



UCL

PROJECT PROFILE

Japan

Kyushu Shinkansen Kagoshima route

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Centre for Mega Projects in Transport and Development

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A INTRODUCTION

Outline of the project

The Kyushu Shinkansen Kagoshima route will be a railway line of about 257km in length, starting at Hakata Station, the terminal station on Sanyo Shinkansen, passing through the prefectures of Saga and Kumamoto, and ending at Nishi-Kagoshima Station. As the transport means connecting the northern and southern cities in Kyushu to each other and forming an axis in the Japanese territory, this line will play an important role in the high-speed traffic networks of the 21st Century, and will constitute the infrastructure needed to improve living standards and activate the industries in this region.

In August 1991, construction work for a 'super express system' line between Yatsushiro and Nishi-Kagoshima started, after receiving the Government's authorisation. Later, the decision was made to construct the whole Kagoshima route in accordance with the full standard, after additional authorisations were given for the construction of this route in March 1998 and April 2001. In addition to the railway sections that have been opened, therefore, construction work is being carried out for the section between Hakata and Shin-Yatsushiro.

The Shin-Yatsushiro ~ Kagoshima-Chuo section was opened in March 2004. The total length of this section is about 128km including the elevated section of 1km (car storage truck) starting at Shin-Yatsushiro Station.

The construction project for the Kagoshima route (between Shin-Yatsushiro and Kagoshima-Chuo) will be outlined as follows:

Standard:

- New standard-gauge railway line (full standard);

Total lengths:

- Total length of constructed line: 127.6km;
- Total length of railway line: 126.1km.

Stations and their locations:

- Shin-Yatsushiro Station (Yatsushiro city, Kumamoto prefecture);
- Shin-Minamata Station (Minamata city, Kumamoto prefecture);
- Izumi Station (Izumi city, Kagoshima prefecture);
- Sendai Station (Satsuma-Sendai city, Kagoshima prefecture);
- Kagoshima-Chuo Station (Kagoshima city, Kagoshima prefecture).

Construction standards:

- Designed maximum speed: 260 km/h;
- Minimum curve radius: 4,000m (basic);
- Maximum grade: 35%;
- Track spacing: 4.3m;
- Electric mode for trolley line: 25,000 V (AC).

Types and total lengths of structures:

- Roadbeds: 15.0km (12%);
- Bridges: 9.0km (7%);
- Elevated bridges: 15.7km (12%);
- Tunnels: 87.9km (69%).

(cited from the 'Execution of Civil Works', P004).

Site and positions

Kyushu Shinkansen (between Shin-Yatsushiro and Kagoshima-Chuo) is a railway line of 127.6km length, between Yatsushiro city, Kumamoto prefecture and Kagoshima city, Kagoshima prefecture.

(cited from the 'Post-Assessment Report', 2.2 Outline of Project).




Current conditions


With the opening of the Kyushu Shinkansen line, the required time for a train to run on the railway line between Yatsushiro Station (the existing station) and Kagoshima-Chuo Station is about 35 minutes, compared to about two hours on the existing Kagoshima Main Line. The required time between Hakata and Kagoshima-Chuo will be two hours and ten minutes on the Shinkansen route including the transfer at Shin-Yatsushiro Station, compared to three hours and 40 minutes on the existing railway line. Thus, the required time on the Hakata ~ Kagoshima-Chuo Shinkansen line will be reduced by one hour and 30 minutes.

In March 2011 when the Hakata ~ Kagoshima-Chuo route is completed, the required time between Hakata and Kagoshima-Chuo will be about one hour and 20 minutes, shorter by about two hours and 20 minutes than the corresponding journey on the Kagoshima Main Line.

(cited from the 'Execution of Civil Works', P006).

Figure 1: Basic Plan for Shinkansen Railway Network

Total		Total length of route (to be constructed)	6,852 km
Operating routes 	Tokaido (Tokyo ~ Shin-Osaka)	515.4 km	2,175.9 km Projected Shinkansen 340.8 km
	Sanyo (Shin-Osaka ~ Hakata)	553.7 km	
	Tohoku (Tokyo ~ Morioka)	496.5 km	
	Tohoku (Morioka ~ Hachinohe)	96.6 km	
	Joetsu (Omiya ~ Niigata)	269.5 km	
	Hokuriku (Takasaki ~ Nagano)	117.4 km	
	Kyushu (Shin-Yatsushiro ~ Kagoshima-Chuo)	126.8 km	
Projected routes (Sections under construction) 	Hokkaido (Shin-Aomori ~ Shin-Hakodate)	148.8 km (148.7 km)	634.2 km (628.6 km)
	Tohoku (Hachinohe ~ Shin-Aomori)	81.8 km (81.2 km)	
	Hokuriku (Nagano ~ Kanazawa)	228.0 km (231.1 km)	
	Hokuriku (section around Fukui Station)	0.8 km (0.8 km)	
	Kyushu (Hakata ~ Shin-Yatsushiro)	130.0 km (121.1 km)	
	Kyushu (Takeo-Onsen ~ Isahaya)	44.8 km (45.7 km)	
Projected routes (Sections for which the construction work has not yet started) 	Hokkaido (Shin-Hakodate ~ Sapporo)	211.5 km	Approx. 532.7 km
	Hokuriku (Kanazawa ~ Tsuruga)	125.3 km	
	Hokuriku (Tsuruga ~ Osaka)	Approx. 123.3 km	
	Kyushu (Shin-Tosu ~ Takeo-Onsen)	Approx. 51.3 km	
	Kyushu (Isahaya ~ Nagasaki)	21.3 km	

Routes under Basic Plan 	Approx. 3,510 km
Hokkaido (Sapporo ~ Asahikawa)	
South of Hokkaido (Oshamanbe ~ Muroran ~ Sapporo)	
Uetsu (Toyama ~ Niigata ~ Akita ~ Aomori)	
Ou (Fukushima ~ Yamagata ~ Akita)	
Chuo (Tokyo ~ Osaka)	
Hokuriku-Chukyo (Tsuruga ~ Nagoya)	
San'in (Osaka ~ Matsue ~ Shimonoseki)	
Chugoku (Okayama ~ Matsue)	
Shikoku (Osaka ~ Takamatsu ~ Oita)	
Shikoku (Okayama ~ Takamatsu ~ Kochi)	
Higashi-Kyushu (Fukuoka ~ Oita ~ Kagoshima)	
Kyushu (Oita ~ Kumamoto)	

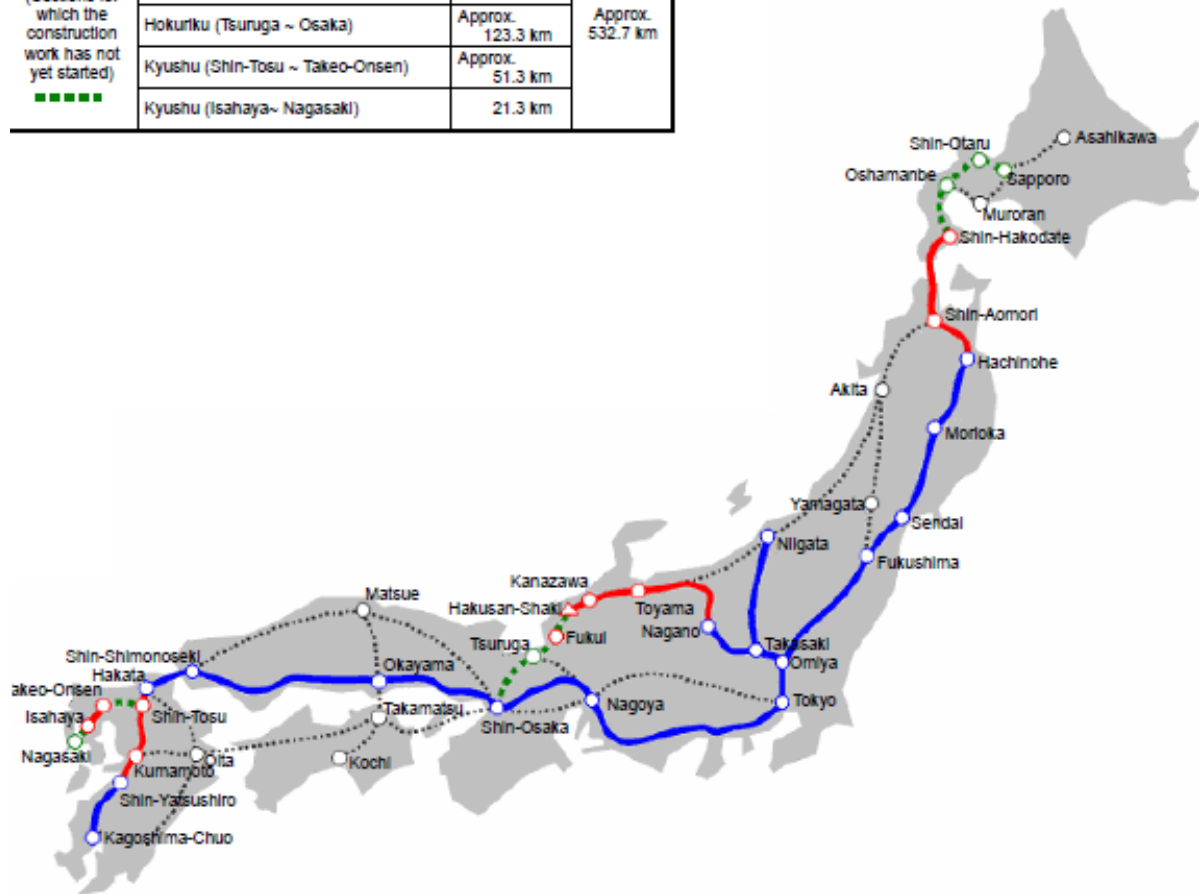
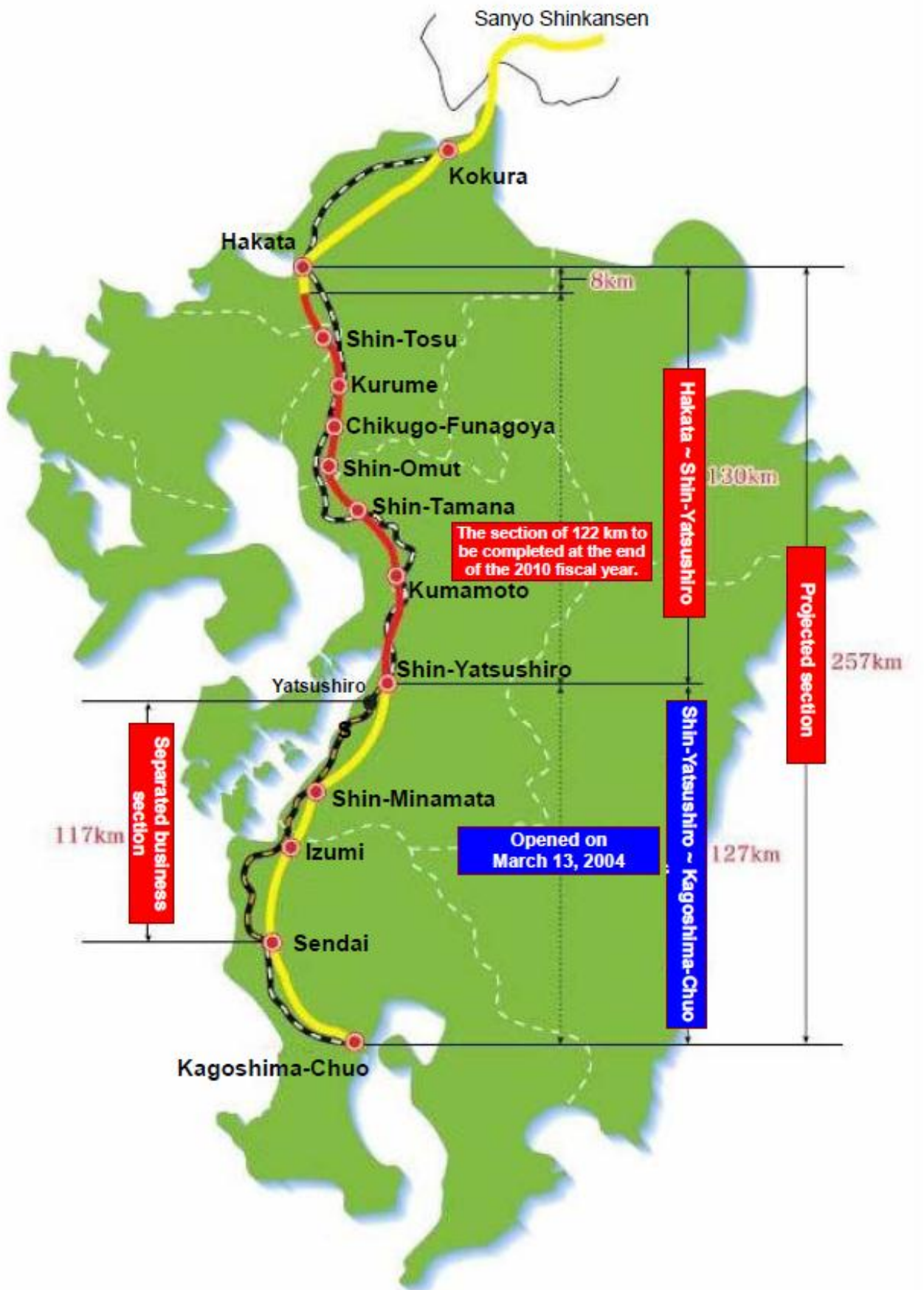


Figure 2: Kyushu Shinkansen Kagoshima Route



B BACKGROUND OF THE PROJECT

Main objective of the project

The Kyushu Shinkansen Kagoshima route is a part of the national Shinkansen railway network under the National Shinkansen Railway Construction Law, which aims to develop the national economy, enlarge the people's living scope, and contribute to the development of regional industries.

(cited from the 'Post-Assessment Report', 2.1 Objectives of Project).

Key enabling mechanisms

History before the start of construction was decided

The Construction Project for Kyushu Shinkansen Kagoshima Route (hereinafter referred to as the Project) was initially planned in accordance with the full standard (New standard-gauge railway line). However, the financial resources problem made it very difficult to construct the whole route. Therefore, the Review Committee, held in May 1988 to decide the initial priorities for construction of railway sections initially, confirmed that priority should be given to some sections to reduce construction costs. In June 1988, the Committee reviewed whether Hakata ~ Kumamoto and Kumamoto ~ Nishi-Kagoshima sections of Kyushu Shinkansen Railway should be partially constructed in accordance with the full standard, and proposed also the option of the super express system (a new line meeting the Shinkansen Railway Standard) for the Kumamoto ~ Nishi-Kagoshima section.

As a result, it was decided that the southern sections should be constructed first: the deciding factors included, but were not limited to, the existence of many single-line sections in the south of Kyushu, which had a bad linearity, and the potential to significantly reduce the time required for a train to run on these southern sections. In August 1988, the Japanese Government and the ruling party agreed on and published the option of the super express system as provided by the Ministry of Transport. Based on this option, they agreed on the construction of the Yatsushiro ~ Nishi-Kagoshima section in December 1990.

History after the start of construction work was decided

In August 1991, the construction of the Yatsushiro ~ Nishi-Kagoshima section in the super express mode was authorised and started. In March 1998, the construction of the Funagoya ~ Shin-Yatsushiro section in super express mode was authorised. In October 1998, however, the construction project for the Yatsushiro ~ Nishi-Kagoshima section was changed to set the starting point at Shin-Yatsushiro.

In December 1999, The Council for Promoting the Construction of the Projected Shinkansen Railways in the ruling party confirmed that the construction of the Hakata ~ Funagoya section should be started as soon as possible, and that the super express mode in the construction project for the Shin-Yatsushiro ~ Nishi-Kagoshima section should be changed into the full standard. In December 2000, the Government and the ruling party agreed that the Shin-Yatsushiro ~ Nishi-Kagoshima and Hakata ~ Shin-Yatsushiro sections should be constructed in accordance with the full standard, and that the Shin-Yatsushiro ~ Nishi-Kagoshima section should be completed by the end of 2003. As a result, in April 2001, the Shin-Yatsushiro ~ Nishi-Kagoshima section was changed from the super express system into the full standard, and the work execution plan was also changed and authorised.

(cited from the 'Post-Assessment Report', 2.3 Background of Project).

Table 1: Summarised chronological table of Kyushu Shinkansen Railway

Year	Month	Description
1970	May	The National Shinkansen Railway Construction Law was established.
1972	June	The Basic Plan [for Kyushu Shinkansen (Kagoshima route between Fukuoka and Kagoshima Cities)] was decided.
1973	November	The Construction Project [for Kyushu Shinkansen (Kagoshima route between Fukuoka and Kagoshima Cities)] was decided, and the construction order was issued.
1982	September	Based on the report by the Temporary Administrative Investigation Board, the Projected Shinkansen Railway Construction Plan was suspended temporarily [the Cabinet's decision].
1984	March	The summarised descriptions of the stations and routes where the environmental assessment should be made were published.
	October	The draft Environmental Assessment Report was published.
1986	August	The application for approval of the implementation of the Kyushu Shinkansen Railway (between Hakata and Nishi-Kagoshima) Construction Project was made.
1987	January	The Cabinet decision of September 1982 was changed (unfreezing the suspension of the Projected Shinkansen Railway Construction Plan).
1988	January	The Committee for Promoting the Construction of the Projected Shinkansen Railways was established.
	August	To start construction works for five sections on the three projected Shinkansen railways, the priorities were decided [Agreement between the Japanese Government and the Government party] Option M (Yatsushiro ~ Nishi-Kagoshima section: New line meeting the Shinkansen Railway Standard) proposed by the Ministry of Transport was adopted for Kyushu Shinkansen railway.
1989	August	The interim construction project for Kyushu Shinkansen railway (between Hakata and Nishi-Kagoshima) (New line meeting the Shinkansen Railway Standard) was decided, and the construction order was issued.
1990	December	It was decided to start construction work for a Kyushu Shinkansen section (between Yatsushiro and Nishi-Kagoshima) [Agreement between the Government and the ruling party].
1991	August	The application for approval of the work execution plan for the Kyushu Shinkansen section (between Yatsushiro and Nishi-Kagoshima) was made.
	August	The work execution plan for the Kyushu Shinkansen section (between Yatsushiro and Nishi-Kagoshima) was approved.
	August	The construction work for the Kyushu Shinkansen section (between Yatsushiro and Nishi-Kagoshima) was started.
1992	August	The application for authorisation of the urgent construction project for a Shinkansen railway station (Nishi-Kagoshima Station) was made and the project authorised.
1996	June	The urgent construction project for Nishi-Kagoshima Station was completed.
1998	March	The work execution plan for a Kyushu Shinkansen section (between Funagoya and Shin-Yatsushiro) was authorised.
	September	The application for the approval to the change in the work execution plan for the Kyushu Shinkansen section (between Yatsushiro and Nishi-Kagoshima) was made. (The starting point of the railway was also changed from Yatsushiro to Shin-Yatsushiro, and consequently, the railway section was changed from Yatsushiro ~ Nishi-Kagoshima to Shin-Yatsushiro ~ Nishi-Kagoshima.)
	October	The change in the work execution plan for the Kyushu Shinkansen section (between Yatsushiro and Nishi-Kagoshima) was approved.

Year	Month	Description
2000	December	It was decided to construct the Shin-Yatsushiro ~ Nishi-Kagoshima section in accordance with the full standard [Agreement between the Government and the ruling party].
2001	April	An additional application was made and approved regarding the work execution plan for the Kyushu Shinkansen section (between Shin-Yatsushiro and Nishi-Kagoshima). The work execution plan for the Kyushu Shinkansen section (between Hakata and Shin-Yatsushiro) was approved. (The Standard for this railway was changed from the New Line meeting the Shinkansen Railway Standard into the full standard.)
2004	March	The Kyushu Shinkansen section (between Shin-Yatsushiro and Kagoshima-Chuo) was opened. The name of Nishi-Kagoshima Station was changed to Kagoshima-Chuo Station.

Main related organisations

- The Central Government;
- The Ministry of Transport/Ministry of Land, Infrastructure, Transport and Tourism;
- Local governments (Kagoshima Prefecture and Kagoshima City);
- Japan Railway Construction Corporation/Japan Railway Construction, Transport and Technology Agency
- Japan National Railways/JR;
- Economic organisation (Kyushu and Yamaguchi Economic Federation).

Planning and environmental systems

The plan for rebuilding the Japanese Archipelago

The 'Plan for Rebuilding the Japanese Archipelago' was published in June 1972. The author, Mr Kakuei Tanaka, later became Prime Minister. From various viewpoints, this book describes techniques for solving "land development and city problems." It describes the Shinkansen railway projects as follows:

"These Shinkansen railways must be constructed not only to connect the densely populated regions to each other but also to construct new railway stations in the thinly populated regions intentionally to promote the implementation of the regional development projects around the stations. In this case, Japan National Railways, local governments, and other organizations will have to cooperate with each other in order to preferentially acquire the construction sites for the new stations and for railways in the surrounding areas. As a part of the comprehensive city plans in these regions, the related facilities such as railway stations, station buildings, station squares, and traffic terminals should be constructed around the stations. To construct, operate, and manage the related facilities, it will be desirable to establish the third sector comprising local governments and private sector companies. It may well be considered to adopt the same technique if Highway Corporations construct new interchanges on highways to promote the regional development by using them as bases."

(cited from the 'Plan for Rebuilding the Japanese Archipelago', p121).

National Shinkansen Railway Construction Law

National Shinkansen Railway Network Plan

- Concept of national Shinkansen railway network

Tokaido Shinkansen Railway was opened in October 1964, when the Olympic Games were held in Tokyo. Subsequently, the construction of Sanyo Shinkansen railway was started. The Shin-Osaka ~ Okayama railway line was opened in March 1972, and the Okayama ~ Hakata railway line started in March 1975. Thus, the Tokaido Shinkansen railway was connected to the Sanyo Shinkansen railway to complete a continuous high-speed railway between Tokyo and Hakata. The Tokaido ~ Sanyo Shinkansen has since functioned as Japan's main artery.

