8.6 SELECTED JAPANESE CASE STUDIES

8.6.1 Gakunan Railway in the Kanto Region

Joint Use Pertinence

The Gakunan (pronounced "ga-koo-non [as in non stop]") Railway was established to provide freight service to shippers and manufacturers in an industrial zone, but uses its tracks to provide passenger service for factory workers and residents in the form of light-rail transit with light-weight electric railway cars. Gakunan Railway interchanges freight with Japan Rail-East's Tokaido Main Line. Interline freight, freight switching, and frequent local passenger service share the single track. It is, however, under a single management and dispatching office.

The General Area

An industrial zone immediately south of Mount Fuji where the volcanic slope meets the shore of Suruga Bay on the Pacific Ocean, and midway between the castle cities of Odawara and Shizuoka on the nation's principal highway – the coastal Tokaido Road – and the Japan Rail Tokaido Main Line.

Participants in Joint Use

The participants in joint use/reciprocal running are:

- **Gakunan Railway Company** (Gakunan Tetsudo Kabushikigaisha) – 1067 mm (3'6" gauge, 1,500Vdc catenary – a freight railroad with light-rail transit service.

- **East Japan Passenger Railway Company** (Higashi-Nihon Ryokaku Tetsudo Kaisha) (Japan Rail-East) – 1067 mm (3'6") gauge, 1,500Vdc catenary.

The Components of the Joint Use Facilities

The components of joint use are all under one management, being the:

- Gakunan Railway, an electrified 9.2-km (5.72-mile) *single-track* railroad from Yoshiwara on the Japan Rail-East Tokaido Main Line to Gakunan-Eno, having twelve stations, some of which are right in factory grounds. There are many marshaling yards and numerous sidings.

Services Operated

There are 35 daily scheduled passenger round trips with a minimum headway of ten minutes. The passenger trains, comprised of two-car light-rail vehicle sets, thread their way among moving freight trains and standing freight car consists.

Freight cars are interchanged with Japan Rail-East at Yoshiwara, where an interchange track links the Gakunan Railway and Japan Rail yards. Electrification of the Gakunan Railway and of this district of Japan Rail is 1,500Vdc catenary, so the two systems' locomotives can (but do not routinely) enter onto each other's tracks. Gakunan LRVs do not currently venture onto Japan Rail track (see Figure 8-2).

To avoid fouling passenger operations, an electric box cab freight locomotive waits in one of the Yoshiwara station stub tracks for its assignments. Freight is switched during the day under supervision of a Gakunan dispatcher. There are usually two or more freight trains in motion at any time. Six of the stations have passing sidings and island platforms; hence, there is ample opportunity for freight and opposing passenger trains to pass and to

run the passenger train on the wrong-direction track (i.e., right-hand track inasmuch as Japan's rule of the road is to the left) if the proper direction track is occupied by a freight movement.

Brief History with Emphasis on Joint Use

The Japanese Government Railways' Tokaido Main Line was routed through Yoshiwara and Fuji in 1889. In 1925, a shorter route along the coast and tunneled through the steaming rock of the peninsula had shortened the distance to 146.2 km (90.85 miles) of fast, low-gradient route. Initially, a forest-fed paper industry dominated the area east of the city of Fuji, but chemical companies came here, too. During 1949-1953, the 1067mm (3'6") Gakunan Railway was built and electrified to connect the Japanese National Railways' (JNR) Tokaido Main Line to the heavy-industry plants near Yoshiwara in the city of Fuji and to switch their freight cars. A passenger service was provided from the start with interurban cars to carry workers. In gaps between factories, old villages grew and residential areas developed until the freight railway's passenger business amounted to 40% of its revenue.

Notes on Implementation

Gakunan Railway was built after decades of experience in railway operation in Japan. Unlike most Japanese railway mileage, it was built foremost to carry freight, and secondarily to carry passengers. It was not difficult, therefore, to decide to construct the line to suit Japanese National Railway standards of clearance and electrification, then purchase passenger rolling stock that would fit the railroad clearances but not otherwise be regarded as railroad-compatible (by FRA-type standards). When positioning idle freight cars, the dispatcher and train crews are careful to keep a main track open.

Other Information

In addition to its original fleet, Gakunan Railway acquired second-hand JNR mainline electric locomotives. There are about seven active locomotives and ten passenger cars. Gakunan Railway twice replaced its own passenger rolling stock with second-hand cars from the Tokyu interurban operations in suburban Tokyo. High (car-floor level) platforms prevail. The original cars and the second-hand cars are of JNR clearance standards wide enough for car-floor level high platforms set back sufficiently to clear standard railroad freight cars or larger locomotives. Passenger service ends at Yoshiwara at stub track platforms separate from the Japan Rail platforms connected by a pedestrian overpass. Gakunan Ry. carries daily averages of 5,730 passengers and 80 carloads of freight over its short 6-mile system.

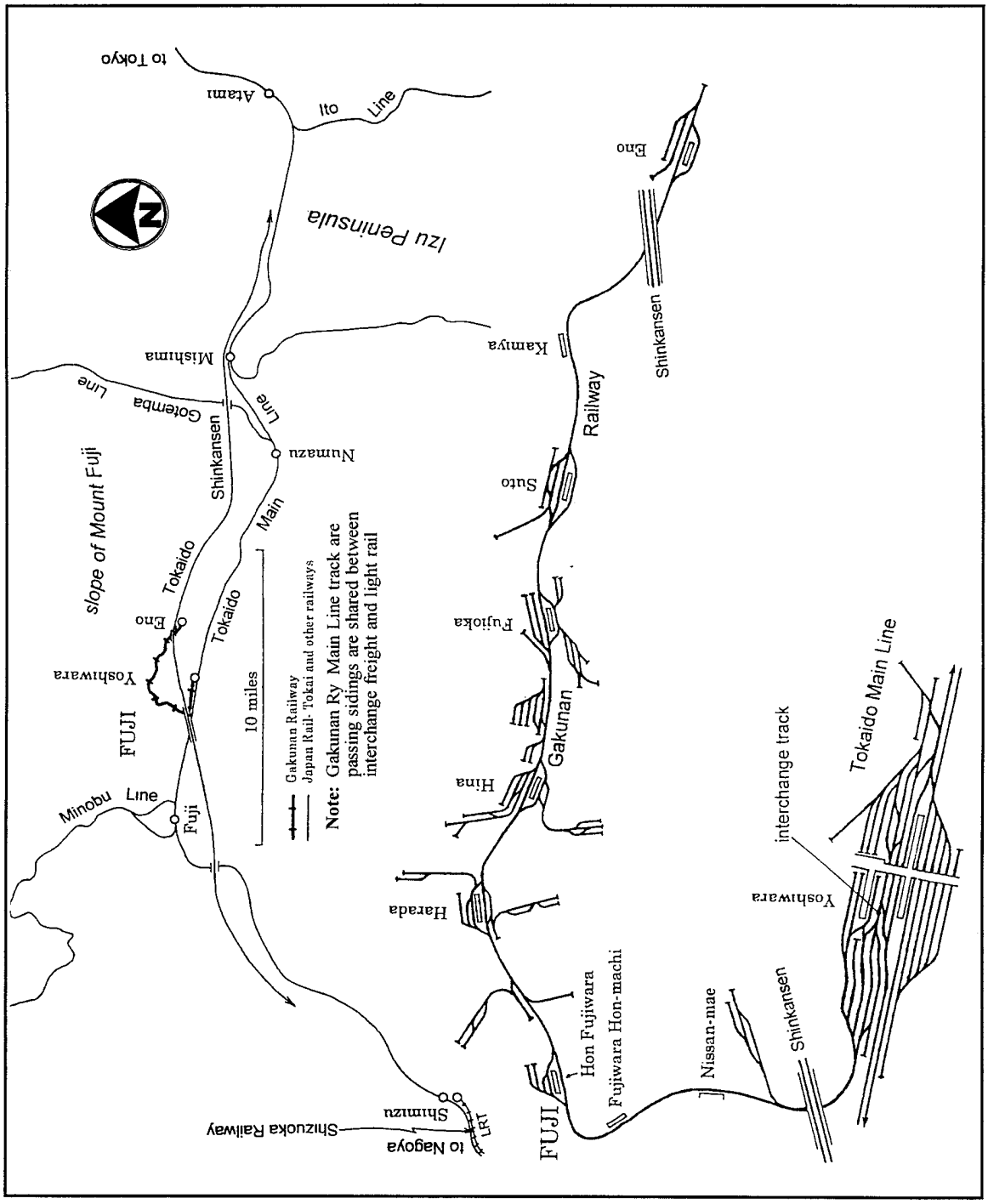
8.6.2 Hankyu Electric Railway in the Kansai Region with Multiple Examples

Joint Use Pertinence

The Hankyu (pronounced "hanqueue") interurban network provides three examples of joint-use of track:

- A subsidiary Third-Sector railway established to extend a municipal subway line into Osaka suburbs.
- Municipal subway trains to operate on the interurban company's tracks for a considerable distance into the hinterland, as well as to enable interurban trains from another city to reach downtown Osaka on municipal rapid transit tracks.

Map of Gakunan Ry. - Figure 8-2



GAKUNAN RAILWAY

G. Thompson 5-98

- The City of Kobe and four interurban companies cooperate to bring the interurbans through the heart of the city and offer rapid transit service to the people of Kobe by running over each other's tracks.

The General Area

The Kansai region/Osaka-Kyoto-Kobe commutershed encompasses commercial Osaka, historic (but of significant manufacturing importance) Kyoto, and the industrial port of Kobe. It is Japan's second-largest conurbation – one-and-a-half times larger than metropolitan Los Angeles!

