

Overview of Hokkaido Shinkansen (Opening between Shin-Aomori and Shin-Hakodate-Hokuto)

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Introduction

The Hokkaido Shinkansen (between Shin-Aomori and Sapporo) is essential for the revitalization of Hokkaido Railway Company (JR Hokkaido) as well as Hokkaido as a whole, and we would like to see it fully opened as soon as possible. The much anticipated service on the section between Shin-Aomori and Shin-Hakodate-Hokuto started on 26 March 2016.



Series H5 logo

(JR Hokkaido)

Hokkaido Shinkansen Line Conditions

About 149 km of the approximately 360 km of the Hokkaido Shinkansen between Shin-Aomori and Sapporo was opened recently between Shin-Aomori and Shin-Hakodate-Hokuto. More than half that or about 82 km including the 53.9-km Seikan Tunnel is shared between shinkansen and freight trains using dual-gauge tracks (Figure 1).

Work on this shared section started in 1964 with the construction of the Seikan Tunnel, and it opened in 1988 as the conventional Kaikyo Line with a catenary voltage of 20 kV and using a cab signal block system.

Kaikyo Line structures such as tunnels and bridges were built to shinkansen specifications right from the start, but shinkansen rails and three-rail turnouts and conversion of overhead catenary equipment to 25 kV were needed before the start of service to Shin-Hakodate-Hokuto.

Moreover, opening the Hokkaido Shinkansen to Shin-Hakodate-Hokuto involved the following unprecedented special characteristics.

- Works, such as construction and renovation of equipment and test runs of rolling stock until just before the start of shinkansen services, were limited to specific periods, such as late at night when conventional services had stopped.
- Tests before the start of shinkansen services (ATC signal aspect tests, passing tests, etc.) differed from those just for shinkansen due to the presence of equipment for conventional services (three-rail turnouts, dual-gauge DS-ATC, etc.).

To handle these special characteristics, discussions were held with related organizations and adjustments were made, such as setting increased intervals between trains and cancelling some overnight sleeper trains.

Before the start of shinkansen services, equipment inspections were made from late FY2013, and crew training runs started from August 2015. Completion inspections were made by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) from 16 November 2015, and an inspection certificate was received on 24 December 2015.

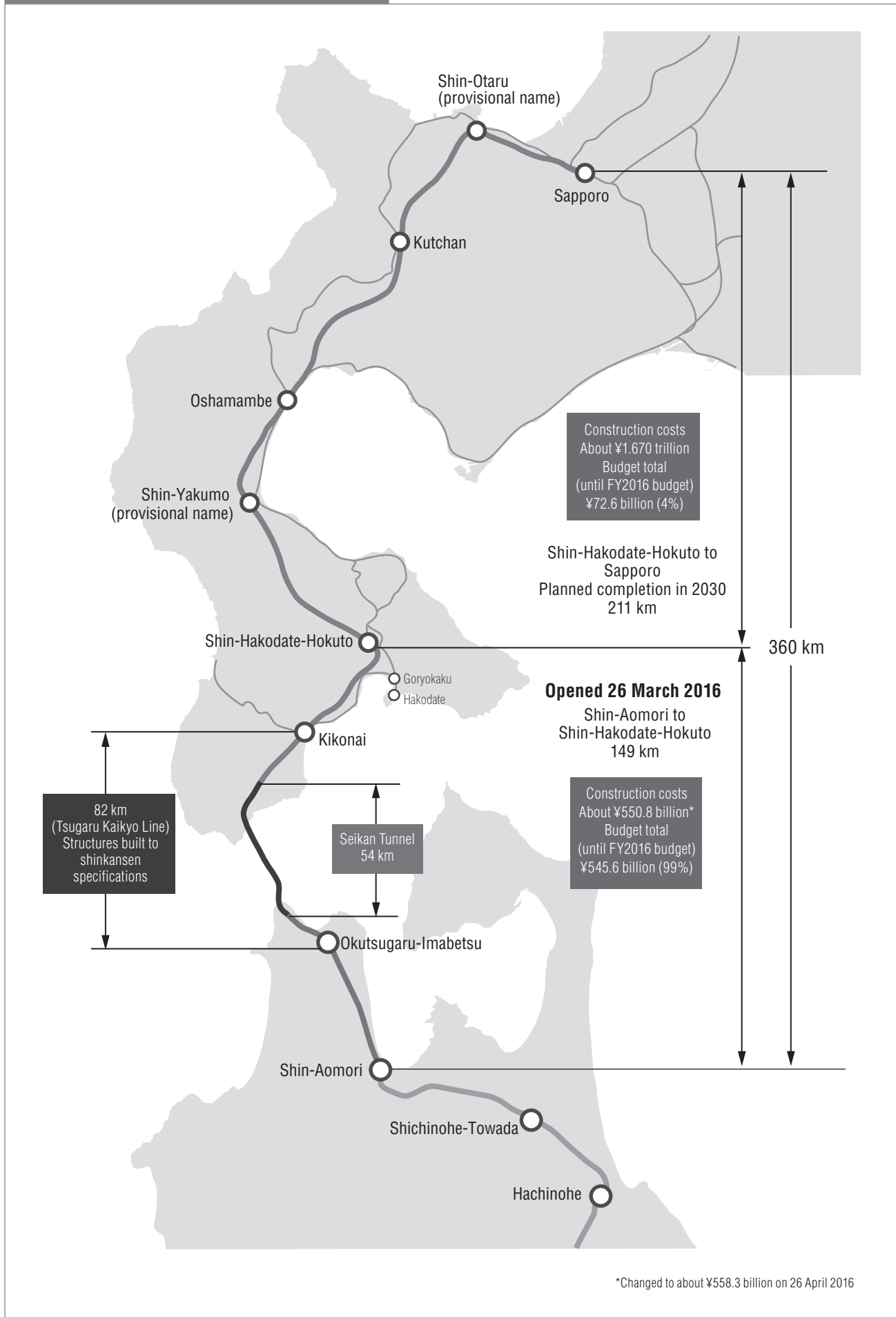
Hokkaido Shinkansen Cold-Weather Countermeasures