The opportunity to construct the national trunk railway network of Shinkansen railways has gradually ripened since the construction of Sanyo Shinkansen railway began in 1967. At that time, the Japanese economy was rapidly developing. As a result, the population and social and economic functions were rapidly concentrated on specific cities and regions, while local regions became more and more depopulated. Thus, problems have emerged from the gaps between local and metropolitan regions and the solution of these problems has been highlighted as an important challenge for the people. In these circumstances, people recognised the need to construct the national Shinkansen railway network to shorten travel times between regions, in order to eliminate the gaps between regions by decentralising population and industries and distributing profits accumulated in metropolitan cities to local regions. As a result, various concepts of Shinkansen railway networks were published by experts in various fields.

In the general meeting of the Civil Engineering Society of May 1967, the president proposed to reorganise the existing railway network, based on the high-speed railway network running through the Japanese territory. In addition, Japan National Railways published its concept of a national Shinkansen railway network in August 1967. In August 1968, Japan Railway Construction Corporation published its tentative concept of a national Shinkansen railway network in its report 'The Present Situation and Future Perspectives of New Railway Construction Projects'.

In these circumstances, the Japanese Government planned to drastically reform its National Land Use Planning from the viewpoints of solving the problems of densely and thinly populated regions and correcting the situation of unbalanced land uses to produce a new social environment. Thus, the Government completely revised the National Comprehensive Development Plan as prepared in 1962, and the Cabinet decided the new National Comprehensive Development Plan in May 1969. This was the long-term plan in which the 1965 and 1985 fiscal years were set as reference year and target year respectively. The Plan presented the concept of the national trunk railway network of 7,200km total length, which should constitute the integral component of a new traffic and communication network and should be constructed to concentrate central control functions and systematise logistic functions. Thus, the new National Comprehensive Development Plan was incorporated in the Government's National Land Use Planning and provided the foundation of subsequent Shinkansen railway construction projects.

- National Shinkansen Railway Construction Law

The Sanyo Shinkansen railway construction project was approved as the construction of an additional route. However, an important development took place in the Railway Construction Council meeting of June 1969. The Council, which was established to investigate and deliberate on important matters related to new railway lines, resolved the preparation of a

new bill to be submitted to the next regular session of the Diet, considering that the construction project for the new Shinkansen railway network except Sanyo Shinkansen railway should be reviewed from the viewpoints of balanced land development and the installation of a traffic system favourable for users. This resolution decided the Council's policy to carry out its future activities, and became the driving force to establish new related laws. The Council resolved the 'Outline of the draft National Shinkansen Railway Construction Law' in its meeting of March 1970. In May 1970, the 'draft National Shinkansen Railway Construction Law' was submitted to and adopted by the Diet and established. Subsequent Shinkansen railway construction projects have been implemented in accordance with the 'National Shinkansen Railway Construction Law' promulgated in May 1970.

The 'National Shinkansen Railway Construction Law' provides for the objectives of construction of Shinkansen railways, the definition of Shinkansen railway, routing conditions, procedures ranging from preparation of the basic plan and construction projects to the construction of Shinkansen railways, etc. The Law is characterised by the fact that to avoid the presentation of any projected railway route plan by any other interested party, the Land, Infrastructure, Transport and Tourism Minister decides the plan, based on the advice given by the Council. This proceeding was selected, considering the flexible response to the change of the time.

- National Shinkansen Railway Network

In 1971, the necessary proceedings were followed to start construction for the Tohoku Shinkansen railway (between Tokyo and Aomori in the basic Plan or between Tokyo and Morioka in the construction project) and the Joetsu and Narita Shinkansen railways. In 1972, the basic plans were decided for five Shinkansen railway routes: Tohoku, Hokkaido, Hokuriku, Kyushu (Kagoshima route) and Kyushu (Nagasaki route). In 1973, the construction projects for the five routes were decided, and the construction order was issued for Tohoku Shinkansen (between Tokyo and Aomori) and Hokkaido Shinkansen (between Aomori and Sapporo). In addition, the basic plans for twelve new routes including Chuo Shinkansen were decided. The five former routes are generally known as 'projected Shinkansen railways' or 'five projected routes'. Figure 1 shows the Shinkansen routes under the existing basic plans and construction projects as specified in the National Shinkansen Railway Construction Law, including the existing Shinkansen railways.

Projected Shinkansen railways

- Way to the start of construction work

The construction works for the projected Shinkansen railways were not promptly started after these projects had been decided, unlike the conventional Shinkansen railways. The construction work for the Takasaki ~ Karuizawa route on Hokuriku Shinkansen railway was started in 1989, several years after the project had been decided.

The reasons were that the construction costs were estimated at JPY five trillion in total, and that the Government and the National Railways were driven into severe financial difficulties by two oil shocks. In 1982, the Cabinet decided to freeze these projects. In 1985, however, the 'Review Committee on Problems such as financial resources for the projected Shinkansen railways' was established by the Government and the ruling party, and the Cabinet's decision to freeze the projects was abolished in 1987.

In January 1988, the Government and the ruling party established the 'Deliberative Committee for Promoting the Construction of the Projected Shinkansen Railways', which made concrete deliberations to start construction works for the projected Shinkansen

railways. Based on the standard proposed by the Ministry of Transport, in August 1988, the Government and the ruling party agreed on the priorities of the projected Shinkansen railways for which construction works should be started: [the first priority: Hokuriku Shinkansen railway section (between Takasaki and Karuizawa), the second: Hokuriku Shinkansen section (between Isurugi and Kanazawa), the third: Tohoku Shinkansen railway, the fourth: Kyushu Shinkansen Kagoshima route (between Yatsushiro and Nishi-Kagoshima), the fifth: Hokuriku Shinkansen railway section (between Itoigawa and Uozu)]. In January 1989, the Government and the ruling party agreed:

- that the construction costs should be shared by JR, the Government, and the local governments interested;
- that the Japan Railway Construction Corporation as the main contractor for the execution of construction works should own the facilities constructed, and lend them to the companies operating them (by the method of separating the upper and lower parts of the facilities); and
- that various requirements should be established at the start construction works, including the requirement that existing railways of conventional types (such as Shin'etsu Main Line between Yokokawa and Karuizawa) running in parallel with Shinkansen railways respectively should be disused when the latter are opened.

Thus, construction works for the projected Shinkansen railways were sequentially started in August 1989. It should be noted that the construction costs for Joetsu and other Shinkansen railways were partially paid by the Government and partially borrowed from financial institutions, and that the constructed facilities will become the assets owned by JR which operates them.

In December 1990, the Government and the ruling party agreed that before approving the construction of Shinkansen railways, they should confirm that conventional railways running in parallel with the Shinkansen sections to be constructed should be separated from the JR business when the Shinkansen railway sections were opened. In December 1996, the financial resources scheme was reviewed by consensus of the Government and the ruling party. In December 2000, the Government and the ruling party agreed that the construction periods for the sections under construction should be reduced, and that the construction works for new sections should be executed. The present situation resulted from these agreements and consensus.

- The standard option proposed by the Ministry of Transport and the priorities of Shinkansen railways for which construction works should be started.

The Shinkansen railways under construction present several differences from conventional Shinkansen railways. Especially from the viewpoint of facilities, they use three construction methods as described below, and present the significant feature that sections to be constructed are not the conventional type of Shinkansen and do not meet the full standard.

To solve the financial resources problem and reduce construction costs as well as travel time, the Ministry of Transport proposed the standard option which was the combination of three systems:

- the same 'new standard-gauge line (full standard)' as the conventional Shinkansen standard;
- the 'new Shinkansen railway standard line' (Seikan tunnel or super express system), which meets the full standard and is equipped with new narrow-gauge rails

- connected directly to the existing railways, as used in the Seikan tunnel; and
- the 'straight through type Shinkansen railway line (direct connection system or Mini Shinkansen railway' for which a rail is installed in addition to the two rails on the existing line to connect the line directly to a Shinkansen line.

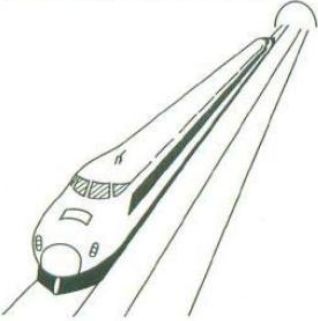
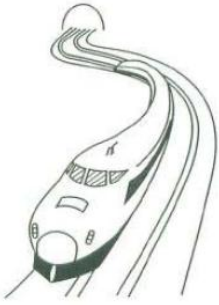
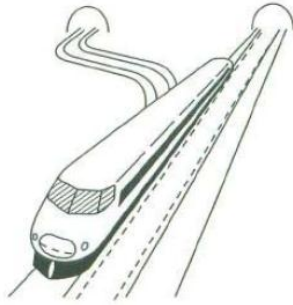
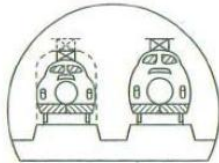
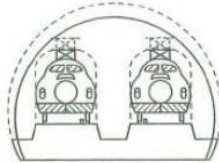
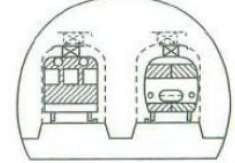
After the existing standards had been thus reviewed, the priorities of the line sections for which construction works should be started were decided in August 1988, considering various factors such as:

- long-term profitability in the railway business;
- the effects of investment on the national economy;
- future business outlooks and policies for the construction of Shinkansen railways expressed by JR companies operating Shinkansen railways; and
- the consensus reached by residents in affected areas regarding the construction of Shinkansen railways.

In 1991, the National Shinkansen Railway Construction Law was amended to temporarily construct 'Super Express railways' and 'Mini Shinkansen railways' under the Law.

Article 2 of the National Shinkansen Railway Construction Law provides that the 'Shinkansen railway' shall be defined as the trunk railway in which any train can run at a maximum speed of at least 200km/h on the main section. Therefore, the Super Express lines on which trains run at maximum speeds of 160 km/h to 200 km/h and the Mini Shinkansen lines on which trains run at a maximum speed of 130 km/h do not fall into the 'Shinkansen railway' category. However, the Super Express and Mini Shinkansen lines have functions alternative to those of the 'Shinkansen railway' meeting the full standard, and they are considered as temporary railways which can be used until the Shinkansen railways meeting the full standard start are constructed in the future. Therefore, the National Shinkansen Railway Construction Law was amended to set down the 'temporary' provisions on the Super Express and Mini Shinkansen lines in its schedule.

Figure 3: Shinkansen Systems

Standard Shinkansen (full standard)	Straight through Shinkansen line (direct connection system)	Shinkansen standard line (Seikan tunnel system)
		
 <p data-bbox="220 891 580 913">Mini Shinkansen Standard Shinkansen</p>	 <p data-bbox="724 891 863 913">Mini Shinkansen</p>	 <p data-bbox="1203 891 1326 913">Super Express</p>
<p data-bbox="277 943 539 965">(Maximum speed: 260 km/h)</p> <ul data-bbox="220 965 580 1077" style="list-style-type: none"> • A new roadbed is constructed in accordance with the Shinkansen standard. • The standard-gauge line is installed so that Shinkansen trains can run on it. 	<p data-bbox="676 943 938 965">(Maximum speed: 130 km/h)</p> <ul data-bbox="619 965 979 1077" style="list-style-type: none"> • The standard-gauge rails are added to the narrow-gauge rails on the existing roadbed. • The small-type Shinkansen trains run on the Mini Shinkansen line. 	<p data-bbox="1018 943 1390 965">(Maximum speed: 160 km/h to 200 km/h)</p> <ul data-bbox="1018 965 1390 1111" style="list-style-type: none"> • A new roadbed meeting the Shinkansen standard is constructed. (The standard-gauge rails may be installed in the future.) • The narrow-gauge line is installed for the time being so that high-speed trains can run on it.

Acquisition of sites

“Before we implemented the Project while obtaining the good understanding of the Project from residents in the related areas, we had published the summarised descriptions of stations and routes, made the environmental assessments, obtained the authorisation for the work execution plans, made the explanation of the Project in each related district, made consultations on designing with the persons responsible for controlling water supply and sewer systems and on the acquisition of sites, and made the explanation of construction works. It can be said that the Project could be completed without any significant trouble in cooperation with the related local governments by making effective use of our experiences in the past similar projects.”

(cited from the ‘Post-Assessment Report’, 9. Necessity of reviewing how to plan and investigate the main projects and the project assessment technique).

C MAIN FEATURES OF THE PROJECT

Selection of route

In the southern part of Kumamoto Prefecture, the selected route starts at Shin-Yatsushiro Station, which is built at the point where the Shinkansen route intersects with Kagoshima Main Line about 1.4km from Yatsushiro Station on the existing line toward Hakata. From Shin-Yatsushiro Station, the route goes south in the Yatsushiro plain, passes through a tunnel, intersects with Houhi Main Line and the Kuma River, passes through a series of tunnels penetrating the Kuma mountain district, and reaches Shin-Minamata Station on this route running in parallel with the existing line. Then, this route runs in parallel with the existing line, passes through the tunnel laid to the south in the hilly land facing the Yashiro Sea, and enters Kagoshima Prefecture. The route then crosses the elevated bridge near Sendai Station in common with the existing line, passes through the third Shibisan tunnel, the longest on this route, to the west of the Shiosan, the highest mountain in the northern Satsuma area, enters Sendai City, runs across the Sendai River and reaches Sendai Station in common with the existing line. From Sendai Station, this route passes by Sendai car depot towards Kagoshima, through many tunnels in the *shirasu* (a type of light gray volcanic ash) plateau specific to Kagoshima district and through the last Satsuma Tagami tunnel, reaching Kagoshima-Chuo Station by an elevated structure, intersecting with the existing line at right angles.

(cited from the 'Execution of Civil Works', p005).

Information about railway stations

Changes in the conditions of the developed areas around the railway stations (cited from the 'Post-Assessment Report', 5.3(6)).

Shin-Yatsushiro Station

The photos of Shin-Yatsushiro Station before and after the opening of the Kyushu Shinkansen railway are shown below.

Figure 4: Shinkansen route before its opening (Shin-Yatsushiro)

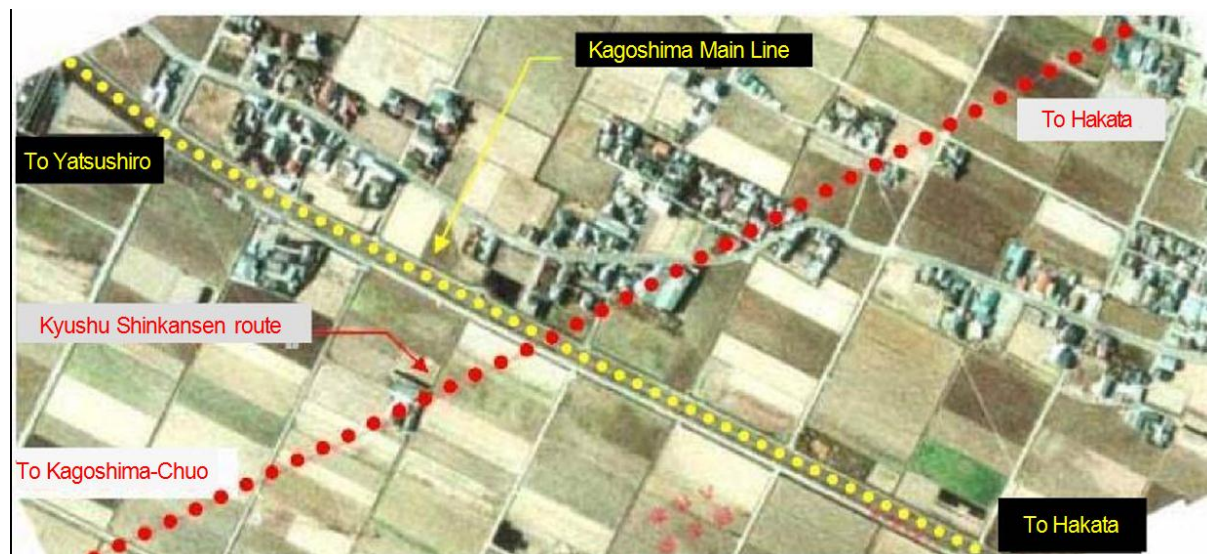
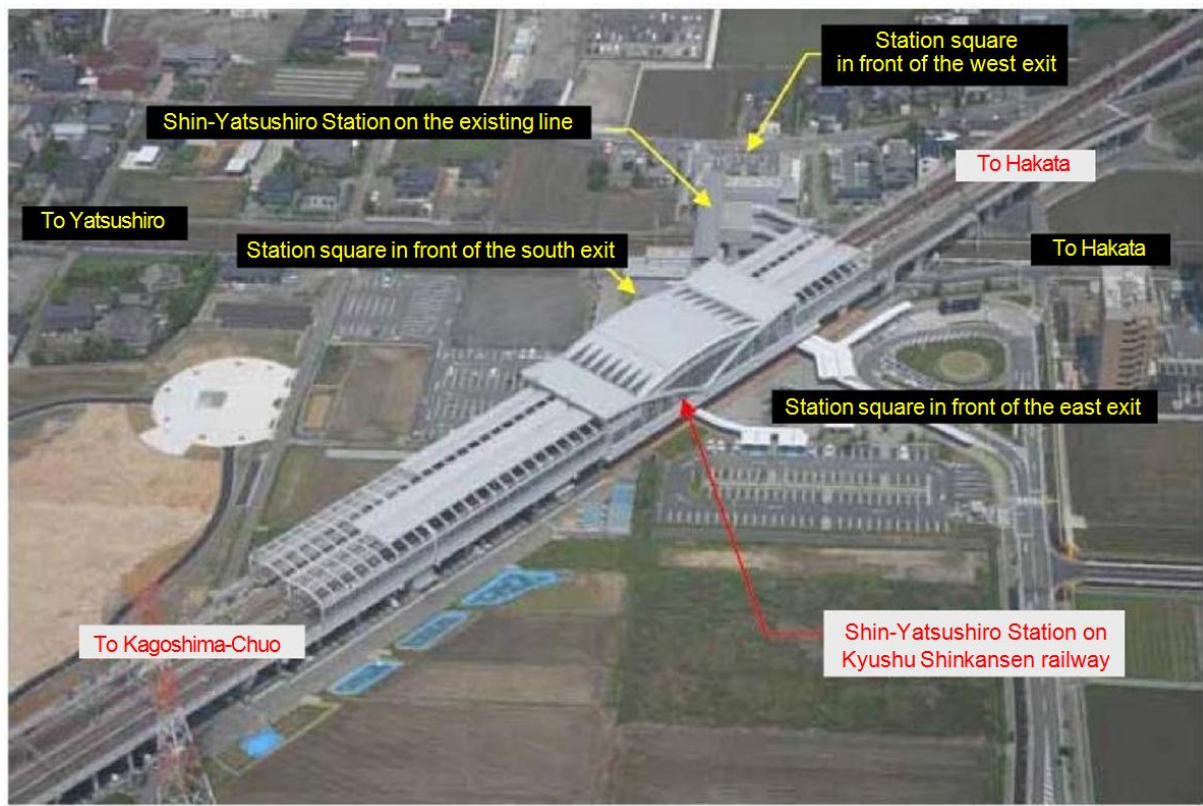


Figure 5: Shinkansen route after its opening (Shin-Yatsushiro)



Shin-Yatsushiro Station on the Kyushu Shinkansen railway is an elevated station constructed about 3km north of the existing Yatsushiro Station. Shin-Yatsushiro Station was also installed on the existing line at the same time. In the station building, a tourist information office has been installed to provide information about tourist and public facilities and to exhibit products in Yatsushiro City and Yatsushiro County.

A business hotel was opened in 2007 by the east side of the station, and an apartment building is under construction in the adjacent site. A produce museum called 'Yatsushiro City Yokatoko (good place)' was completed in December 2008, and a sports museum was opened by Mr Nobuhiko Matsunaka, professional baseball player, in January 2009.

In January 2009, a private junior high school in the city was moved to a new schoolhouse constructed by the west side of the station.

Figure 6: Image of the Square by the east side of Yatsushiro Station



For the Kyushu Shinkansen section (between Shin-Yatsushiro and Kagoshima-Chuo), it was planned to construct the south section first in order to significantly reduce travel times. However, it was decided to construct the south section in the Super Express mode, because this section was not yet connected to the existing Shinkansen network. When the entire Kyushu Shinkansen railway section is open, after the Hakata ~ Shin-Yatsushiro section is built, it may be necessary to make changes in the gauge and other features. Therefore, the south section was constructed in accordance with the full standard and opened. As a result, it became necessary for passengers to transfer at Shin-Yatsushiro. It is generally considered that one transfer could take about 30 minutes and so the transfer has a significant impact on convenience. At Shin-Yatsushiro Station, various ingenious transfer methods were adopted to minimise the inconvenience of transfer.

Method of transfer on the same platform

To eliminate transfer troubles, passengers can transfer from the Shinkansen line to the existing Express line and vice versa on the same platform at Shin-Yatsushiro Station. The existing Express line branches from the Kagoshima Main Line and reaches Shin-Yatsushiro Station through the approach line. Thus, passengers can easily transfer from Shinkansen trains to Express trains and vice versa without moving up and down in the station. It will generally take only three minutes for passengers to transfer from a Shinkansen train to an Express train in Shin-Yatsushiro Station. Therefore, they can transfer without hurrying, because they only move horizontally on the platform.

This transfer method received the third Japan Railway Prize (in the division 'Aiming at the Convenient and Attractive Railway') and the '2004 Award for the Persons Who Have Rendered Distinguished Services in Spreading Barrier-Free Designs' (from the Chief Cabinet Secretary).

(Cited from the 'Post-Assessment Report', 5.4 Ingenious transfer methods used at Shin-Yatsushiro Station).