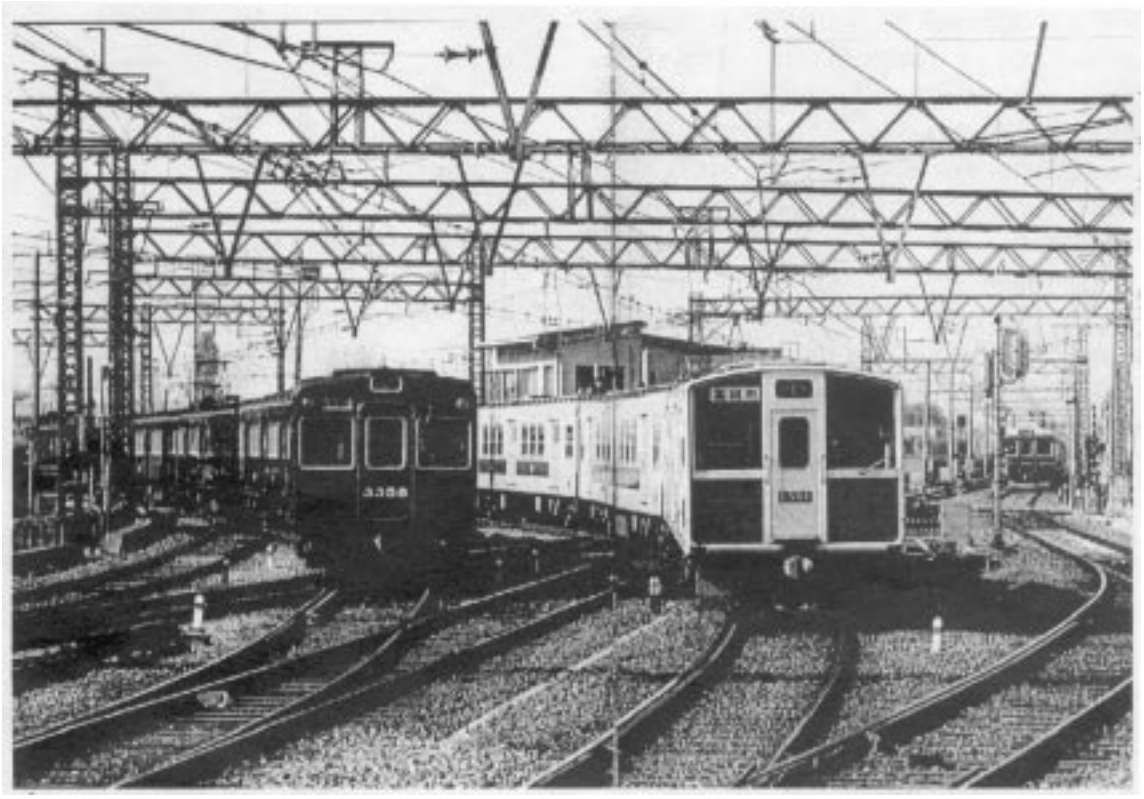
The foothills of the inland mountains come much closer to the bay at Osaka than at Tokyo. The electric railway's ability to negotiate gradients more economically than steam railroads enabled residential development on a grand scale away from teeming city centers. One developer built trolley lines and sold lots simultaneously on the slopes, as well as opening attractions which Osaka inhabitants had to ride his trolleys in order to reach. This grew and evolved into the Hankyu interurban system, one of the most modern, progressive, and aggressively marketed railways in the world. Hankyu's service territory, northeast of Osaka, is almost entirely residential – a bedroom community for Osaka's central commercial district. But it contains shrines, resorts, sports facilities, and new towns with their own retail centers. Hankyu Electric Railway was the originator of three joint-use situations in the Kansai Region.

The Hankyu Interurban Network

The Hankyu Electric Railway Company is a 1435-mm (4'8½") gauge, 1,500vDC catenary electric railway network linking the region's three major cities – Osaka, Kyoto, and Kobe. It has many other lines and branches. Two of its three mainlines emanating from Osaka are closely paralleled by three other competing rail services, yet Hankyu attracts its share of ridership. Under its own name, it operates 124.4 km (86.88 miles) of line with 87 stations and a fleet of 1,136 cars. The network consists of three mainlines radiating from Umeda terminal on the north edge of the Osaka business district. One of its mainlines runs through with the Osaka brown line subway no. 6, one cross-connecting line, and several branches. With 5,700 employees, Hankyu's trains carry two million riders on an average day.

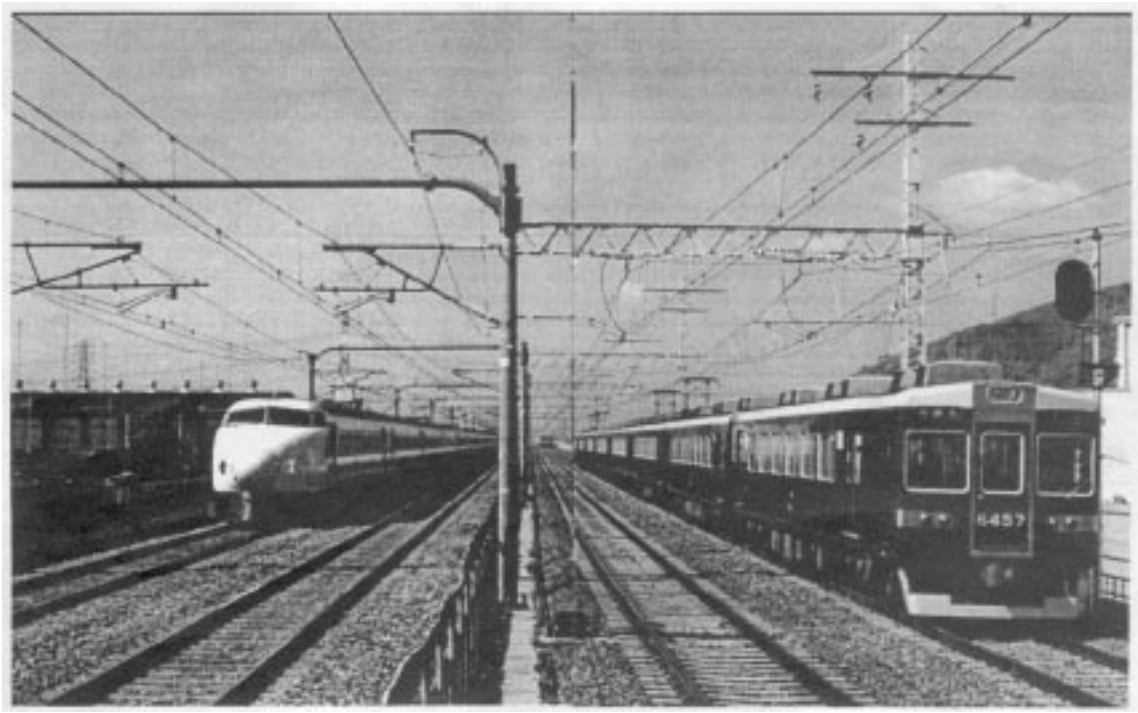
Expanding its surface transportation influence, the railway also operates a large suburban network of local bus routes, a fleet of sightseeing buses, funiculars, and aerial cableways. Although its *railway* operations are not necessarily profitable (see the earlier section on Japanese Interurban Railways), the Hankyu *corporation* is very profitable and plows much of its earnings back into the railway. In fact, without the railway, the corporation would not be profitable. It is an inseparable foundation for other revenue producers. Hankyu owns a department store chain (Hankyu Depato), hotel chains (Hankyu and Shin-Hankyu), a 40,000-seat baseball stadium (and its own Hankyu Braves Pacific League baseball team), travel bureaus, hydrofoils on the Inland Sea, a truck line, a cargo airline, a motion-picture production company, a land-planning and real-estate development firm, the Kansai television network, its own rolling stock manufacturing company (under the trade name "Alna-Koki"), and an assemblage of enterprises at suburban Takarazuka. It also has financial interest in the Third-Sector rapid transit company – Kita-Osaka Kyuko – and two other interurban railways – Kobe Electric Railway and Nose Electric Railway.

Hankyu Electric Railway in Japan - Figure 8-3a



Hankyu Electric Ry. intercity interurban trains mix with Osaka rapid transit rolling stock. Hankyu trains will be entering Osaka subway portal shortly.

H. Morokawa
Nihon no Shitetsu



Hankyu Electric Ry. shares right-of-way and catenary poles with Shinkansen trains.

H. Morokawa
Nihon no Shitetsu

In turn, Kobe Electric Railway has an interest in the Hokushin Express Railway, which participates in reciprocal running with the Kobe Municipal Transport System. The diverse nature and extensive scope of Hankyu's complex ownership typifies how Japanese enterprise combines complementary transport and non-transport entities.

While the focal point of the Umeda terminal complex in Osaka is Japan Rail's main Osaka station, Hanshin Electric Railway interurbans also terminate here in their own subway, and three city subway lines burrow under, the dominant facility is Hankyu's. Travelers seeking a Hankyu train must enter the Hankyu department store and pass through their commercial joint development complex.

More people use the terminal (and trains) because of the floor space added by Hankyu's office tower and store annex. Retail sales have gone up, and Hankyu Electric Railway *Company* is turning a profit. In the U.S., we would call this "value capture".

From Umeda terminal, Hankyu's Kyoto Main Line extends 47.7 km (29.64 miles) to Kawaramachi on the far side of Kyoto, the Takarazuka Main Line runs 23.3 km (14.48 miles) to Takarazuka, and the Kobe Main Line reaches 32.3 km (20.07 miles) to Hankyu-Sannomiya in the heart of Kobe. Leaving Umeda station, the three mainlines each have their own double-track line, amounting to an elevated six-track railroad and 0.4-mile of multi-span bridges over the Shin-Yoda River. At Juso station, topped by a branch of the Hankyu department store, the six-track trunk splits into the three double-track mainlines which quickly diverge.

This is not a complete description of the far-flung Hankyu network, nor of the extensive diversified business corporation that nurtures it. The three instances are profiled of the Hankyu network being engaged in joint use of track with other rail operators. They are:

- the Midosuji Line/Kita-Osaka arrangement;
- the Sakaisuji Line/Senri Line arrangement; and
- the Kobe (pronounced "ko-bay") Rapid Railway arrangement.

8.6.2.1 The Midosuji Line/Kita-Osaka Arrangement

Participants in Joint-Use

The participants in joint-use/reciprocal running are:

Hankyu Electric Railway Company (Hankyu Dentetsu Kabushikigaisha) – 1435mm (4'8½") (using 1,500vDC catenary on its own lines) – a private interurban company.

