operating company were not clear, and for this reason, the real value of the shinkansen operating companies is difficult to evaluate. Second, the amount of liability of shinkansen operating companies could be fixed because access charge could be changed in future under the current

arrangement. Third, the operating companies could not reserve depreciation funds, while they are responsible for the maintenance and renewal of the tracks.

Some JR companies therefore preferred to own shinkansen tracks themselves. Transfer of shinkansen tracks was even thought essential for the Government to list the shares of the shinkansen-operating JRs on the stock exchange, because investors would demand a clear and detailed financial statement for each company.

### **3.3. Purchase of shinkansen tracks by JRs**

In 1991, the Government sold the shinkansen infrastructure held by SHC to the three shinkansen-operating JR companies. The purchase price was recalculated and set at 9.1 trillion yen. In other words, 1.1 trillion yen was added to the current value. The Government used this additional 1.1 trillion yen as a part of funds for shinkansen extension, through a newly created state-owned body. The Government established a kind of exclusive fund for shinkansen construction by this arrangement, but the amount is very modest compared to the huge funds for road construction. Moreover, this fund is borne in the end by the users of existing shinkansen, especially those taking trains on the busiest Tokaido Shinkansen.

### **3.4. New arrangement for shinkansen extension**

After the 1987 railway reform, political pressure for shinkansen extension regained strength, as politicians thought that the railway's crisis was over. The Ministry of Transport decided to take a step forward to resume the construction that had been frozen since 1982. In 1988, after a series of discussions, the following outline was agreed between the Ministry and the ruling political parties.

To reduce the financial burden on the newly created JRs, it was agreed that the central government and the local authorities bear half (35 % by the central government and 15 % by local governments concerned) of the costs, not including rolling stock. The remainder is to be borne by JRs. The Japan Railway Construction Public Corporation (JRCC) is entrusted with engineering works, and the ownership of the completed lines remains in the hands of JRCC. The JRs are to operate their trains on these lines paying duly calculated track usage charges.

Another consideration to ease JR's burden was to separate the parallel narrow-gauge line from their responsibility. If local residents want to keep the narrow-gauge line, the local authority concerned has to found a new company to operate it. Tracks are given to the new company free of charge. The closure of existing lines may raise problems not only with local residents but also with JR Freight, unless a cheap access charge for freight trains is assured.

### **3.5. Reducing construction costs**

A substantial cut of total costs was needed to justify resuming the expensive construction works. It



was therefore agreed that some sections with smaller traffic should be built either as 'narrow-gauge tracks built on shinkansen track bed' (called *Super Express* option) or as 'standard-gauge tracks built on existing narrow-gauge alignment' (*Mini Shinkansen* option).

The first shinkansen line built under this arrangement to full shinkansen standards was Takasaki-Nagano section of the Hokuriku-Shinkansen, which was due open in October 1997 in order to serve the 1998 winter Olympic games. Construction works started, with *Super Express* and *Mini Shinkansen* options, for Tohoku Shinkansen extension as well as some sections of Hokuriku and Kyushu Shinkansen.

Local residents were not happy with the 1988 agreement, especially with the *Super Express* and *Mini Shinkansen* options. Some people even argued that such cheaper versions were discrimination to their provinces.

From December 1996 to January 1998, there were discussions between the Government and the ruling political parties. Under strong political pressure, some sections previously planned with cheaper options were changed to full-standard shinkansen. Construction plans were approved for some new sections. It was confirmed that JR's burden should not go beyond the amount that JR would benefit from the new shinkansen operations.

### **3.6. Mini shinkansen for Yamagata and Akita**

There are a number of regions that will never be served by shinkansen even the current projects are all completed. Seeking a realistic solution, some regions proposed rebuilding existing narrow-gauge lines into standard gauge to enable through operations with nearby shinkansen lines.

Yamagata Shinkansen is the first successful example of this kind. It started commercial services in 1992, using the 87-km stretch of Ou Main Line between Fukushima and Yamagata. The line is connected to the Tohoku Shinkansen at Fukushima. Most sections were converted into standard gauge, but one section was rebuilt to mixed gauge to assure freight operation. In 1999, Yamagata Shinkansen was extended from Yamagata to Shinjo (62 km).