Figure 7: Image of transfer at Shin-Yatsushiro Station

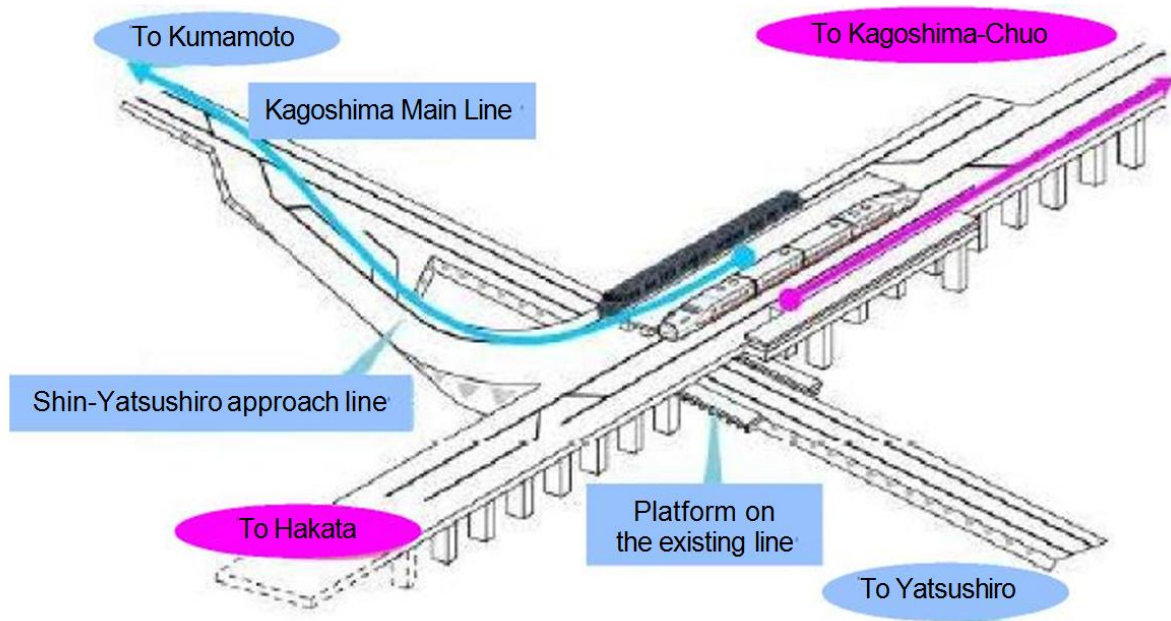


Figure 8: Passengers transferring trains on the platform in Shin-Yatsushiro Station



Train operating schedule, train guide, seat reservation method, and tickets common to the trains on the existing and Shinkansen lines

- Train operating schedule and guide common to the trains on the existing and Shinkansen lines

The Express trains on the existing line (or Shinkansen trains) for transfer are prepared for all the Shinkansen trains (or Express trains on the existing line) which arrive at Shin-Yatsushiro Station (namely, the same number are used both for the Express and Shinkansen trains).

Thus, passengers will not need to be anxious about their trains for transfer. In the station, the same train guide is used both for Shinkansen trains and Express trains on the existing line.

Figure 9: Timetable for Trains 'Tsubame (Swallow)' on Kyushu Shinkansen Railway

列車番号	48F	48P	50F	50P	52F	52P	54F	54P	56F	56P	58F	58P	60F	60P	62F	62P	64F	64P	66F	66P	70F	70P	200F	200P	202F	202P	
列車予約コード	35018	28012	35050	28014	35052	28016	35054	28018	35056	28020	35058	28022	35060	28024	35062	28026	35064	28028	35066	28030	35070	28032	20000	20000	20200	20200	
列車名	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	
発車番線	13	14	11	12	13	14	11	12	13	14	11	12	13	14	11	12	13	14	11	12	13	14	11	12	13	14	
鹿児島中央発	1317	1352	1413	1452	1513	1546	1613	1656	1717	1752	1814	1844	1914	1943	2012	2044	2020	2057	2117	2155	2245	2269	2245	2269	2301	2340	
川内発	1331	1406	1427	1506	1527	1607	1627	1705	1730	1805	1827	1857	1927	1956	2026	2057	2038	2108	2130	2208	2245	2269	2245	2269	2301	2340	
出水発	1343	1431	1439	1531	1539	1631	1639	1742	1755	1839	1859	1939	1958	2038	2058	2108	2117	2143	2221	2245	2269	2245	2269	2301	2340	2380	
新八代発	1350	1431	1447	1531	1547	1631	1647	1750	1804	1864	1917	1947	1947	2015	2045	2117	2150	2228	2245	2269	2245	2269	2245	2269	2301	2340	
博多発	1404	1431	1500	1531	1600	1627	1700	1730	1804	1831	1900	1930	2000	2020	2060	2130	2204	2242	2245	2269	2245	2269	2245	2269	2301	2340	
列車番号	48M	12N	50M	14M	52M	16M	54M	18M	56M	20M	58M	60M	62M	64M	66M	68M	70M	72M	200M	200M	202M	202M	200M	200M	202M	202M	
列車予約コード	35018	28012	35050	28014	35052	28016	35054	28018	35056	28020	35058	28022	35060	28024	35062	28026	35064	28028	35066	28030	35070	28032	20000	20000	20200	20200	
列車名	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	つばめ	
新八代	1407	1434	1505	1534	1605	1630	1705	1735	1807	1854	1905	1935	2008	2032	2102	2133	2158	2223	2207	2245	2269	2245	2269	2245	2269	2301	2340
代官	1428	1455	1526	1555	1626	1651	1726	1756	1828	1854	1929	1954	2024	2054	2122	2154	2229	2254	2227	2265	2269	2245	2269	2245	2269	2301	2340
新八代	1431	1458	1529	1558	1630	1655	1725	1755	1815	1841	1915	1941	2014	2044	2112	2144	2219	2244	2227	2265	2269	2245	2269	2245	2269	2301	2340
新八代	1447	1474	1545	1574	1646	1671	1741	1771	1815	1841	1915	1941	2014	2044	2112	2144	2219	2244	2227	2265	2269	2245	2269	2245	2269	2301	2340
新八代	1500	1524	1600	1624	1700	1724	1800	1825	1900	1924	2000	2024	2056	2123	2152	2223	2258	2253	2207	2245	2269	2245	2269	2245	2269	2301	2340
代官	1509	1534	1609	1634	1709	1734	1809	1834	1909	1934	2010	2034	2106	2130	2205	2229	2258	2253	2207	2245	2269	2245	2269	2245	2269	2301	2340
代官	1514	1539	1614	1639	1714	1739	1815	1841	1914	1941	2015	2041	2111	2135	2210	2234	2263	2258	2207	2245	2269	2245	2269	2245	2269	2301	2340
代官	1522	1545	1622	1645	1723	1745	1823	1842	1922	1943	2023	2045	2120	2142	2219	2242	2270	2253	2207	2245	2269	2245	2269	2245	2269	2301	2340
代官	1529	1550	1629	1650	1729	1750	1829	1849	1929	1950	2029	2050	2127	2148	2225	2246	2274	2253	2207	2245	2269	2245	2269	2245	2269	2301	2340
代官	1550	1612	1650	1712	1750	1811	1850	1909	1951	2012	2052	2111	2138	2160	2235	2256	2284	2253	2207	2245	2269	2245	2269	2245	2269	2301	2340
到着番線	13	14	11	12	13	14	11	12	13	14	11	12	13	14	11	12	13	14	11	12	13	14	11	12	13	14	

《ご案内》九州新幹線(つばめ)と鹿児島(リレーつばめ)は、新八代駅の同一ホームで接続します。

Figure 10: Arrival and departure board (in Kagoshima-Chuo station)



- Seat reservation method and tickets common to the trains on the existing and Shinkansen lines.

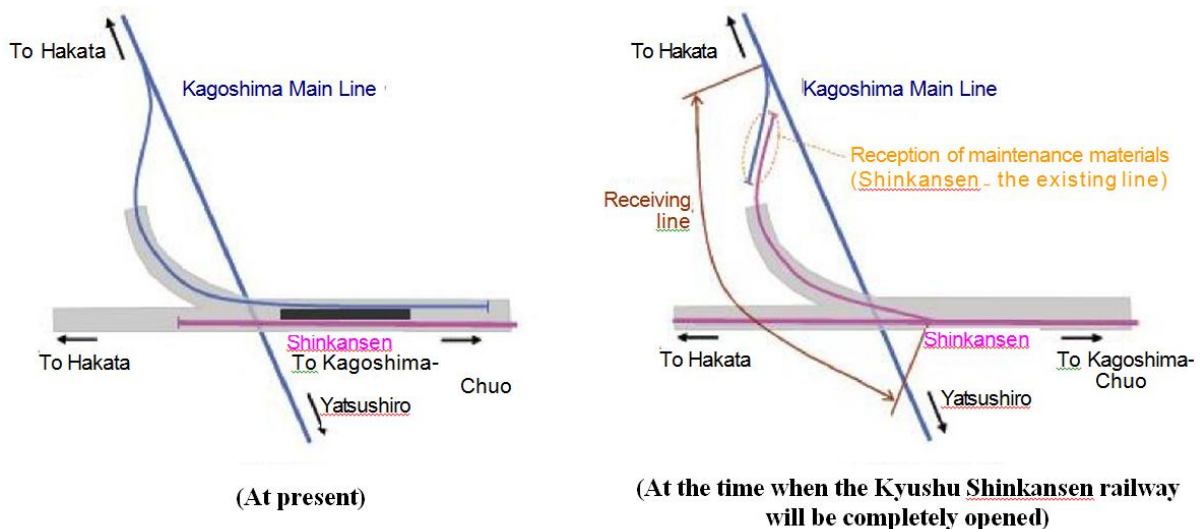
The same reserved seat numbers and train numbers are used both for the Shinkansen trains and Express trains on the existing line. Thus, moving distances for passengers can be minimized.

If a passenger uses both a Shinkansen train and an Express train on the existing line, he or she must generally have bought a 'passenger ticket', a 'Shinkansen Express ticket', and a 'ticket for Express train on the existing line'. However, the 'Shinkansen Express ticket' and the 'ticket for Express train on the existing line' are now unified into a single ticket.

Ingenious method for constructing the approach line

The existing Express line branches from the existing Kagoshima Main Line and reaches Shin-Yatsushiro Station through an approach line. This approach line is designed by nature as a receiving line for maintenance, and will be replaced with a standard-gauge line as a receiving line for maintenance when the Kyushu Shinkansen railway is completely opened. From this time, passengers will not have to transfer from Shinkansen trains to Express trains on the existing line and vice versa at Shin-Yatsushiro Station and, consequently, Express trains on the existing line will not have to use the approach line. Additional investment for transfer on the same platform is made only in the installation of a narrow-gauge line (1.067mm), the electrification of the approach line, the replacement of the approach line with a standard-gauge line (broad-gauge to narrow-gauge), etc. The additional investment is paid by JR Kyushu as a part of the business measures taken by the operator.

Figure 11: Image of receiving line at Shin-Yatsushiro



Shin-Minamata Station

The photos of the area around Shin-Minamata Station before and after the opening of the Kyushu Shinkansen railway are shown below.

Shin-Minamata Station on the Kyushu Shinkansen railway is a new elevated station constructed about 4km from the existing Minamata Station. Shin-Minamata Station on the Hisatsu Orange railway was constructed at the same time. In the Shinkansen station, an

Exchange Centre was installed to provide tourist and guide information and an environmental learning programme, and to sell agricultural produce and its processed products supplied by local producers.

Under the national road No. 3 improvement project implemented by the Ministry of Land, Infrastructure, Transport and Tourism, the surrounding area development project is being implemented to construct the station square and other facilities in order to strengthen the traffic node.

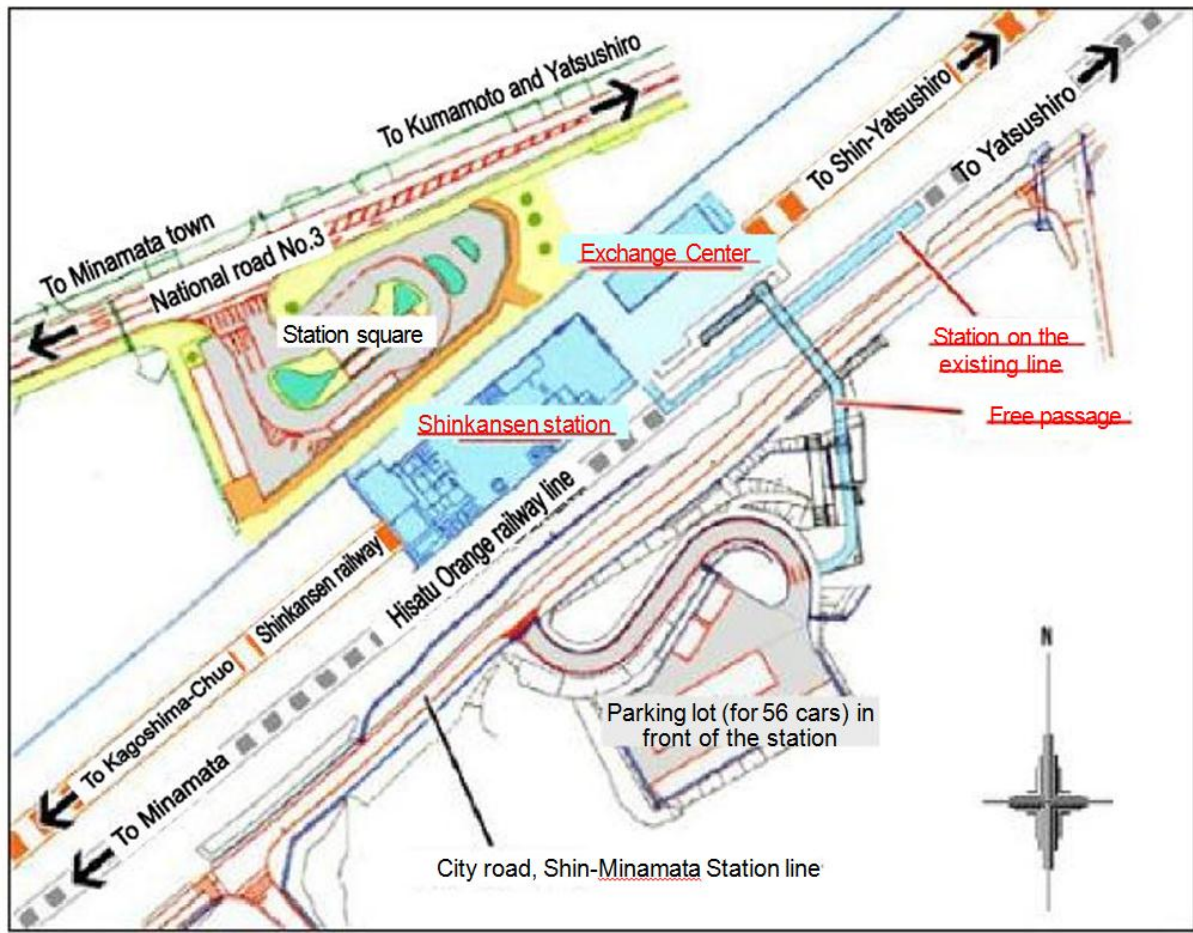
Figure 12: Shinkansen route before its opening (Shin-Minamata)



Figure 13: Shinkansen route after its opening (Shin-Minamata)



Figure 14: Development of the area around Shin-Minamata Station



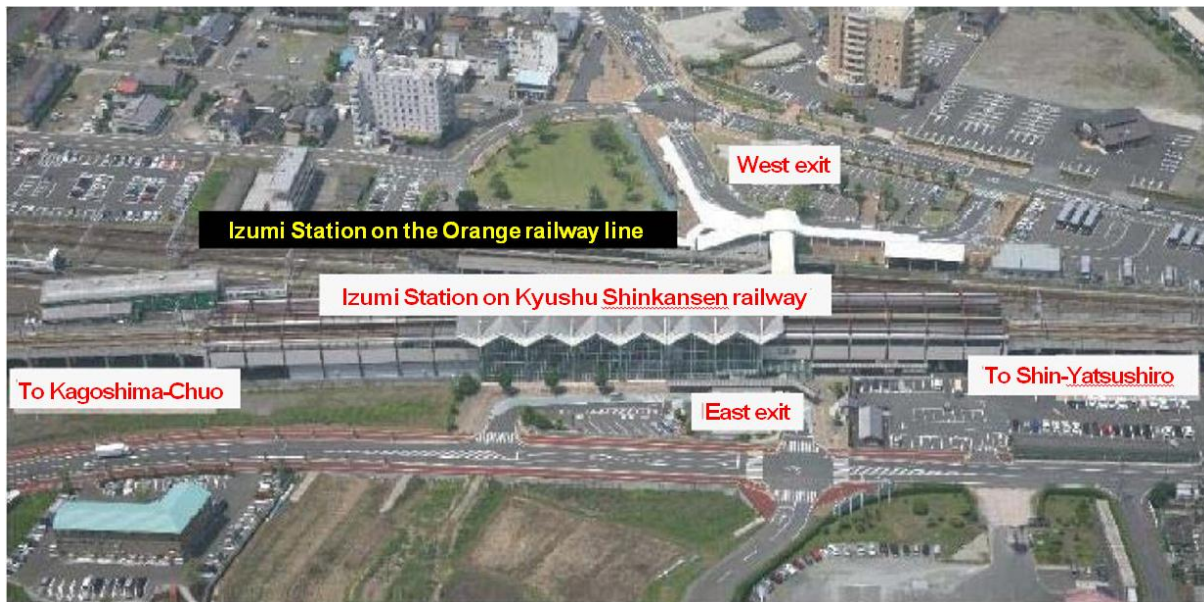
Izumi Station

The photos of the area around Izumi Station before and after the opening of the Kyushu Shinkansen railway are shown below.

Figure 15: Shinkansen route before its opening (Izumi station)



Figure 16: Shinkansen route after its opening (Izumi station)



Izumi Station on the Kyushu Shinkansen railway is combined with Izumi Station on the existing line. The tourist and special-produce museum 'Hirari' owned and operated by Izumi City is installed in Izumi Station. This museum is a composite facility that was constructed under the 'City Centre Activation Law' and has various functions such as selling special products, providing a comprehensive tourist guide, and containing a city hall and a multi-purpose hall.

Two hotels and an apartment building were constructed after the Kyushu Shinkansen railway had been opened.

Sendai Station

The photos of the area around Sendai Station before and after the opening of the Kyushu Shinkansen railway will be shown below.

Figure 17: Shinkansen route before its opening (Sendai station)

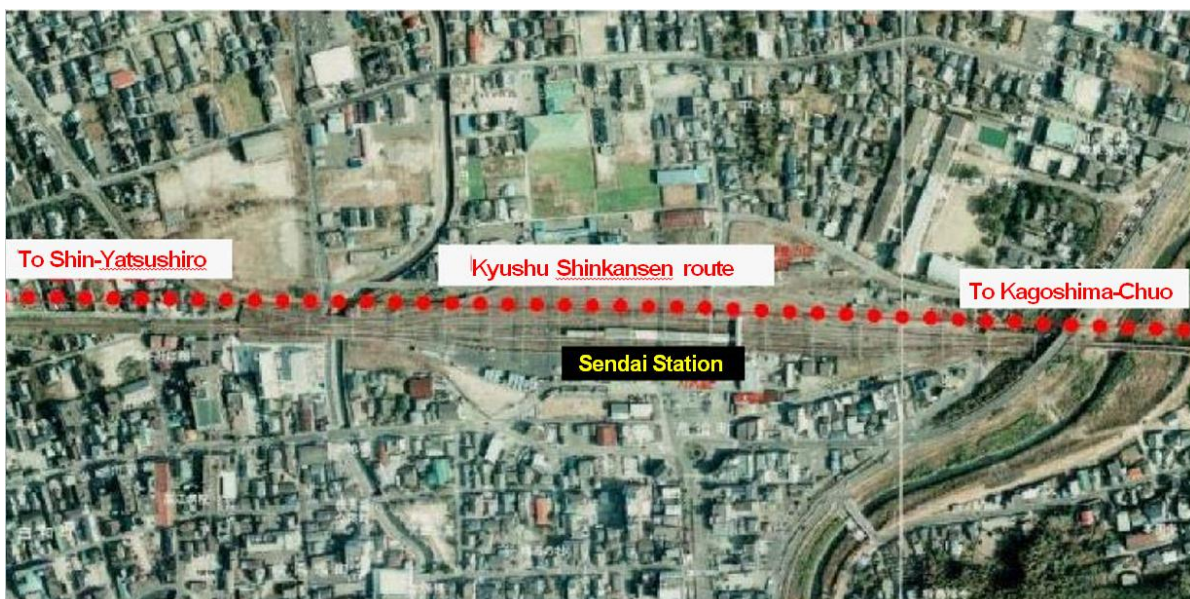


Figure 18: Shinkansen route after its opening (Sendai station)



Sendai Station on the Kyushu Shinkansen railway line is a bridge station combined with the existing station on the existing line. When the Shinkansen station was constructed, a free east-to-west passage, the station squares in front of the east and west exits, a bus rotary, parking lots, etc., were also constructed. The Land Rezoning Project for the district around Sendai Station is being implemented in the area by the east exit side of the station and apartment buildings and hotels are also under construction.

Kagoshima-Chuo Station

The photos of the area around Kagoshima-Chuo Station before and after the opening of the Kyushu Shinkansen railway line will be shown below.

Figure 19: Shinkansen route before its opening (Kagoshima-Chuo station)



Figure 20: Shinkansen route after its opening (Kagoshima-Chuo station)



Kagoshima-Chuo Station on the Kyushu Shinkansen railway line is combined with the existing station on the existing line, and its name was changed from 'Nishi-Kagoshima' to 'Kagoshima-Chuo' when the Shinkansen railway line was opened. Under the Nishi-Kagoshima Station Square Construction Project, the bus stop which had been located on the central divider of the road along the station square in front of the east exit was moved to the station square, and the converged flows of pedestrians and motor vehicles were effectively separated from each other when the pedestrian underpass was constructed. This Project received the Land, Infrastructure, Transport and Tourism Minister's Prize in the Street Construction Project Contest. Several urban redevelopment projects have been completed or are under implementation in the district around Kagoshima-Chuo Station.

The Station Terminal Building is a large commercial facility having the second largest area of sales floors in Kagoshima Prefecture. It was opened in September 2004, six months after the Kyushu Shinkansen railway line was opened and has since received about eleven million visitors every year.