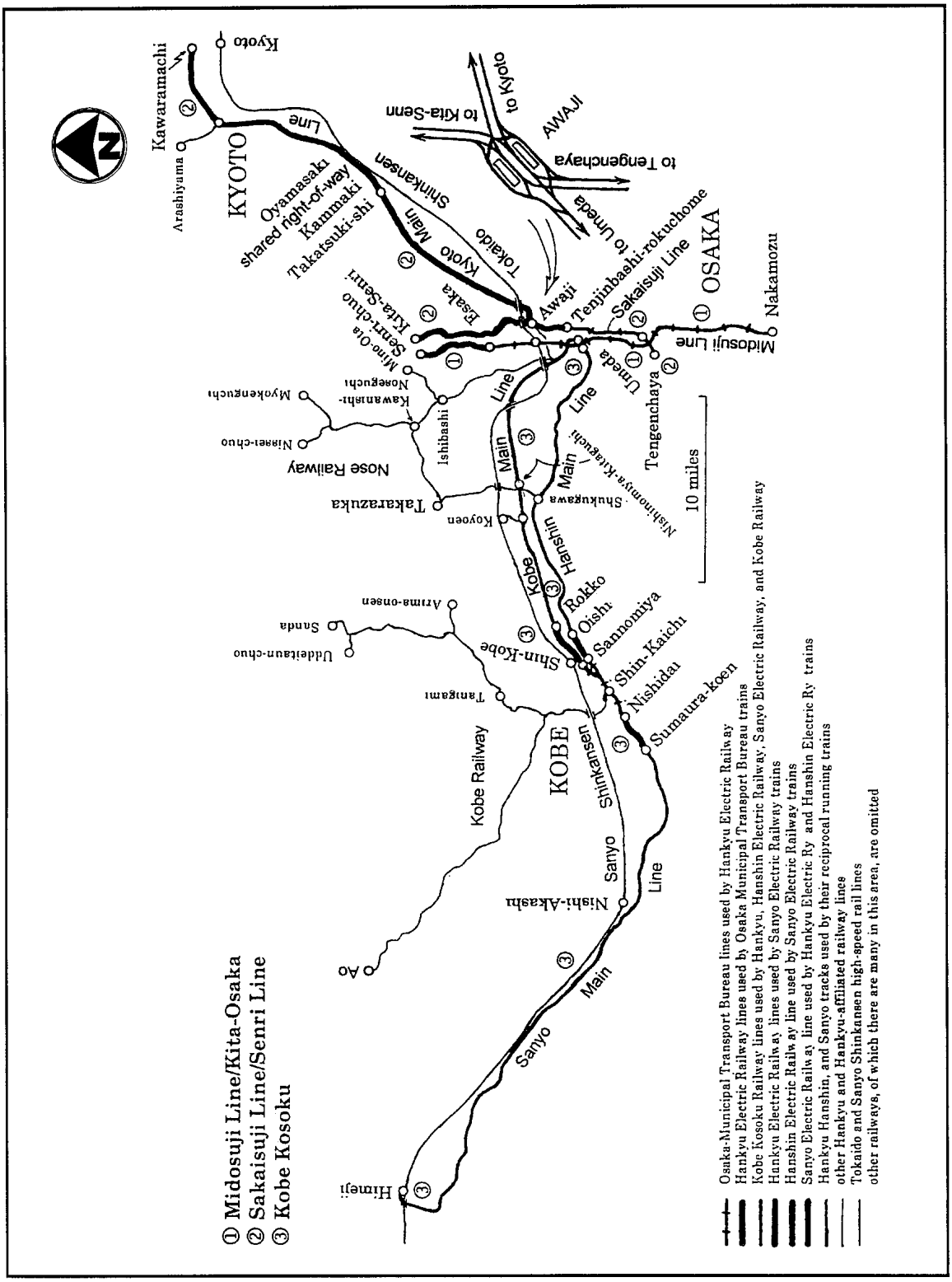
North Osaka Express Electric Railway Company (Kita-Osaka Kyuko Dentetsu Kabushikigaisha) – 1435mm (4'8½"), 750vDC third-rail – a Third-Sector railway company partly owned by Hankyu Railway Company.

Osaka Municipal Transport Bureau Rapid Railway (Osaka-shi Kotsu Kyoku Kosoku Tetsudo) – 1435mm (4'8½"), 750vDC third rail – a municipal rapid transit system.

The Components of the Joint-Use Facilities

- Osaka Municipal Transport Bureau Rapid Railway's Midosuji Line runs from Nakamozu in the south suburbs, north through the center of Osaka for 23.5 km (14.60 miles) to Esaka.

Map of Hankyu Electric Ry in Kansai Region - Figure 8-3b



HANKYU ELECTRIC RAILWAY

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This is a double-track standard-gauge heavy rapid transit line entirely in subway. It shares a four-track subway with Osaka Municipal Transport bureau's parallel Yotsubashi Line for 18 blocks, forming its outer two tracks, and its Daikoku-cho station; there are grade-separated track connections north of the station, but they are not used in regular service. The Midosuji Line carries heavy rapid transit trains of its own and those of the Kita-Osaka Express Railway.

- Kita-Osaka Express Railway's Namboku Line, from Esaka north for 5.9 km (3.67 miles) to Senri-chuo. This is a fully grade-separated double-track rapid transit line mostly in the median of a freeway, but with some subway construction to reach the heart of Senri new town. It carries trains of its own and those of the Osaka Municipal Transport Bureau.

Services Operated

Osaka Municipal Transport Bureau Rapid Railway and Kita-Osaka Express Electric Railway pool similar rolling stock for terminal-to-terminal through service. The joint-use venture is more of institutional contrasts than vehicle or infrastructure contrasts. The mix of financiers and participants is particularly dramatic. Trains run every two to four minutes during peak periods and every four to eight minutes during off peak. Kita-Osaka's trains are maintained at the Momoyamadai shops near the north end of the line, and the Osaka Municipal Transport Bureau's trains are maintained at the Abiko shops near the south end of the line.

Brief History with Emphasis on Joint-Use

The City of Osaka was building a rapid transit line from the south end of the city, through the city, to the north toward the site of the 1970 Japan World Exposition (Expo 70). The then-available funds only allowed construction of this Midosuji Line to reach a point – Esaka – still some distance from the Expo site. Reaction to the inability to complete the line in time for Expo 70 prompted the private sector, in 1967, to cooperatively form the Kita-Osaka Kyuko Dentetsu (North Osaka Express Electric Railway). The private Hankyu Railway company took the lead by investing 50%. The City of Osaka put in 25%, and the remaining 25% came from the Kansai Electric Company, the Osaka Gas Company, the Sanwa Bank, the Daiwa Bank, and the Taiyo Kobe Bank. Under Hankyu leadership, the rapid transit line was extended 9.1 km (5.66 miles) from Esaka to the Expo grounds. The joint-venture company was formed on December 11, 1967, and the service opened on February 24, 1970 – 26½ months in all. During Expo, the intermediate Senri Chuo (a planned new town) was served by a temporary station. After Expo, 3.2 km (1.99 miles) of the line was abandoned back to the temporary station and re-extended in another direction to a more conveniently-located Senri Chuo station in the heart of the new town.

Notes on Implementation

For the Kita-Osaka situation, the new Third-Sector Kita-Osaka Kyuko Dentetsu company adopted the already-established standards of the Osaka Municipal Transport Bureau's Midosuji Line, which was already well along in construction when the new company was formed. Although Kita-Osaka rolling stock is different in appearance and paint scheme, it is technically identical to the Osaka Municipal Transport Bureau's rolling stock

for the Midosuji Line. Osaka Municipal Transport Bureau's operating practices, signal system, and common train control system prevail. This jointly-operated core rapid transit line serves 100,573 passengers daily.

8.6.2.2 The Sakaisuji Line/Senri Line Arrangement

Participants in Joint-Use

The participants in joint-use/reciprocal running are:

Hankyu Electric Railway Company (as described previously)

Osaka Municipal Transport Bureau Rapid Railway (as described previously)

The Components of the Joint-Use Facilities (note map Figure 8.3b)

- Osaka Municipal Transport Bureau Rapid Railway's Sakaisuji Line from Tengachaya for 8.1 km (5.03 miles) to Tenjinbashisuji-rokuchome. This is a double-track heavy rapid transit line entirely in subway. It has no track connection with any other of Osaka's seven heavy rapid transit lines, because it is the only one using catenary instead of third rail. This accommodates rapid transit trains of the Osaka Municipal Transport Bureau and interurban trains (local and express) of the Hankyu Electric Railway.

- Hankyu Electric Railway's Senri Line from Tenjinbashisuji-roku-chome north for 3.5 km (2.17 miles) to Awaji station on Hankyu Electric Railway's Kyoto Main Line. It is grade-separated by being on embankment as far as the wide Yoda River, where a major bridge was built. It is at grade the rest of the way with road crossings protected by gates, electronic "bells," and flashing lights. These tracks carry rapid transit trains of the Osaka Municipal Transport Bureau and interurban trains (local and express) of the Hankyu Electric Railway.

- Hankyu Electric Railway's Senri Line from Awaji for 10.1 km (6.28 miles) to Kita-Senri. It is a double-track at-grade electric railroad serving another part of the Senri new town. This line carries local interurban trains of the Hankyu Electric Railway and rapid transit trains of the Osaka Municipal Transport Bureau.

- Hankyu Electric Railway's Kyoto Main Line from Umeda northeast for 6.6 km (4.10 miles) to Awaji. It is a double-track at-grade interurban mainline carrying mainline interurban local trains, express trains, and limited express trains, as well as locals of the Senri Line.

- Hankyu Electric Railway's Kyoto Main Line from Awaji northeast for 16.4 (10.19 miles) to Takatsukishi. This continues the double-track at-grade interurban mainline, carrying Hankyu local, express, and limited-express trains from the mainline Umeda terminal, as well as Hankyu and Osaka Municipal Transport Bureau local trains from central Osaka via the Senri Line.

- Hankyu Electric Railway's Kyoto Main Line northeast from Takatsukishi for 24.7 km (15.3 miles) to Kawaramachi on the far side of Kyoto. This continues the double-track at-grade interurban mainline, carrying local, express, and limited-express trains from the mainline Umeda terminal, as well as express trains from central Osaka via the Senri Line, to downtown Kyoto. It

enters Kyoto in a Hankyu-built and Hankyu-owned subway with three stations. For a 4.2-km (2.61-mile) section through the villages of Kanmaki and Minase to Oyamazaki, Hankyu and the Tokaido Shinkansen share the at-grade right-of-way, appearing as a four-track mainline with joint use of catenary-support girders.

Services Operated

Focused on the Awaji station which is arranged as a pair of "Y"s coupled at their stems (where the station is situated), a variety of passenger services are operated. All trains except the limited expresses stop or turn at Awaji. In the city-subway section of the combined services, any passenger can board any train. Interurban trains, therefore, supplement the rapid transit line's capacity.

Brief History with Emphasis on Joint-Use

Mr. Kobayashi, a real estate developer, completed his first trolley line from Umeda at the north edge of downtown Osaka, then to the main railroad station north to Takarazuka, in 1910. Another separate line was opened in October, 1925 from the north edge of the Osaka business district at Tenjinbashisuji-rokuchome north to Awaji. In August, 1963, it was extended to the Senri new town's south edge. In March, 1967, it was completed through the new town to Kita Senri. This became Hankyu's Senri Line. By 1929, the original line had spawned two major spurs, one west to Kobe, the other northeast toward Kyoto. The tracks reached in subway to Omiya station in the middle of Kyoto in 1931 and were extended in subway to Kawaramachi on the east side of downtown Kyoto in June, 1963. This is Hankyu's present Kyoto Main Line, linking Kyoto and Osaka subways.

Line 6 of the Osaka municipal rapid transit network was opened southward from an end-on-end connection with Hankyu's Senri Line at Tenjinbashisuji-rokuchome in subway in December, 1969. According to plan, this introduced reciprocal running to the Osaka rapid transit system. It was extended one more station to Tengachaya in April, 1989.

