Chapter 5 Reconstruction of Homes and Cities

Section 8 Railways

1. Overview of damage

(1) JR East (Shinkansen and conventional lines)

On the Tohoku Shinkansen Line, there were occurrences such as damage to viaduct pillars and other facilities (about 100 locations) and the breaking of electrified pillars (about 540 locations) as a result of the shaking produced by the earthquake. There was damage at about 1,200 locations on the whole line, and ceiling materials were damaged or fell at five stations, including Sendai Station.

On conventional lines, 23 stations were washed away by the tsunami in seven railroad sections: the Hachinohe Line, the Yamada Line, the Ofunato Line, the Kesennuma Line, the Ishinomaki Line, the Senseki Line and the Joban Line. In addition, about 60 km of railroad tracks were washed away and buried in the rubble.

Figure 5-8-1 JR East disaster situation

Source) Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "Records of Tohoku District Transport Bureau Activities After the Great East Japan Earthquake: Steps Toward Reconstruction" (March 2012)

(2) Subways, third sector railways, etc.

On the Sendai Subway Namboku Line, the shaking of the earthquake caused occurrences such as the damage of abutments of bridges.

On the Sendai Airport Line (Sendai Airport Transit), significant damage occurred like submergence of the tunnel under the runway of Sendai Airport as a result of the tsunami and damage to the equipment of the transport command center at Sendai Airport Station.

There were occurrences involving catastrophic damage seen at 30 locations, such as the washing away of stations and viaducts on the Sanriku Railway's North Rias Line and South Rias Line.

In addition, the Abukuma Express and the IGR Iwate Galaxy Railway Line sustained damage such as the caving in of roadbeds as a result of the shaking of the earthquake.

Figure 5-8-2 Disaster situation of subways, third-sector railways, etc.

Source) Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "Records of Tohoku District Transport Bureau Activities After the Great East Japan Earthquake: Steps Toward Reconstruction" (March 2012)

(3) Freight railways

At JR Freight, container freight cars of freight trains running on the Joban Line were washed away by the tsunami. On the Ishinomakiko Line, severe damage was inflicted upon the tracks, station facilities, stored locomotives and freight cars, and so on. In addition, the Hachinohe Rinkai Railway, the Iwate Development Railway, the Sendai Rinkai Railway, and the Fukushima Rinkai Railway all sustained serious damage which included tracks being washed away.

Figure 5-8-3 Disaster situation of freight railways

ＪＲ貨物・石巻港駅

仙台臨海鉄道・仙台臨海鉄道線

Source) Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "Records of Tohoku District Transport Bureau Activities After the Great East Japan Earthquake: Steps Toward Reconstruction" (March 2012)

2. Emergency recovery

(1) Substitute transportation using rail replacement buses, etc.

Starting on March 14, three days after the earthquake, bus operators implemented substitute transportation using rail replacement bus services and fixed route buses (hereinafter referred to as "rail replacement buses, etc."), starting with operation between Dainohara Station and Izumi-Chuo Station, which had constituted an interrupted section of the Sendai Subway. After confirming the restoration and safety of roads, etc., in April and thereafter, train services one by one began to operate in the areas where railway service had been interrupted, securing transportation in the disaster-affected areas. After that, the sections of operation and timetables for rail replacement buses, etc. were also reviewed in accordance with changes in terms of sections where railway services were interrupted.

The suspension of the Tohoku Shinkansen Line led to the disconnection of a major means of transportation between the Tokyo Metropolitan Area and the disaster-affected areas. In coordination with the National Police Agency, the Ministry of Land, Infrastructure, Transport and Tourism designated highway buses as emergency vehicles on March 14, 2011, and ensured the prompt resumption of highway bus service between Niigata and Sendai. As a result, the Tokyo Metropolitan Area and Sendai were indirectly connected via the Joetsu Shinkansen Line between Tokyo and Niigata.

Although commercial flights were gradually resumed at Sendai Airport from the end of March 2011, Sendai Airport Transit was still unable to operate; therefore, the Ministry of Land, Infrastructure, Transport and Tourism issued a request to the bus association with respect to the direct operation of access buses between the airport and Sendai Station. The request was responded by 18 bus operators who operated access buses.

Figure 5-8-4 Rail replacement buses, etc. (JR Senseki Line) running in Higashi-Matsushima City (Miyagi Kotsu Co., Ltd.)

Source) Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "Records of Tohoku District Transport Bureau Activities After the Great East Japan Earthquake: Steps Toward Reconstruction" (March 2012)

(2) Rapid restoration of railway facilities

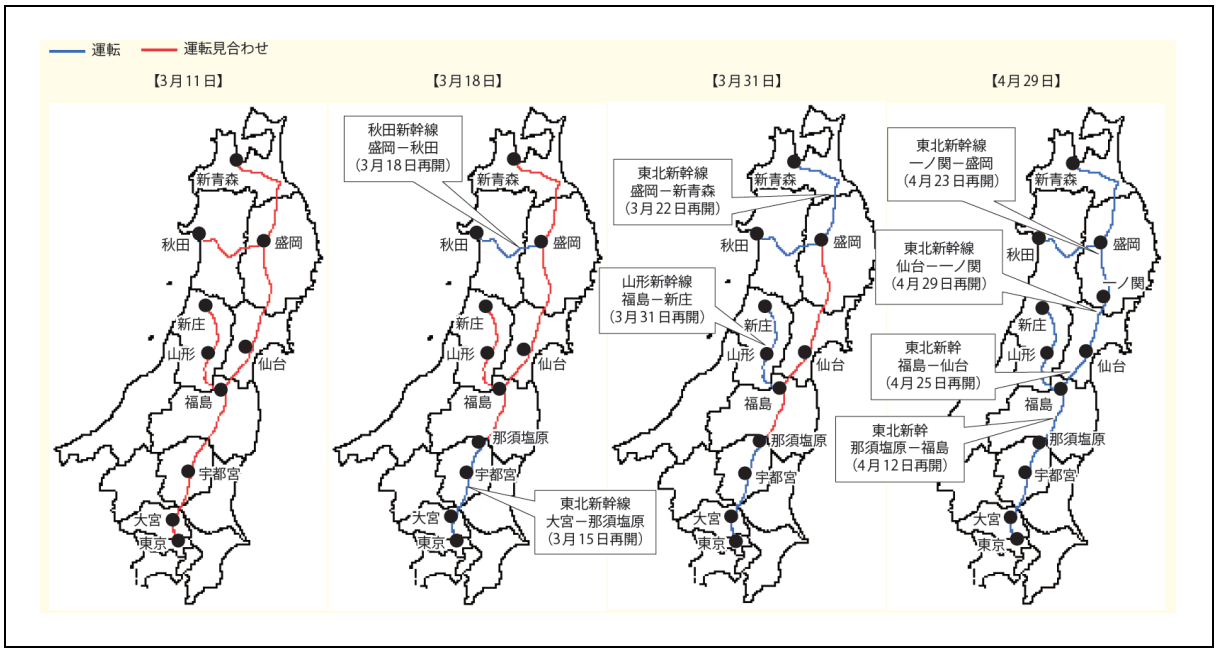
After the earthquake, due to the earnest efforts of railway operators and other concerned parties, operation gradually resumed, mainly in the sections that were relatively less damaged. By around Golden Week, most of the train networks in the Sendai metropolitan area (including the JR Tohoku Main Line and the Namboku Line of the Sendai Subway) had resumed operations, with the exception of the coastal areas that were damaged by the tsunami.

In addition, the restoration work for the Shinkansen Line was proceeded with in a speedy manner. The Akita Shinkansen Line (between Morioka Station and Akita Station) resumed operation on the March 18 and the Yamagata Shinkansen Line (between Fukushima Station and Shinjo Station) on March 31. Restoration of the Tohoku Shinkansen also moved forward progressively with operation south of Nasushiobara Station resuming on March 15, operation between Shin-Aomori Station and Morioka Station resuming on March 22, and so on. As a result of the aftershock occurring on April 7, the operation of each Shinkansen line was suspended again, but the operation of all Shinkansen lines had resumed by 49 days after the earthquake on April 29.

For about a month after the earthquake, Sendai and the other disaster-affected areas surrounding it had been running out of automobile fuel. The JR vehicles (automobiles) which carried out surveys and inspections of the damaged Tohoku Shinkansen line and other lines were thus unable to operate sufficiently, which served as an obstacle to early restoration. In response to a request from JR East, the Tohoku District Transport Bureau of the Ministry of Land, Infrastructure, Transport and Tourism issued “emergency vehicle certificates” to vehicles used for disaster-related investigations and restoration work on the Tohoku Shinkansen Line, after coordinating with oil wholesalers. This enabled the vehicles to receive priority refueling at emergency vehicle gas stations in Miyagi Prefecture. Since March 18, immediately after the earthquake, this certificate was issued to 792 vehicles belonging to JR East and 44 construction companies, contributing greatly to the early restoration of the Tohoku Shinkansen Line. Similar certificates were also issued to JR Freight (in relation to emergency oil shipment via the Banetsu Lines), Sendai City Transportation Bureau, and Sendai Rinkai Railway.

Thanks to the efforts described above, the restoration work on the Shinkansen lines took a very short time compared to the resumption of operation (81 days later) on the Sanyo Shinkansen Line after the Great Hanshin-Awaji Earthquake occurring in January 1995 and the resumption of operation (66 days later) on the Joetsu Shinkansen Line after the Niigata-Chuetsu Earthquake of October 2004. It is thought that there were two factors that contributed to early restoration. One was of course, the efforts of JR East and the fact that organizations across the nation, meaning railway operators, construction companies, manufacturers, research institutes, the Japan Railway Construction, Transport and Technology Agency, and related organizations, made a concerted effort to secure personnel, procure materials, and undertake other such action to support the restoration effort. The second of these factors, was the fact the seismic reinforcement of facilities, the enhancement of early earthquake detection systems, and the implementation of elements such as measures to prevent train derailment and deviation, which were undertaken based on the lessons learned from the Great Hanshin-Awaji Earthquake and the Niigata-Chuetsu Earthquake, meant that no fatal damage such as the collapse of viaducts or the derailment of commercial trains had occurred.