In Kagoshima-Chuo Station, additional construction works are being executed toward the complete opening of the Kyushu Shinkansen railway line. When the station is completed, its total floor area will be about 13,000m², about 1.5 times larger than at present.

Figure 21: Underpass under the station square in front of the east exit



New facilities such as a bus rotary, taxi stand, and parking lots were installed in the station square in front of the west exit. In this area, a business hotel and other buildings were constructed when the Kyushu Shinkansen railway was partially opened. In addition, reconstruction and additional development is planned for Kagoshima-Chuo Station as well as the development project for the district around the west exit.

Figure 22: Station square in front of the west exit



Table 2: Urban redevelopment projects

Block name	Outline of project
East Exit Block 6	A multi-storey parking garage (for 645 cars and 430 bicycles) will be constructed.
East Exit Block 10	A multi-purpose building (for commercial and public use) will be constructed.
Chuo-cho Block 22	Commercial and business facilities and a multi-storey parking garage will be constructed.
Chuo-cho Block 23	Commercial and business facilities, houses, and a multi-storey parking garage will be constructed.

Figure 23: Urban redevelopment project for the areas around Kagoshima-Chuo Station



Construction of parking lots in front of stations

Parking lots are installed in front of all the stations on the Kyushu Shinkansen railway, and are owned and operated by the related municipal corporations and the JR Kyushu group's companies. Few other parking lots meant for temporary use are observed around the stations except Kagoshima-Chuo Station.

Recently, the availability of parking lots near many stations has been leveling off or slightly lower than when the parking lots were opened, probably because many users used inexpensive chauffer services and parked their cars only for a short time, based on their experiences. On the contrary, other users have parked their cars for a long time in parking lots in front of stations and used Shinkansen trains to make trips to distant places. Many people have used the park and ride discount service provided by JR Kyushu for users of Shinkansen trains. Considering these moves, Izumi City reviewed the parking fee system and took actions such as the reduction of long-time parking fees to satisfy users' needs.

Table 3: Uses of parking lots near each station (in 2006)

Name of station	Capacity of parking lots installed by local government	Capacity of parking lots installed by JR	Total capacity	Number of cars parked
Shin-Yatsushiro	106 cars	206 cars	312 cars	280
Shin-Minamata	56 cars	214 cars	270 cars	100
Izumi	195 cars	255 cars	450 cars	220
Sendai	170 cars	170 cars	340 cars	270
Kagoshima-Chuo		1,370 cars	1,370 cars	3,230

Table 4: Comparison between Park & Ride service charges and regular fee

Charge by parking time in case of using a Shinkansen train	Regular fee
JPY 500 for up to 24 hours parking JPY 1,000 for up to 48 hours parking JPY 1,500 for up to 72 hours parking Regular parking fee for more than 72 hours	JPY 150 per 30 minutes parking

Figure 24: New parking lot (Shin-Minamata)



D PROJECT COSTS

It was decided that the Kyushu Shinkansen railway line would be only partially constructed because of the problem of financial resources. The railway section between Yatsushiro and Nishi-Kagoshima was selected for the partial construction for reasons such as the existence of many single lines having a low linearity along this section and the potential to significantly reduce travel times if this section was constructed.

Since the section between Yatsushiro and Nishi-Kagoshima was not connected to the existing Shinkansen network, it was decided that the section would be constructed in the Super Express mode which did not require any transfer on the Hakata ~ Nishi-Kagoshima railway.

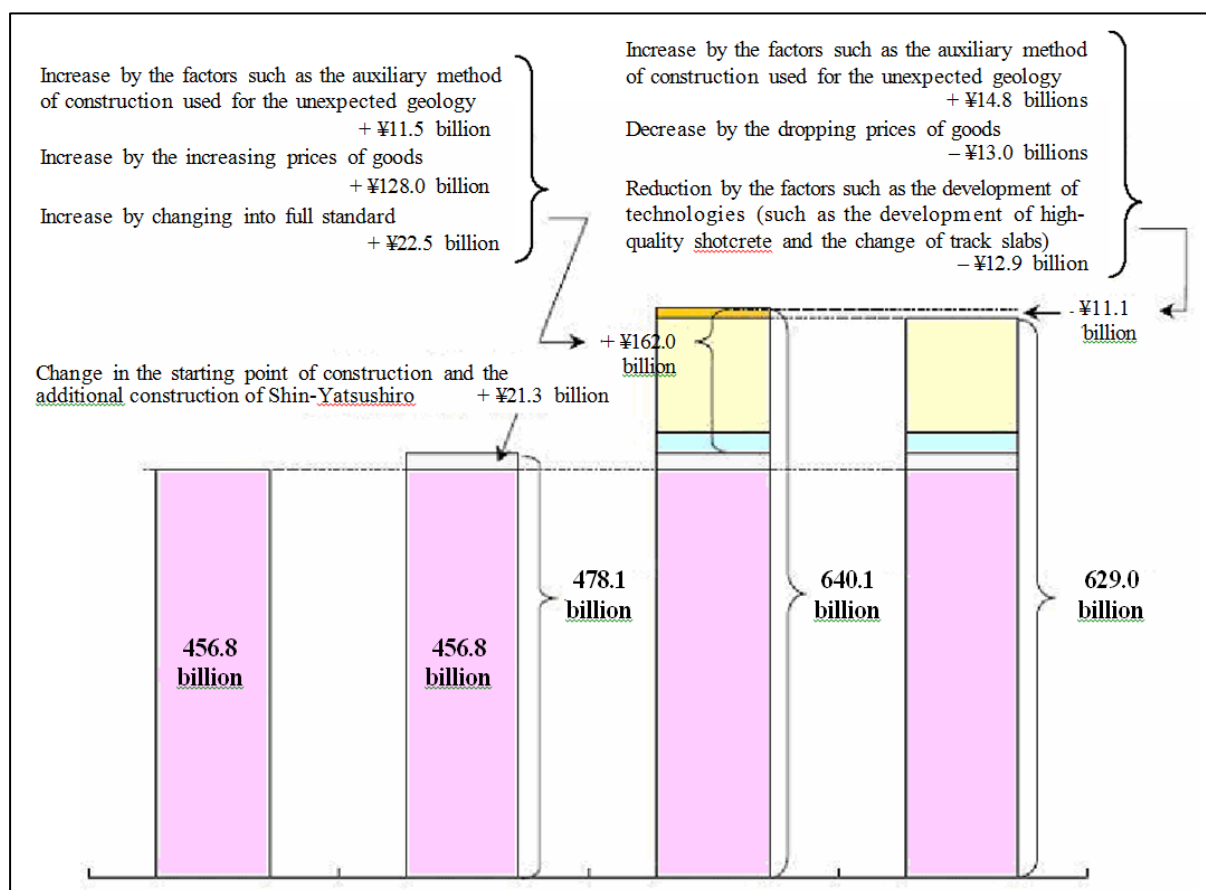
The standard and construction section were changed for the Kyushu Shinkansen railway section (between Shin-Yatsushiro and Kagoshima-Chuo) between the authorisations granted in 1991 and 2001. The current standard and construction sections were authorised in 2001, and the project costs for this section amounted to JPY 640.1bn. Several factors such as the change in the auxiliary method of construction and falling goods prices affected the project costs since the current standard and construction section was authorised. However, cost reduction efforts were made, enabling the project to be completed for the cost of JPY 629.0bn, lower by about JPY 11.0bn than the authorised amount.

When the authorisation was granted in 1991, the approved costs were JPY 456.8bn for the interim construction project for the Yatsushiro ~ Nishi-Kagoshima section in the Super Express mode. In October 1998, the starting point of construction was changed (and consequently the total length of the construction section was increased by about 4km) and the construction of Shin-Yatsushiro Station was added. Thus, the project costs increased to JPY 478.1bn. In April 2001, the full standard was adopted instead of the Super Express system, and the project costs amounted to JPY 640.1bn. The most important factor for the increase of JPY 162.0bn was the increasing prices of goods.

(cited from the 'Post-Assessment Report', 3.2 Project costs).

	Authorized in August 1991	Authorized in October 1998	Authorized in April 2001	Finally authorized
Standard	Super Express	Super Express	Full standard	Full standard
Section	Yatsushiro ~ Nishi-Kagoshima	Shin-Yatsushiro ~ Nishi-Kagoshima	Shin-Yatsushiro ~ Nishi-Kagoshima	Shin-Yatsushiro ~ Kagoshima-Chuo

Figure 25: Evolution of project costs for Kyushu Shinkansen railway section (between Shin-Yatsushiro and Kagoshima-Chuo)



Construction work scheduling

As for the Kyushu Shinkansen railway section between Shin-Yatsushiro and Kagoshima-Chuo, the interim construction project for the Yatsushiro ~ Nishi-Kagoshima section as a new line meeting the Shinkansen railway standard was authorised in August 1991. The starting point of the construction was changed to Shin-Yatsushiro in October 1998, and the change into the full standard was approved in April 2001.

For the Shin-Yatsushiro ~ Nishi-Kagoshima section, the projected fiscal year of completion was estimated to be about 2001, ten years after the first authorization was granted in August 1991. When the additional application for the change to full standard was authorised in April 2001, it was decided that the project should be completed at the end of 2003. At this point in time, consultations with local residents slowed down in some local areas. Therefore, it was predicted that it would be very difficult to complete the construction project at the end of 2003. However, the civil engineering and site acquisition divisions made concerted effort in actively consulting with local residents and adopted new technology for rapid execution of works. As a result, the inspection of all the ground facilities was completed in September 2003, the construction project was also completed as scheduled, and the Shin-Yatsushiro ~ Kagoshima-Chuo section was opened on 13 March 2004.

(cited from the 'Post-Assessment Report', 3.3 Period of construction).

Table 5: Work scheduling of the construction project for the Shin-Yatsushiro~Kagoshima-Chuo section (plan and results)

Item	Fiscal year Plan	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
		Site	Authorized on August 25, 1991	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)
	Authorized on April 25, 2001	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)
	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
Road-bed	Authorized on August 25, 1991	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)
	Authorized on April 25, 2001	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)
	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
Track	Authorized on August 25, 1991						Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)
	Authorized on April 25, 2001						Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)
	Results						Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
Electricity	Authorized on August 25, 1991					Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)	Plan (Super Express)
	Authorized on April 25, 2001					Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)	Plan (Full standard)
	Results					Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
Inspection & test operation (results)														Results		
Residual works																Results

Plan (Super Express)
 Plan (Full standard)
 Results

The structures will be delivered to JR in December 2003.

Main technical features

Special geology (*Shirasu*)

Shirasu (a type of light gray volcanic ash) is distributed in the southern part of the Kyushu region. It comprises falling pumice deposits, pyroclastic flow sediment, and secondary sediment produced by volcanic activities in Aira, Ata, Kakutou and other areas.

Shirasu presents engineering features and problems such as particle structure, erosion, strength, earth pressure, liquefaction and slope collapse, of which the most important problem is erosion. *Shirasu* earthworks in underground water may cause problems such as the softening and fluidisation of *shirasu* by water, which constitute the great demerits of *shirasu* foundations. In the plateaus covered with alluvium deposit of *shirasu*, its liquefaction in an earthquake is more likely than that of general sandy foundations.

(cited from 'Japanese Geology 9 – Kyushu Region', p256).

Technological developments

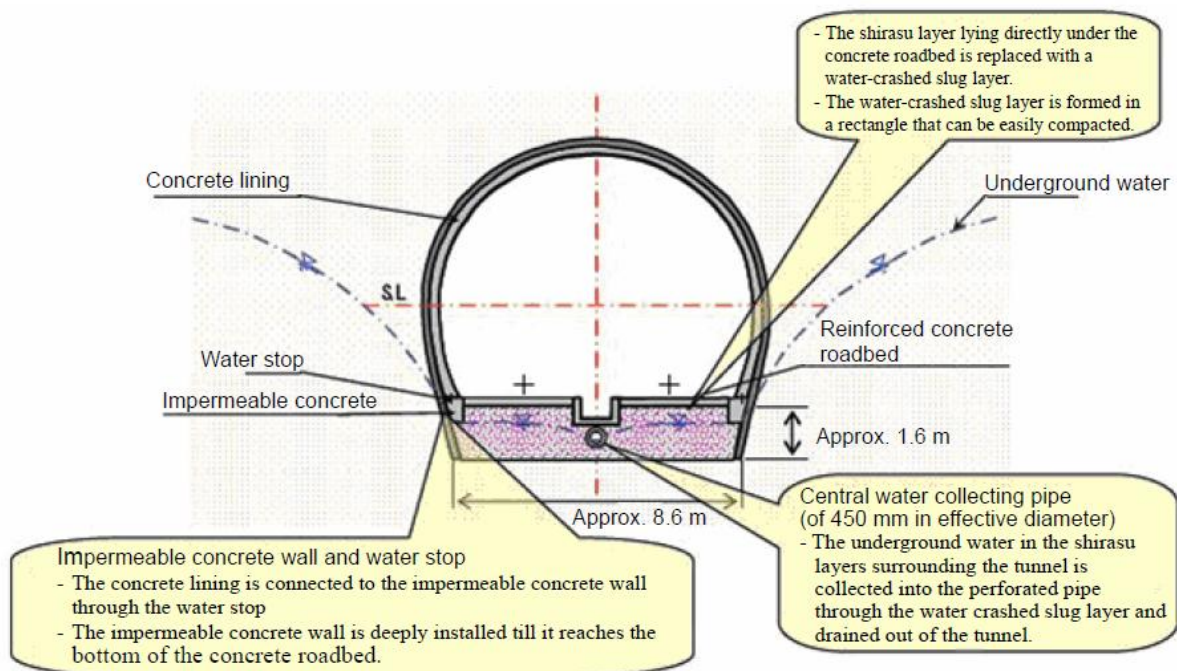
Development of the tunnel structure and construction method for a tunnel passing through the mountain comprising a shirasu deposit in underground water

The section of about 20km from the end point of the Kyushu Shinkansen railway section

(between Shin-Yatsushiro and Kagoshima-Chuo) passes through the zone of *shirasu* as a special foundation typical in Japan. On this section, a tunnel of about 7km in length had to be designed so that it could be constructed on the *shirasu* layer in the underground water. Therefore, there were concerns about the cavitation and mud pumping actions caused behind the linings of the tunnel by the inner erosion of the mountain comprising *shirasu* layers, which are extremely vulnerable to water. To solve the problem of tunnel maintenance control and reduce construction cost, a permeable roadbed was developed to positively dewater out of the tunnel by using the water-crashed slug having a high permeability and high hydraulicity. Thus, the design and construction work methods for the railway tunnel were established. As the first attempt in Japan, the railway tunnel was constructed through the mountain comprising *shirasu* layers, and the technology used to construct the tunnel was appreciated as one of those deserving the technological prize awarded by the Civil Engineering Society.

(cited from the 'Post Assessment Report', 5.8 Technological Developments).

Figure 26: Structure of the tunnel passing through a mountain comprising *shirasu* layers in underground water



New technologies for bridges

For the bridge over the Sendai River, the four-span continuous PC (prestressed concrete) oblique suspension bridge was adopted to ensure space for an intersecting road under the girders of the bridge and to take the landscape of the neighbouring towns into consideration. The PC oblique suspension bridge was constructed by the oblique suspension members covered with concrete plates, and it was first adopted for the Kyushu Shinkansen railway ahead of the others. For the Harada pedestrian bridge over the Kyushu Shinkansen railway in Satsuma Sendai City, the Langer girder system of which the arch parts receive the load of a train was first adopted ahead of the other Shinkansen railways, because the space for an intersecting road under the girders of the bridge was limited and the bridge was as long as 63m.

Figure 27: Harada pedestrian bridge over the Kyushu Shinkansen railway



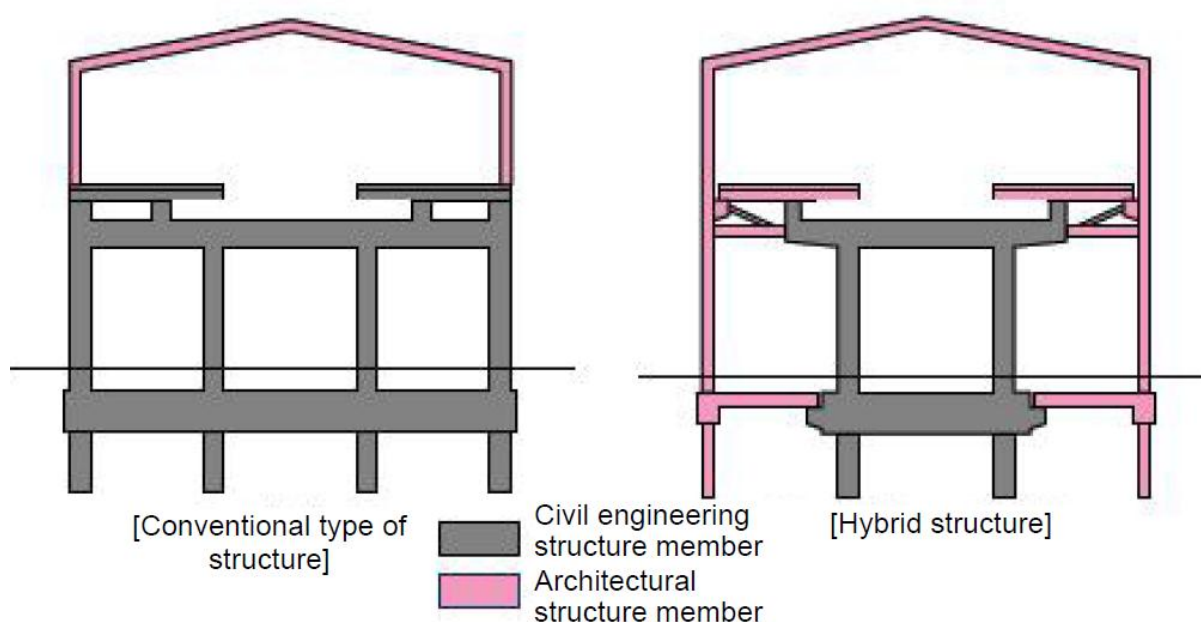
New architectural technologies

The hybrid structure, which is a composite combination of civil engineering and architectural structures, was first adopted for the building of Izumi Station ahead of the other elevated railway stations. The conventional elevated railway stations had economically designed column spacing, with the result that equipment such as elevators and escalators was not freely installed there. Thus, this column spacing presented a serious constraint on the designs of elevated stations. To eliminate this constraint, the new concept of a hybrid structure was developed (and patented). Thus, the hybrid structure could be better designed than the existing structures, reducing construction cost and the required period of construction.

Figure 28: Structures and space inside the ticket barrier in Izumi Station



Figure 29: Comparison between station structures



Received prizes

The main prizes received in relation to the Kyushu Shinkansen railway section (between Shin-Yatsushiro and Kagoshima-Chuo) will be listed below.

Table 6: Main prizes received in relation to the Kyushu Shinkansen railway section (Between Shin-Yatsushiro and Kagoshima-Chuo)

Achievement	Prize	Awarding organization, etc.
The establishment of the tunnel structure and construction method using a permeable roadbed of water-crashed slug for a tunnel passing through a mountain comprising <i>shirasu</i> layers in underground water	Technological Prize (Division I) (2002)	Civil Engineering Society
The construction of Kyushu Shinkansen section (between Shin-Yatsushiro and Kagoshima-Chuo)	Technological Prize (Division II) (2004)	
The construction of the universally designed facilities in Shin-Yatsushiro Station	Award for the Persons Who Have Rendered Distinguished Services in Spreading Barrier-Free Designs (2004)	The Chief Cabinet Secretary
The realization of the transfer (Shinkansen ↔ the existing Express train) on the same platform in Shin-Yatsushiro Station as well as the trip with a single ticket	Japan Railways' Prize in the Division 'Aiming at the Convenient and Attractive Railway' (2004)	The Executive Committee for the 'Day of Railway'
The design of the Shin-Minamata Station on Kyushu Shinkansen railway and the direction of the design of the district around the station	Public Building Prize (2008) Special Prize (Countrywide) Excellence Prize (in Kyushu and Okinawa regions)	Public Buildings Association
The environmental design of Shin-Minamata Station and the contribution to the regional	Kumamoto Art Polis Prize (2004)	Kumamoto Prefecture Governor

Achievement	Prize	Awarding organization, etc.
development		
Lightings for Shin-Minamata Station on Kyushu Shinkansen railway	Excellent Facility Prize (2004)	Kyushu Branch, Lightings Spreading Association, Illumination Engineering Society
Izumi Station on Kyushu Shinkansen railway	The 49 th Association of Architects' Prize	Association of Railway Architects
Kyushu Shinkansen Train	Good Design Prize (Commodity Design Division) (2005) and Laurel Prize (2005)	Japan Industrial Design Promotion Organization and Japan Rail-fan Club

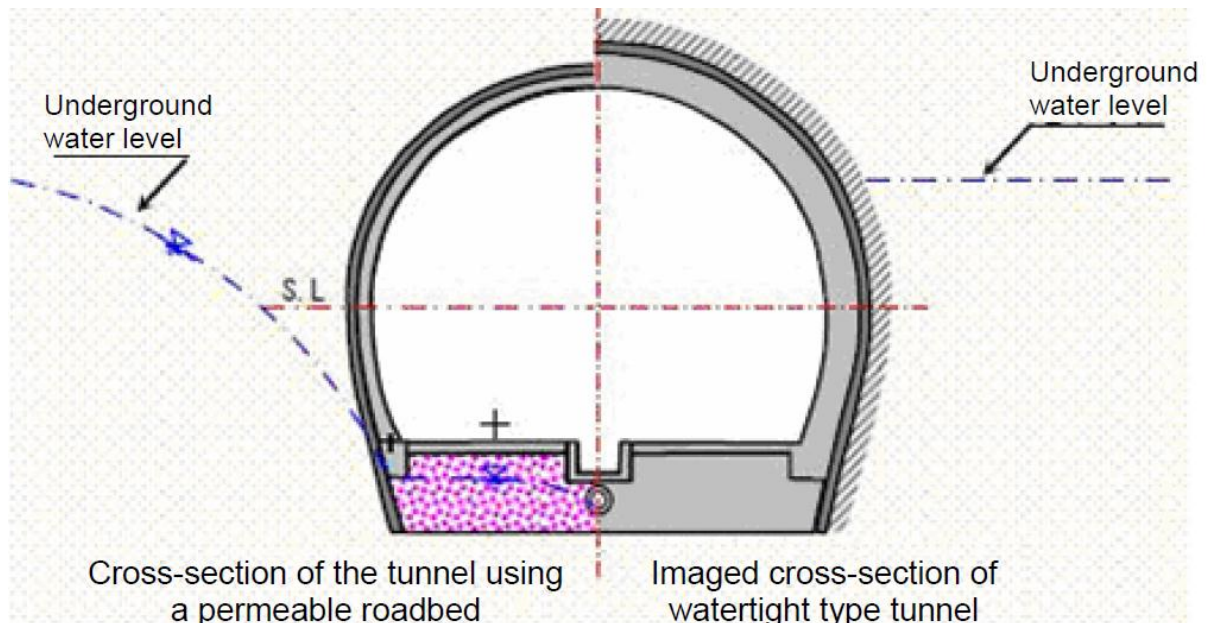
Cost reduction measures

The Kyushu Shinkansen Railway section (between Shin-Yatsushiro and Kagoshima-Chuo) Project reduced construction costs by taking various measures such as technological development.