The Akita Shinkansen opened in 1997 is the second example, linking Morioka at the north end of Tohoku Shinkansen to Akita. It uses the 83-km Tazawako Line from Morioka to Omagari and the 52-km stretch of Ou Main Line from Omagari to Akita. The Tazawako Line was completely rebuilt to standard gauge, whereas the single-track section of Ou Line was rebuilt to standard gauge and the double-track section was separated into one narrow-gauge and one standard-gauge single tracks, to assure narrow-gauge through operation.

Both Yamagata and Akita Mini Shinkansen received substantial financial support from the local authorities concerned, and were welcomed by local residents. Traffic volume increased considerably, with a sharp drop of airline users.

### **3.7. Developments after JNR privatisation**

After the start of new JR companies in 1987, the traffic volume on shinkansen rose sharply, helped by the economic boom in the late 1980s. However, the traffic volume stopped to grow after the burst of the so-called bubble economy in 1991. Due to stagnant economy and declining active population, there is no sign of traffic growth in recent years.

The JRs have kept virtually the same fare levels for more than 16 years. Despite the severe noise-protection guidelines, train speeds were improved on all shinkansen routes up to 270 km/h. Some trains run at 300 km/h on San'yo Shinkansen.

The growth of Tokyo Metropolitan Area resulted in the spread of population into neighbouring areas. Some people started to use shinkansen trains for commuting between their homes and offices. As employers started to pay allowances for buying expensive shinkansen season tickets, the number of shinkansen commuters grew rapidly. JR East, in charge of Tohoku and Joetsu Shinkansen, built entirely double-decked trains to increase seating capacity for commuters.

## **4. Current Topics**

### **4.1. Saturating Tokaido and MAGLEV project**

Tokaido Shinkansen run by JR Central carries more 300 thousand passengers every day, and 11 trains per hour depart from the Tokyo terminal during peak hours. The line is almost saturating, and if the traffic continues to grow, another shinkansen will be needed in the near future.

The MAGLEV (magnetic levitation) project is envisaged for this reason. The technical research started by JNR engineers as early as in 1962. A test track was built in Kyushu and an unmanned test train attained a speed record of 517 km/h in 1979.

After the 1987 JNR reform, the project was taken over by JR Central and the newly founded Railway Technical Research Institute. A new test track was built some 100 km west of Tokyo on the alignment where the second Tokyo–Osaka Shinkansen (officially called Chuo Shinkansen) is to be built. An unmanned test train established a maximum speed of 550 km/h in December 1997. The test is being continued using two train sets.

Although the recent achievements show that at least the project may be technically feasible, no one knows how much it will cost to build and operate a maglev line until all technical details are fixed.

Moreover, there are some serious doubts on the future of the project. Apart from the technical and financial feasibility of the maglev system, the problem of incompatibility with the existing rail network must be examined carefully. The past arguments concerning shinkansen extension were fuelled by the inability of through operation between shinkansen and conventional lines. The introduction of totally different system may cause similar conflicts.

Future demand should also be examined carefully. Recent statistics show that Japan's population soon starts to decline. The nation is ageing rapidly, with a sharp decrease in active population. In the meantime, JR Central opened a new station at Shinagawa in October 2003, as a temporary relief to the busy Tokaido Shinkansen.. Located 7 km south of Tokyo Station with two platforms and four tracks, the new station enables 15 train departures per hour in each direction.

#### **4.2. Opening of new sections and current construction works**

Following the opening of the 117-km Takasaki–Nagano section of Hokuriku Shinkansen (Usually called Nagano Shinkansen) in 1997, the 97-km Morioka–Hachinohe section of Tohoku Shinkansen was opened in 2002. The 127-km Yatsushiro–Kagoshima section of Kyushu Shinkansen will be opened in March 2004. This section will be isolated shinkansen line until the 130-km Hakata–Yatsushiro section is completed.

Construction works are under way on the 82-km Hachinohe–Aomori section of Tohoku Shinkansen, the 170-km Nagano–Toyama section and the 24-km Isurugi–Kanazawa section of Hokuriku Shinkansen, and the 130-km Hakata–Yatsushiro section of Kyushu Shinkansen. Due to limited construction funds, it will take many years to complete these sections.