Figure 5-8-5 Recovery situation for Shinkansen lines



Source) Ministry of Land, Infrastructure, Transport and Tourism, "White Paper on Land, Infrastructure, Transport and Tourism in Japan, 2010"

The details in terms of the process of railway restoration taking place from the time immediately after the disaster are described below.

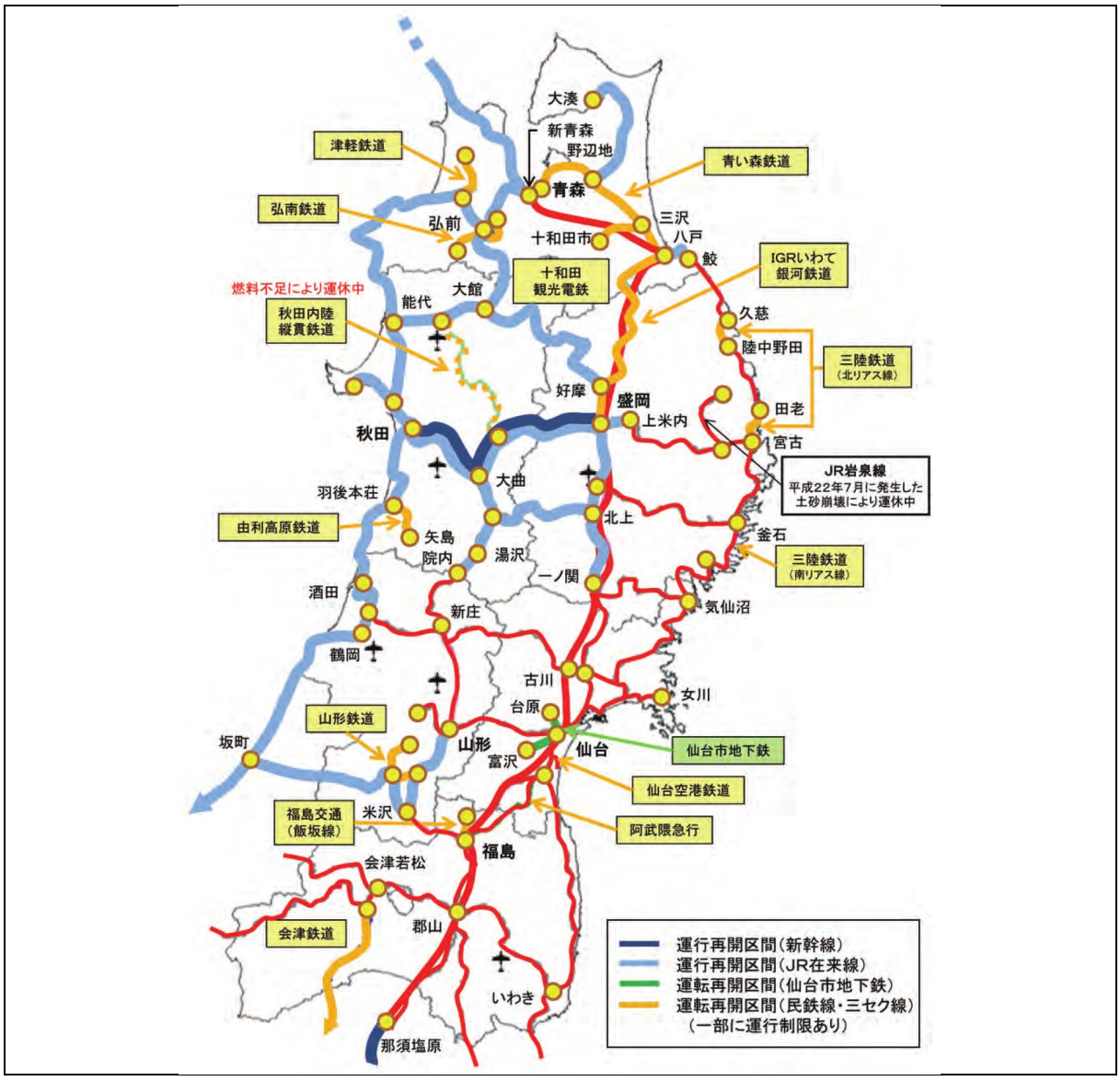
1) Situation leading up to March 21 (10 days after the earthquake)

Immediately after the earthquake, all railways within the jurisdiction of Tohoku were temporarily suspended. Each railway company started inspection and restoration work of railway facilities, etc., after arranging internal systems, etc. according to the situation of the disaster.

On March 14, operation resumed in the section between Tomizawa Station and Dainohara Station on the Namboku Line of the Sendai Subway, which was relatively less damaged. On March 17, all lines of the Aoimori Railway and the IGR Iwate Galaxy Railway saw service resumed. On March 18, the section between Akita Station and Morioka Station of the Akita Shinkansen Line resumed operation. By 10 days after the earthquake, that is March 21, train service gradually resumed on lines located on the Sea of Japan side and in the northern Tohoku area, including service between Morioka Station and Ichinoseki Station on the JR Tohoku Main Line, service on a portion of the JR Uetsu Line and the JR Ou Line, and service on the JR Gono Line and the JR Hanawa Line (and while railways, expressways, and other routes connecting the Tohoku region and the Tokyo Metropolitan Area were mostly unavailable immediately after the earthquake, the routes connecting the Aizu region in Fukushima Prefecture and the Tokyo Metropolitan Area via the Aizu Railway, the Yagan Railway, and the Tobu Railway, had resumed operation on March 12, the day after the earthquake). By this time, the operation of “disaster reconstruction support trains” had already started on the Sanriku Railway's North Rias Line between Kuji Station and Rikuchu-Noda Station and between Miyako Station and Taro Station.

In addition, JR Freight's “emergency oil train,” which left the Tokyo Metropolitan Area to urgently transport fuel, which had dried up in the disaster-affected areas, arrived at Morioka Freight Terminal Station on the night of the March 19 via the JR Uetsu Line, the JR Ou Line, the Aoimori Railway Line, and the Iwate Galaxy Railway Line (similarly, the train arrived at Koriyama Station from the Tokyo Metropolitan Area via the JR Banetsu West Line on March 26). About this time, some third-sector railways, etc. suspended or reduced train service due to shortages of train fuel although there was no damage present in terms of railway facilities, vehicles, so the supply of fuel to the disaster-affected areas constituted a matter of considerable urgency.

Figure 5-8-6 State of railway restoration 10 days after the earthquake (March 21, 2011)



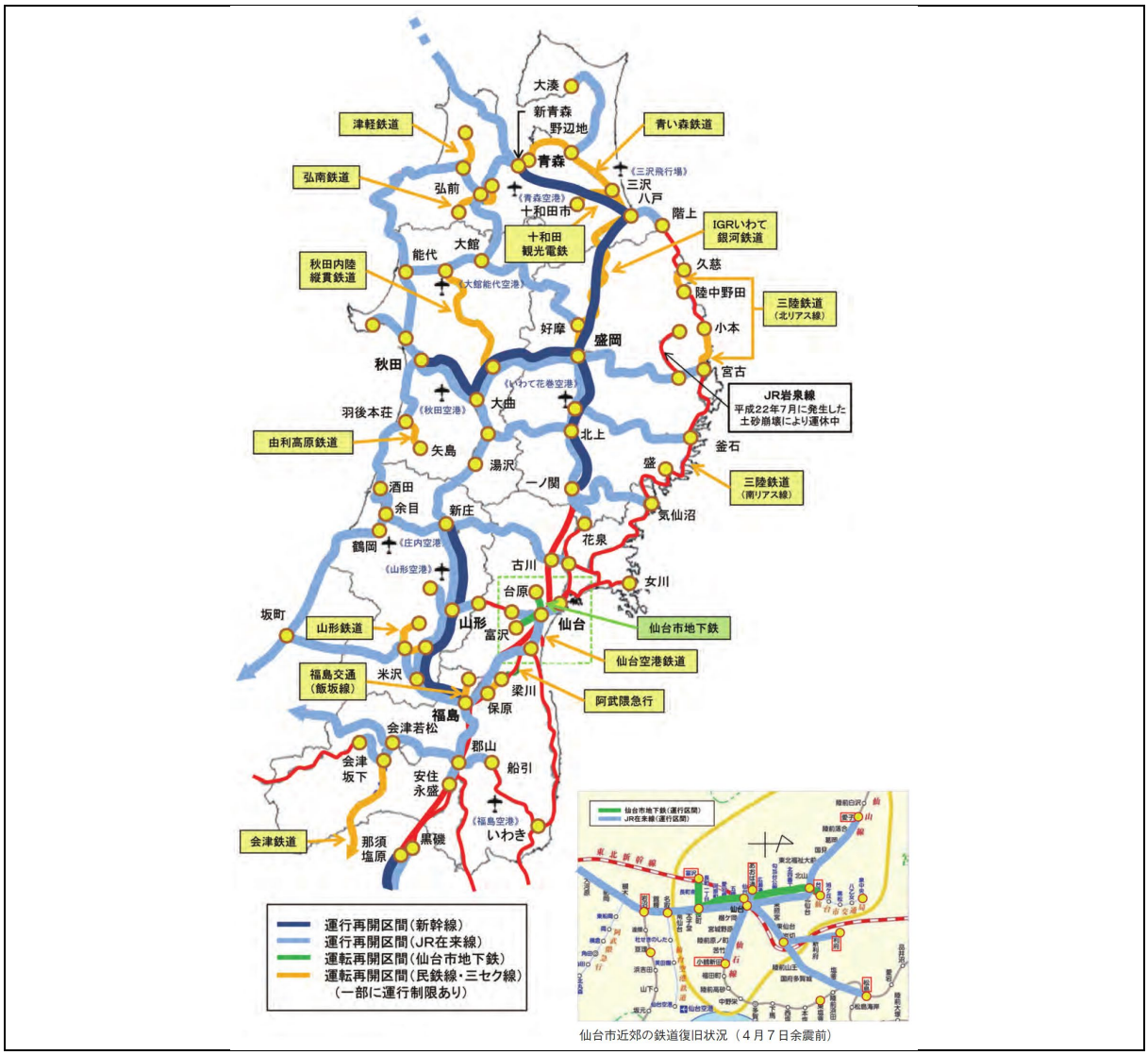
Source) Ministry of Land, Infrastructure, Transport and Tourism Tohoku District Transport Bureau, "Yomigaere! Michinoku no Tetsudo: Reconstruction in the Wake of the Great East Japan Earthquake" (September 2012)

2) Situation leading up to April 7 (before the aftershock)

Sections where operation resumed were gradually extended. The Yamagata Shinkansen Line (between Fukushima Station and Shinjo Station) resumed operation on March 31. The Tohoku Shinkansen Line resumed operation between Shin-Aomori Station and Morioka Station on March 22 and up to Ichinoseki Station on April 7.