Notes on Implementation

For the Senri Line situation, the Osaka Municipal Transport Bureau adopted the physical, electrical, and rolling-stock dimensions of the Hankyu interurban system when designing and building its basic Sakaisuji Line and its southward extensions.

The Sakaisuji Line/Senri Line services are operated by a pool of rolling stock supplied by both Osaka Municipal Transport Bureau and Hankyu Electric Railway. *For three peak-hour round-trips each weekday, Osaka subway cars find their way into the Kyoto subway as a result of pooling among the two entities.* The Senri Line does not have its own maintenance facility. Hankyu's cars are serviced at Shojaku.

8.6.2.3 The Kobe Kosoku Arrangement

Participants in Joint-Use

The participants in joint-use/reciprocal running are:

Hankyu Electric Railway Company (described previously)

Hanshin Electric Railway (Hanshin Denki Tetsudo Kabushikigaisha) 1435mm (4'8½"), 1,500Vdc catenary – a private interurban company.

Kobe Rapid Railway Company (Kobe Kosoku Tetsudo Kabushikigaisha) – 1435mm (4'8½") and 1067mm (3'6"),

1,500Vdc catenary– a Third-Sector rapid transit system.

Sanyo Electric Railway Company (Sanyo Denki Tetsudo Kabushikigaisha) – 1435mm (4'8½"), 1,500Vdc catenary – a private interurban company.

There are other railways affiliated with Hankyu that will be mentioned, but not detailed.

The Components of the Joint-Use Facilities

- Hankyu Electric Railway's Kobe Main Line west from Umeda terminal in Osaka for 27.4 km (17.03 miles) to Rokko. This is a double-track at-grade interurban mainline with many long stretches of grade separation achieved by elevating the tracks. It carries Hankyu mainline interurban local trains, express trains, and limited express trains.

- Hankyu Electric Railway's Kobe Main Line continuing west from Rokko for 4.9 km (3.04 miles) to Hankyu-Sannomiya. This is a mostly-elevated double-track electric railroad. It carries the Hankyu local, express, and limited express trains, and the Sanyo interurban limited express trains *as locals.* At Hankyu-Sannomiya, the tracks run end-on-end with the Kobe Kosoku Tetsudo tracks.

- Kobe Rapid Railway Company's Hankyu Line (northeast leg) from Hankyu-Sannomiya west for 2.2 km (1.37 miles) to Kosoku-Kobe. It is a double-track heavy rapid transit line almost entirely in subway. It carries Hankyu interurban limited express trains and Sanyo limited express trains, both *as locals.*

- Kobe Rapid Railway Company's Tozai Line (west leg) from Kosoku-Kobe for 0.6 km (0.37 miles) to Shin-Kaichi. It is a four-track heavy rapid transit line in subway. It carries Hankyu interurban limited express trains, Sanyo limited express trains, and Hanshin express and limited express trains, all *as locals.*

- Kobe Rapid Railway Company's Tozai Line (west leg) from Shin-Kaichi for 2.9 km (1.80 miles) to Nishidai. It is a double-track heavy rapid transit line almost entirely in subway. It carries Hankyu interurban limited express trains, Hanshin limited express trains, and Sanyo local and limited express trains, all *as locals.*

- Sanyo Electric Railway Company's Sanyo Main Line from Nishidai for 5.1 km (3.17 miles) to Sumaura-koen. This is a double-track interurban mainline. It carries Hankyu interurban limited express trains, Hanshin limited express trains, and Sanyo local and limited express trains, all *as locals.*

In January, 1995 the Hanshin Earthquake caused considerable damage to the Sanyo Shinkansen, Japan Rail-Tokai, the four interurban companies, and the two rapid transit systems. All systems immediately started bus service to ferry passengers around the devastated area and promptly started debris-clearance and restoration work. By April 8, the Shinkansen was back to normal. By June 26, 1995, Hankyu had fully restored its facilities and services. All joint use operations were restored to pre-earthquake levels.

Services Operated

Hankyu runs through from its Kobe Main Line to Sumaura-koen on the Sanyo Electric

Railway. Hanshin Electric Railway also runs through from the east to Sumaurakoen. And Sanyo Electric Railway runs through from the west alternately to Rokko on the Hankyu tracks and Oishi on the Hanshin tracks.

The overlapping services provided by the three interurban railway companies accumulate to a train every three minutes. All trains, whether local or express on other parts of their lines, stop at all stations on the shared trackage.

Brief History with Emphasis on Joint-Use

Kobe has two subway systems. The earlier one is for the four private interurban companies that focus on this industrial port city. It accommodates two gauges (though not on dual gauge tracks). The Hankyu, Hanshin, and Sanyo interurban companies (as well as Hankyu's subsidiary Kobe Railway) joined with the City to form the Third-Sector Kobe Kosoku, which built a subway through the heart of downtown. The project was completed in 1968. In exchange for using the subway, the interurban companies agreed to run over each other's trackage to the farther extremity of the city. These overlapping services provide very frequent train service from city limit to city limit. *The City of Kobe gained rapid transit service without buying rolling stock or hiring operating employees.*

This subway permitted a pattern of moving interurbans off city street trackage, abandoning affected streetcar lines, and grade-separating approaches to the city core similar to events in Cincinnati, Cleveland, Los Angeles, Milwaukee, Newark (NJ), and Rochester. Only the Cleveland and Newark examples survive in the form of LRT. These U.S. counterparts never matured enough to make the transition into joint use.

In addition to the joint subway project, each interurban company grade-separated its tracks approaching Kobe. This reciprocal running arrangement provides Kobe residents with a one-seat ride over 119.1 km (74.00 miles) of interurban railway lines, *not* counting the Kobe Electric Railway's 71.2-km (44.24-mile) network. This first subway line and its interurban extensions serve older, mature neighborhoods, carrying 262,860 passengers each day. But to serve other parts of the city, Kobe built a separate rapid transit network primarily to open new territory for residential development.

Notes on Implementation

For the Kobe Kosoku situation, negotiation and compromise were necessary among the four cooperating interurban railway companies. All four already had the same electrification system – 1,500Vdc catenary. Three of the four had the same track gauge – 1435mm (4'8½"). It would have been uneconomical to convert the 1067mm-(3'6"-) Kobe Tetsudo's 71.2-km (44.24-mile) route network and re-gauge its 132 interurban cars to standard gauge; therefore, no arrangement was made for track sharing with the Kobe interurbans. The other three companies had to agree upon details of track construction, station platform configuration, clearance envelope, traction-power substations, etc. Although these three had not developed track connections in the past with each other or with other standard-gauge interurbans in the Osaka area for that matter, they fortunately had independently adopted similar dimensional standards.

A uniform fare structure was devised and adopted by all participants. Ticket vending machines cover the entirety of the Hankyu, Hanshin, Sanyo, and Kobe railways. In 1997, this uniform fare structure was expanded to encompass two other interurban railway companies serving

northeastern and eastern Osaka suburbs, together with the central Osaka Municipal Transport Bureau's rapid transit lines.

Other Information

Reciprocal running extends Kobe's 22.7-km (14.11-mile) rapid transit line by only a short distance, to 30.2 km (18.77 miles). However, together with the Third-Sector rapid transit system, the network accumulates to 51.9 km (32.25 miles). The city is well covered by rail service, and further expansion is not anticipated.

Osaka's municipal rapid transit network has grown to 96.2 km (59.78 miles). Together with the reciprocal-running additions (on Hankyu, Kita-Osaka, and Kinki Nippon railways), it extends by 46.1 km (28.65 miles) to 142.3 km (88.43 miles). Current detailed plans would expand it to 165.5 km (102.84 miles). This total is conservative.

8.6.3 Ise Railway in the Nagoya Region

Joint Use Pertinence

Light-weight diesel railbuses and railroad DMUs, locomotive-hauled intercity passenger, and freight trains comprise the operating mix on the Third-sector Ise (pronounced "eee-say") Railway which is used by Japan Rail as a shortcut. The Ise Railway railbuses run on Japan Rail tracks to reach major cities just beyond each end of its own tracks. This reciprocal running is under two separate managements and joint dispatching.

The General Area

The airline distance from Nagoya to the Kansai region (Osaka-Kyoto-Kobe) is relatively short, but for the rail lines along the south coastline, it is very long. The west shore of Ise Bay is home to several industrial cities, and the Ise Peninsula contains popular ancient shrines which attract large numbers of visitors. The land, comprising a coastal plain, is fairly flat. Several competing railways reached the shrine area, as well as ferries across Ise Bay. There is direct, fast interurban service to Ise from both Nagoya and Osaka, provided by the private Kinki Nippon Railway interurban network.

Participants in Joint-Use

The participants in joint-use/reciprocal running are:

Ise Railway (Ise Tetsudo) – 1067 mm (3'6") gauge, diesel – a Third-Sector regional interurban company.

Tokai Passenger Railway Company (Tokai Ryokaku Tetsudo Kaisha) (Japan Rail-Tokai) – 1067 mm (3'6") gauge, 1,500vDC catenary and diesel – one of the six publicly-owned corporations comprising the lines of the former Japanese National Railways.

The Components of the Joint-Use Facilities

The components of the Ise situation are as follows, north to south, the middle and last two of which are not treated in further detail:

- Japan Rail-Tokai's Kansai Main Line southwest from Nagoya for 33.0 km (20.51 miles) to Yokkaichi: This is a single-track electrified railroad carrying the Japan Rail-Tokai local, commuter/suburban, and express intercity passenger trains, and Japan Rail-Freight trains.

- Japan Rail-Tokai's Kansai Main Line south from Yokkaichi for 6.9 km (4.29 miles) to Kawarada, junction with the Ise Railway. This is a single-track

Ise Railway in Japan - Figure 8-4a

- *Ise railbuses shares its tracks with Japan Rail freight and passenger trains. Catenary poles are installed in anticipation of electrifying the Ise Railway. These railbuses are bus and coach derivatives.*

H. Iwabori
Tetsudo Fuan

electrified railroad carrying the Japan Rail-Tokai local, commuter/ suburban, and express intercity passenger trains, Japan Rail-Freight trains, and Ise Railway railbuses.

- Japan Rail-Tokai's Kansai Main Line southwest from Kawarada for 15.8 km (9.82 miles) to Kameyama, junction with the Kisei Line, and division point with Japan Rail-West. This is a single-track electrified railroad carrying the Japan Rail-Tokai local, commuter/suburban, and express intercity passenger trains, and Japan Rail-Freight trains.