The Hokkaido Shinkansen must continue running in extremely cold winter months, so it has special cold-weather countermeasures, requiring pre-verification in snow and cold temperatures.

The usual snow countermeasure of sprinkling warm water on tracks could result in icing at very low temperatures, so snow-melting with sprinklers is only used on a few sections, such as near Shin-Aomori Station. Most sections use viaducts with snow-storage spaces where ploughed snow is stored along the track, or open-floor viaducts where snow is dropped down.

Electric snow melters are the basic countermeasure to iced turnouts, along with snow-melting pits at level turnouts and air-jet snow removers used by JR Hokkaido on

Figure 1 Plan for Full Hokkaido Shinkansen Line



conventional lines. This is the first time these technologies have been used on a shinkansen. Rather than using snow-melting pits, snow shelters are used at three-rail turnouts on the shared section. The cold-weather performance of these equipment and on-board equipment, and the like was verified over the two winters of FY2014 and FY2015.

Hokkaido Shinkansen Earthquake Countermeasures

Shinkansen earthquake countermeasures consist of improving the aseismic performance of civil-engineering

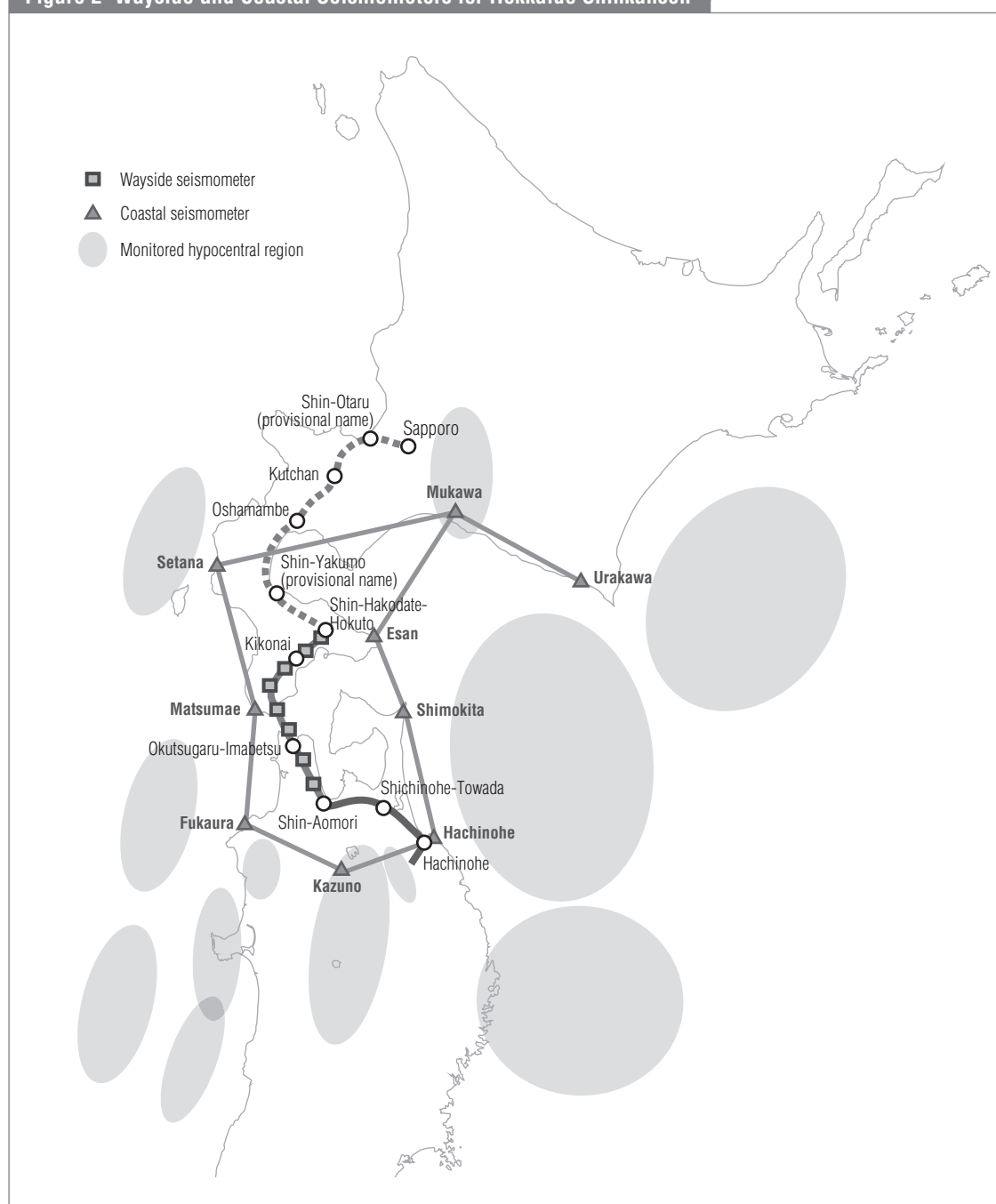
structures as well as taking measures to minimize damage to operating trains when an earthquake strikes.

Earthquake early warning system

A typical countermeasure to earthquakes is prompt early detection to cut power to overhead lines and stop trains. Like other shinkansen lines in Japan, the Hokkaido Shinkansen, has wayside seismometers along lines as well as coastal seismometers installed close to hypocentral regions in order to detect earthquakes.