As for conventional lines, inland area lines such as the JR Ou Line, the JR Rikuu East Line, and the JR Rikuu West Line, resumed operation in their entire lines. Moreover, some sections of the JR Yamada Line, the JR Kamaishi Line, and the JR Ofunato Line, which run from the inland areas to the Pacific coast, and many other lines in the Sendai metropolitan area, had resumed their operations. The Abukuma Express, which had seen the suspension of service implemented throughout the entire line, also resumed operation between Yanagawa Station and Hobara Station on April 6.

Figure 5-8-7 State of railway restoration (April 7, 2011)



Source) Ministry of Land, Infrastructure, Transport and Tourism Tohoku District Transport Bureau, "Yomigaere! Michinoku no Tetsudo: Reconstruction in the Wake of the Great East Japan Earthquake" (September 2012)

3) Situation immediately after April 7 (aftershock)

Late at night on April 7, a large aftershock with a seismic intensity of 6-upper on the JMA Seismic Intensity Scale occurred in Sendai and other areas. This aftershock caused service to be suspended again in almost the entire Tohoku region (including operation taking place due to facility inspections). In addition to the section north of Ichinoseki Station on the Tohoku Shinkansen Line, which had resumed operation once, and some sections of the JR Yamada Line, the JR Kamaishi Line, and the JR Ofunato Line, the JR Tohoku Main Line in Miyagi Prefecture was also severely damaged and suspended again for some time.

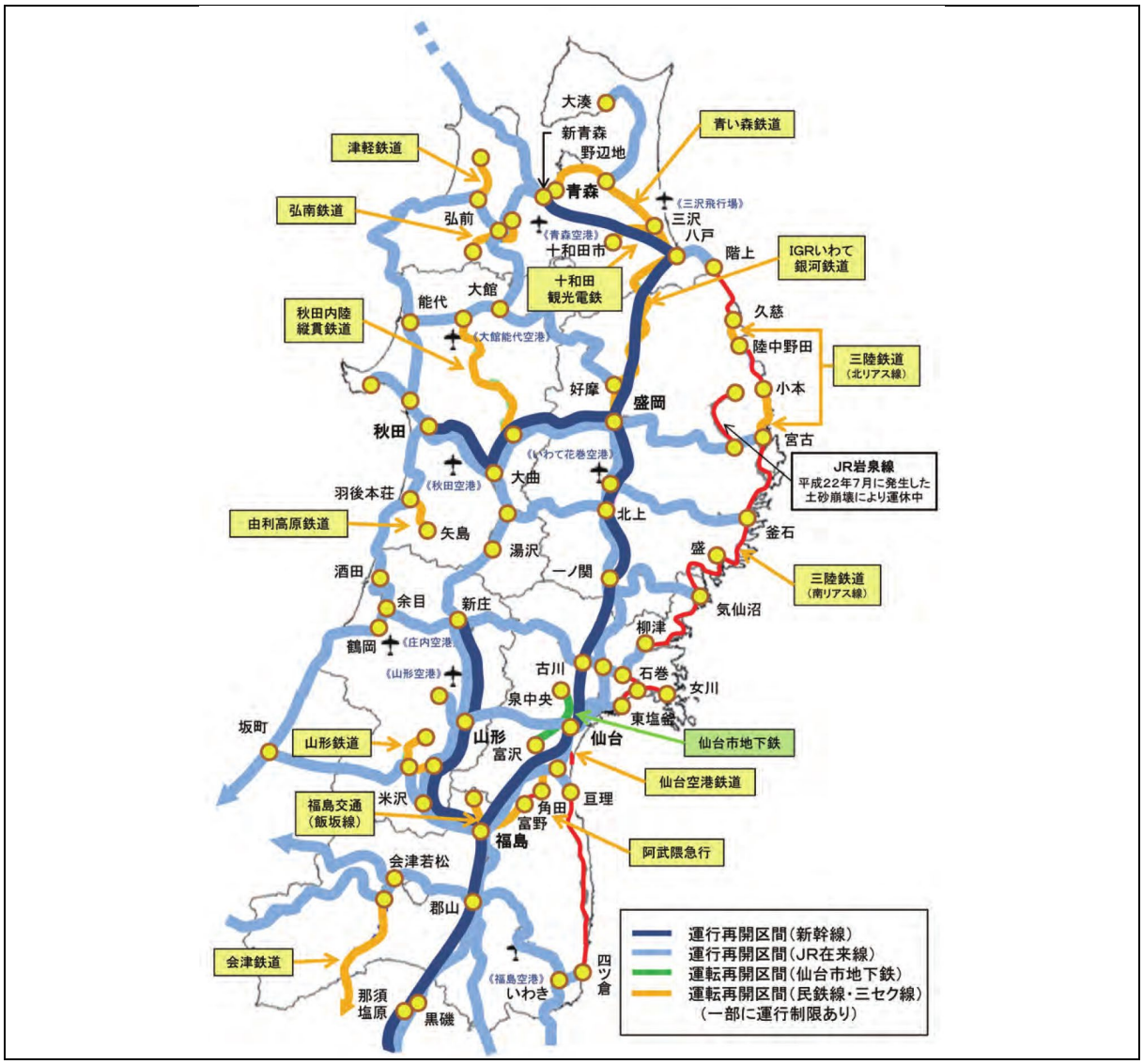
4) Situation leading up to April 29 (49 days after the earthquake)

After the aftershock on April 7, the restoration work was resumed progressively starting from sections for which inspections had been completed, and operating sections were extended once again. The JR Tohoku Main Line and the JR Senzan Line restarted operation April 21 and April 23, respectively. The Tohoku Shinkansen Line and the Sendai Subway Namboku Line also saw the restarting of operation take place on April 29. At this point, most railways had resumed operation with the exception of those on the Pacific coast.

When the section south of Fukushima Station on the Tohoku Shinkansen line resumed operation on April 12, JR East resumed rail transport between the Tokyo Metropolitan Area and Sendai, with a special rapid train called the

"Relay Shinkansen," which ran between Fukushima Station and Sendai Station on the JR Tohoku Main Line by having transfers take place at Fukushima Station (with the 'Relay Shinkansen' running up until April 24).

Figure 5-8-8 State of railway restoration (April 29, 2011)



Source) Ministry of Land, Infrastructure, Transport and Tourism Tohoku District Transport Bureau, "Yomigaere! Michinoku no Tetsudo: Reconstruction in the Wake of the Great East Japan Earthquake" (September 2012)

5) Situation leading up to October 1

The Abukuma Express, which had resumed operation progressively in accordance with the progress of restoration work, resumed operation across the entire line on May 16. On July 23, operation was resumed on the section between Natori Station and Mitazono Station of the Sendai Airport Transit on July 23.

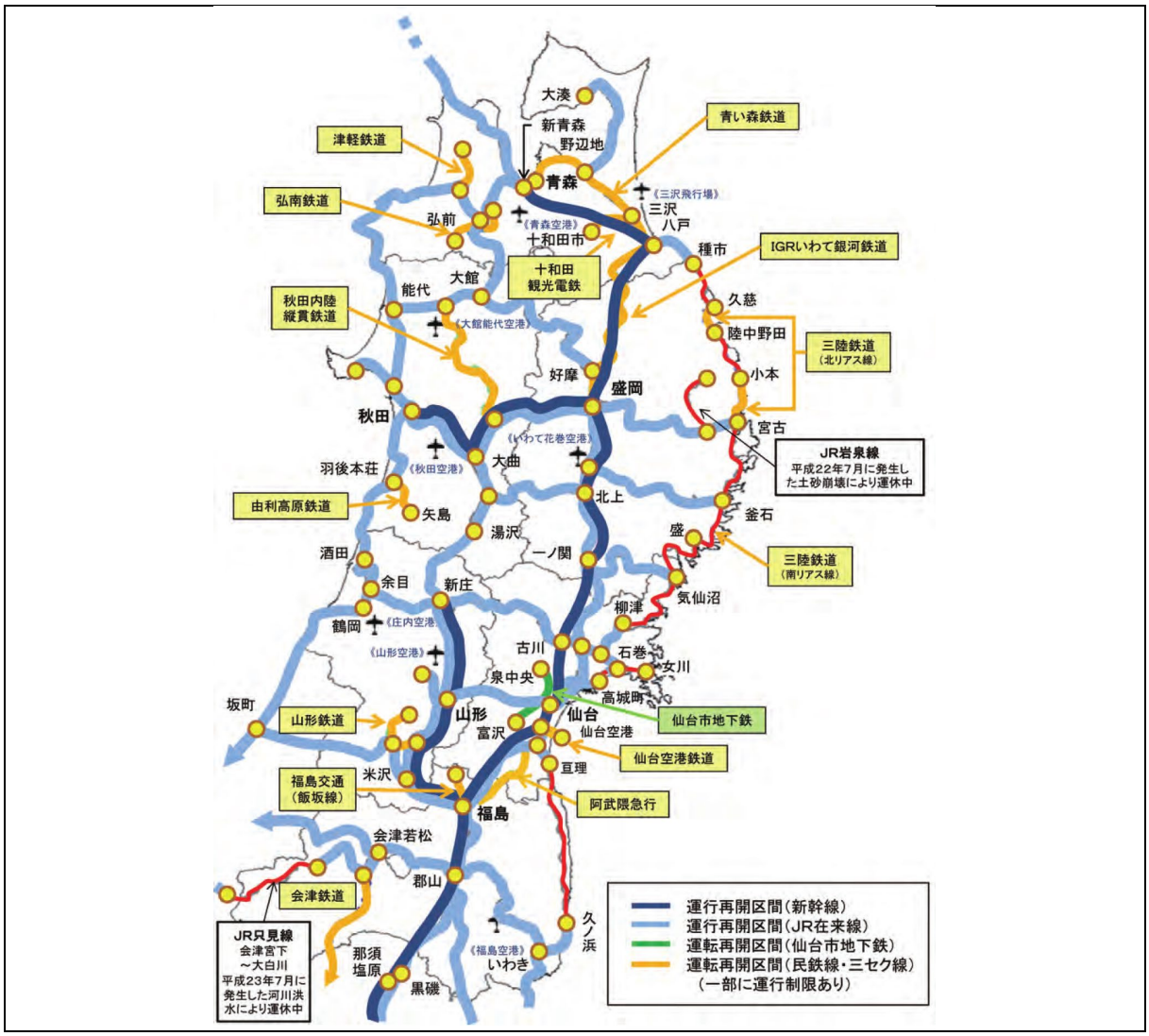
In the case of conventional JR lines, operation was resumed on the JR Joban Line between Yotsukura Station and Hisanohama Station on May 14, on the JR Ishinomaki Line between Maeyachi Station and Ishinomaki Station on May 19, on the JR Senseki Line between Higashi-Shiogama Station and Takagimachi Station on May 28, on the JR Senseki Line between Ishinomaki Station and Yamoto Station on July 16, and then on the JR Hachinohe Line between Hashikami Station and Taneichi Station on August 8.