Cost reduction by using a permeable roadbed of water-crashed slug in a tunnel

The tunnel passing through the mountain comprising *shirasu* layers in underground water was initially designed as watertight type. However, the technological development as described above decreased the weight of the tunnel lining structure and consequently the construction cost of the tunnel was reduced by about JPY 2bn.

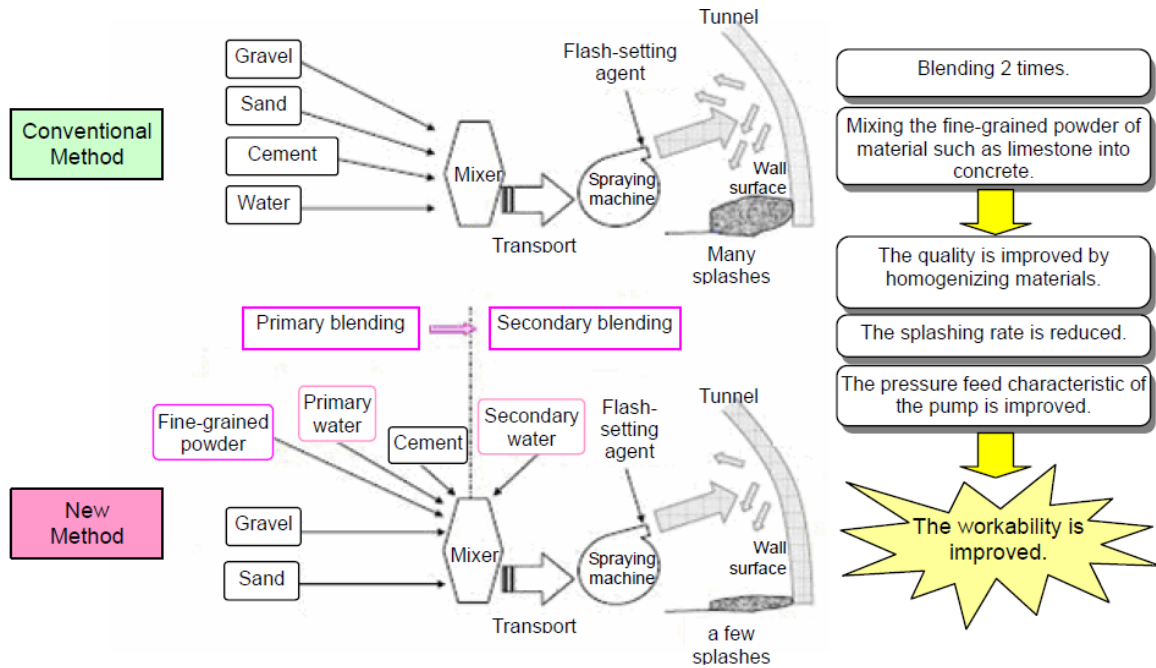
Figure 30: Comparison between the cross-sections of tunnels



Cost reduction by the development of high-quality spraying concrete

The high-quality spraying concrete was developed through tests conducted at the sites where the projected Shinkansen railway tunnels were constructed in Japan. The method of producing the high-quality spraying concrete comprises adding the fine powder of lime into the spraying concrete and adding the blending water into the mixture of concrete and lime powder two times to reduce the splashes and the production of dust. The use of this concrete permitted a review of the required time for a work execution cycle and the required quantities of materials. Thus, construction costs were reduced by about JPY 1bn.

Figure 31: Comparison between spraying methods



Framed track slab adopted for tracks on the sections other than tunnels

The frame type track slabs which were generally installed in tunnels were also adopted on the sections other than tunnels instead of the conventional plate-type track slabs. The use of frame-type track slabs reduced the required quantities of materials, improved workability and consequently reduced construction costs by about JPY 1bn).

Figure 32: Track slabs



Car body lifting and moving equipment adopted for car inspection

The standard car body inspection and repair method used in each car depot for Shinkansen trains generally comprises disconnecting the cars of a train from each other and moving each car body into a car body inspection and repair plant, where it is inspected and repaired if necessary. However, a car lifting and moving system was adopted for the cars of each train used on the Kyushu Shinkansen railway section (between Shin-Yatsushiro and Kagoshima-Chuo). Thus, a car body inspection and repair plant could be combined with a truck and bogie replacing plant to reduce the inspection and repair costs. (The inspection and repair costs were reduced by about JPY 500m in total).

(cited from the 'Post-Assessment Report', 5.9 Cost Reduction).

Figure 33: Car body lifting and moving equipment



Designs considering landscapes

Kuma River Bridge

The Kuma River Bridge is a five-span continuous rigid-frame bridge of 307m that passes over the Kuma River, one of the rapidiest stream rivers in Japan. This bridge is designed so as to be in harmony with the natural landscape of the river running between the mountains, considering various factors such as the shapes of the bridge piers, the continuity between the bridge slabs and its main girders, and the installation of drain pipes.

Figure 34: Kuma River Bridge



Sendai River Bridge

The Sendai River Bridge is a bridge of 338m passing over the Sendai River, one of the general rivers, and the longest of the railway bridges on the Shin-Yatsushiro ~ Kagoshima-Chuo section. The heights of the two main towers were limited as much as possible, and the central bridge piers were of finback type so as to emphasize the continuity of the pier top faces, whilst giving no impression of oppression or complicatedness. The two main towers are designed so that it is loved by local residents and expresses the imaged powers of two teams in the rope pulling contest over the Sendai River, which has been held as a traditional event since the era when Hideyoshi Toyotomi (1537~1598) governed Japan.

Figure 35: Sendai River Bridge



Designs of station buildings

JR Kyushu has made efforts to construct the stations on the Kyushu Shinkansen railway so that the stations express the characteristics of the towns where the stations are installed and are loved by residents in the towns respectively. The station buildings have characteristic appearances and were built according to a design concept comprising natural and landscape motifs.

For example, in Izumi City, which is famous for *manazuru* (white-necked crane) and *nabetsuru* (hooded cranes) as the special natural monuments of Japan coming over the sea into the city, the building of Izumi Station has a roof comprising the motifs of cranes flapping their wings, so that it has a combined effect of shades and slender pillars and consequently gives a light and rhythmical impression.

Figure 36: Appearance of Izumi Station



Design of elevated bridge

The structure of Nishi-Kagoshima elevated bridge, constructed as a girder bridge in Kagoshima City, comprises curved piers, beams and other members to express a soft image creating a less depressing impression, considering the landscape of the neighbouring area and the saving of construction costs.

Figure 37: Nishi-Kagoshima elevated bridge



(cited from the 'Post-Assessment Report', 5.7 Designs considering Landscapes).

Design of railway train (*Tsubame* Series 800)

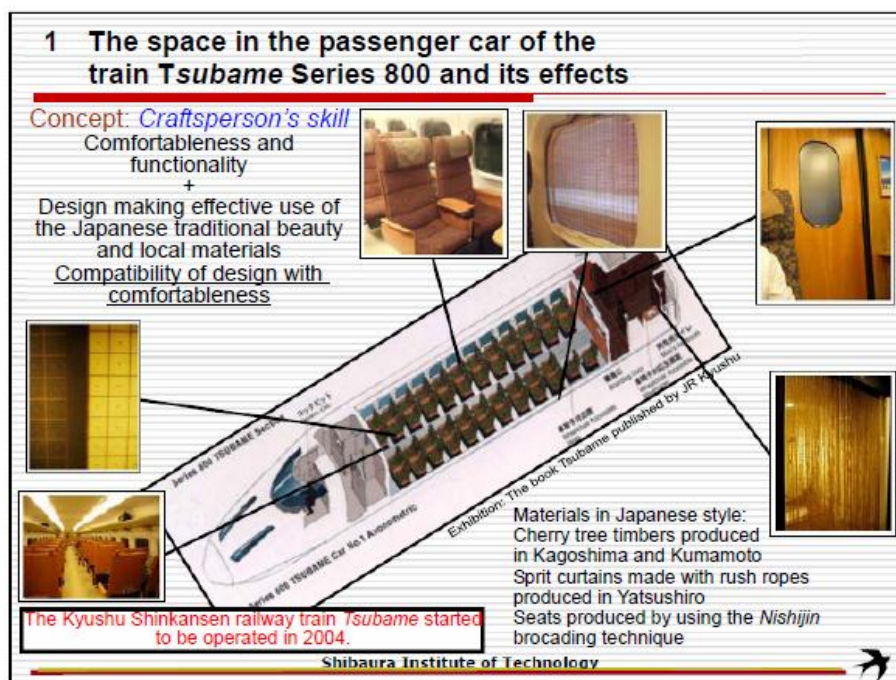
Preface

In 2004, the Kyushu Shinkansen railway train *Tsubame* (Swallow) Series 800 was introduced. This was the first train to run on the Shinkansen railway line in the Kyushu region. The cars of this train have interior spaces which express the enthusiasm of JR Kyushu. An abundance of timbers produced in Kyushu is used in the car rooms, using white as the basic colour. In each passenger room, seats covered with textiles in the Japanese style look attractive in the composed colour arrangement and create a graceful impression of the room. In each toilet room, the rush-worked split curtain gives the mildness specific to the natural material of the room, and completely changes the image of interior spaces in public transport services, which had pursued functionality and comfort. The car rooms, in which the materials and traditional craftworks produced in the Kyushu region are introduced, seem to suggest that a design strategy should be introduced into future public transport services.

The authors anticipate that such a design strategy will create a new value in the limited time or required time of transport and the limited space, especially in case of public transport services predominantly used for tourist trips, and will have effective influence not only on the users and operators of these transport services but also on the development of the areas along railway lines. If local colours are introduced into the key components of trains, users might have a naturally excited feeling of “I’m traveling,” and railway operators could have an opportunity to improve their corporate brands. We also expect that the development of this design strategy may contribute to the revival of traditional craftwork technologies which are gradually disappearing in our country.

In this research, we interviewed representatives of the related companies and analysed problems and solutions regarding the manufacture of the Kyushu Shinkansen railway train *Tsubame*, to search for methods of introducing the optimum design strategy adaptable to the local climate into the interior spaces in public transport services. The traditional craftworks covered by our research include those using local materials.

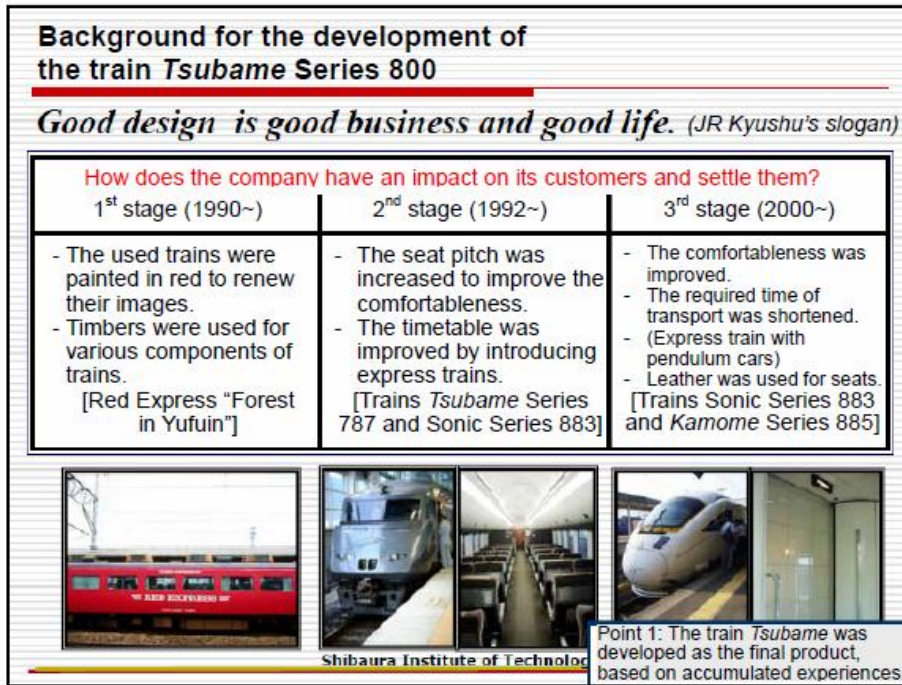
Figure 38: Design of passenger cars



Background to the introduction of traditional craftworks in the Tsubame Series 800

The background for the introduction of traditional craftworks in the *Tsubame* Series 800 will be described hereinafter, based on interviews with representatives of JR Kyushu as well as published papers.

Figure 39: Background for the train series design



When Japan National Railways was privatized, the availability of motor vehicles accounted for more than 70% of all the transport modes in the Kyushu region. JR Kyushu was competing with other public transport companies to obtain a share of the remaining 30%. To discriminate its sensibility value from those of its rivals, JR Kyushu implemented the joint train development project with Mr Eiji Mitooka, consultant designer in Done Design Research Laboratory. As shown in Figure 40, JR Kyushu has had an impact on the users of its railway through its train designs and has made efforts to respond to their demands since the Japan National Railways was privatised. An abundance of timber was used for the floors, walls, handrails and tables in event trains such as 'Forest in Yufuin'. Cowhides were used for all the seats in the train *kamome* (Seagull). JR Kyushu has enlarged the possibility of its trains for 20 years by actively developing the characteristic colouring and train designs, although it committed blunders and made reviews. The train *Tsubame* Series 800 was developed as the final product under the train design strategy by using local materials produced in the Kyushu region and traditional Japanese craftworks, as given in Table 7. The interior decoration of the *Tsubame* Series 800 follows the principle of 'compatibility of design with comfort', uses white as the basic colour, and the seat pitch was increased to create comfortable interior spaces with the array of 'two plus two' seats in the train.

Table 7: interior decorations related companies and the materials and characteristics of interior decorations

Product and manufacturer	Materials and characteristics
Split curtains Inoue Industry	Split curtains made by the rush ropes produced in Yatsushiro
Blinds Kyowa kogyo	Cherry tree (produced in Kagoshima) blinds like bamboo screens
Chairs (seats) Suminoe Textile	Textiles (in lapis lazuli blue, bluish green, and antique lacquer color) woven using the Nishiin brocading technique effectively and having the original patterns modeled on the antique patterns in Japan
Chairs (design and production) Suminoe Industry	Cherry tree timbers (produced in Hokkaido)
Benches, handrails, tables, and picture frames Nittax	Cherry tree timbers (produced in Kumamoto) [Timbers for benches in Persimmon tannin color, light pink, and laurel leaf color]
Gable walls and wooden sheets for sliding doors Hoxan	Camphor tree timbers (produced in Kagoshima)
Floors	PVC (thermally deformable) White sheets with Japanese traditional grid patterns

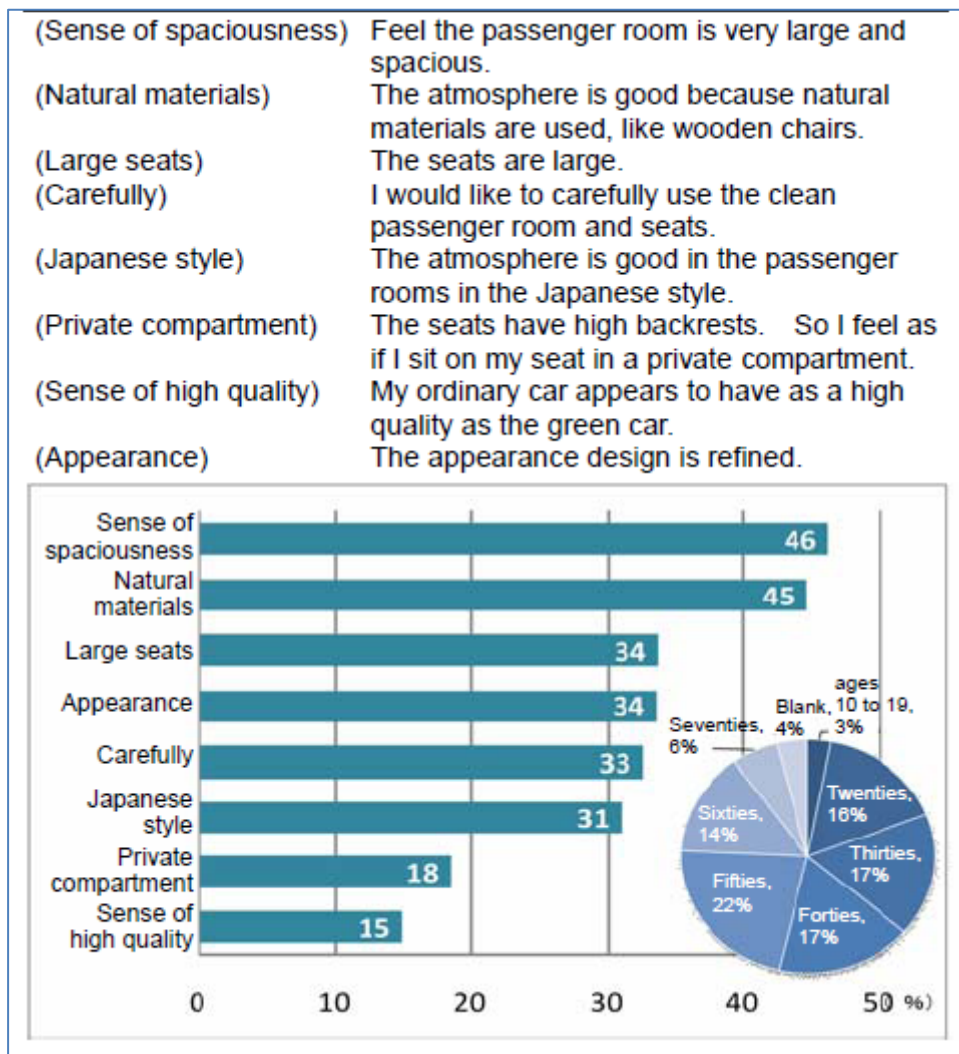
Users' assessment of the designs of trains running on Kyushu Shinkansen railway

Outline of survey

In the 2008 fiscal year, the Institute for Transport Policy Studies (Foundation) sent questionnaires to users of Shinkansen railways as part of the post-assessment of the Kyushu Shinkansen railway business. Several assessment items proposed by the authors were adopted as questions about the train design images. The assessment report summarises all the concepts and design policy and keywords as described in the papers and books written on the Kyushu Shinkansen railway.

Table 8 gives the answers to these questions. In the table, the words in the parentheses () are a summary. The questionnaire asked each of the Shinkansen train *Tsubame* users to check plural answer items that they selected. The number of effective answers was 1,807, of which about 60% were given by men and about 38% by women.

Table 8: results of survey on design of trains



Results of survey of the designs of trains running on Kyushu Shinkansen railway

- Trend of all the effective answers

Table 8 shows the results of appraisals by all effective respondents. The 'sense of spaciousness', 'natural materials', and 'large seats' had the highest percentages among all the answer items.

- Trends by sex and age bracket

Figures 40 & 41 show the results of appraisals by sex and age bracket. The trend in the 10 to 19 age bracket had an obviously great difference from that of all effective respondents. The answer item 'carefully' accounted for the highest percentage in the 10 to 19 age bracket, while the items 'sense of spaciousness' and 'natural materials' were highly appreciated by all respondents. Differences were observed between men and women in the items 'large seats', 'appearance' and 'sense of high class'. The 'appearance' was appreciated more highly by men, the 'large seats' and 'high quality' by women. The item 'natural materials' was highly appreciated by respondents in their thirties to fifties, especially by 50% of respondents in their forties and seventies. The item 'large seats' was more highly supported by women than men in each age bracket, probably because of general differences in body

sizes between men and women. The item 'private compartment' was supported by about 15% of respondents in their twenties and thirties and by 27% of respondents in their seventies. The item 'sense of high quality' was selected by 23% of women in their fifties and about 15% of women in their twenties to sixties.