As shown in Figure 2, there are wayside seismometers at nine locations near hypocentral regions for anticipated

Figure 2 Wayside and Coastal Seismometers for Hokkaido Shinkansen



major earthquakes plus eight coastal seismometers at 20-km intervals along the line. These seismometers are housed in seismological observation huts with two types of seismometer for redundant protection.

At an earthquake, trains are stopped automatically and wayside equipment is inspected based on the spectrum intensity (SI) measured by the seismometers. Operation restarts after safety has been confirmed.

Derailment countermeasures

The earthquake early warning system stops trains as soon as an earthquake occurs, but seismic waves can strike tracks quickly in an inland earthquake. The first ever shinkansen derailment occurred in the 2004 Mid-Niigata Prefecture Earthquake, so countermeasures have been taken to minimize damage in similar circumstances. Deviation prevention guides keep carriages upright and close to the rails even when derailed.

Hokkaido Shinkansen Operation Control

Train protection and operation

The Hokkaido Shinkansen operation control centre in Sapporo controls operations between Shin-Aomori and Shin-Hakodate-Hokuto. The track section shared with freight trains uses the CYGNUS operation control system to integrate control of both shinkansen and conventional trains. The conventional Kaikyo Line initially used cab signal block signalling (using analogue ATC), but ATC for dual-gauge track supporting track sharing by shinkansen and freight trains was introduced when shinkansen services started. This new ATC is based on the system used on the Tohoku Shinkansen.