- Ise Railway's Ise Line from Kawarada on the Japan Rail-Tokai's Kansai Main Line for 22.3 km (13.86 miles) to Tsu on the Japan Rail-Tokai Kisei Line. This is a single-track non-electrified interurban line carrying Ise Railway local railbuses and Japan Rail-Tokai intercity express trains. Its trackbed and structures are set up for eventual double track. There are grade-separation structures in place at both the north and south junctions with Japan-Rail-Tokai. Ise Railway track occupies the flyover at the north. But the south flyover remains trackless, inasmuch as it is presently only a single-track line switching into a single-track line. Guy poles are in place along the Ise Railway for future electrification.

- Japan Rail-Tokai's Kisei Main Line southeast from Kameyama for 15.5 km (9.63 miles) to Tsu. This is a single-track non-electrified railroad carrying Japan Rail-Tokai's intercity passenger trains, Japan Rail-Freight trains and Ise railbuses at its southern extreme.

- Japan Rail trains that run via the Ise Railway shortcut (rather than stay with Japan Rail tracks through Kameyama) continue on Japan Rail-Tokai's Kisei Main Line southwest from Tsu for 169.0 km (105.02 miles) to Shingu, and on Japan Rail-Tokai's Sangu branch line east from Taki for 29.1 km (18.08 miles) to Toba. These are single-track non-electrified railroads carrying Japan Rail-Tokai intercity local and express passenger trains and Japan Rail-Freight trains. Electrification is planned (see accompanying map Figure 8-4b).

Joint-Use Services Operated

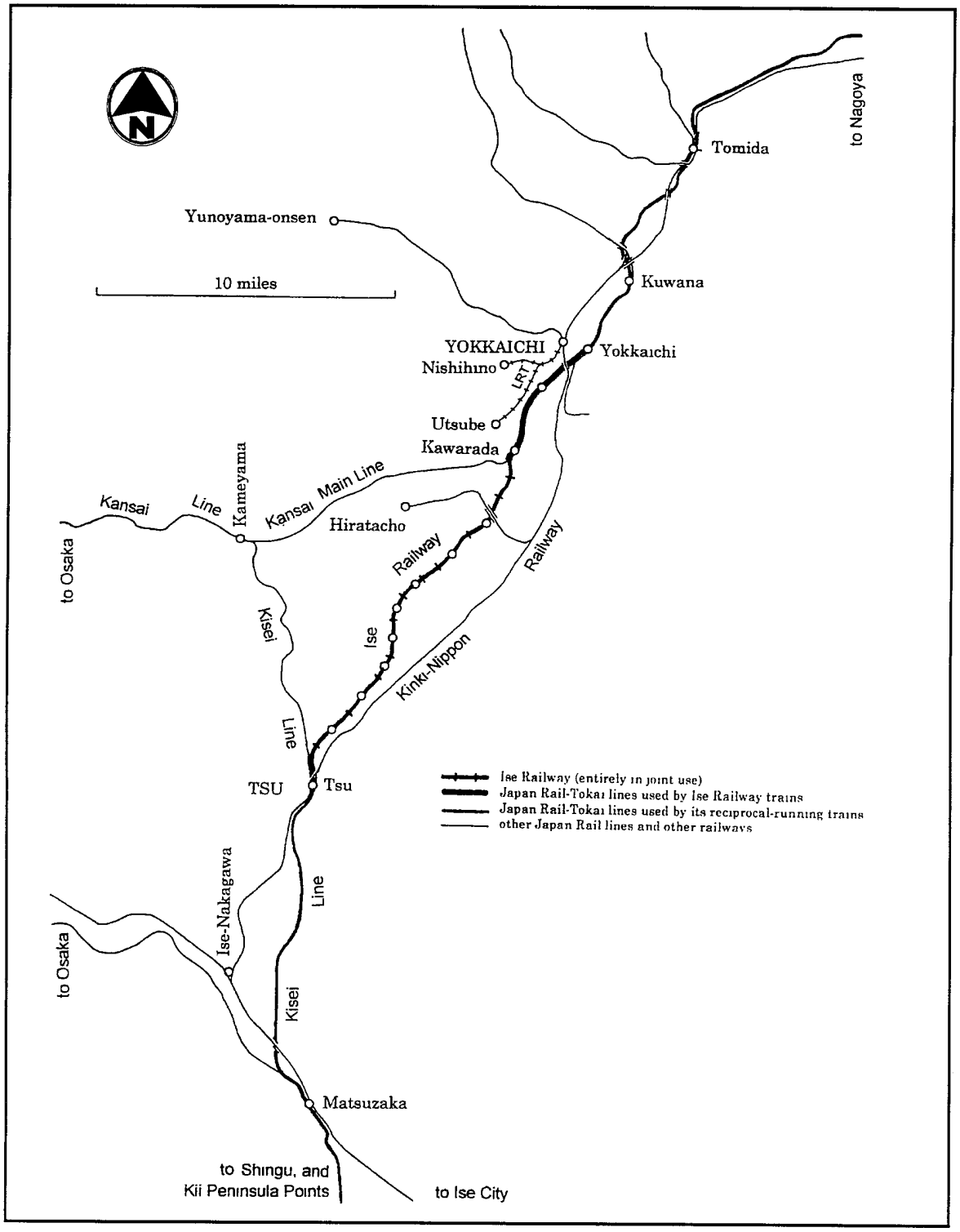
Japan Rail-Tokai operates EMU commuter/suburban trains on the Kansai Main Line from Nagoya to Kameyama with about half the trains turning back at Yokkaichi. It also operates local service with DMUs from Kameyama (where passengers transfer from and to the electric trains from Nagoya and the Japan Rail-West DMUs from Osaka) to the city of Ise and beyond.

Ise Railway runs diesel railbuses between Yokkaichi and Tsu, using Japan Rail-Tokai tracks and stations at both ends of its trips. Ise Railway offers 19 round-trips daily with three 46-seat railbuses. In addition, 13 Japan Rail non-stop diesel express trains use Ise Railway track each way each day.

Japan Rail-Tokai runs its nonstop express trains from Nagoya through Tsu to points south on the Kii Peninsula to Shingu via Ise Railway's more direct route, saving 15.9 km (9.88 miles) and 23 minutes (plus transfer time).

The three sections of the joint use arrangement have different mixes of rail traffic.

Map of Ise Railway in Nagoya Region - Figure 8-4b



ISE - RAILWAY

G. Thompson 5-98

Brief History with Emphasis on Joint-Use

Japanese Government Railways reached Kameyama and Yokkaichi from Osaka in 1890, and by 1895 the gap from Yokkaidi to Nagoya had been closed. In 1891, the Kisei Line was built from Kameyama to Tsu, and continued to Taki by 1893. The JNR Sangu Branch was completed from the junction at Taki and onward to Toba by 1911. Construction resumed on the Kisei Line in 1923, to meet construction coming the other way from Osaka at Nigishima in 1959. The Kisei Line was slated for electrification, along with the Ise Line shortcut.

In recent years, JNR electrified the Kansai Main Line from Nagoya to Kameyama, started through service (Nagoya to Kii peninsula destinations) with diesel train-sets that reversed ends at Kameyama, and constructed an all-new link to complete the triangle and enable trains to run directly from Nagoya to Tsu, Matsuzaka, and the Kii peninsula. This Ise Line opened for use on September 1, 1973 with JNR DMUs. Seven local round trips were operated, and three through express trains used this shortcut. Called a *baipasu* (bypass), this single-track (but double-track-roadbed), fully-grade-separated railway was discarded when JNR became the Japan Rail Group.

Local government and private enterprise created the Ise Railway, took over the dormant project, finished it, and equipped it with railbuses. This is a typical Third-Sector enterprise among those that took over pieces of the JNR network. The new line is 22.3 km (13.86 miles) long between Kawarada and Tsu, with seven intermediate stations. Japan Rail took advantage of this action and gained trackage rights over the Third-Sector railway; hence, it achieved its original purpose for through express trains. In turn, Ise railway has trackage rights for 6.9 km (4.29 miles) over Japan Rail-Tokai track north into the city of Yokkaichi. Japan Rail has yielded local traffic among its three stations on the shared track to the Ise Railway and runs non-stop through this territory. On the south, Ise Railway runs on Japan Rail track into the Tsu station. The total Ise railway operation is 29.2 km (18.15 miles) with 11 stations.

Notes on Implementation

With a heritage as an intended Japanese National Railways line, the Ise Line was built to JNR clearance standards. Ise Railway had only to purchase rolling stock that would fit. In order for the new rolling stock to operate on the JNR trackage to reach its terminal cities, Ise Railway was required to adopt and install the new JNR signal and train-protection apparatus, including wireless ATS (automatic train stop) that Japan Rail-Tokai had implemented when it electrified the Kansai Main Line. Ise railbuses are light weight, high-platform loading.

Other Information

Galvanized-steel poles are in place at the storage yard/maintenance facility and along most of the line for erection of catenary. Future electrification of Japan Rail's Kii Main Line will likely continue. Although electrification would not be warranted for the Ise Railway's traffic alone, it is likely that the Ise Railway would replace the railbuses with Japan Rail-compatible interurban EMUs when the Japan Rail overhead wires become available.

8.6.4 Nagoya Railway at Gifu in the Nagoya Region

Joint Use Pertinence

Streetcar lines that met interurban lines at the edge of the city furnished their in-street trackage routes for the interurbans to run to the heart of the city. Previously, passengers

had to transfer at the edge of the city. Although all under one corporate management, several compromises had to be made in order to introduce the through service by joint-use of street trackage. Low-floor streetcars, light-rail vehicles, and high-floor interurbans of two voltages coexist.

The General Area

Gifu (pronounced "Gi (as in gig) foo") is a city of 407,058 population in the north side of the Nagoya Region. The seat of Gifu Prefecture, it is located on the Tokaido Main Line, but was bypassed by the Tokaido Shinkansen on a new alignment. The city occupies the north edge of the coastal plains at the toe of the foothills of the interior mountains. In time, it became the hub of JNR lines in three direction, and interurban lines in five directions – all eventually came under the management of the Nagoya Railway.

Nagoya is sometimes termed the "Detroit of Japan" because of its manufacturing focus on automobiles. Like metropolitan Detroit, automobiles are more prominent in the Nagoya Region than in other large Japanese urbanized areas. The Nagoya Railway, one of Japan's largest interurban networks, has to work harder to compete with the automobile than its counterparts elsewhere in Japan. This is reflected in policies for, among other things, attempting to provide seats for as many passengers as possible – hence transverse seating rather than the typical longitudinal seating of urban railway cars in the larger cities, and in offering direct and through services rather than requiring passengers to transfer at junctions and connecting points. Nagoya Railway does not charge extra fare for riding express trains. Service is frequent to minimize wait times. Antimacassars are provided on the seatbacks of even the Gifu streetcars.

Participants in Joint-Use

The participants in joint-use/reciprocal running are:

Nagoya Railway (Nagoya Tetsudo) street railway division – 1067 mm (3'6") gauge, 600vDC trolley wire and catenary – a private interurban railway company.