On the Tohoku Shinkansen Line, full-scale restoration work including the restoration of electrification poles was completed, and the service according to the regular pre-disaster timetable started with the first train of the day on September 23. The speedy recovery of the area taking place during the span of about six months after the disaster was widely reported as extremely positive news which served to boost the reconstruction of the entire Tohoku

region.

Furthermore, on October 1, Sendai Airport Transit resumed operation of the entire line (with the newly resumed sections being between Mitazono Station and Sendai Airport Station).

Figure 5-8-9 State of railway restoration (October 1, 2011)



Source) Ministry of Land, Infrastructure, Transport and Tourism Tohoku District Transport Bureau, "Yomigaere! Michinoku no Tetsudo: Reconstruction in the Wake of the Great East Japan Earthquake" (September 2012)

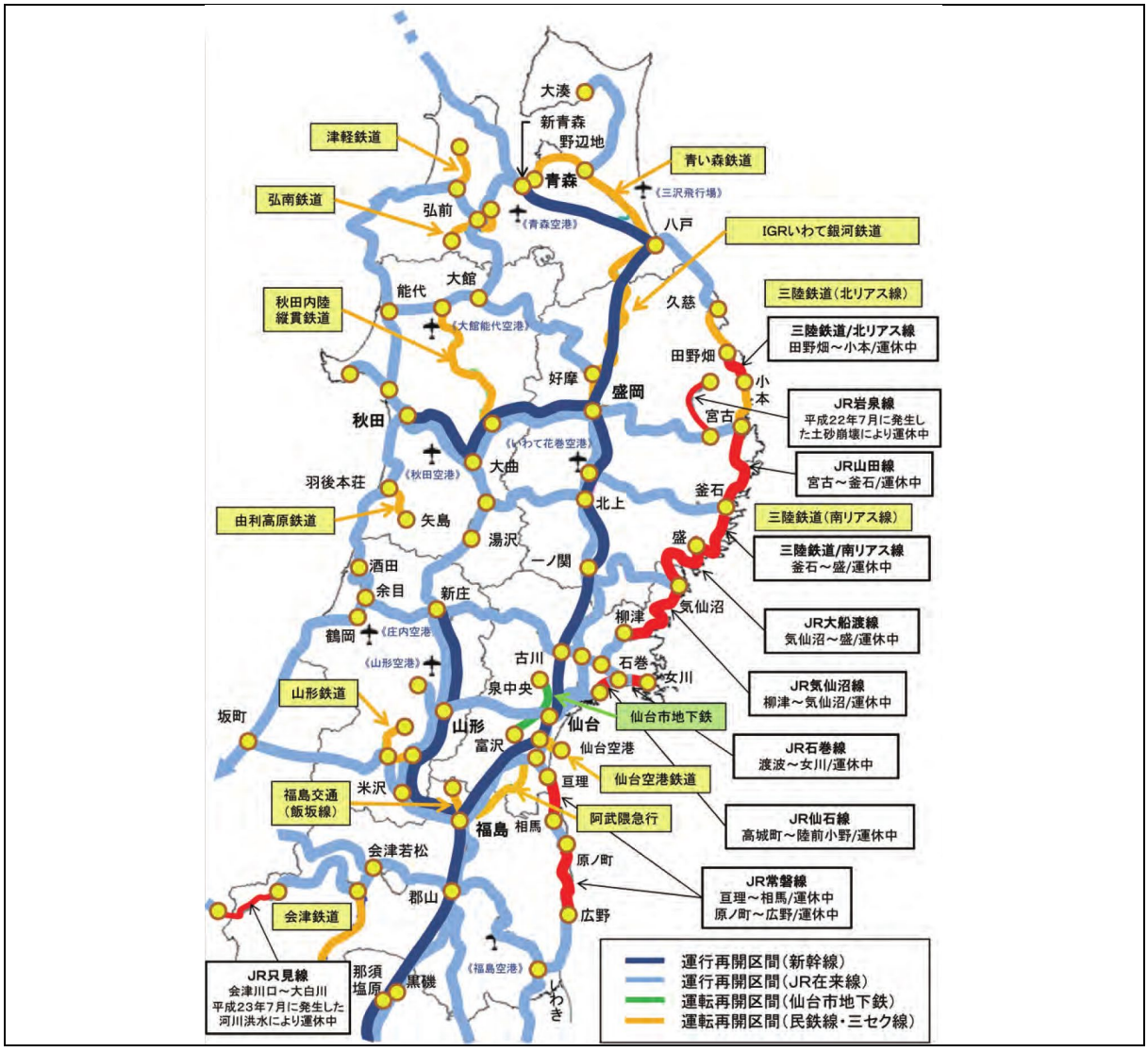
6) From October 1 to April 2012

Operation of the section between Hisanohama Station and Hirono Station on the JR Joban Line resumed on October 10 and the section between Haranomachi Station and Soma Station resumed on December 21. The entirety of the JR Hachinohe Line (with the section of newly resumed operation being between Taneichi Station and Kuji Station), the section between Ishinomaki Station and Watanoha Station on the JR Ishinomaki Line, and the section between Rikuzen-Ono Station and Yamoto Station on the JR Senseki Line, resumed operation on March 17, 2012. Then, the section between Rikuchu-Noda Station and Tanohata Station of the Sanriku Railway's North Rias Line saw operation resuming on April 1. In particular, operation of the section between Haranomachi Station and Soma Station (about 20.1 km) on the JR Joban Line was resumed after the delivery of vehicles and the preparation of a vehicle inspection and repair system had taken place, since operation was to be undertaken by means of shuttle transportation between the area corresponding to the no-entry zone of the Fukushima Dai-ichi Nuclear Power Plant (south side) and the area which had been severely damaged by the tsunami and for which rerouting was under consideration (north side).

On December 1, 2011, Abukuma Express, which was running at reduced speed in some sections, returned to the ordinary timetable.

To accommodate commuter train service going from the Ishinomaki area to the Sendai area, the JR Senseki Line, which had been suspended in some sections, was bypassed and the operation of direct trains running between Ishinomaki Station and Kogota Station and between Kogota Station and Sendai Station via the Ishinomaki Line and Tohoku Main Line started on December 1 (with one train in the morning on weekdays). Direct train service also commenced between Sendai Station and Kogota Station and between Kogota Station and Ishinomaki Station on January 10, 2012 (with one train in the evenings on weekdays).

Figure 5-8-10 State of railway restoration (April 1, 2012)



Source) Ministry of Land, Infrastructure, Transport and Tourism Tohoku District Transport Bureau, "Yomigaere! Michinoku no Tetsudo: Reconstruction in the Wake of the Great East Japan Earthquake" (September 2012)

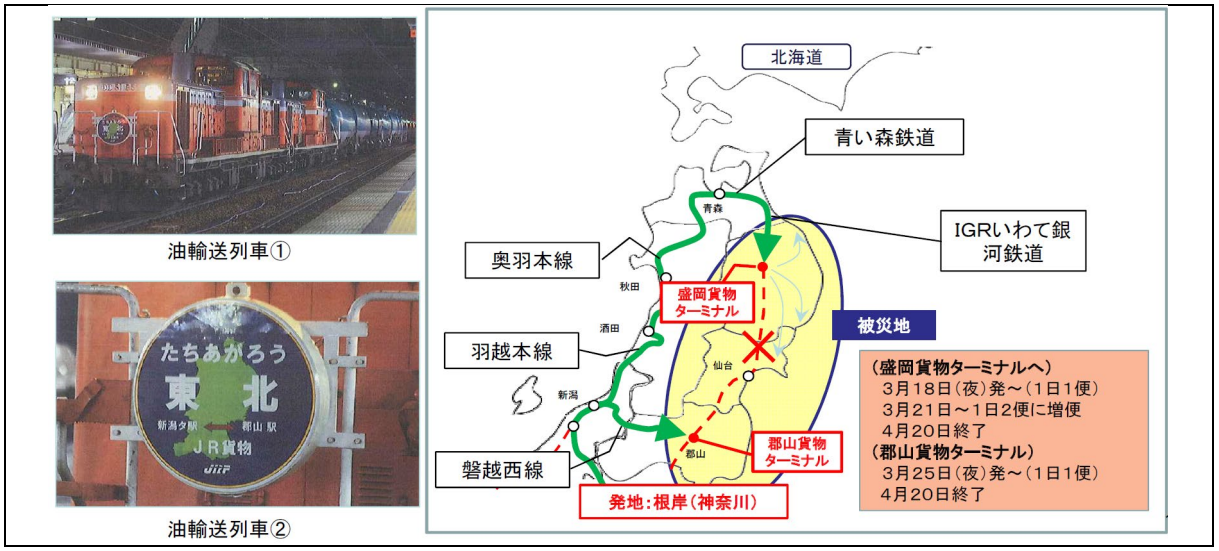
(3) Emergency oil trains and disaster reconstruction support trains

Immediately after the earthquake, to urgently transport fuel to disaster-affected areas that had ran out of fuel, JR Freight's “emergency oil trains” departed from the Tokyo Metropolitan Area and bypassed the disrupted Tohoku Main Line, arriving at Morioka via Niigata using the Sea of Japan and Aomori route (on the night of March 19) and at Koriyama via Niigata using the Banetsu West Line route (on March 26). The operation of these trains, of course, required the efforts of JR Freight, and the cooperation of JR East, Aoimori Railway and IGR Iwate Galaxy Railway, all of which had completed restoration work within a limited period of time, was indispensable.