Figure 40: appraisals by sex and age

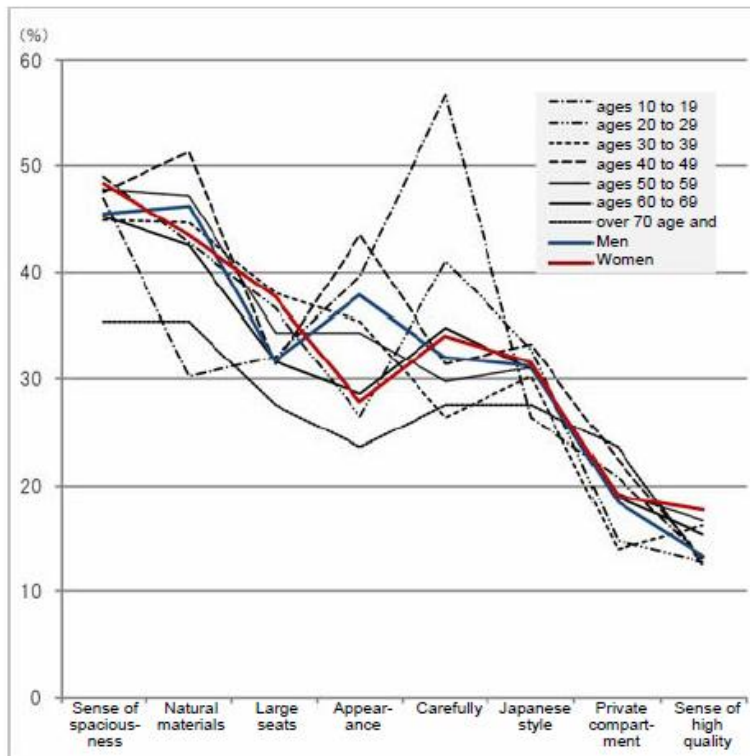
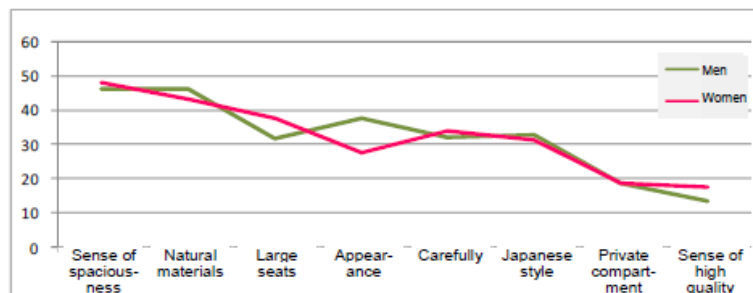


Figure 41: appraisals by sex



- Results of appraisals by living area

Of all the samples (n = 39) living in the metropolis of Tokyo, 59% selected 'natural materials' which was thus ranked No.1, while 36% highly appreciated 'sense of spaciousness' and 'appearance' which were ranked No.2. The two figures were much higher than those for other items. Similar results of appraisals were provided by the samples living in the Kanto region.

Of the samples living in Kyoto and Nara (n = 34), only 20% supported the 'Japanese style', although it was expected that this style would be highly appreciated by these samples,

because the seats produced using the Nishijin brocading technique were used in many Shinkansen trains.

Finally, the samples living in Kyushu region (n = 1220) indicated almost the same trend as the other samples. However, the item 'carefully' was supported by 35% of respondents living in Kyushu region and thus ranked No.3. The figure was higher than the average value given by all respondents to this item.

Considerations

The items that make the interiors of cars comfortable were highly appreciated by all respondents. The item 'carefully' was highly appreciated by the 10 to 19 and 20 to 29 age brackets, and so can be noticed as the item which may improve users' morale. It is interesting that 'sense of high quality' was more highly appreciated by women than by men in each age bracket, although it was appreciated by a low percentage of all respondents.

In the appraisals by living region, the item 'natural materials' was so highly appreciated by respondents living in Tokyo that it is desirable to introduce designs using natural materials into the Shinkansen railways connecting the Greater Tokyo Metropolitan area to local regions.

Respondents using the Kyushu Shinkansen railway line supported the items, 'sense of spaciousness', 'natural materials', and 'large seats', which are directly related to comfort. The other items were reacted to differently by respondents in different age brackets and living in different regions. Therefore, it can be said that design concept strategies targeting users will contribute to the future development of spaces in cars.

Survey by interviewing representatives of interior decoration-related companies

Outline of survey

JR Kyushu had adopted a policy of limiting the operating cost for the Shinkansen train *Tsubame* to a lower value than that for conventional trains. To take cost reduction measures, therefore, JR Kyushu entrusted Mr Mitooka with all works ranging from designing to selection of materials, while it took responsibility for checking train functions and purchasing the great quantities of materials without taking care of their coarse textures. Mr Mitooka gave first priority to the use of natural materials. Although an abundance of timbers was used in the train *Tsubame* Series 800, he reduced production costs by using even materials which might be usually disposed of as waste. He supposed that he wanted to use natural woods rather than beautiful timbers and that timbers with nodes were natural. This know-how was applied to the leather-covered seats in the express train Series 885 before the train *Tsubame* Series 800 had been constructed. Thus, it seems that past experiences were effectively used. However, it is supposed that it will significantly increase production costs to realise such high-quality spaces in cars and to produce a relatively small quantity of trains. In this research, therefore, we conducted interview surveys not only on technical and cost problems that interior decoration related companies encountered when they introduced traditional craftworks into their products but also

on the solutions that they adopted to solve these problems. In the interview surveys, we asked the following three questions of interviewees:

- What problems were caused by using new materials for trains? (Technical problems);
- You said that "the trains *Tsubame* Series 800 had been produced without increasing the production cost". However, increased production costs should have been inevitable if new materials were used to meet different standards. How did you solve this problem? (Cost problem);

- What influences did the development and production of the train *Tsubame* Series 800 have on your and other companies? (Delivery influence).

Challenges and keys to solutions in production process

The answers provided by the six companies engaged in the production of the train *Tsubame* are given in Table 9. In terms of the production process, the train *Tsubame* Series 800 presents remarkable characteristics as follows:

- it needed not only the express speed required for Shinkansen trains but also tourist factors because Kyushu region is dependent on tourism;
- the companies had to produce small lots because the Kyushu Shinkansen railway was partially opened, and because the daily number of operations was lower for the train *Tsubame* than for the others;
- the use of natural materials caused technical and maintenance problems; and
- sophisticated designs were required.

These characteristics had great influences on the production process.

- Technical challenges

Technical challenges were caused by producing the introduced materials in accordance with train design standards. The products used for interior decorations in the Shinkansen trains are required to meet high standards such as light weight, flame resistance and incombustibility, and durability.

- Weight reduction

Efforts were made to reduce the weights of products by gram unit, and it was required by customers to make technical efforts for each item of products to be delivered. For example, Lonseal Corp. was required to submit its floor materials to fire resistance and anti-slip processing under the constraint of weight reduction. Since Mr Mitooka adopted the policy of using timbers to produce seats, Suminoe Industry also was required to further reduce the weights of its chairs, which were lighter than those of conventional products. To satisfy the requirement, the company manufactured test products by balancing the product's strength and weight. These challenges were solved by establishing a flexible system including effective use of the knowledge accumulated in their research laboratories as well as formation of special teams.

- Flame resistance and incombustibility

The companies used their own technologies to process their products in order to make them flame resistant and incombustible.

Table 9: Challenges and keys to solutions in production process

Company	Challenges	Keys to Solutions
Inoue Industry	A. Technical challenge	<ul style="list-style-type: none"> - Our techniques were repeatedly improved. - We had many skillful artisans. - We had an ambition of spreading rush-made products. - We expected to receive subsequent orders.
	Thinner ropes than the ordinary ones had to be developed.	
Kyowa	A. Technical challenge	<ul style="list-style-type: none"> - Our experiences in introducing our wooden

Company	Challenges	Keys to Solutions
Kogyo	Wooden blinds for train cars had to be manufactured.	blinds into train cars were effectively used in the event train operated by JR Kyushu. - Our building division's knowledge was effectively used. - The manual works permitted us to flexibly respond to the demand. - A lumbering company gave us its cooperation. - Our employees had consciousness as artisans. - We were proud of our products to be delivered to Shinkansen Trains.
	B. Cost problems The wooden blinds had a minor mass-production effect.	
Suminoe Textile	A. Technical challenges The wear resistance of textiles had to be improved. (The wear resistance of moquette is low.) The balance between the quantity, weight and strength of threads had to be adjusted.	- The knowledge accumulated in related and other divisions was effectively used. - Because we had developed many products we could develop a few techniques for the products in use for the train <i>Tsubame</i> and make an effort to reduce the development cost.
	B. Cost problem A small number of seats was produced so the initial production cost was relatively high.	
Suminoe Industry	A. Technical challenges The weights of our products had to be decreased. (The weights of our products were decreased by using wooden material, but a further decrease in weight was required by the customer.)	- The parts that may not affect the strength of our products were removed by experiments. - Small quantities of many items could be produced for a short period because of our flexible production lines. - two designers were used, though one designer was usually in charge. - Our company established the back-up system. - Our experience in developing new type chairs (for the train <i>Kamome</i> Series 885) was effectively used. - Our employees adopted their good ideas by a consensus. - We had a stable technical base (automobile division). - We expected to receive the next orders.
Hoxan	B. Cost problem Our products have a little effect of mass production.	- We could supply good products because JR Kyushu insisted on the use of natural materials without taking care of their nodes. - Our experiences in developing a wide range of new wooden products could be effectively used. - We could make a little effort in reducing the production cost for our products in use for the train <i>Tsubame</i> because we had developed many products.
Lonseal Corp.	A. Technical challenges The characteristics of material (It was difficult to print geometric patterns on PVC sheets having a thermal deformability.) Design (A little deformation or a few stains may look remarkable on the white floor of 20m in length with grid patterns.)	- We have established a flexible system to receive orders for any quantity of products. - Our research laboratory could be effectively used to develop new products. - We were aware that these technical challenges might contribute to improving our technologies. - We were aware that these technical challenges might contribute to improving the publicity effect of our products.

Company	Challenges	Keys to Solutions
	Weight reduction (Values such as incombustibility, anti-stain and anti-slip had to be added to thin PVC sheets.)	<ul style="list-style-type: none"> - We have accumulated experiences for many years. - We formed the special team for the train <i>Tsubame</i>.
	B. Cost problems	
	Our products did not have any mass production effect so the initial production cost was increased. The production cost was increased by producing a small quantity of products. The production speed was lowered. Our products involved the copyright of a designer.	

- Durability

Durability was featured by the fact that the train *Tsubame* targeted tourists rather than business passengers. The interior decorations of Shinkansen trains are generally replaced after seven to eight years of operation. If textiles are used for the interior decorations of business trains requiring durability, they may have an unreasonable influence on the service life of the interior decorations. Moquette is generally used for seats in railway cars. However, Suminoe Textile used textiles which are inferior to moquette in several properties such as durability, strength and service life. Therefore, the challenge for the company was to develop technology for improving the strength and wear resistance of textiles as used for silk curtains. Suminoe Textile has operated a polytechnic centre to conserve textile technologies, and the centre's knowledge was effectively used to produce seats for the Shinkansen trains.

- Sophisticated design

Lonseal Corp., which produced the floor sheets for the Shinkansen trains, was required to adopt the Japanese traditional design of grid and dot patterns on a white sheet. However, it was very difficult for the company to paint the PVC sheets as floor materials in white and draw the geometric grid patterns on them, because any stain was not allowed to stick on them. A PVC sheet roll of 20m and 140kg may expand and shrink due to its weight and thermal deformability. Therefore, the products were repeatedly checked by decreasing the production speed. Some remarked that there was a difference in the production span between Lonseal and the train manufacturer so that the floor sheet production process did not have any mass production effect. Based on its experiences accumulated over many years, however, Lonseal's products contributed to improving the publicity effect for its own technologies.

- Cost problems

The companies encountered problems with increasing costs because new products of high quality designs were developed and a small quantity of trains was produced. The rate of losses was slightly increased by producing a small quantity of products. However, the companies made efforts to reduce production costs for their products, expecting that the product delivery effect might exceed the higher producing cost. The cost reduction techniques adopted can be roughly divided into two categories:

- flexible production lines could respond to the small quantities of many items ordered (Inoue Industry, Kyowa Kogyo, Suminoe Industry, and Lonseal Corp.); and
- a small effort could be made to reduce production costs for products in use for the

train, because many new products were developed annually and because departments other than the related ones were stable within the companies (Suminoe Textile and Hoxan).

- Maintenance

As a maintenance challenge, it was supposed that production costs might be increased by the defects of natural materials. However, interviewees answered that 'the products of high quality designs were carefully used' (JR Kyushu), and that 'spare parts were stocked for maintenance, but little delivered' (Kyowa kogyo). This means that the higher quality of the interior decorations in trains could limit the rise of maintenance costs.

The representative of JR Kyushu reported that although it was very onerous to clean the white body of the train *Tsubame*, the train manufacturers had improved their consciousness through the production of high quality trains and come to consider that "it was natural to maintain the clean environment".

- Cooperative system

In the hearing, many participants gave the same comment that 'they have established a cooperative system to produce their products for the train *Tsubame* Series 800'. They were not only profoundly impressed with and supported JR Kyushu's and Mr Mitooka's intentions of 'providing artisan's skill', 'using natural materials', and 'producing the unique Shinkansen trains reflecting the local features of Kyushu' but also they expected with pride that they would 'produce the best Shinkansen trains'. It can be said that production of high quality trains which may gain topicality improved employees' consciousness as 'artisans' in the companies.

- Delivery effects

The challenges faced by the companies were solved by the effect of delivery. As shown in Table 9, interviewees' answers such as 'the delivery of their products to the Shinkansen trains seen by many people had a great publicity effect', and 'the number of customers was increased by the publicity effect' revealed that the delivery effect of their products had made a great appeal on outsiders. In addition, their answer 'their technological levels were improved' suggested that they positively appreciated their efforts in developing new technologies and reducing production costs.

Reactions by local industries

After the Kyushu Shinkansen railway line had been opened, various industries showed their reactions. Suminoe Textile reported that "it had given a lecture on the development of its textiles (and its physical standards) to meet the request made from the Hakata textile manufacturers in Kyushu region" and that the manufacturers had had the intention of introducing their products into the trains running in their local areas. Hoxan also reported that such requests had been made not only from the parties related to the train *Tsubame* Series 800 but also from other public facilities including the prefecture governments.

Conclusion

This research focused on the design strategy for the train *Tsubame* Series 800 and described the challenges and solutions which were clarified by interviews with the companies engaged in producing the products in use for the train.

With regard to the construction of the trains *Tsubame* Series 800, the companies faced

many challenges. The following two solutions made a great contribution to solving these challenges:

- 'accumulated experiences' were effectively used, including continuous improvements made in technologies, effective use of knowledge accumulated in related and other departments in the companies, and the presence of their research laboratories;
- a flexible production system was established, including accumulated experiences and knowledge mutually shared by related and other departments in the companies and the manual assembly processes added to the automatic production lines.

D CHRONOLOGICAL TABLE OF THE PROJECT

Table 10: Chronological table of the Project

Year	Month & day	Event
1964	December 1	The Tokaido Shinkansen railway between Tokyo and Osaka was opened.
		The Japan National Railways recorded a deficit in this fiscal year.
1970	April 1	The Kyushu Shinkansen Railway Construction Promotion Committee was established.
	May 13	The National Shinkansen Railway Construction Law was established.
	May 18	The National Shinkansen Railway Construction Law was promulgated.
1972	May 15	The Sanyo Shinkansen railway section between Shin-Osaka and Okayama was opened.
	June 29	The Basic Plan for the construction of the five projected Shinkansen railways was decided.
1973	November 13	The construction project for the five projected Shinkansen railways was decided. (The construction order was issued.)
1975	March 10	The Sanyo Shinkansen section between Okayama and Hakata was opened.
1979	January 23	The order to make an environmental impact assessment on the projected Shinkansen railways was issued.
1981	June 12	The National Shinkansen Railway Construction Law was amended (to set down that the related local governments shall share the construction costs).
	November 10	The Liberal Democratic Party decided to conduct surveys on the order of priority.
1982	June 23	The Tohoku Shinkansen section between Omiya and Morioka was opened.
	September 24	The cabinet decided to freeze the Construction Project for the Projected Shinkansen Railways.
	November 15	The Joetsu Shinkansen section between Omiya and Niigata was opened.
1984	March 27	The outline of the railway route between Fukuoka and Kagoshima was published to make an environmental assessment along the route.
	November 2	Mr Sadatoshi Kozato took office as the parliamentary under-secretary of transport.
	December 28	The government and the ruling party (Liberal Democratic Party) made an arrangement (on the budget for the 1985 fiscal year). The memorandum regarding the installation of facilities necessary to prepare for starting the construction of the Kyushu Shinkansen railway
1985	January 26	The facilities necessary to prepare for starting the construction of the Kyushu Shinkansen railway were installed in Kumamoto and Kagoshima.
	March 14	The Tohoku and Joetsu Shinkansen sections between Ueno and Omiya were opened.
	August 22	The government and the ruling party established the Review Committee on the financial resources and other problems of the projected Shinkansen railways. The government and the ruling party made an arrangement. (They decided the policies of matters such as budget appropriation to the environmental development projects around Shinkansen stations.)
	November 28	The street campaign for promoting the construction of Kyushu Shinkansen Kagoshima route was developed in front of the Sony building at Ginza in Tokyo.

Year	Month & day	Event
	December 27	The government and the ruling party made an arrangement. (The treatment of the projected Shinkansen railways was decided)
1986	October 28	The eight bills for the reform of the Japan National Railways were voted.
	December 29	The government and the ruling party made an arrangement. (The Memorandum on unfreezing and starting the construction of the projected Shinkansen railways was published.)
1987	January 30	The cabinet's 'Decision of freezing the Construction Project for the Projected Shinkansen Railways' was abolished. (The Project was unfrozen.)
	February 24	The environmental development project around Nishi-Kagoshima Station began implementation.
	March 28	The environmental development project around Nishi-Kagoshima Station was completed.
	April 1	The Japan National Railways was wound up, divided and privatised (JR Kyushu was established).
	December 16	JR Kyushu published its written opinion titled 'About the Projected Shinkansen Railway'.
	December 23	The 'Meeting for Promoting the Development of Kyushu as One Region' was held. A budget examiner in the Ministry of Finance remarked, "the three most foolish examinations for the period of Showa (1926 to 1989)."
	December 27	The government and the ruling party made an agreement (on the budget for the 1988 fiscal year). (The government published its policy of giving priorities to the projected Shinkansen railways to be constructed.)
1988	January 29	The Review Committee for Promoting the Construction of the Projected Shinkansen Railways proposed the partial construction method.
	April 4	The opening ceremony of the free passage in Nishi-Kagoshima Station was held.
	August 11	The Ministry of Transport submitted its tentative plan. JR Kyushu published its written opinion titled 'About the Construction of the Kyushu Shinkansen Railway Kagoshima Route'.
	August 31	The government and the ruling party made an arrangement. (The priorities of the three projected Shinkansen railways to be constructed were decided.)
1989	January 17	The government and the ruling party made an arrangement (on the treatment of the projected Shinkansen railways). The costs for the project of executing difficult works for the projected Shinkansen railways were included in the budget.
	August 8	The third Shibisan tunnel started to be constructed. (The difficult construction work for the section started to be executed.)
1990	May 16	Mr Michio Watanabe visited and inspected the construction work site in a helicopter.
	December 1	The governors of Kagoshima and Kumamoto prefectures talked with the President of JR Kyushu. (They agreed on the separation of the management.)
	December 24	The government and the ruling party made an arrangement on matters such as starting the construction of the projected Shinkansen railways. It was decided to start the construction of Kyushu Shinkansen section between Yatsushiro and Nishi-Kagoshima.
1991	June 20	The Tohoku and Joetsu Shinkansen sections between Tokyo and Ueno were opened.
	August 9	The application for the authorisation to the project for executing the

Year	Month & day	Event
		construction works for the Kyushu Shinkansen section between Yatsushiro and Nishi-Kagoshima was made.
	August 22	The project for executing construction works for the Kyushu Shinkansen section between Yatsushiro and Nishi-Kagoshima was authorised.
	September 7	Construction works for the Kyushu Shinkansen section between Yatsushiro and Nishi-Kagoshima started. (The ground-breaking ceremony was held.)
1992	July 1	The Yamagata Shinkansen section between Fukushima and Yamagata was opened. (Mini Shinkansen railway)
	October 17	The ground-breaking ceremony was held for the urgent construction project of the Nishi-Kagoshima Station.
1996	June 19	The urgent construction project of Nishi-Kagoshima Station was completed.
	December 25	The government and the ruling party made an arrangement on the 'treatment of the projected Shinkansen railways'. The financial resources scheme was decided.
1997	March 22	The Akita Shinkansen section between Morioka and Akita was opened. (Mini Shinkansen railway)
	October 1	The Hokuriku Shinkansen railway between Takasaki and Nagano was opened (as the projected Shinkansen railway No. 1 opened).
1998	March 12	The project for executing construction works for the Kyushu Shinkansen section between Funagoya and Yatsushiro was authorised.
	March 21	The Kyushu Shinkansen section between Funagoya and Yatsushiro began construction.
	September 25	The application for changing the construction work execution project was made (to change the starting point of work from Yatsushiro to Shin-Yatsushiro).
1999	December 4	The Yamagata Shinkansen section between Yamagata and Shinjo was opened (Mini Shinkansen railway).
2000	December 18	The additional application on the construction work execution project was developed and authorised. (It was decided to construct the Kyushu Shinkansen section between Yatsushiro and Nishi-Kagoshima in accordance with the full standard.)
2001	April 25	The additional works to the construction work execution project were authorised.
	June 2	The Kyushu Shinkansen section between Hakata and Funagoya began construction.
2002 (H14)	October 22	The agreements for the Third Sector-operated existing lines in parallel with the Kyushu Shinkansen railway were concluded (between JR Kyushu and Kumamoto and Kagoshima prefectures).
	December 1	The Tohoku Shinkansen section between Morioka and Hachinohe was opened (as the projected Shinkansen section No.2 opened).
2003 (H15)	January 12	The Shinkansen railway structures were delivered to JR.
2004 (H16)	March 13	The Kyushu Shinkansen section between Shin-Yatsushiro and Kagoshima-Chuo was opened. Nishi-Kagoshima Station was renamed Kagoshima-Chuo Station. The Hisatsu Orange railway (existing line in parallel with the Shinkansen railway) was opened.
2011 (H23)	March	The Kyushu Shinkansen section between Hakata and Shin-Yatsushiro will be opened.

Important arguments on the chronological table

Freezing and unfreezing the construction of the projected Shinkansen railways

The construction project for the projected Shinkansen railways was decided in 1973. However, the construction project did not make progress as expected because it was affected by the enormous deficit recorded by Japan National Railways (JNR). With the lapse of time, priority was given to the commitment of the reconstruction of the JNR over the construction of the new Shinkansen railways. A variety of measures were taken to reconstruct the JNR. On the other hand, the cabinet decided to freeze the construction project for the projected Shinkansen railways on 24 September 1982. Thus, the construction project was suspended.