Nagoya Railway (Nagoya Tetsudo) interurban division – 1067 mm (3'6") gauge, 1,500vDC catenary – a private interurban railway company.

The Components of the Joint-Use Facilities

The components of the Gifu situation are as follows:

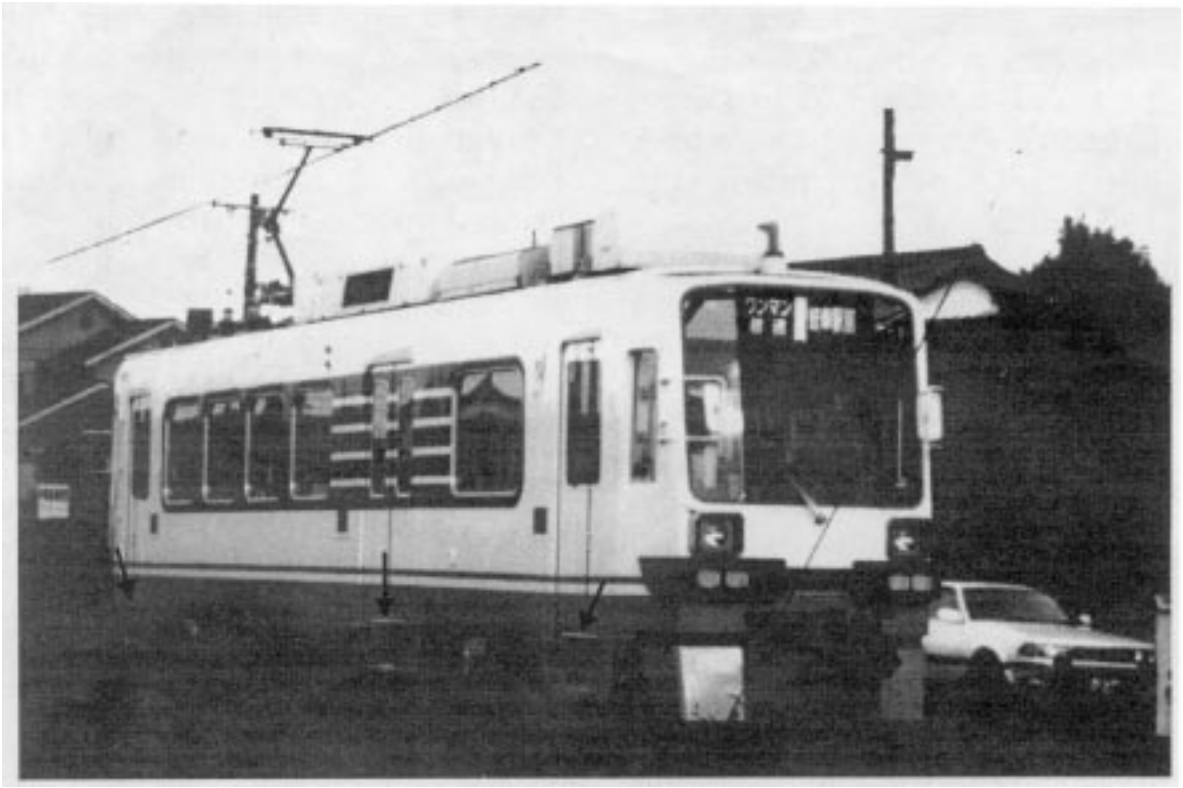
Northwest Lines:

- Nagoya Railway's Gifu-shinai streetcar line from Gifu Station north for 3.7 km (2.30 miles) to Chusetsu. This is a conventional double-track street railway line in busy paved main streets, electrified with single-strand trolley wire. The tracks carry streetcars in the city and light-rail vehicles from the suburbs and rural districts.

- Nagoya Railway's Ibi interurban line from Chusetsu west for 12.7 km (7.89 miles) to Kurono. It is an essentially rural single-track interurban line through predominantly agricultural land, serving numerous small communities along the way. It carries interurban trains and light-rail vehicles.

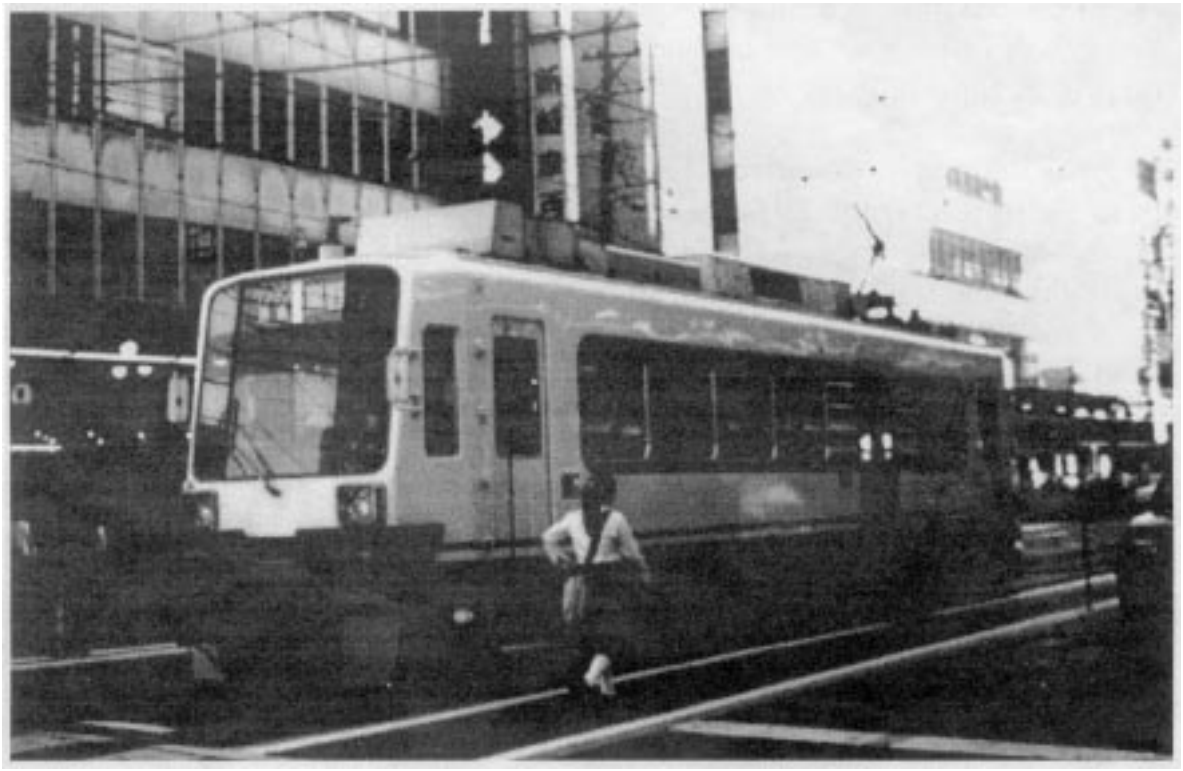
- Nagoya Railway's Ibi and Tanigumi interurban lines from Kurono for 5.6 km (3.48 miles) to Hon Ibi, and for 11.2 km (6.96 miles) to Tanigumi. These are single-track rural trolley lines to the mountains.

Nagoya Railway at Gifu - Figure 8-5a



Nagoya Ry. LRV on Ibi line with sill extenders positioned out for high platform loading.

J. Lozier



Same class Nagoya Ry. (1997 vintage Nippon Sharyo car loading on the street in Gifu.

J. Lozier

Northeast Line:

- Nagoya Railway's Kakamigahara interurban line from Shin-Gifu for 1.1 km (0.68 miles) east to Tagami junction. This is a double-track interurban line electrified with 1,500Vdc catenary.

- Nagoya Railway's Kakamigahara interurban line from Tagami junction 16.5 km (10.25 miles) east to Shin-Unuma. This is a double-track interurban line electrified with 1,500Vdc catenary. It runs end-on-end with Nagoya Railway's Inuyama Line to and from Nagoya.

- Nagoya Railway's Tagami Line from Tagami Junction for 1.4 km to Keirinjomae, a specially-built singletrack connection to link the Minomachi Line to the Kakamigahara Line to afford fast access for suburban riders to the Shin-Gifu downtown terminal. The line is half in paved street and half on private right-of-way.

- Nagoya Railway's Minomachi Line from Tetsumeicho for 1.9 km (1.18 miles) to Keirinjomae. This is a mostly double-track streetcar line in busy main street. It is electrified with single-strand trolley wire.

Nagoya Railway's Minomachi Line from Keirinjomae for 16.2 km (10.07 miles) to Shin-Zeki. This is a suburban/rural single-track interurban line serving agricultural plains below the mountains. Much of the way, the track is roadside, on the shoulder of the highway. Note map Figure 8-5b.

Services Operated

The basic Ibi Line service is provided by high-level loading interurban cars between Chusetsu and Kurono. Connecting city streetcars, which load from street surface, run between Gifu Station and Chusetsu. Shuttles are run with older interurban cars from Kurono on the branches to Tanigumi and Hon-Ibi every 30 minutes. Overlaying this pattern of service are articulated light-rail vehicles (LRVs) running from Gifu Station through Chusetsu to Kurono. There is a streetcar zone, an interurban zone, and the common denominator light-rail vehicle service covering both zones. No freight is carried, but a variety of vehicles of railroad and light rail derivations coexist.

The basic Kakamigahara Line service is a combination of local trains from Shin-Gifu on the Inuyama Line, and of express trains from Shin-Gifu via the Inuyama Line to central Nagoya and beyond. Although there are no freight trains, the passenger equipment is mixed.