At that time, it was assumed that rolling blackouts would occur due to the tightened supply and demand of electric power. As such, the Director of the Tohoku District Transport Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, issued a request (on March 17, 2011) to the Chairman of the Tohoku Electric Power Company for the "postponement of rolling blackouts that may affect the operation of the emergency oil trains of JR Freight" and secured the company's cooperation in relation to the operation of the emergency oil trains.

While the Sanriku Railway was devastated by the earthquake, it was quick to resume operation in sections that were less damaged in order to support and be of service to the people living along the lines. Five days after the earthquake, it ran "disaster reconstruction support trains" on the North Rias Line between Kuji Station and Rikuchu-Noda Station and between Miyako Station and Taro Station, providing free local transportation.

Figure 5-8-11 Transport of oil to the disaster-affected areas using "emergency oil trains"



Source) Tohoku District Transport Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "Transport-Related Efforts of Tohoku District Transport Bureau After the Great East Japan Earthquake"

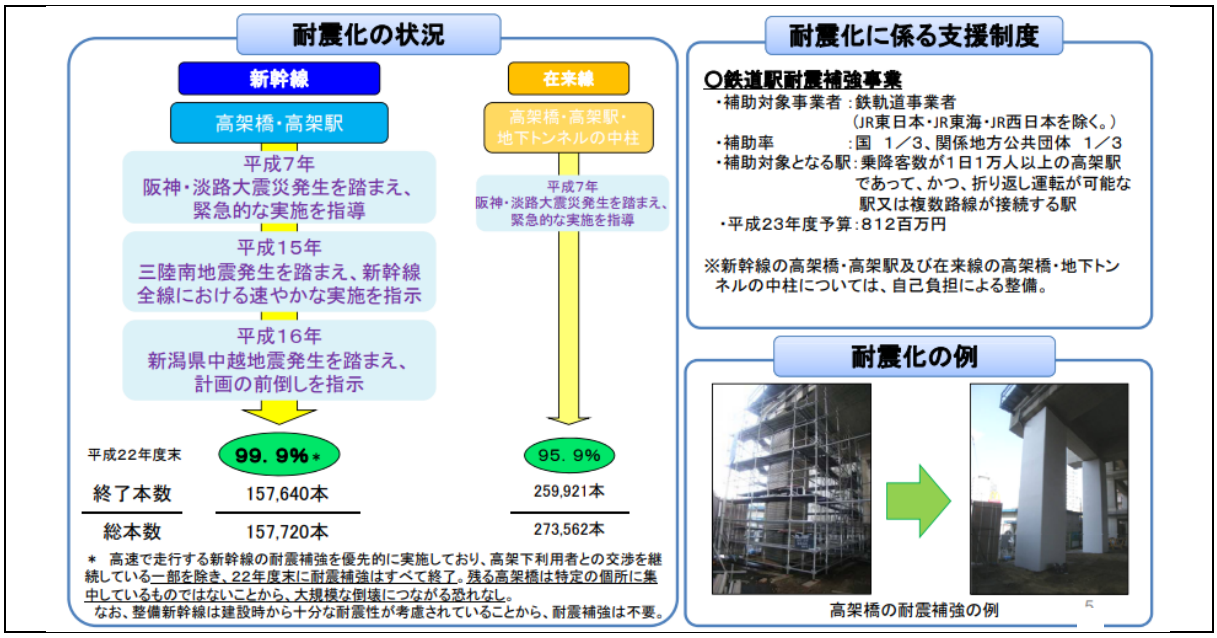
3. Restoring and reconstructing

(1) Development policy based on the Great East Japan Earthquake

1) Earthquake proofing of railway facilities, etc.

The Great Hanshin-Awaji Earthquake in 1995 caused extensive damage, including the collapse of elevated bridges on the Sanyo Shinkansen Line. In December 1998, seismic standards for railway civil engineering structures were strengthened. After that, in preparation for a large-scale earthquake that was expected to occur, to prevent damage to railway facilities and to prevent the spread of damage when it did occur, the earthquake proofing of elevated bridges and stations was promoted, with the earthquake proofing of Shinkansen lines and regular railway lines being generally completed in FY2010.

Figure 5-8-12 Overview of earthquake proofing Shinkansen lines and conventional lines



Source) Ministry of Land, Infrastructure, Transport and Tourism, "The Eighth Meeting of the Railway Section of the Land Transport Subcommittee of the Council of Transportation Policy (Material 2)" (August 10, 2011)

Meanwhile, the Great East Japan Earthquake did result in a certain amount of damage to railway facilities. Therefore, the Council for Shinkansen Derailment Measures of the Ministry of Land, Infrastructure, Transport and Tourism decided to share information on the situation in terms of damage to railway facilities caused by the Great East Japan Earthquake, verify existing earthquake countermeasures such as seismic reinforcement, and improve as necessary. The Railway Structures Seismic Standards Review Committee also reviewed the seismic standards for Shinkansen and conventional railway lines and inspected elements such as the status of ensuring the safety of railway passengers in the event of a tsunami, and decided to examine issues and countermeasures to address them. The Council of Transport Policy of the Ministry of Land, Infrastructure, Transport and Tourism, indicated in terms of concrete measures, that elevated railway stations should be reinforced against earthquakes, that disaster prevention measures such as the installation of revetment walls should be implemented to protect railway facilities in the event of a disaster, and that other such action should be undertaken.

Figure 5-8-13 Measures to strengthen disaster prevention functions of railway facilities in relation to earthquakes and tsunamis

Source) Ministry of Land, Infrastructure, Transport and Tourism, "The Eighth Meeting of the Railway Section of the Land Transport Subcommittee of the Council of Transportation Policy (Material 2)" (August 10, 2011)

2) Reconstructing railways in a manner integrated with town planning

The Sanriku Railway and the JR Hachinohe Line suffered localized damage due to the tsunami, so it was decided that the restoration should essentially be carried out in situ without route changes and so on. Meanwhile, in coastal areas that were devastated by the tsunami, reconstruction plans (such as new community development plans) formulated by the disaster-stricken municipalities involved the examination of elements such as the relocation to higher ground of hamlets and the raising of the ground. As such, even if the railways were restored in situ in advance, the hamlets would be relocated from their original locations and as a result, stations would be left in extremely inconvenient locations for users. Therefore, when it came to the restoration of railways in these devastated areas, it was necessary to examine, in accordance with the need, elements such as changes in routes and the location of stations while maintaining consistency with the town planning of the areas located along railway lines on the premise of safe railways.

For this reason, the Tohoku District Transport Bureau established "Reconstruction Coordination Councils" in May 2011 for each JR conventional line section (Joban Line, Senseki Line and Ishinomaki Line, Yamada Line, Ofunato Line and Kesennuma Line) along the coast which had been devastated by the disaster, with members of those councils consisting of people from JR East and people from the governments of the cities and towns along the lines, the prefectures involved, and the national government (Regional Bureau of Reconstruction, Tohoku Regional Development Bureau, and the Tohoku District Transport Bureau). Then, studies were undertaken with respect to elements such as restoration policies. For the Joban Line (Yamamoto Town and Shinchi Town) and the Senseki Line (Tomei and Nobiru districts of Higashimatsushima City), elements such as routes to be integrated with town planning and the schedule leading up to the resumption of operation were discussed. For the Kesennuma Line, a wide range of transport modes other than railways were also studied, and JR East proposed to organizations such as municipalities located along the line, the temporary restoration of the line using a BRT (Bus Rapid Transit) system.

In the sections where the railway service was suspended, local people were able to travel by means of rail replacement buses and existing route buses (substitute transport). However, given that it would take several years to restore the entire railway line, and that rail replacement buses, etc. had issues in terms of the frequency and punctuality of transportation, causing considerable inconvenience and burdens for users, Reconstruction Coordination Council meetings were also used as venues to discuss ways to improve the service of organizations providing rail replacement transportation.