Final wayside equipment switchover

Prior to the start of Hokkaido Shinkansen services, conventional trains were running on the Kaikyo Line, including through the Seikan Tunnel and on sections at the tunnel portals, so a conventional operation control system was used between Aomori and Goryokaku. When Hokkaido Shinkansen services started, freight trains would be running through operations in the sections between Aomori and Shin-Naka-Oguni junction (conventional line operation control system), between Shin-Naka-Oguni junction and Kikonai (CYGNUS), and between Kikonai and Goryokaku (conventional line operation control system). For this reason, it was necessary to switchover the conventional line operation control system

after the start of shinkansen service, enabling exchange of train numbers for freight trains between the operation control systems of the three sections.

The risk of such a large-scale system switchover on the same day as shinkansen service started was deemed too high, so the system was switched on 22 March 2016 before the start of shinkansen service. At the same time, the catenary voltage was changed to 25 kV and the protection system was changed to digital ATC with discontinuation of the cab signal block system. Conventional passenger services were completely suspended and the final switchover of wayside equipment was finished by 25 March to confirm 24-hour stable operation of systems and equipment.

Ahead of the final switchover, as a trial, all conventional passenger services were suspended from New Year's Eve 2015 to early 2 January 2016 during the New Year holidays when freight trains were not running, and the condition after the trial switchover was confirmed separately by teams for operation control, signalling, stations, depots, rolling stock maintenance, and others.

Completely suspending conventional passenger services to conduct final switchover of wayside equipment and advance confirmation inconvenienced passengers, but was a key task in opening the Hokkaido Shinkansen without major problems.

Overview of Hokkaido Shinkansen Operations

H5 Rolling stock

The Series H5 cars used by the Hokkaido Shinkansen have the same basic specifications as the Series E5 used by JR East with 10-car trainsets, the same onboard equipment, and a top speed of 320 km/h, taking into consideration through services from the Tohoku Shinkansen. The Series



Series H5 running through snow

(JR Hokkaido)

Table 1 Operations between Tokyo and Shin-Hakodate-Hokuto

Service Name	<i>Hayabusa</i>	<i>Hayabusa</i>	<i>Hayate</i>	<i>Hayate</i>	<i>Hayabusa</i> with shortest travel time
Number of runs	10 round trips	1 round trip	1 round trip	1 round trip	
Tokyo	●				●
Ueno	■				
Omiya	●				●
Sendai	●	●			●
Furukawa		●			
Kurikoma-kogen		●			
Ichinoseki		●			
Mizusawaesashi		●			
Kitakami		●			
Shin-Hanamaki		●			
Morioka	●	●	●		●
Iwate-Numakunai	■	●	●		
Ninohe	■	●	●		
Hachinohe	■	●	●		
Shichinohe-Towada	■	●	●		
Shin-Aomori	●	●	●	●	●
Okutsugaru-Imabetsu	■		●	●	
Kikonai	■		●	●	
Shin-Hakodate-Hokuto	●	●	●	●	●

Notes: ■ indicates some trains stop

H5 is further equipped with snowploughs, covered under-floor equipment, etc. It is designed to handle temperatures down to -20°C based on past meteorological data. The top operating speed on the Hokkaido Shinkansen section is 260 km/h (140 km/h for the time being on the section shared with conventional trains).