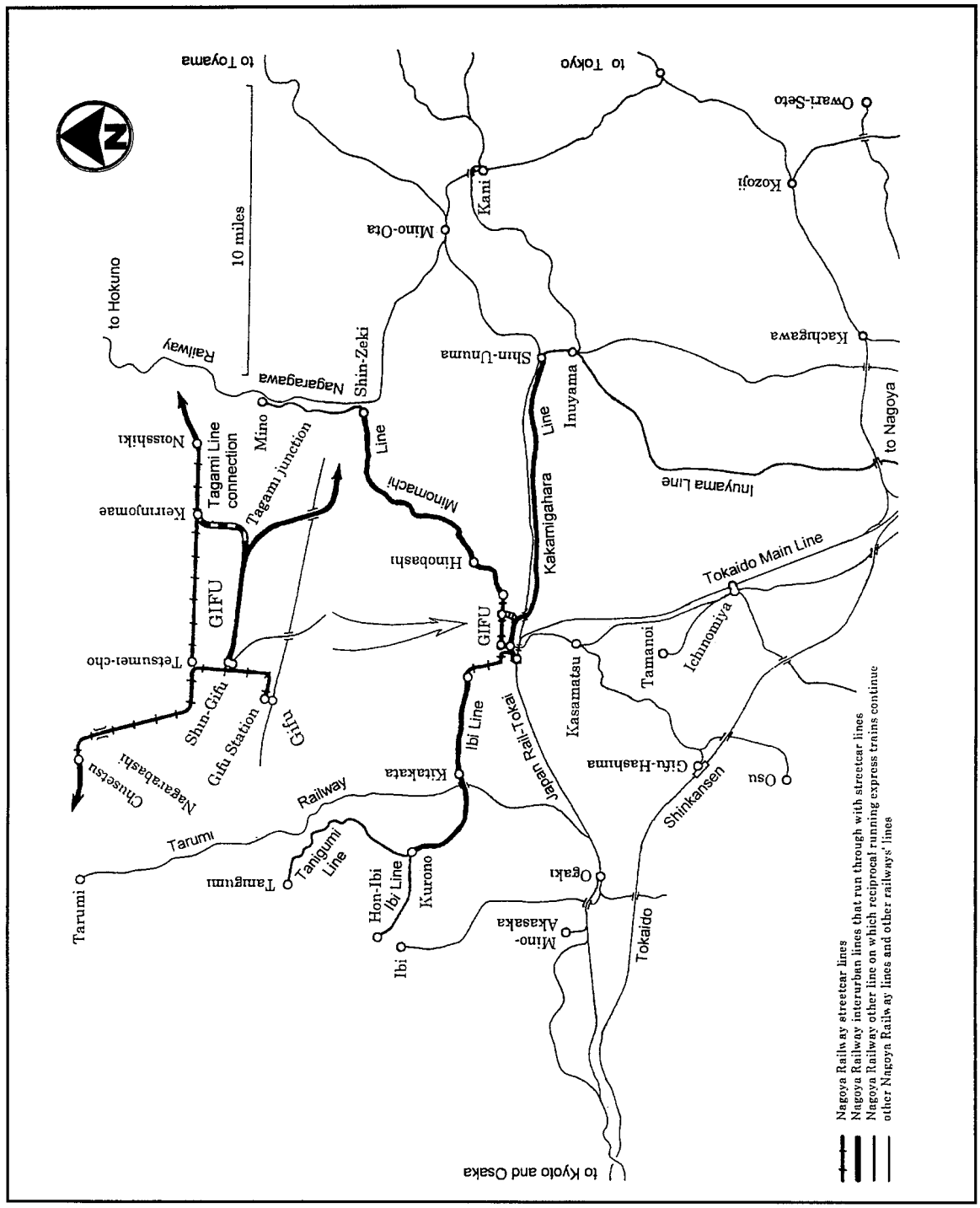
The basic Minomachi Line service is provided by *dual-voltage light-rail vehicles* between Shin-Gifu and Shin-Zeki. These run every 15 minutes. Connecting streetcars run from Tetsumeicho to Hinobashi overlapping the LRVs. A shuttle service is provided by interurban cars between Shin-Zeki and Mino, running every 30 minutes.

By the use of dual-capability light-rail vehicles, Nagoya Railway provides a one-seat ride for most passengers and reduced transferring for the shuttle passengers from two to one in order to reach the center of the city.

Brief History with Emphasis on Joint-Use

The basic street railway and interurban line to Mino were opened in February 1911, and the central city system extended north to Nagarabashi in 1912 and south to the main railroad station in 1913. The trunk interurban lines had reached from Nagoya to Gifu by 1914.

Map of Nagoya Ry. At Gifu - Figure 8-5b



NAGOYA RAILWAY at GIFU

G. Thompson 5-98

Mostly as a measure to effect economy and efficiency of management during World War II, these and other Nagoya Region railways were brought into the Nagoya Railway network.

The inner section of the Minomachi Line was relocated in 1950 for a better connection with the street railway system. In 1954, the northwest streetcar line was extended in a new street bridge over the Nagara River to a terminal in Chusetsu to which the interurban tracks were relocated. The streetcars and interurbans exchanged passengers in a convenient across-the platform transfer arrangement. The tracks were connected. Through service was instituted at Chusetsu in 1967 with the modification of some cars transferred from the Minomachi Line. And in 1970, a new link was built between the Minomachi Line and the Kakamigahara interurban line to afford more direct service to downtown Gifu and the street section was reduced to a shuttle service. For this direct service, the special dual-voltage rolling stock was ordered.

Notes on Implementation

When Nagoya Railway decided to run the interurban service to downtown Gifu, it chose somewhat differing means for each of its northwest and northeast lines out of Gifu.

Initially for the Minomachi Line, Nagoya Railway purchased articulated light-rail vehicles with capability to load passengers from the British-type compromise-height platforms at the stations along the interurban line and from the street pavement height safety zones on city streets. The run on city streets still encountered traffic congestion, so a new 1.4-km (0.87-mile) link was built south from the Minomachi Line and west along a canalized stream to one of the interurban lines that reaches the heart of the city on private right-of-way. For this service, Nagoya Railway purchased unique dual-voltage light-rail vehicles that could operate from the Minomachi Line's overhead wire power of 600vDC *and* the Kakamigahara interurban line's catenary power of 1,500Vdc.

For the Ibi Line, the articulated cars displaced by the dual-voltage cars on the Minomachi Line were transferred. Their ability to load from both compromise level and street level platforms enabled the through service to downtown Gifu. The Ibi Line interurban cars do *not* reach downtown and LRVs do not reach the outer terminal of the branches. Dual-voltage cars are not necessary on this line because the rural interurbans and streetcars had the common 600vDC system.

The streetcars and the rural-shuttle interurbans use conventional fareboxes and are one-man operated, but the LRVs carry conductors.

Other Information

Nagoya Railway is Japan's second-largest private railway, with 544 km (338 miles) of interurban, light-rail transit, and streetcar lines. It also operates a monorailway line and a freight-only line, and has an interest in several additional interurban companies and Third-Sector railway companies. Nagoya Railway has several track connections with Japan Rail-Tokai for interchange of freight.

Moreso than other Japanese cities, Nagoya is sprawled, urbanization is not contiguous, and much of the major employment is in the suburbs.

8.6.5 Sanriku Railway in Northeastern Honshu

Joint Use Pertinence

A Third-Sector railway organization, using railbuses and reciprocal running arrangements, enabled a prefecture to complete two dormant JNR projects, restore branch lines discarded during the creation of the Japan Rail group, and provide no-transfer through service. Japan Rail-East track links the two separate divisions of the Sanriku (pronounced "son-(as in sonic) ree-koo") Railway. The principal objective was to bring the isolated villages of a large coastal region into the mainstream economy. Connecting at four points with Japan Rail lines, the new railway affords Japan Rail-East the opportunity to run selected trains between its own lines, and offer a one-seat ride to the coastal communities. Regular service is provided by Sanriku Railway light-weight railbuses and Japan Rail railroad-class DMUs. In addition, Tokyo-oriented streamlined train sets connect the Sanriku stations via Japan Rail to an interchange station with the high-speed Shinkansen network. Freight trains add to the mix.

Sanriku Railway was the first of the Third-Sector railways to be formed toward the end of JNR. As such, it was a pioneer in solving problems associated with organizing, planning, and operating the joint-use of track/reciprocal-running arrangements.

The General Area

The northeastern prefecture on the main Island of Honshu is Iwate, one of Japan's least-populated in terms of density – 93 persons per square kilometer as compared with a national average of 331 per km^2 (239 persons per square mile compared with 857 per square mile).

The northeast coast of Honshu is a mountainous region with a rocky shoreline indented with numerous coves and inlets. It has been bypassed by intensive development northward from Tokyo along the inland plains – the course of early roads and railroads. Industry sprouted at the mouths of several larger rivers. The cities of Kamaishi and Miyako became centers of iron and steel production. Lateral railways were built from the Tohoku Main Line to the coast, but a rail line along the coast was deferred. Several of the spine-to-coast rail lines were projected to extend along the coast. Construction was slow because of the succession of tunnels and bridges necessary to overcome the terrain. A through line still had not been achieved by the time Japanese National Railways broke into the Japan Rail group of companies, and economic concerns had earlier halted construction of missing links along the coast.

Participants in Joint-Use

The participants in joint-use/reciprocal running are:

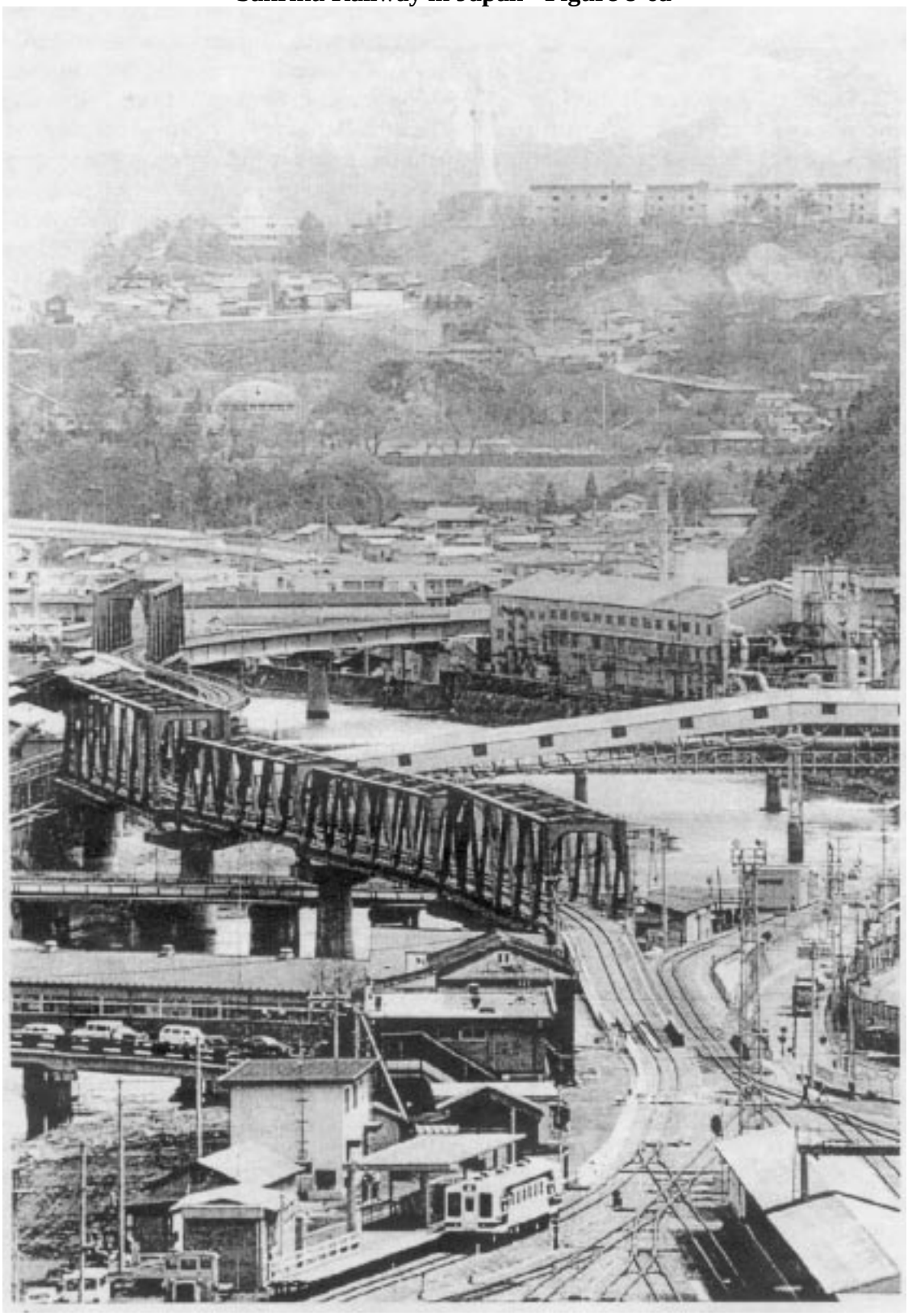
Sanriku Railway (Sanriku Tetsudo) – 1067mm (3'6") gauge, diesel – a public/private joint-venture Third-Sector railway.