The following is a summary of what was discussed by the Reconstruction Coordination Councils for the Joban Line, the Senseki Line and Ishinomaki Line, and the Kesennuma Line.

a. Joban Line (between Watari Station and Soma Station)

In the vicinity of Yamashita Station, Sakamoto Station, and Shinchi Station on the Joban Line, all of which were severely damaged by the tsunami, the relocation of the railway route to the landward side undertaken in conjunction with the town planning of municipalities found along the line (Yamamoto Town and Shinchi Town) was being examined. At the Third Meeting of the JR Joban Line's Reconstruction Coordination Council held on September 21, 2011, a proposal for the relocation route was presented and agreed upon, and at the fourth meeting held on March 2, 2012, the relocation route was reviewed. Then, on March 5, JR East announced the schedule for developments thereafter, saying that it "expects that operation would resume in about three years after the start of railway construction."

b. Senseki Line (between Takagimachi Station and Yamoto Station)

In the vicinities of Tomei Station and Nobiru Station on the Senseki Line, which were severely damaged by the tsunami, a plan to relocate the railway route to higher ground in the inland area was discussed in conjunction with the urban development of Higashi-Matsushima City. A plan to relocate the railway route was presented and agreed upon at the Third Meeting of the JR Senseki Line and Ishinomaki Line Reconstruction Coordination Council held on September 30, 2011. At the fourth meeting held on February 23, 2012, it was agreed that "mutual cooperation would be undertaken by the concerned parties to have the entire line opened as soon as possible, with the goal being the reopening of the entire line in FY2015."

c. Ishinomaki Line (between Ishinomaki Station and Onagawa Station)

The revetment of Mangokuura, which is located adjacent to the railway line, was damaged by the earthquake, and the urban area of Onagawa Town was devastated by the tsunami. At the Third Meeting of the JR Senseki Line and Ishinomaki Line Reconstruction Coordination Council held on September 30, 2011, it was decided that the existing route to the vicinity of Urashuku Station would be restored after first carrying out construction for revetments in the section between Watanoha Station and Urashuku Station, where railway land was submerged. It was also decided that a study would be undertaken with respect to the route for the urban area of Onagawa Town while keeping it consistent with the future urban development of Onagawa Town.

In response, on March 5, 2012, JR East announced that it would resume operation between Watanoha Station and Urashuku Station by the beginning of FY2013 with the assumption being that construction of the bank protection would proceed smoothly. Operation between Ishinomaki Station and Watanoha Station resumed on March 17, 2012.

d. Kesennuma Line (between Kesennuma Station and Yanaizu Station)

At the Third Meeting of the JR Kesennuma Line Reconstruction Coordination Council held on December 27, 2011, a hearing was held on the results of discussions concerning restoration measures, including transport modes other than railways, with the City Bureau of the Ministry of Land, Infrastructure, Transport and Tourism. In conjunction with that, a proposal for provisional restoration using BRT was also received from JR East. At the fourth meeting of the council held on March 3, 2012, specific discussions were held on provisional restoration using BRT.

Figure 5-8-14 Restoration and reconstruction of coastal railways

Source) Ministry of Land, Infrastructure, Transport and Tourism, "The Eighth Meeting of the Railway Section of the Land Transport Subcommittee of the Council of Transportation Policy (Material 2)" (August 10, 2011)

3) Example of the restoration of a damaged railway

Since the restoration of railway facilities may require a large amount of funds depending on the disaster situation, it was essential to hold sufficient discussions and build consensus among the relevant parties, such as railway operators and local governments, with respect to the ideal state of things when it comes to maintaining public transportation after restoration.

Taking into account discussions at Reconstruction Coordination Council meetings and other meetings mentioned above, some local areas decided to operate different routes from the ones operated before restoration (the route between Miyako Station and Kamaishi Station on the JR East Yamada Line). Others decided to operate using a BRT system with a higher level of service (the route between Yanaizu Station and Kesennuma Station on the JR East Kesennuma Line and the one between Kesennuma Station and Sakari Station on the Ofunato Line).

The following are examples of major cases in which agreement was reached to maintain railways after restoration in a manner different from what was the case before restoration.

Figure 5-8-15 Example of operation taking place in a different form than operation before restoration

Business operator name (before disaster)	Route name	Operation types after restoration and background of events leading up to decision on the restoration policy
JR East	Yamada Line (between Miyako Station and Kamaishi Station)	[Type of operation after restoration] • After the recovery was undertaken by JR East, operation was transferred to the Sanriku Railway Company (a third-sector company). [Background of events leading up to the decision on the restoration policy] • In June 2011, the JR Yamada Line Reconstruction Coordination Council was established to study the possibility of restoration through railways. The council discussed matters such as the formulation of a restoration plan that would ensure safety against tsunamis by undertaking action such as raising the railway heights and which would be integrated with town planning. • JR East presented a rough estimate of about 14 billion yen for restoration costs (covered by JR East) and about 21 billion yen for the total project costs (at the Fifth Meeting of the Reconstruction Coordination Council in March 2013). • JR East proposed that Sanriku Railway Company operate the North and South Rias Lines and the Yamada Line (between Miyako and Kamaishi) in an integrated manner (at the Seventh Meeting of the Reconstruction Coordination Council held in January 2014). • Subsequently, in November 2014, JR East provided support such as cooperation funds for the transfer (3 billion yen). In February 2015, JR East, local municipalities, and other organizations involved, reached an agreement on the transfer of operations. In March 2015, JR East started restoration work. • On January 10, 2019, Sanriku Railway, relevant municipalities, and JR East, submitted an application for a railway business restructuring implementation plan that included a change in the entity implementing the project from JR East to Sanriku Railway. Certification was provided by the Minister of Land, Infrastructure, Transport and Tourism on January 31, 2019. • The operation of the line was transferred from JR East to Sanriku Railway Company and restarted with the line running as the Sanriku Railway Rias Line (March 23, 2019). As a result, the Sanriku Railway became the nation's longest third-sector railway, connecting 163 kilometers of coastal areas in Iwate Prefecture.

Shown below is an example of a route for which it was decided that restoration would take place using BRT after raising service levels.

Figure 5-8-16 Examples of a routes for which it was decided that restoration would take place using BRT after raising service levels

Name of operator (before disaster)	Route name	Operation types after restoration and background of events leading up to decision on the restoration policy
JR East	Kesennuma Line (between Kesennuma Station and Yanaizu Station)	[Type of operation after restoration] • Restoration by BRT: (operation, facility ownership and management) JR East [Background of events leading up to the decision on the restoration policy] • On March 11, 2011, bridges and station buildings were washed away by the tsunami caused by the Great East Japan Earthquake. • In July 2011, the JR Kesennuma Line Reconstruction Coordination Council was established to study the possibility of restoration through railways. The council discussed matters such as the formulation of a restoration plan that would ensure safety against tsunamis, which would also include the construction of new routes, and which would be integrated with town planning. • While the Reconstruction Coordination Council had been discussing measures to restore the railways, it would have taken a considerable amount of time to restore the railways. Thus, the BRT was used for temporary restoration in order to secure alternative transportation during the suspension of the railways (with full-scale operation beginning in December 2012). • JR East presented a plan to relocate the route in consideration of ensuring the safety of passengers (at the Seventh Meeting of the Reconstruction Coordination Council held in August 2013). • JR East presented a rough estimate of about 30 billion yen for restoration costs and about 70 billion yen for the total project costs in the case of a relocation route (at the Eighth Meeting of the Reconstruction Coordination Council in February 2014). • In June 2015, "Heads of Municipalities Locate Along the Kesennuma Line" was held to discuss the restoration policy for the Kesennuma Line at a high level, with the State Minister of Land, Infrastructure, Transport and Tourism as a chair. • JR East proposed full-scale restoration using BRT (July 2015; The Second Meeting of Heads of Municipalities Located Along Railway Lines). • Minamisanriku Town and Tome City agreed on the acceptance of full-scale restoration using BRT (December 2015; The Third Meeting of Heads of Municipalities Located Along Railway Lines). • Kesennuma City also announced its acceptance of full-scale restoration using BRT (March 2016).
JR East	Ofunato Line (between Kesennuma Station and Sakari Station)	[Type of operation after restoration] • Restoration by BRT: (operation, facility ownership and management) JR East [Background of events leading up to the decision on the restoration policy] • On March 11, 2011, station buildings and tracks were washed away by the tsunami caused by the Great East Japan Earthquake. • In July 2011, the JR Ofunato Line Reconstruction Coordination Council was established to study the possibility of restoration through railways. The council discussed matters such as the formulation of a restoration plan that would ensure safety against tsunamis, which would also include the construction of new routes, and which would be integrated with town planning. • While the Reconstruction Coordination Council had been discussing measures to restore the railways, it would have taken a considerable amount of time to restore the railways. Thus, an agreement was reached between JR East and the municipality to the effect that temporary restoration would be undertaken using BRT when it came to the securing of alternative transportation during the suspension of the railways (October 2012). Operation commenced in March 2013. • JR East presented a plan to relocate the route in consideration of ensuring the safety of passengers and in consideration of town planning (September 2013; the Fifth Meeting of the Reconstruction Coordination Council). • JR East presented a rough estimate of about 13 billion yen for restoration costs and about 40 billion yen for the total project costs in the case of a relocation route (February 2014; the Sixth Meeting of the Reconstruction Coordination Council). • In June 2015, "Meeting of Heads of Municipalities Located Along the Ofunato Line" was held to discuss the restoration policy for the Ofunato Line at a high level, with the State Minister of Land, Infrastructure, Transport and Tourism as a chair. • JR East proposed full-scale restoration using BRT (July 2015; The Second Meeting of Heads of Municipalities Located Along Railway Lines). • An agreement was reached on the acceptance of full-scale restoration via BRT (December 2015; The Third Meeting of Heads of Municipalities Located Along Railway Lines).

Figure 5-8-17 Image of BRT Introduced on the JR East Kesennuma Line and Ofunato Line

Source) Tohoku District Transport Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, "The Great East Japan Earthquake: Records of the Three Years After the Earthquake" (March 2014)

An example of conversion from railways to buses is also shown.

Figure 5-8-18 Route which was converted to bus services

Name of operator (before disaster)	Route name	Operation types after restoration and background of events leading up to decision on the restoration policy
JR East	Iwaizumi Line (between Moichi Station and Iwaizumi Station)	[Type of operation after restoration] • Restoration using conversion to buses: operation by Higashinihon Kotsu [Background of events leading up to the decision on the restoration policy] • Damaged by a landslide on July 31, 2010. • During the period spanning from July to October 2012, JR East provided explanations on elements such as alternative transportation to local communities (four times in total). • Starting in September 2013, proposals were provided to and discussions undertaken with Iwate Prefecture, Miyako City, and Iwaizumi Town (three times in total) about elements such as alternative transportation, with a final agreement being reached in November.