The parties interested in Kagoshima, Kyushu, actively made efforts to get the construction project unfrozen, including the development of lobbying activities as well as the construction of the potential Shinkansen stations implemented in their own charge to meet the government request. Their efforts and enthusiasm bore fruit: on 30 January 1987, the government abolished the cabinet's decision of 'Freezing the construction project for the projected Shinkansen railways'.

Financial resources problem

It was absolutely necessary to solve the financial resources problem in order to implement the construction project for the projected Shinkansen railways. To do so, it was necessary to obtain financial resources for the construction project from the limited budget. However, the Ministry of Finance, which controlled the National Budget, expressed disapproval of the project. Especially, a budget examiner in the Ministry of Finance remarked that the examination of the project was one of the "three most foolish examinations". The government and the ruling party (Liberal Democratic Party) had a negative attitude to implementing the project, though they decided to unfreeze it. In addition, the financial resources problem was far from being solved.

In these circumstances, the interested parties requested Mr Michio Watanabe, the Chairman of the Policy Research Committee in the Liberal Democratic Party at that time, to give his support to the project, although he was not interested in the project. Initially, he expressed disapproval of the project. However, a cooperative system was established after several persuasive requests had been made to him. Under this system, the Review Committee for Promoting the Construction of the Projected Shinkansen Railways met on 29 January 1988, and proposed a partial construction method, taking the financial resources problem into consideration. As the section to which the partial construction method would apply, it was decided to review the section between Yatsushiro and Nishi-Kagoshima (between Shin-Yatsushiro and Kagoshima-Chuo at present), which was the existing line section with many curved subsections and opened first as a Shinkansen railway section.

Priorities for construction

The construction project for the projected Shinkansen railways decided in 1973 planned to construct five lines in Hokkaido, Tohoku, Hokuriku, Kagoshima (Kyushu), and Nagasaki (Kyushu). When the national budget for the 1988 fiscal year was decided on 27 December 1987, it was decided to prioritise construction of five sections of three lines in Tohoku, Hokuriku, and Kagoshima (Kyushu). However, higher priority was given to construction of the sections that might be more profitable. Therefore, it could not be predicted when construction of the lower priority sections would start. Before the priorities were finally decided on 31 August 1988, it was revealed that the Kyushu Shinkansen railway Kagoshima route was fourth priority for the construction of the five lines. Thus, the interested parties had

a growing sense of crisis with regard to the construction of the Kagoshima route.

An interested party, who aimed at starting construction of the three lines at the same time, worked out the plan in which higher priority would be given to a section such as tunnels requiring more difficult works and a longer period of construction than the others, and succeeded in adding the statement “the section requiring a more difficult work shall be constructed earlier without respecting the priorities of construction” to the proviso in the draft document of priorities, just before the priorities were finally decided. As a result, construction of the third Shibisan tunnel started in 1989, before construction of the full Kyushu Shinkansen Kagoshima route started. On 7 September 1991, construction of the section between Yatsushiro and Nishi-Kagoshima began to be executed full scale, after efforts had been made to obtain financial resources.

E FINANCIAL ASSISTANCE AND FUND RAISING FOR THE PROJECT

Background to financial assistance and fund raising (the deficit problem and reform of Japan National Railways)

An annual deficit was recorded by JNR in 1964 when the Tokaido Shinkansen railway was opened and the Tokyo Olympic Games were held. JNR had run up a deficit every year since recording a deficit of about JPY 30bn in 1964, and the amount of deficit had increased year by year. JNR had a loss carried forward in 1966 and a deficit before depreciation in 1971. At last, JNR came to reschedule its obligations in 1976 and 1980.

JNR prepared First, Second and Third Plans in the period from 1957 to 1971. These were the so-called 'expansion' plans including increase of traffic and construction of the Tokaido Shinkansen railway. JNR had drawn up five reconstruction plans or management improvement plans since recording the first deficit before depreciation in 1971 but these plans had no significant effect. Thus, JNR continued to suffer from the worsening conditions of its business management as well as increasing obligations, and these problems became issues of public concern.

At last, JNR was divided and privatised in April 1987, and its businesses were taken over by Hokkaido, East Japan, Tokai, West Japan, Shikoku and Kyushu Passenger Railway Companies, and Freight Railway Companies. In addition, related laws such as the Railway Construction Law were abolished, the Railway Enterprise Law was established, and the National Shinkansen Railway Construction Law was partially amended.

In September 1987, the Japan Railway Construction Corporation took over the business of JNR related to the construction of the Kyushu Shinkansen railway from the Kyushu Passenger Railway Company as the main contractor. Thus, the 'Law on the Japan Railway Construction Corporation Taking over the Business Related to the Construction Projects for Shinkansen Railways Implemented by the Passenger Railway Companies Limited as the Main Contractors' was promulgated as a legal action taken to ensure that one railway construction company would construct all Shinkansen railways.

(Cited from the 'Sociology on the Government's Failure—the Construction of the Projected Shinkansen Railways and the Long-Term Obligation Problem of the former Japan National Railways', Chapter 9, Paragraph (1) Deficit recorded by Japan National Railways for a single fiscal year and the "Shinkansen Railways—All the High-Speed Railway Technologies, 1.1.7 Reform of Japan National Railways and Shinkansen railways).

Funding sources and their sharing rates

Financial resources and ownership of properties

Financial resources for construction and the history of fund raising

- Tokaido and Sanyo Shinkansen railways

It was considered that the Tokaido and Sanyo Shinkansen railways would be constructed as new lines, and the funds including the capital invested by JR, the government's treasury investment and loan fund, and the money borrowed from the private sector were introduced into the construction costs. For the Tokaido Shinkansen railway, a loan granted by the International Bank for Reconstruction and Development (IBRD) (World Bank) was added to these funds.

- Tohoku Shinkansen (between Tokyo and Morioka) and Joetsu Shinkansen railways

The fund invested from the government's general account budget was appropriated to a part of the construction costs for Tohoku and Joetsu Shinkansen railways. The other financial resources included funding debt, special debt, and other debts granted by the Trust Fund Bureau of the Ministry of Finance. In 1979, money borrowed from the private sector began to be introduced into the construction costs.

The action of giving a grant was taken to pay the interest on the money with interest borrowed for the construction costs.

- Projected Shinkansen railways
 - From 1989 to the 1996 fiscal year

The financial resources for the construction costs included:

- the debt appropriated by the Industrial Investment Special Account Budget, whose fund was constituted by the revenue obtained by selling the NTT shares held by the government;
- the Shinkansen Railway Holding Organisation's grant, of which the financial resources were constituted by the surplus of the rental revenue from leasing the existing Shinkansen railways (and for which the Fund was established in the 1991 fiscal year by using a part of the revenue obtained by the transfer of the existing Shinkansen railways to JR companies);and
- the government's treasury investment and loan fund.

JR companies decided to invest 50% of the total fund for construction costs. It was decided that the government and the local governments interested would pay 40% and 10% respectively of the total fund for Class 1 works (works related to railway facilities such as railroads and other main facilities), and 25% each of the total fund for Class 2 works (works related to stations and the other railway facilities closely related to local communities' interests). Local governments, including the governments of the capitals and prefectures, would bear the costs of executing works in their jurisdictions respectively. Common costs would be shared by the government and the local governments interested depending on their percentages of the total costs for executing Class 1 and 2 works.

- From the 1997 fiscal year to the present time

At present, the financial resources for constructing the projected Shinkansen railways are shared by the government and the local governments interested in a ratio of 2:1, except that part of the rental revenue from leasing Shinkansen railways is appropriated to the financial resources. Thus, the total amount of the fund is constituted by public grants, but does not include any fund with interest. The other specific financial resources are constituted by a part of the total revenue from the transfer of the existing Shinkansen railways by JR companies. The common costs are shared by the government and the local governments interested depending on their percentages of the total costs for executing Class 1 and 2 works, as described above.

As for the Hokuriku Shinkansen railway (between Takasaki and Nagano), interest-bearing debts were exceptionally procured in addition to public grants to raise the total fund for the project, because the Shinkansen railway had to be opened by February 1998 when the Winter Olympic Games were held in Nagano. It was decided that the interest-bearing debts would be repaid with the rental revenue from leasing the constructed Shinkansen railway.

Procedure for constructing the projected Shinkansen railways

- Procedure for constructing the projected Shinkansen railways

Based on recommendations by the Traffic Policy Council, the Land, Infrastructure, Transport and Tourism Minister decides the basic plan for constructing Shinkansen railways in accordance with the National Shinkansen Railway Law, considering factors such as trends in demand for railway transport and priorities under the land development policy.

The minister then orders the Japan Railway Construction Corporation and other designated juridical persons to conduct the necessary surveys of the construction of Shinkansen railways, decides the construction projects as specified in the basic plan, and orders the Japan Railway Construction Corporation and other designated juridical persons to implement the projects.

The Japan Railway Construction Corporation and other designated juridical persons receiving the minister's order prepare Work Execution Projects based on the construction projects (or if juridical persons except operators receive the minister's order, they consult with the operators beforehand), and obtain the minister's authorisation before constructing Shinkansen railways.

- Procedures for constructing the new railway lines meeting the Shinkansen railway standard and the new railway lines to be connected directly to Shinkansen railways

Considering the circumstances regarding the construction of Shinkansen railways, and to contribute to the establishment of the high-speed transport system by constructing high-speed railways which are equivalent to Shinkansen railways and temporarily form a part of the countrywide Shinkansen railway network, the Land, Infrastructure, Transport and Tourism Minister decides the plan for temporarily constructing new lines meeting the Shinkansen railway standard (Super Express lines) and those to be connected directly to Shinkansen railways (Mini Shinkansen lines), and orders the Japan Railway Construction Corporation to temporarily construct the new lines, on all sections or some sections of the lines on which the Minister orders construction of the new lines.

- Scope of the Japan Railway Construction Corporation's businesses

The Japan Railway Construction Corporation, on receiving the minister's order to construct a Shinkansen railway:

1. constructs the railway facilities;
2. conducts the necessary surveys on the construction of the railway and its facilities;
3. leases the completed railway facilities;
4. executes works to restore the affected railway facilities in the event of a disaster; and
5. provides any services incidental to the businesses (1) to (4).

Ownership of Shinkansen railway sections

Shinkansen railways other than the Tokaido and other projected Shinkansen railways

The Tokaido, Sanyo, Tohoku (between Tokyo and Morioka), and Joetsu Shinkansen railways opened before 1991 are owned by the JR companies operating them.

Projected Shinkansen railways

The projected Shinkansen railways opened in 1997 and afterwards [Hokuriku (between

Takasaki and Nagano), Tohoku (between Morioka and Hachinohe), and Kyushu Kagoshima route (between Shin-Yatsushiro and Kagoshima-Chuo)] are owned by the Japan Railway Construction Corporation (Japan Railway Construction, Transport and Technology Agency at present) and the JR companies operating the railways have to pay rents within their earned profits respectively. (This is called an up and down separation system).

(cited from ‘Shinkansen Railways—All the High-Speed Railway Technologies’, 2.2 Mechanism of construction)

Description of how to treat the financial assistance and fund raising systems

Projected Shinkansen Railway Construction Project Fund and the Grant to the Projected Shinkansen Railway Construction Project Costs

Outlines of the systems

At present, the Railway Construction Quarters, the Japan Railway Construction, Transport and Technology Agency (Foundation) is building six sections of five projected Shinkansen railways [Hokkaido (Shin-Aomori ~ Shin-Hakodate), Tohoku (Hachinohe ~ Shin-Aomori), Hokuriku (Nagano ~ Kanazawa) (the section passing through Hukui Station), Kyushu (Kagoshima route) (Hakata ~ Shin-Yatsushiro), and Kyushu (Nagasaki route) (Takeo Onsen ~ Isahaya). Part of the construction project costs is covered not only by the Project Fund constituted of revenue from the transfer of the four existing Shinkansen railways to three JR companies (JR East Japan, JR Tokai, JR West Japan) but also by the government’s grant rant for project costs.

Structures of the systems

- Targeted costs
Work costs (site costs and work execution costs) + control costs = project costs;
- Amount of money covering the project costs
Project fund: JPY 72.4bn
Grant for project costs Fixed amount of money
(Grant under the National Shinkansen Railway Construction Law);
- Structure of granting system (see Table 11).

Table 11: Structure of granting system

Project fund	Grant for project costs	
Revenue from the transfer of the four existing Shinkansen railways	Government’s grant (for public project-related costs)	Local government’s fund
$\frac{2}{3}$	$\frac{1}{3}$	

- Evolution of budget (see Table 12)

Table 12: Evolution of budget

Unit: JPY m

Fiscal year	2003	2004	2005	2006	2007	2008
Project fund	72,431	72,431	72,431	72,431	72,431	72,431
Grant for project costs	68,600	68,600	70,600	70,600	70,600	70,600

Table 13: Project costs by railway section (in the 2008 fiscal year)

Shinkansen railway and its sections		Total length km	Project costs JPY m
Hokkaido	Shin-Aomori ~ Shin-Hakodate	149	17,800
Tohoku	Hachinohe ~ Shin-Aomori	82	70,000
Hokuriku	Nagano ~ Kanazawa	228	90,600
	Section passing through Hukui Station	1	500
Kyushu (Kagoshima route)	Hakata ~ Shin-Yatsushiro	130	127,046
Kyushu (Nagasaki route)	Takeo-Onsen ~ Isahaya	45	1,000
Total		635	306,946

(cited from the 'Guidebook for Subsidising Railways', IV Construction of the projected Shinkansen railways, 1. Construction of the projected Shinkansen railways)

F IMPACTS

Impacts of project

Benefit evaluation technique in cost-benefit analysis

The efficiency of a project is evaluated by cost-benefit analysis from social and economic viewpoints. The benefit evaluation technique as specified in the 'Manual for the Railway Project Evaluation Technique 2005' (supervised by the Railway Bureau, the Ministry of Land, Infrastructure, Transport and Tourism) consists of evaluating the direct benefit, which is calculated by adding the user's benefit to the supplier's benefit.

Prerequisites in cost-benefit analysis

To produce a cost-benefit analysis, prerequisites for predicting demand are given in the table below.

Table 14: Prerequisites for predicting demand

Item		Description
Real economic growth rate		Real economic growth rates were used for 2005 and 2006 and the average of the annual growth rates in four cases as specified in the latest prediction report by the Japanese government, the 'Future Outlook and Strategy of the Japanese Economy—the Opened Country, the Growth Attained by All Participants, the Coexistence with the Environment' (submitted to the Council on Economy and Fiscal Policy on 17 January 2008) (prepared by the cabinet office) was used for 2007 to 2011. The growth rates for 2012 and subsequent years were estimated by regression analysis using real values for 2005 and 2006 and the predicted values for 2007 to 2011.
Population		The populations of previous years were estimated by the linear interpolation method using the results of national censuses (in 2000 and 2005). The estimated median values as shown in 'Future Populations in the Capital and Prefectures' (May 2007) published by the National Institute of Population and Social Security Research (JPSS) were used for populations in future years.
Construction of each transport means	Airline	Existing airports and airports to be opened by 2010 (Hyakuri and Shizuoka) were taken into account.
	Highway	Existing highways and highways projected by the 2 nd Land Development and Motorway Construction Meeting (February 2006) were taken into account.
Fare level by transport means	JR, private railway, and airline	Current values: Fare levels in October 2005 Future values: Fare levels in April 2008
	High-speed bus, passenger ship, and ferryboat	The current fare levels as of October 2005
Required time and number of services	Existing and Kyushu Shinkansen railways	Values as specified in the timetable in April 2008 Values were estimated by classifying trains into slow and rapid types. The average travel time was adopted.
Required time and number	With high-class trains on the	Current values: Specified in the timetable in October 2005 Future values: Specified in the timetable in April 2008

Item		Description
of services	existing lines	Values were estimated by classifying trains into slow and rapid types. The travel time for the representative train was used.
	Without high-class trains on the existing lines	Values as specified in the timetable in October 2003. The travel time for the representative train was used.
	Other high-class trains on the existing lines	Current values: Specified in the timetable in October 2005 Future values: Specified in the timetable in April 2008 Values were estimated by classifying trains into slow and rapid types. The travel time for the representative train was used.
	With aircraft	Current values: Specified in the timetable in October 2005 Future values: Specified in the timetable in April 2008 Values were estimated by classifying trains into slow and rapid types. The travel time for the representative train was used.
	Without aircraft	Same as described above, except that values as specified in the timetable in October 2003 were used only for Fukuoka and Kagoshima airports.
	Motor vehicles	Values were estimated on the basis of the road traffic census in the 2005 fiscal year.

Annual demands used in cost-benefit analysis

The annual demands used in the cost-benefit analysis are given in the table below.

Table 15: Annual demands (transportation density) used in cost-benefit analysis

Person-kilometers/day·km except commuter pass users

Fiscal year	Real demand	Estimated demand			
	2007	2010	2020	2030	2050
Without construction	-	4,000	4,000	3,900	3,400
With construction	8,600 *2)	8,300	8,200	8,100	6,900

*1) Transportation density is on the Kyushu Shinkansen section between Shin-Yatsushiro and Kagoshima-Chuo.

*2) The real demand (total value for commuter pass users and nonusers) is cited from 'Railway Transport Statistics' (published by the Ministry of Land, Infrastructure, Transport and Tourism).

Results of cost-benefit analysis

The results of the cost-benefit analysis are given in the table below.

The Kyushu Shinkansen railway (between Hakata and Kagoshima-Chuo) will be fully opened in the 2010 fiscal year. This cost-benefit analysis was made for 50 years, supposing that the section between Hakata and Shin-Yatsushiro were not yet opened.

The analysis indicated a current net value (B - C) of JPY 116.5bn and benefit/cost ratio of about 1.1. It also revealed that the railway (between Hakata and Kagoshima-Chuo) would significantly reduce travel time, by about 90 minutes, and that the benefit/cost ratio was restricted to about 1.1 because the analysis assumed that the railway section between Hakata and Shin-Yatsushiro was not yet opened. If this section was opened, it was assumed that the cost-benefit analysis for the section between Shin-Yatsushiro and Kagoshima-Chuo would probably produce a higher value.

When the Kyushu Shinkansen railway (between Hakata and Kagoshima-Chuo) is fully opened in 2010, Fukuoka City, the largest city in Kyushu, will be connected to Kagoshima City, and the travel time between the two cities will be reduced. Therefore, it is expected that a higher value of benefit will be provided by the line between Shin-Yatsushiro and Kagoshima-Chuo.

Table 16: Results of cost-benefit analysis

Benefit (B)	Cost (C)	Current net value (B - C)	Benefit/cost ratio (B/C)	Economic profit rate
¥1,030.4 billion	¥913.9 billion	¥116.5 billion	Approx. 1.1	4.6%

*1) The benefit and cost are estimated as the total values for 50 years after the opening of the railway by converting the values in each fiscal year into the current values respectively.

*2) The reference fiscal year for the conversion is the 2008 fiscal year.

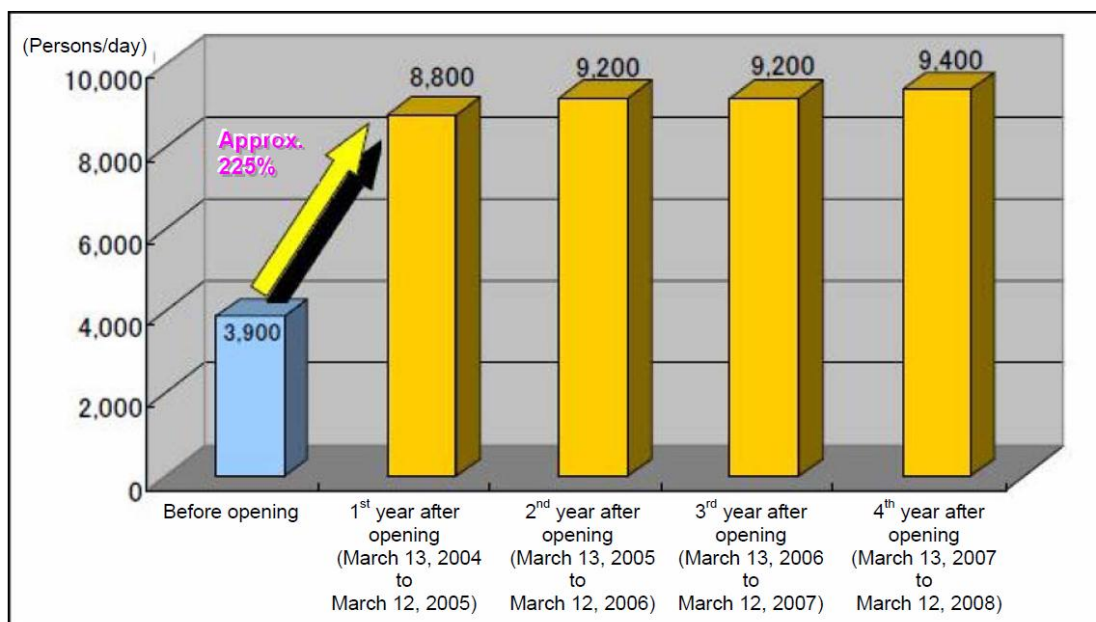
(cited from the 'Post-Assessment Report', 4. Efficiency of project).

Transport volume

Evolution of railway transport volume

The number of persons transported on the Kyushu Shinkansen railway section between Shin-Yatsushiro and Kagoshima-Chuo was 3,900 per day in 2003 before the opening of the section, 8,800 per day in the first year after opening (about 225% higher than the previous year), and 9,412 per day (promptly reported value) in 2007, the fourth year after opening of the section, which recorded the highest value in the past.