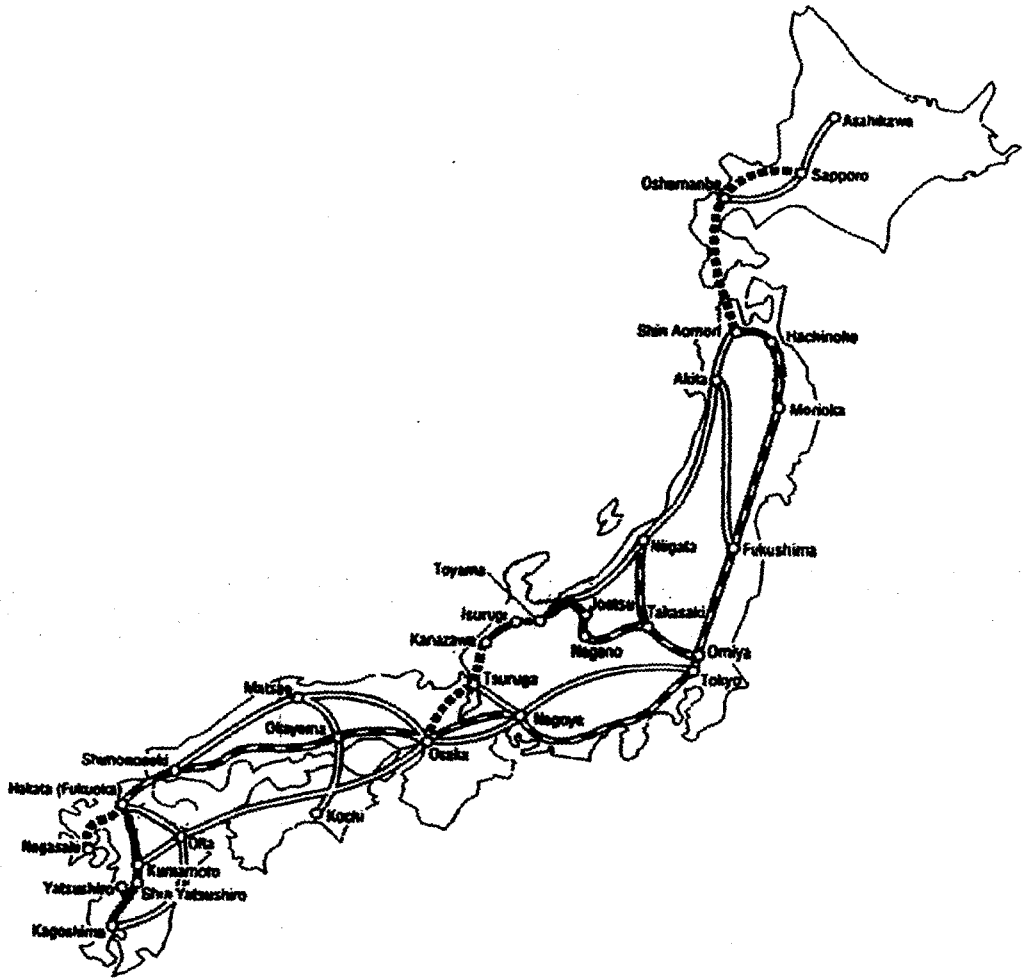
#### **Conclusion**

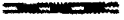



In Japan, the railway still shows its strengths in very crowded metropolitan areas and on congested intercity routes, but otherwise car has become people's first choice. Japan's high economic growth ended many years ago, and the coming years will see, even after the current recession is overcome, more stabilised, if not stagnant, economy with ageing population. Japan is in transition from an industrial to a post-industrial society.

Under such circumstances, one may question whether people really want expensive new shinkansen lines in return for losing existing narrow-gauge services that are more closely related to their daily life. Japan already has a 2,000-km network of high-speed railways covering the majority of industrialised and urbanised areas. It will be extremely difficult to run additional shinkansen lines in profit, even if substantial financial supports are granted for construction.