(2) Railway business

1) Support for restoration projects

Third supplementary budget for FY2011 (total amount: about 12.1 trillion yen)

In this budget, the expenses required for the full-scale restoration project of the disaster-stricken railways (national expenditure: about 6.6 billion yen) were allocated.

2) Activity overview and achievements produced thus far

Reconstruction Coordination Councils (Secretariat: Tohoku Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism), which consisted of railway business operators, municipalities found alongside the railway lines, and the relevant ministries and agencies, were established in the six sections affected by the disaster: the JR Joban Line (between Watari and Soma), the JR Senseki Line, JR the JR Ishinomaki Line, the JR Yamada Line, the JR Ofunato Line, and the JR Kesennuma Line. Council meetings were held to discuss railway restoration plans in accordance with the town reconstruction plans formulated by the disaster-stricken municipalities. As a result, various creative efforts were made according to the actual situations of the region, with examples being those such as cases involving operation taking place in a different form than was the case before the earthquake and cases involving the introduction of new methods such as BRT, which have been mentioned above.

Construction costs were significantly reduced for lines restored using BRT thanks to elements such as asphalt being paved instead of the laying of tracks taking place. The total cost of construction for the Kesennuma Line and the Ofunato Line was estimated to be about 110 billion yen if they were to be relocated and restored as railway lines. Going with BRT reduced the cost to about 30 billion yen. In addition, the adoption of BRT improved things in terms of the route income and expenditure. For example, the operating ratio[1] of the Kesennuma Line was 656.9 in FY2009 before the earthquake and was 255.2 in FY2014 after the BRT was opened. The operating ratio of the Ofunato Line was 671.1 in FY2009 and 248.5 in FY2014 meaning that the operating ratios of both lines saw significant improvements. In addition, increases were also seen in the number of vehicles in service since the BRT lines opened compared to before the earthquake. As for the Kesennuma Line, in 2009 before the earthquake, there were nine inbound vehicles and 10 outbound vehicles running between Maeyachi and Kesennuma, and one inbound vehicle and two outbound vehicles (with one vehicle being suspended on holidays) running between Motoyoshi and Kesennuma, meaning that there was a total of 10 inbound vehicles and 12 outbound vehicles running. Meanwhile, in 2022, sometime after BRT service began, there were 15 inbound vehicles running between Yanaizu and Kesennuma Station (including with arrivals and departures from Maeyachi), one outbound vehicle between Rikuzen-Tokura and Kesennuma (with no operation on holidays), three inbound vehicles and six outbound vehicles between Shizugawa and Kesennuma, and 13 inbound vehicles and 12 outbound vehicles between Motoyoshi and Kesennuma (with two suspending service on holidays), resulting in a total of 31 inbound vehicles and 34 outbound vehicles. This is about three times the number vehicles in service than there was before the earthquake. Thus, it can be said that this has greatly contributed to the improvement of convenience for local residents.

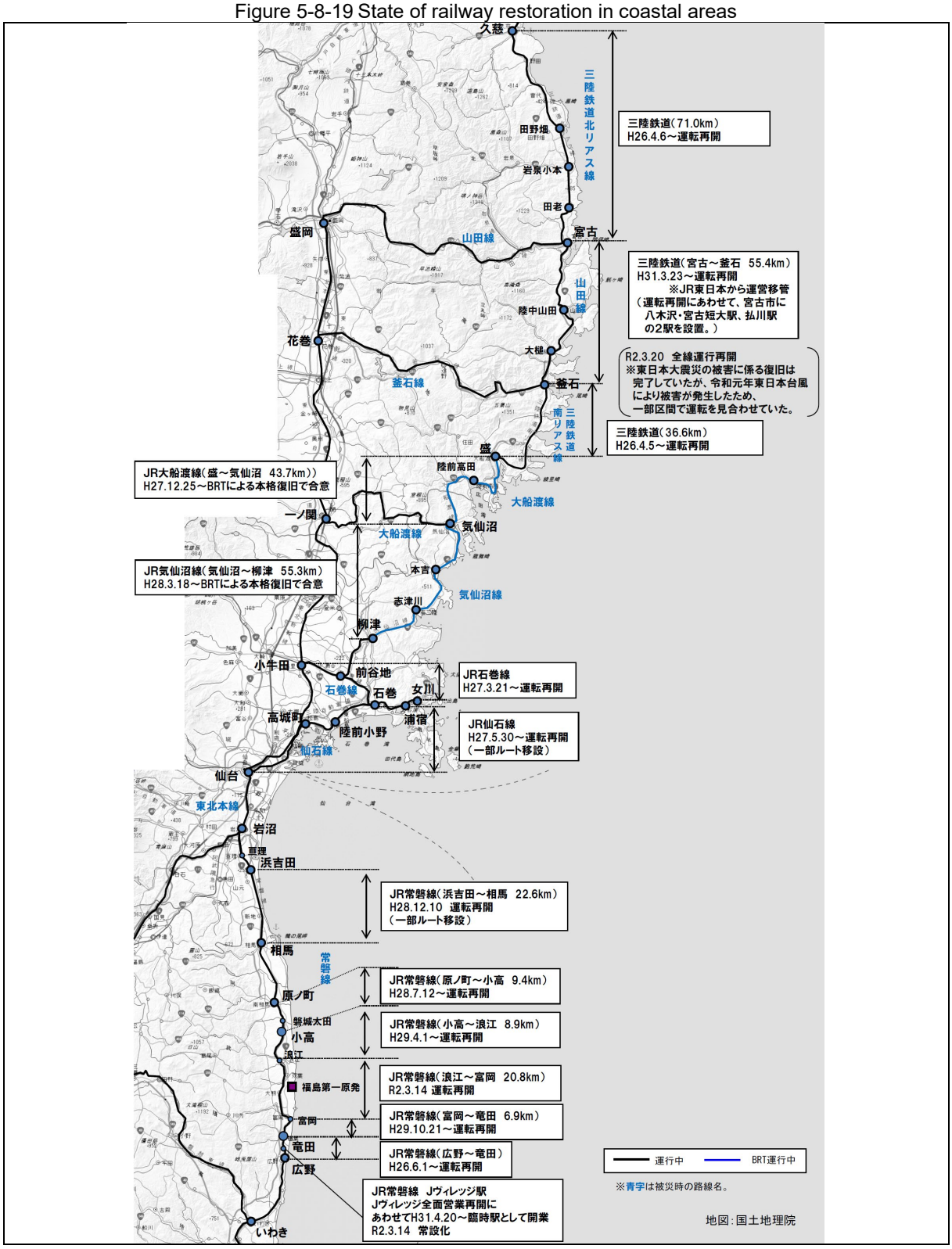
Also, a new system was established (a measure undertaken using the special local allocation tax for reconstruction from disasters) under which, when a municipality restores railway facilities and owns them, the national government bears half of the restoration cost and the local government bears the remaining half (the subsidy rates under the existing system is 1/4 for the national government, 1/4 for municipalities, and 1/2 for railway operators). With the application of this system, all lines of Sanriku Railway's North and South Rias Lines resumed service in April 2014.

Seismic measures for railway facilities were promoted through efforts such as guidance provided by elements such as ministerial ordinances on seismic resistance based on each earthquake disaster, subsidies on project costs for comprehensive safety measures for railway facilities (seismic measures), and support provided through special tax provisions for fixed asset taxes. In FY2015, a subsidy on flood control measures was added to the subsidy for project costs on comprehensive safety measures for railway facilities. This meant the promotion of improvements involving water stop plates, waterproof doors, etc. at subway stations and other such locations where damage is expected in the future.

As described above, the Sanriku Railway Rias Line restarted operation in March 2019 and the opening of the section between Namie Station and Tomioka Station in March 2020 meant the opening of the entire JR Joban Line. Thus, all of the railway lines damaged by the Great East Japan Earthquake were restored, including those restored by BRT.

[1] Operating ratio: The cost required to generate operating revenue of 100 yen. An operating ratio of less than 100 indicates a profit, while an operating coefficient of more than 100 indicates a loss.

Figure 5-8-19 State of railway restoration in coastal areas



4. Issues that arose in project implementation and responses, etc.

(1) Issues that arose in project implementation and responses

The Japan Railway Construction, Transport and Technology Agency provided various kinds of support for the early restoration of the disaster-stricken railways. In order to restore the Sendai Airport Line, an advance survey team was dispatched in mid-March 2011 at the request of Miyagi Prefecture to investigate the damage, and in early April, two employees were dispatched to Sendai Airport Railway Co., Ltd. In addition, a support team was established within the JRTT to provide support from inside and outside the organization. For the purpose of restoration of the Tohoku Shinkansen Line, construction machinery and other equipment necessary for the maintenance of tracks used for the construction of Hokuriku Shinkansen Line was lent out for one month starting from the beginning of March based on a request provided by JR East. In addition, "conducting of a survey of tsunami damage and study of restoration measures for small and medium private railways" was commissioned by the Ministry of Land, Infrastructure, Transport and Tourism. Starting in May, surveys were conducted on tsunami damage and studies were undertaken concerning restoration policies on behalf of Sanriku Railway, Iwate Development Railway, Sendai Airport Transit, Sendai Rinkai Railway, and Fukushima Rinkai Railway.

The Railway Bureau and the Tohoku District Transport Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, provided technical advice to Sendai City together with JR East. As a result, the restoration method for the section between Dainohara Station and Izumi-Chuo Station on the Namboku Line of the Sendai Subway was reviewed, and the start of operation was moved forward from the end of May to April 29.

Figure 5-8-20 Technical support for early restoration of the Sendai Subway

Source) Ministry of Land, Infrastructure, Transport and Tourism, "The Ninth Meeting of the Railway Section of the Land Transport Subcommittee of the Council of Transportation Policy (Material 1)" (September 30, 2011)

(2) Lessons learned and know-how gained

1) Structural countermeasures

When the Great East Japan Earthquake occurred, the early restoration of the Tohoku Shinkansen Line contributed greatly to the recovery of the disaster-affected areas. However, the long-term suspension of other trains had immense societal and economic impacts. Therefore, it is necessary to further improve the seismic performance of

viaduct pillars and other structures to enable the early restoration of railway facilities.