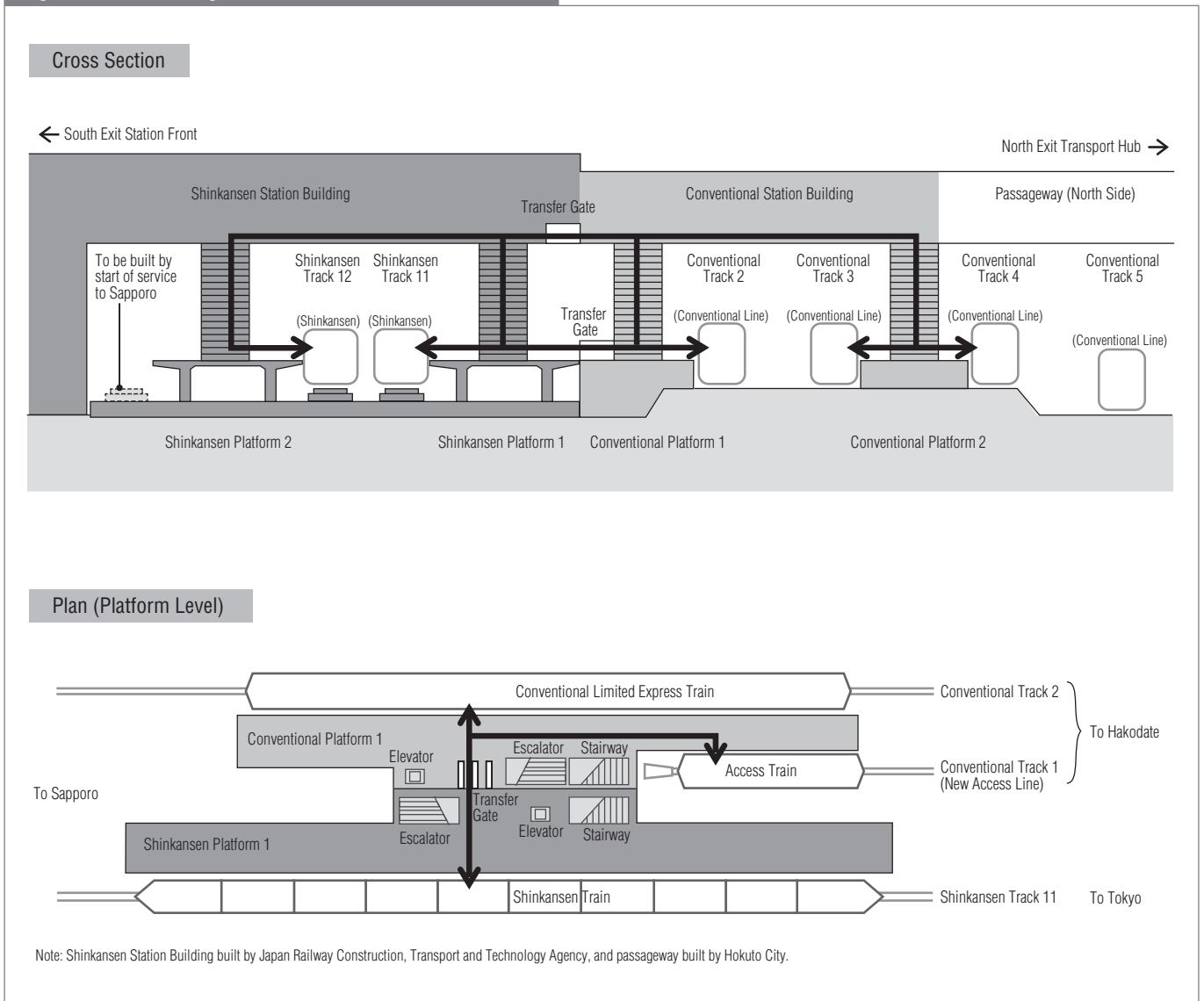
Operation structure of Tohoku/Hokkaido Shinkansen

The train diagram (Table 1) considered the initial numbers of passengers after the service start and factors such as convenience. *Hayabusa* services make 10 round trips between Tokyo and Shin-Hakodate-Hokuto and one round trip between Sendai and Shin-Hakodate-Hokuto, and *Hayate*

services make one round trip between Morioka and Shin-Hakodate-Hokuto and between Shin-Aomori and Shin-Hakodate-Hokuto, for a total of 13 round trips. Trains stop at Kikonai Station on eight round trips and at Okutsugaru-Imabetsu Station on seven round trips. Moreover, there are plans to run extra trains during peak travel times, such as during the Golden Week spring holiday, Obon summer holiday, and New Year's holiday.

The fastest time between Tokyo and Shin-Hakodate-Hokuto is 4 hours 2 minutes. *Hayabusa* No. 5 departing Tokyo at 08:20 and *Hayabusa* No. 11 departing Tokyo at 09:36 with stops at Omiya, Sendai, Morioka, and Shin-Aomori are the fastest outbound trains, and *Hayabusa* No.

Figure 3 Train Change at Shin-Hakodate-Hokuto Station



34 departing Shin-Hakodate-Hokuto at 17:20 is the fastest inbound train. The fastest time between Omiya and Shin-Hakodate-Hokuto is 3 hours 38 minutes, and the fastest time between Sendai and Shin-Hakodate-Hokuto is 2 hours 30 minutes.

With the start of shinkansen service, the travel time of the fastest trains from Tokyo to Hakodate was cut by 53 minutes from 5 hours 22 minutes to 4 hours 29 minutes, and the travel time of the fastest trains from Tokyo to Sapporo was cut by 1 hour 23 minutes from 9 hours 7 minutes to 7 hours 44 minutes.