Although politicians are still insisting on the 30-year-old shinkansen extension programme, it is probably worthwhile to return to the drawing board and rethink the whole projects seriously. If people really want new shinkansen lines, every effort should be made to form a national consensus to arrange reasonable funding method comparable with that of road construction.

**Figure 1. Nationwide Shinkansen Master Plan in 2003**



	In service	2,050 km
	Under construction	533 km
	Preparatory plan decided	767 km
	Basic project only	3,510 km
	<b>Total</b>	<b>6,860 km</b>

**Table1 Growth of Shinkansen Traffic (million passenger-kilometers)**

Year *1	Network length	Tokaido+Sanyo	Tohoku	Joetsu	Hokuriku	Total
1964/65	515 km *2	3,912				3,912
1965/66		10,651				10,651
1966/67		14,489				14,489
1967/68		17,991				17,991
1968/69		21,027				21,027
1969/70		22,816				22,816
1970/71		27,890				27,890
1971/72		26,795				26,795
1972/73	676 km *3	33,835				33,835
1973/74		38,990				38,990
1974/75		40,671				40,671
1975/76	1,069 km *4	53,318				53,318
1976/77		48,149				48,149
1977/78		42,187				42,187
1978/79		41,074				41,074
1979/80		40,986				40,986
1980/81		41,790				41,790
1981/82		41,717				41,717
1982/83	1,804 km *5	41,489	3,743	873		46,105
1983/84		42,186	5,989	2,265		50,440
1984/85		42,197	6,174	2,455		50,826
1985/86	1,832 km *6	43,864	8,393	3,166		55,423
1986/87		44,230	8,525	3,188		55,943
1987/88 *7		45,276	8,929	3,209		57,414
1988/89		51,091	9,677	3,583		64,351
1989/90		52,406	9,892	3,666		65,965
1990/91		57,406	10,678	4,089		72,173
1991/92	1,835 km *8	58,119	11,689	4,413		74,221
1992/93		56,816	11,837	4,408		73,061
1993/94		56,529	11,695	4,339		72,563
1994/95		52,218	11,763	4,267		68,248
1995/96		54,576	11,956	4,295		70,827
1996/97		56,429	12,165	4,354		72,948
1997/98	1,953 km *9	56,066	12,278	4,400	469	73,213
1998/99		53,554	12,071	4,589	795	71,019
1999/00		52,502	12,146	4,589	799	70,035
2000/01		53,475	12,297	4,575	806	71,153

**Notes**

- \*1 From 1 April to 31 March
- \*2 The first shinkansen from Tokyo to Shin-Osaka opened in October 1964
- \*3 Sanyo Shinkansen between Shin-Osaka and Okayama opened in March 1972
- \*4 Sanyo Shinkansen extended to Hakata in March 1975
- \*5 Tohoku Shinkansen opened between Omiya and Morioka in June 1982  
Joetsu Shinkansen opened between Omiya and Niigata in November 1982
- \*6 Tohoku and Joetsu Shinkansen extended to Tokyo (Ueno) in March 1985
- \*7 Privatisation of JNR took place in April 1987
- \*8 Tohoku and Joetsu Shinkansen extended to Tokyo Central in March 1985
- \*9 Hokuriku Shinkansen from Takasaki to Nagano opened in October 1997

Source: Ministry of Transport, Japanese National Railways

Table 2. Balance between Shinkansen and Conventional Operations within Same Sections in FY 1985

		Tokyo-Hokkaido			Tochoku	Joetsu	Total
		Tohoku	Sanyo	Total			
Shinkansen	Revenue	6,756	2,063	9,599	2,976	6,815	12,49
	Expense	2,857	2,003	4,922	3,667	1,594	10,183
	Profit & Loss	3,899	9,776	4,677	-1,591	-9,779	2,307
Conventional	Revenue	3,206	1,503	4,949	1,533	6,606	7,09
	Expense	4,943	3,449	8,392	2,52	1,068	11,96
	Profit & Loss	-1,557	-1,946	-3,443	-9,987	-9,460	-4,890
Total	Revenue	10,142	4,406	14,548	3,699	1,423	19,590
	Expense	7,800	5,514	13,314	6,167	2,662	22,163
	Profit & Loss	2,342	-1,108	1,234	-2,578	-1,239	-2,583

(Billion Yen)