As for soil structures, since many embankments and other structures collapsed during the Great Hanshin-Awaji Earthquake, the Niigata-Chuetsu Earthquake, and the Great East Japan Earthquake, it is necessary to evaluate the earthquake resistance of such structures from now on and improve those structures starting with high-priority areas. Seismic reinforcement is also necessary to prevent non-structural members such as ceilings from falling in locations where people stay, such as railway stations.

In addition, in consideration of the possibility of damage to underground facilities caused by tsunami intrusion, it is necessary to prepare facilities such as waterproof boards, doors, and step-ups as inundation countermeasures at places such as underground shopping malls and building entrances connected to underground stations. It would be effective for the managers of underground malls, underground stations and connecting buildings to promote development through conferences and other such gatherings hereafter. However, if discussions do not proceed, it would be effective for local governments and the national government to actively coordinate such discussions.

2) Ensuring the safety of railway passengers in the event of a tsunami

At the "Conference on Railway Passenger Safety in the Event of a Tsunami" of the Ministry of Land, Infrastructure, Transport and Tourism, a summary was compiled on elements such as issues faced and response policies to be deployed for railways in relation to tsunamis, which was based on the state of responses undertaken by the railway operators during the tsunami that occurred during the Great East Japan Earthquake, and the lessons learned, and the basic approaches to be undertaken in relation to a tsunami produced by a massive earthquake in the Nankai Trough as discussed at the Central Disaster Prevention Council, etc. (February 2013). The overview is as follows.

① Designating sections with a possibility of inundation
- Railway operators themselves shall designate sections where there is a possibility of flooding for each line section.

② Taking actions when communication is interrupted
- Crew members and other such individuals shall proactively obtain information on tsunami warnings, etc. from the radio, disaster warning system, nearby residents, and so on.
- Passengers shall be evacuated promptly according to the situation based on the independent judgments of crew members and other such individuals.

③ Getting off quickly from trains that have stopped between stations
- Standard wording for announcements that would lead to the prompt evacuation of passengers shall be prepared.
- It shall be assumed that when the tsunami arrival time is short, the doors of all vehicles will be opened at the same time and that the method of getting off the train will be known.

④ Evacuating passengers and others promptly at stations
- The elevation shall be indicated at stations in sections where there is a possibility of inundation occurring.
- Display, etc. of posters showing evacuation routes, etc.

⑤ Implementing education and training based on manuals, etc.
- Implementation of regular education and training on evacuation guidance, etc.

3) The ideal in terms of the resumption of operation of capital region railways in the event of a large-scale earthquake

In March 2012, the Ministry of Land, Infrastructure, Transport and Tourism's "Council on the Resumption of Train Operations in the Tokyo Metropolitan Area in the Event of a Large-Scale Earthquake," examined matters such as the situation in terms of the resumption of train operations in the Tokyo Metropolitan Area when the Great East Japan Earthquake occurred and the provision of information to passengers, and identified issues and formulated countermeasures. The overview is as follows.

a. Speeding up evacuation-related guidance for passengers

If safety can be ensured, moving a train stopped between stations to the nearest station at a low speed is one effective measure for quickly evacuating passengers to a safe location. However, since there are cases in which trains cannot be moved, it is conceivable that the installation of equipment such as ladders and lighting in

accordance with the number of cars in a formation to enable passengers to get off trains safely is a course of action that would also lead to faster evacuation-related guidance.

b. Securing means of communication, etc.

It is important to introduce disaster priority telephones, dedicated railway telephones, satellite mobile phones, etc., as well as to enhance communication systems within railway operators (at head offices and each on-site operation) and systems for communication between railway operators, partner companies that conduct inspections and restorations, and connecting railway operators, including railway operators that provide mutual direct operation.

c. Accelerating the movement of inspection and restoration personnel and the transportation of materials

With regard to inspection and restoration, the movement of personnel and the transportation of materials will be accelerated through the usage of emergency automobiles and emergency transit vehicles. In the event of a major earthquake in the future, there is a possibility that large-scale traffic regulations will be imposed. In order to cope with this situation, it is important for each railway company to secure the necessary number of emergency transit vehicles, including for partner companies that will actually carry out restoration work and other such tasks.

d. Actions such as the provision of information to users and other such individuals

It is important to provide accurate information as quickly as possible so that it can be used as a reference for actions such as how users and other individuals should move when a large earthquake occurs. For that purpose, it is effective to ensure that prompt provision of information can take place on operation statuses (including connecting routes and alternative transportation) and the expected resumption times through mass media outlets, etc.

4) What railways should aim for in terms of measures against hazards originating from outside railway sites

Based on the experience of the Great East Japan Earthquake and other disasters, in December 2020, the Ministry of Land, Infrastructure, Transport and Tourism’s "Study Group on Risks in Terms of Hazards Originating From Outside Railway Sites" compiled a "Proposal on Risks Posed by Hazards Originating From Outside Railway Sites." In the proposal, "matters to be examined in terms of legal systems" and "matters to be examined in terms of perspectives other than legal systems" have been sorted out. The following is the overview of that.

a. Matters to be examined in terms of legal systems

In order to prevent hazards originating from outside railway sites and to ensure early recovery, it is necessary for railways to examine legal systems based on items such as the Road Traffic Act (Act No. 180 of 1952), the Electricity Business Act (Act No. 170 of 1964), and the Telecommunications Business Act (Act No. 86 of 1984). With the aim of creating new legal systems, the national government should examine the following points while ensuring the cooperation of railway operators and other relevant parties in relation thereto.

ア） Felling trees, etc.

Given the frequent occurrence of transport disruptions due to fallen trees, it is considered that the risk to safe and stable transport can be greatly reduced if the trees along the railway line can be cut down or transplanted when there is a risk of causing interference to railway facilities and when it is unavoidable to do so.

イ） Enter into and temporarily use areas outside railway sites

In order to restore railways as soon as possible after a disaster occurs, it is considered necessary to establish a system whereby off-site areas can be used temporarily as material storage areas and work yards.

ウ) Disposing soil and stones, etc.

When considering risks in terms of hazards originating from outside railway sites, the obstacles that end up becoming disaster risks are not limited to trees. In addition to the damage caused by fallen trees, there is also damage caused by sediment inflow and falling rocks. As with the trees mentioned above, if it becomes legally possible to prevent soil and stones found along railway lines from entering railway sites under certain conditions, it is considered possible to respond to disaster risks in advance.

b. Matters to be examined in terms of perspectives other than legal systems

Regardless of the legal system, it is also important to examine the following efforts in order to reduce physical damage to railways and human-related damage in the event of a disaster and to achieve early restoration after the disaster. Essentially, it would be desirable for railway companies to take the lead in these efforts. In addition, the national government and other relevant organizations should make necessary coordination to facilitate these efforts.

ア) Conducting risk assessments

In order to prevent damage to infrastructure facilities due to disasters, it would be desirable to conduct surveys in advance with respect to the risks posed by trees, soil and stones adjacent to railway lines that become the causes of disasters, and to assess the risk in terms of hazards originating from outside railway sites.

In order for SMEs to be able to assess risks along railway lines, it is necessary to conduct research on subjects such as risk assessment methods along railway lines that are appropriate to actual situations at low costs. In addition, by having technical support provided to SMEs by railway operators with know-how in terms of risk assessments and organizations such as the Railway Technical Research Institute with technical knowledge, SMEs will become able to undertake risk assessments starting with simple areas.

イ) Building smooth relationships with owners of land outside railway sites

Although the relationships with landowners have not gone well due to pollution problems such as noise and undetermined boundaries, it would be desirable for railway business operators to build smooth relationships with landowners outside railway sites on a regular basis.

ウ) Further cooperating with relevant organizations including local municipalities

In order to facilitate restoration in the wake of a disaster, it is important for railway operators to cooperate on a daily basis with local governments such as municipalities and with the regional organizations of the national government.

エ) Promoting inter-project coordination

In order to restore railways damaged by natural disasters as soon as possible, it is important to coordinate and cooperate with related projects such as those related to roads, rivers, erosion control, and afforestation.

オ) Cooperating among railway operators

Reflecting the declining birthrate and aging population in Japan, railway operators are facing issues such as shortages of engineers. For this reason, it would be effective for railway operators to provide assistance mutually with one another, such as by having railway operators with high levels of technical expertise and know-how on disaster responses provide technical and personnel-related support to railway operators affected by a disaster.

カ) Organizing a database for sharing information on disaster responses

As responses to disasters become more diverse, it would be effective to share information among business operators in the event of a disaster. For example, it is important to develop an environment in which each railway operator can make use of the lessons learned from past disaster responses, such as by establishing a database of disaster response-related information pertaining to railway sector which is possessed the Ministry of Land, Infrastructure, Transport and Tourism to share with railway operators nationwide.

キ) Linking with land policies such as measures for situations where the owner of a piece of land is unknown

In terms of measures to deal with situations where the owner of a piece of land is unknown, measures to prevent and eliminate the occurrence of such unidentified land are being considered. This is also an important point of view when it comes to preventing hazards originating from outside railway sites.

5) Important points for railway restoration and vision of the future in reconstruction-related town planning and railways

As previously described, the important points for railway restoration are ① to be able to resume railway operations with safe routes, ② to have consistency in terms of the locations of stations and routes in relation to new town development, and ③ the building of systems for cooperation among the parties involved in the implementation of projects.

In the Tohoku region, the birthrate has been declining and the population has been aging ahead of the rest of the country. This trend is expected to accelerate, especially in the disaster-affected areas on the coast. It is an extremely serious problem. For this reason, when it comes to a vision for the future of railways and areas along railway lines which takes aim at restoration and reconstruction, it will be extremely important to create compact cities centering on stations and promote the development of more comfortable living environments and comprehensive transportation systems.

It will furthermore be desirable to undertaken efforts such as the strengthening of nodal functions for secondary traffic coming from stations, such as that of route buses and demand-responsive transport, making facilities barrier-free, and improving traffic information guidance.