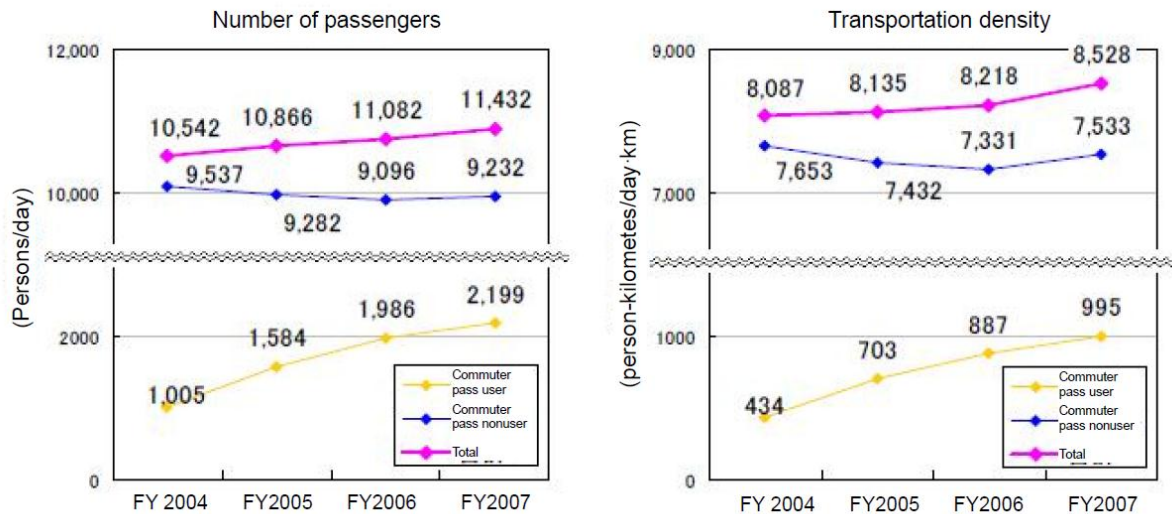
Figure 42: The real number of persons transported by Kyushu Shinkansen railway



After the section was opened, the number of commuter pass nonusers has leveled off, while the number of commuter pass users has tended to increase. The total number of passengers has also tended to increase. The number of commuter pass users in 2007 was about twice that in the 2004 fiscal year. This means that people have more and more frequently used the Shinkansen railway in their daily life. In the 2007 fiscal year, the number

of commuter pass users accounted for 19% of total passengers and 12% of total transportation density.

Figure 43: Evolution of number of passengers and transportation density on Kyushu Shinkansen railway



Effects on users

Decreasing travel time

The travel time between Hakata and Kagoshima has been reduced by about 90 minutes from three hours and 40 minutes before the opening of the Shinkansen railway to two hours and twelve minutes, about ten minutes shorter than by air. The travel time between Kumamoto and Kagoshima was reduced by about 90 minutes from two hours and 23 minutes before the opening of the Shinkansen railway to 58 minutes.

The travel time between Kumamoto and Fukuoka was one hour and 16 minutes, about 50% shorter than the journey of two hours and 23 minutes between Kumamoto and Kagoshima, before the Shinkansen railway was opened. The travel time between Kumamoto and Kagoshima was 58 minutes and 16 minutes, shorter than that between Kumamoto and Fukuoka after the opening of the Shinkansen railway.

Figure 44: Decreasing effect on the required times of transport between Fukuoka and Kagoshima or between Kumamoto and Kagoshima

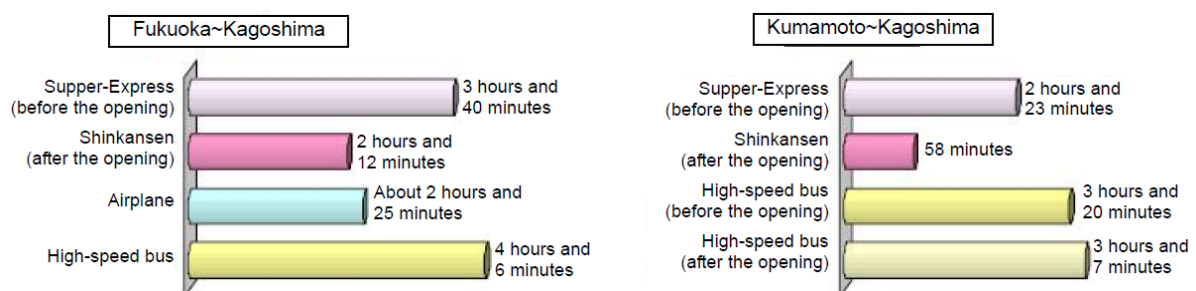
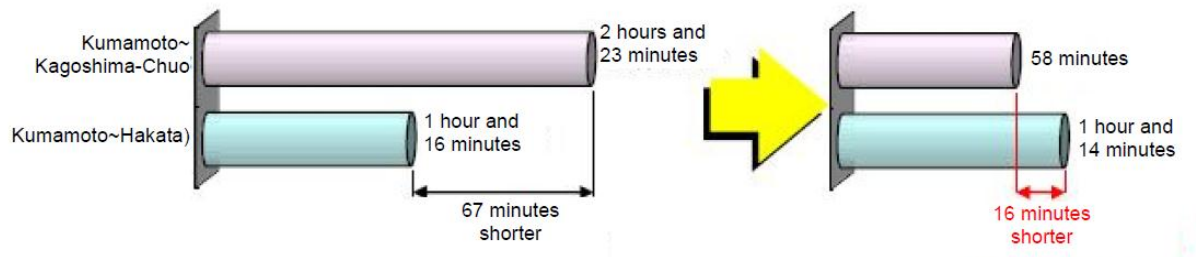


Figure 45: The required time of transport from Kumamoto to Fukuoka or Kagoshima



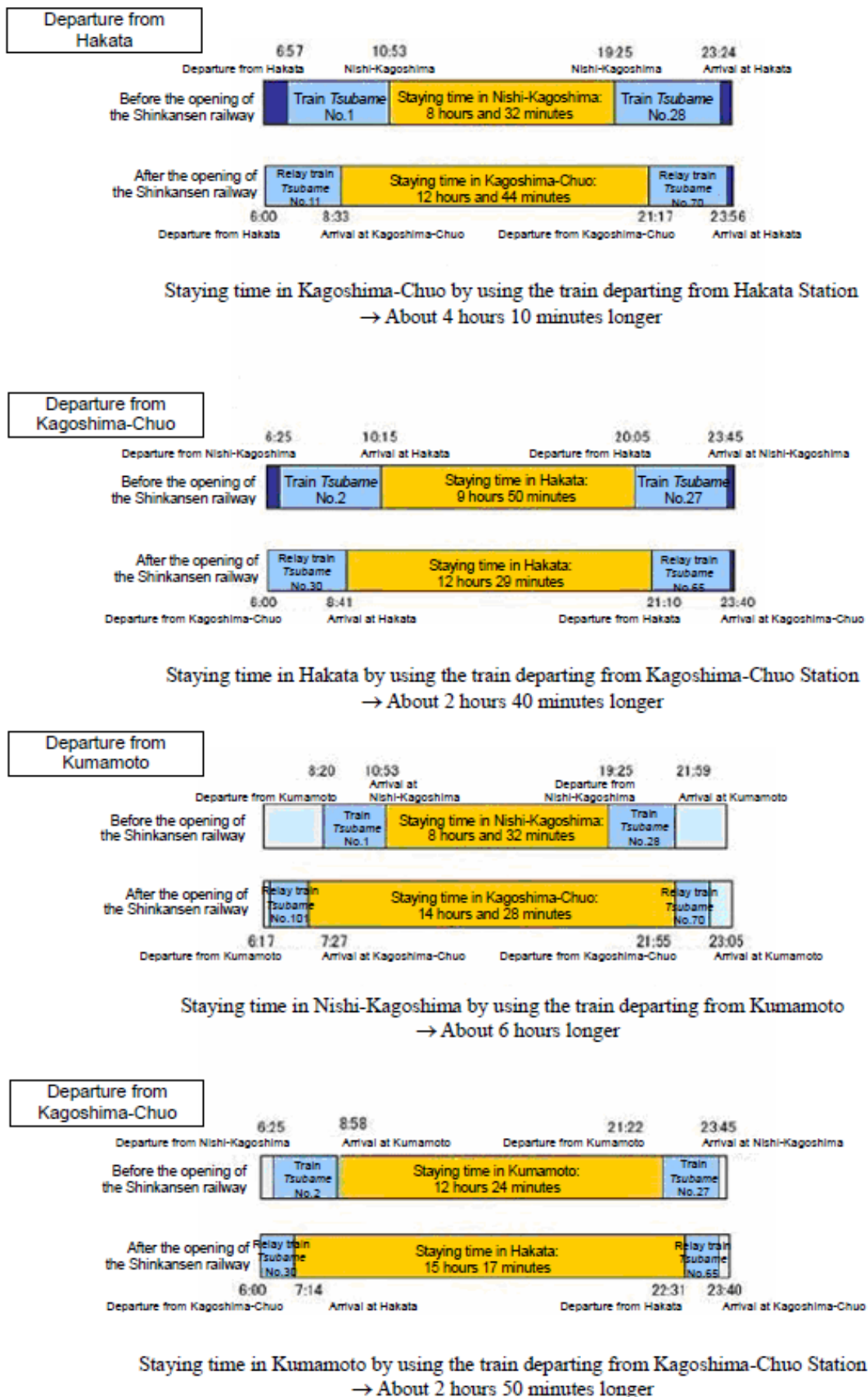
Changes in potential duration of visits

Supposing that passengers used the first and last Super-Express and Shinkansen trains to make a daily round trip between Hakata and Kagoshima or between Kumamoto and Kagoshima, comparison was made between the potential duration of their stay in Hakata, Kumamoto, and Kagoshima before and after the opening of the Shinkansen railway. The results will be described below.

If passengers used trains running between Hakata and Kagoshima-Chuo, the potential duration of their stay in Kagoshima-Chuo was significantly increased (by about four hours and ten minutes) from about eight hours and 30 minutes to about twelve hours and 40 minutes. If passengers used the trains running between Kagoshima-Chuo and Hakata, the potential duration of their stay in Hakata was significantly increased (by about two hours and 40 minutes) from about nine hours and 50 minutes to about twelve hours and 30 minutes.

If passengers used the trains running between Kumamoto and Kagoshima-Chuo, the potential duration of their stay in Kagoshima-Chuo was significantly increased (by about six hours) from about eight hours and 30 minutes to about 14 hours and 30 minutes, because the travel time was shorter on Shinkansen trains and because the first and last relay trains *Tsubame* running from and to Kumamoto, respectively, were introduced. If passengers used the trains running between Kagoshima-Chuo and Kumamoto, the potential duration of their stay in Kumamoto was significantly increased (by about two hours and 50 minutes) from about twelve hours and 20 minutes to about 15 hours and 20 minutes.

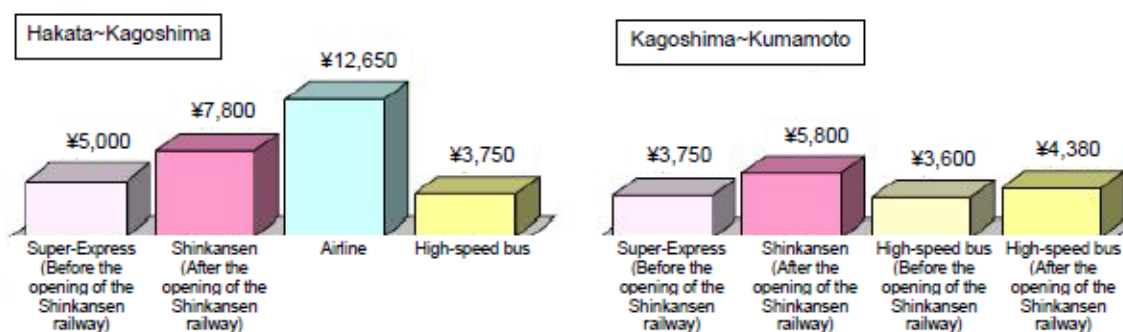
Figure 46: Change in staying time (from Hakata to Kumamoto)



Change in traffic costs

The railway fare between Fukuoka and Kagoshima was increased by JPY 2,800 from JPY 5,000 before the opening of the Shinkansen railway to JPY 7,800 after the opening. The fare between Fukuoka and Kagoshima on the Shinkansen railway is JPY 4,850 less than the air fare. The railway fare between Kumamoto and Kagoshima was increased by JPY 2,050 from JPY 3,750 before the opening of the Shinkansen railway to JPY 5,800 after the opening.

Figure 47: Change in traffic costs between Fukuoka and Kagoshima and between Kumamoto and Kagoshima



(cited from the 'Post-Assessment Report', 5.1 and 5.10-13).

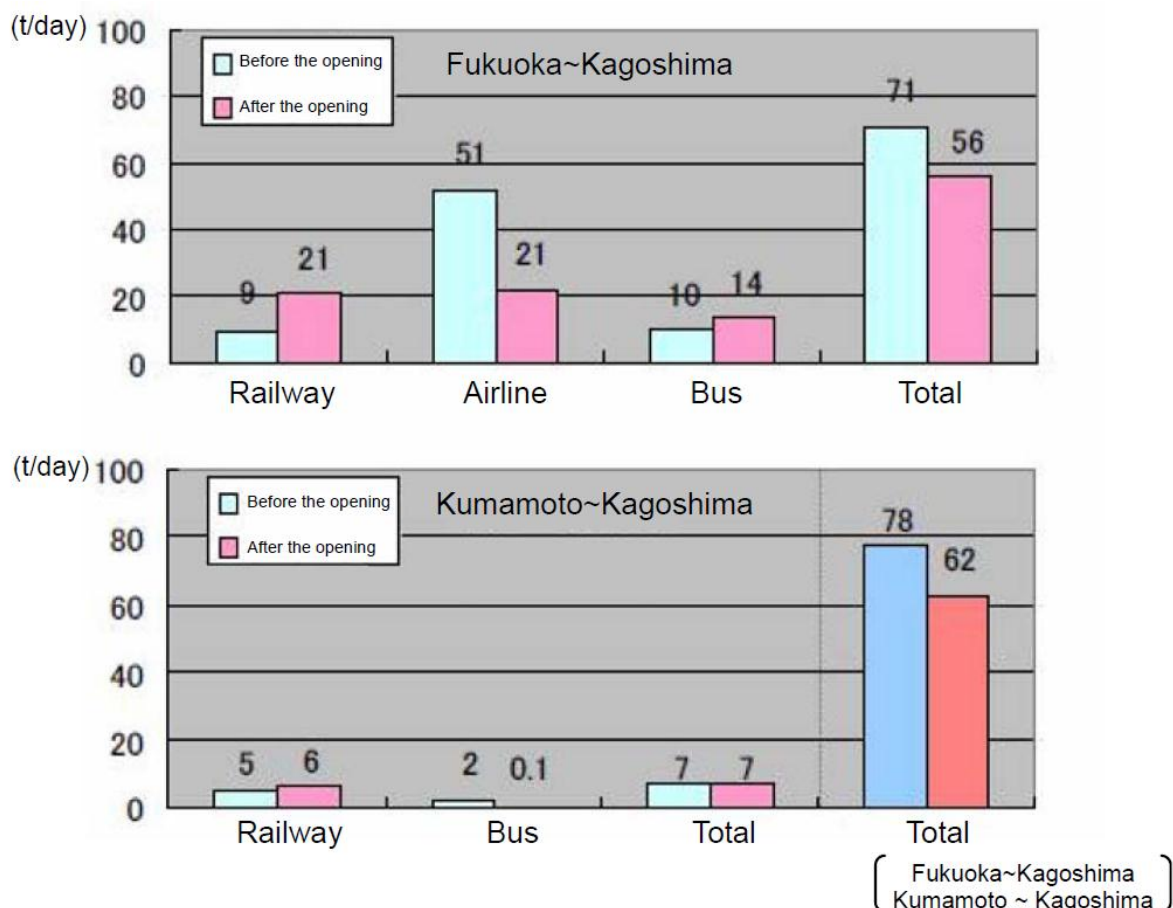
Environmental impact

Reduction of CO₂ emission

CO₂ emissions by trains between Fukuoka and Kagoshima and between Kumamoto and Kagoshima, before and after the opening of the Kyushu Shinkansen railway, were estimated as described below, based on the OD values between prefectures in the net passenger flow survey on the trunk lines.

Estimated CO₂ emissions from rail traffic have increased because the number of railway passengers had increased by the opening of the Kyushu Shinkansen railway. Estimated CO₂ emissions by airline decreased, although the intensity of emissions was higher for airlines than for railways. Total CO₂ emissions by all transport means between Fukuoka and Kagoshima and between Kumamoto and Kagoshima was estimated to be reduced (by about 20% or 16 tons per day) from 78 tons per day before the opening of the Kyushu Shinkansen railway to 62 tons per day afterwards. Therefore, it can be considered that the construction of the Shinkansen railway contributed to decreasing the environmental load.

Figure 48: CO₂ emission by transport means before and after the opening of the Kyushu Shinkansen railway



Environmental impact on surrounding areas

To minimise the environmental impact that the structures on the line might have on surrounding areas, the routing plan was drawn up so as to ensure that the selected route did not pass through densely built-up areas and that the heights of the structures were as low as possible. Because it was expected that TV radio interferences might occur in the areas along the line, however, an investigation of TV radio interference was made there beforehand, and the necessary works were executed to take countermeasures in the areas that might be affected. If the railway structures were likely to prevent buildings from receiving sunshine, compensation was given to owners of the most affected buildings earlier, in accordance with the standard.

Appropriate measures such as installing noise-blocking walls and improving wheel treads on rails were taken to minimise noise and vibration produced by trains, where possible. In areas where noise levels did not meet environmental standards, however, efforts were made not only in executing soundproofing works for buildings and houses to protect the environment but also in obtaining residents' understanding of the project.

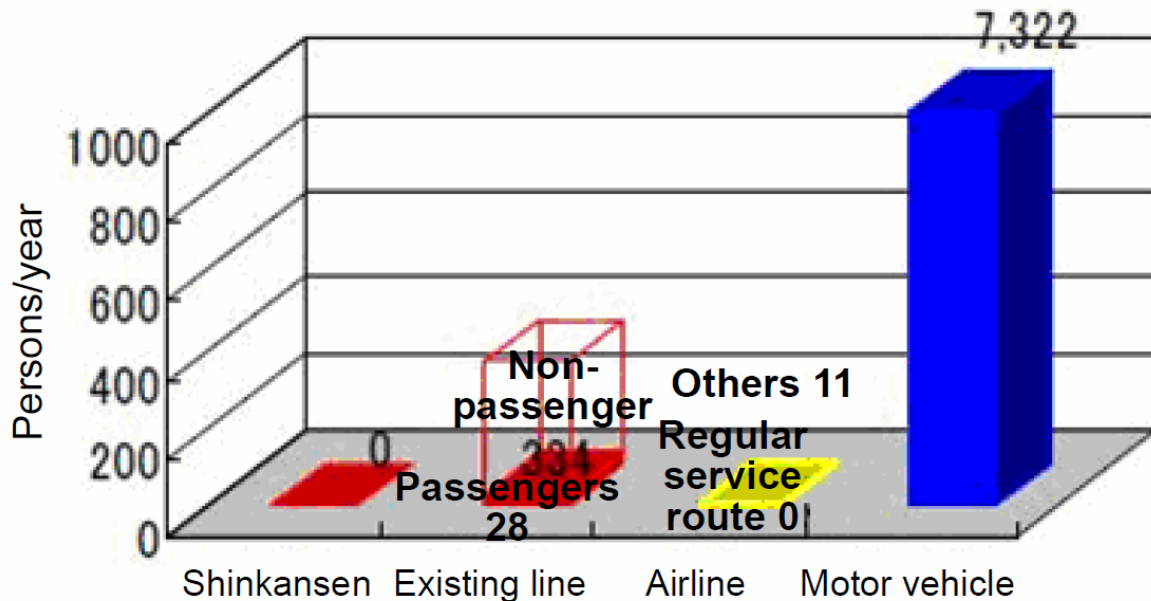
(cited from the 'Post-Assessment Report', 5.5 Environmental impact).

Safety measures

Reduction of passenger casualties

No accidents involving the death of a passenger or passengers have occurred since the Tokaido Shinkansen railway was opened. Thus, the Shinkansen railways have a very high safety level and the scope of the transport network with high safety levels was further enlarged by the opening of the Kyushu Shinkansen railway.

Figure 49: Annual passenger casualties by transport means



Reduction of accidents caused by excellent trains on railway crossings

There were 205 railway crossings on the Kagoshima Main Line (between Yatsushiro and Nishi-Kagoshima) before the Kyushu Shinkansen railway was opened. However, the potential accidents by excellent trains on railway crossing will be reduced, because only vertical crossings were constructed on the Kyushu Shinkansen railway.

(cited from the 'Post-Assessment Report', 5.6 Effects on safety).

Explanations

Effects on users

Change in the number of railway users

The number of railway users increased on the projected railway section. The daily average number of users on the section between Shin-Yatsushiro (Yatsushiro) Station and Kagoshima-Chuo (Nishi-Kagoshima) Station (for excellent trains) increased from 3,900 (before the opening of the Shinkansen railway) to 9,400 (in the fourth year after the opening).

Change in share by transport mode

Changes in the main transport modes' shares (from 2000 to 2005 fiscal year): The modal

shares of railways and airlines changed from 41% to 71% and 42% to 12% respectively between Fukuoka and Kagoshima prefectures.

Increased number of services

The number of services increased on the main railway sections: The number from Hakata to Kagoshima-Chuo Station increased from 16 (before the opening of the Shinkansen railway) to 31 (in 2008).

Effects on the life of residents

Change in the number of people who can reach a specific city within a specified time: The number of people who can reach Hakata within 3.5 hours increased from 240,000 to 1,230,000.

The number of commuters including students increased: The number was about eleven times higher in the third year after the opening of the Shinkansen railway than before the opening.

Effects on regional economy

Effects on commercial and business activities

Effects on enterprise activities: Business trip costs were reduced, the scope of business activities was enlarged, etc.

Change in the number of conventions held: The number of conventions held in Kagoshima City and the numbers of participants increased.

Ripple effect on the economy

GDP increased by improved productivity: Annual GDP increased by about JPY 25.0bn in the fifth year after the opening of the Kyushu Shinkansen railway.

Effects on tourism

Change in the number of visitors: The number of visitors coming from the north and south parts of Kyushu and staying in hotels increased.

According a survey in Kagoshima Prefecture, 90% of tourist facilities reported that the opening of the Shinkansen railway had positive effects on their businesses.

(cited from the 'Post-Assessment Report', Summary, the revealed effects of the project, 2) Effects of the project).

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