With the Hokkaido Shinkansen opening, Series 261 carriages were introduced on the *Hokuto* limited expresses travelling between Hakodate and Sapporo. This increased the number of round trips between the cities by three to 12 per day (24 runs) with all services stopping at Shin-Hakodate-Hokuto, which is the end of the line for the

Hokkaido Shinkansen for the time being. Excluding the *Super Hokuto* No. 1 starting at Hakodate Station and the *Super Hokuto* No. 24 ending there, 11 of these round trip runs connect to the shinkansen. To provide the most convenience for passengers changing trains, the transfer between the limited express and shinkansen services has been kept across platform as far as possible (Figure 3).

The section between Goryokaku and Shin-Hakodate-Hokuto was also electrified in conjunction with the start of shinkansen service and *Hakodate Liner* access trains were introduced. Four Series 733 EMUs (three-car basic trainsets) were introduced, and 16 round trips are set for the line with connections to all shinkansen trains. Two types—express with travel time in mind and ordinary—cover the 17.9 km between Hakodate and Shin-Hakodate-Hokuto in as little as 15 minutes. Expresses stop only at Goryokaku, while ordinary services stop at Goryokaku, Kikyo, Onakayama,



CG Image of interior of Series 733-1000

(JR Hokkaido)



CG Image of exterior of Series 733-1000

(JR Hokkaido)

and Nanae stations. Most trainsets are three cars (total capacity of 439 and seated capacity of 148), but six-car trains are sometimes run when there are many passengers, such as on the Hokkaido Shinkansen opening day.

The *Hakodate Liner* rolling stock is based on Series 733 EMUs operating in the Sapporo area, and the livery image concepts are 'linkage to and sense of integration with the shinkansen' and 'Hokkaido-ness'. The main colour is the same purple as the Hokkaido Shinkansen Series H5 rolling stock with a stripe in the same light green as JR Hokkaido's corporate colour. The interior design concepts are 'the rich nature of Hokkaido' and the 'exotic atmosphere of Hakodate' with green seats invoking the feeling of Hokkaido's wide fields, wood-grain partitions near passenger doors with a feeling of Hokkaido's nature, and door parts in brick colours reminiscent of the brick warehouses and monasteries of Hakodate.

Training Hokkaido Shinkansen Personnel

Human resource development

Preparations for the opening of the Hokkaido Shinkansen were made by JR Hokkaido as a whole, centring on training some 270 people in charge of work related to the shinkansen. A high safe and stable transport level must be secured for shinkansen, so work such as running tests and training runs was conducted thoroughly. Efforts were put into building an operation structure, including education of necessary personnel, formation of an organization for use at start of service with an eye to business structure, and preparations of rules and manuals.

We received help from JR East in order to learn technologies related to shinkansen operation. Shinkansen crews, dispatchers, rolling stock inspection and maintenance personnel, and construction personnel were sent to JR East for training.

Training runs

Realistic training runs were conducted before the service start. Tasks included mastering driving operations by drivers as well as door operation by conductors, platform door operation by station personnel, and management of train operation by dispatchers. However, this had to be done after conventional operations at night between Shin-Aomori and Shin-Hakodate-Hokuto, so only three round trips could be made each night. Consequently, training was conducted over a long period from August 2015 to the service start.

Future Outlook

The first month of Hokkaido Shinkansen operations between Shin-Aomori and Shin-Hakodate-Hokuto saw a steady

increase in passengers exceeding the average of 2800 a day on conventional limited express and express services between Naka-Oguni and Kikonai. Year-on-year, the number doubled to an average of 5600 a day. Passenger numbers also tended to increase in May and June.

In future, we will run extra shinkansen services at busy periods, while prioritizing continuing safe operation. In operating the *Hokuto* and *Hakodate Liner* express trains for access to the shinkansen, we intend to maintain capacity by means such as operating extras services and coupling extra cars.

Conclusion

I would like to use this space to express our thanks to the various people who have helped with the opening of the Hokkaido Shinkansen, without forgetting that today's achievements are thanks to the efforts, passion, and labour of the many who have gone before us. Using the opportunity provided by the recent start of Hokkaido Shinkansen services, we intend to push forward with continued efforts toward completing services through to Sapporo. ■



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