East Japan Passenger Railway Company (Higashi-Nihon Ryokaku Tetsudo Kaisha) (Japan Rail-East) – 1067mm (3'6") gauge, diesel.

The Components of the Joint-Use Facilities

The components of the Sanriku joint-use/reciprocal running situation are as follows, south to north (refer to Figure 8-6b map):

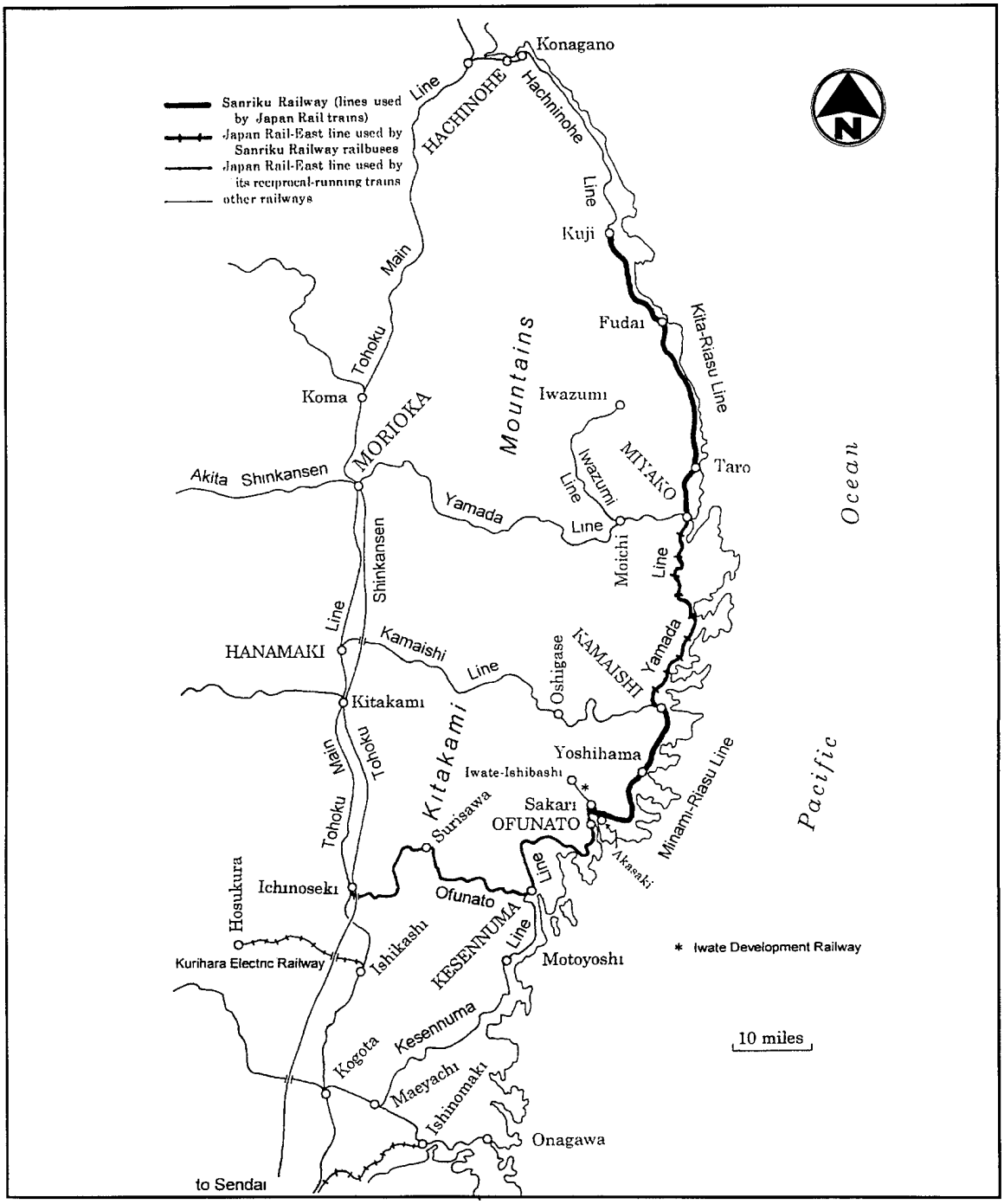
Sanriku Railway in Japan - Figure 8-6a



Sanriku Railway railbus at modern station amidst industrial freight trackage. This environment contrasts with its more typical scenic, sea coast, rural area where it mixes with intercity passenger and freight trains and DMUs JR East.

M. Minami
Seishun Tetsudo

Map of Sanriku Ry. in Kamaishi and Miyako Areas - Figure 8-6b



SANRIKU RAILWAY

G. Thompson 5-98

- Japan Rail-East's Ofunato Line from Ichinoseki for 105.7 km (65.68 miles) to Sakari. This is a single-track branch line connecting the main trunk railroad routes to the Pacific coast. It carries Japan Rail-East intercity passenger trains and superexpress trains, as well as Japan Rail-Freight trains. In season, it also carries school-trippers in the form of DMUs.

- Sanriku Railway's southern division (Minami-Riasu Line) from Sakari for 56.6 km (35.17 miles) to Kamaishi. This is a single-track railroad built to high standards and appearing as a rapid transit line even though this is a rural district. There are numerous tunnels and bridges. The track is often on the rocky ledges overlooking the Pacific Ocean breakers. It carries Sanriku railbuses, Japan Rail-East DMUs, and Japan Rail-East super express trains. The first 21.5 km (13.36 miles) were built as a continuation of the Japanese National Railways (JNR) Ofunato Line. The remainder was completed by Sanriku Railway and contains three significant tunnels.

- Japan Rail-East's Yamada Line from Kamaishi for 55.4 km (34.43 miles) to Miyako. This is a single-track mainline, the trains of which operate through with the Japan Rail-East Miyako branch line. The Kamaishi-Miyako section links the two separate Sanriku Railway divisions and carries Japan Rail-East intercity passenger trains, express trains, Japan Rail-Freight trains, and Sanriku Railway railbuses.

- Sanriku Railway's northern division (Kita-Riasu Line) from Miyako for 71.0 km (44.12 miles) to Kuji. This single-track railroad is similar to the previously-described Sanriku Railway southern division. The first 12.8 km (7.95 miles) from Miyako to Taro were built as the JNR Miyako Line and the last 26.0 km (16.16 miles) were built from Fudai to Kuji as the JNR Kuji Line. Sanriku Railway completed the missing link, containing five significant tunnels.

Services Operated

Sanriku Railway railbuses cover the northernmost Kuji-Fudai section in 33 minutes, making five intermediate stops, compared with the old JNR run with DMUs of 40 minutes with four stops. This increased performance at reduced cost and near recovery of operating expenses has caused Japan Rail companies to consider railbus economies on their own operations. There are 16 daily round-trips over the south division and 17 round-trips over the north division. Ten trips continue over Japan Rail rails between the two divisions, providing a through service. The railbuses are often coupled into two-car trains. A streamlined "Marine-liner" three-car diesel train-set provides an express service; it is built upon railbus technology, and provides theater-type seating at the ends with huge windshields. The company acquired railbuses used to shuttle people to a world exposition at Yokohama harbor; these are built to look like vintage trolleys; Sanriku runs them as its Retoro ("Retro") express between Sakari and Kuji. With the exception of one round trip on the north division, all trains make all stops.

Japan Rail-East provides regular service with DMUs in this territory. The timetable is augmented by trips just between Kamaishi and Miyako, a run of 160.7 km (99.86 miles). Japan Rail DMUs also run over the Sanriku Railway on school trippers.

Brief History with Emphasis on Joint-Use

The inland Tohoku Main Line was completed north from Tokyo to Iwahiri in

1887. Work progressed north to Hachinohe in 1894. Branches began sprouting toward the coast. JNR set out to build a through line, piecemeal, along the difficult northeast coast to link the cities served indirectly by the lateral branch lines. During 1935-1940, the Yamada Line was extended south from Miyako to Kamaishi. In 1934, the Ofunato Line was extended north from Kesennuma to Ofunato and reached Sakari in 1935. Railroad building discontinued during World War II, but the coast was fortified by huge naval artillery guns mounted into the Pacific cliffs. After the postwar priority for restoring the existing railroads diminished, attention returned again to building the north-south alignment.

Two significant gaps remained when the Japan Rail Groups were formed. Japan Rail-East selectively kept lines that *reached* the coast and short sections along the coast to principal seaside cities. Iwate Prefecture joined with served municipalities, the private Iwate Development Railway, Nippon Steel, and other served industries, to form the Sanriku Railway. This new Third-Sector railway picked up the pieces, completed the missing links (including seven significant tunnels on the south stretch and nine on the north leg), and ordered fast railbuses while JNR continued to operate its trains. Sanriku Railway commenced operation on 1 April 1984 – *the first of the post-JNR Third Sector railways to begin service.* Sanriku was also the first to shift to *wanman* (one-man) operation. The result is a modern railway with two sections separated by Japan Rail-East. It was also an early practitioner of joint use employing light-weight railbuses, necessitated by its separate divisions with intervening Japan Rail track.

Notes on Implementation

Centralized Train Control (CTC) controls the single-track line and its passing sidings, and prevents Sanriku railbuses and JNR DMUs from overtaking each other. To create a new image, Sanriku modernized the Japan Rail-East station at Kuji and established its headquarters there, and chose to put extra money into station designs along the way. Sanriku Railway's one-man operation prevails on the Japan Rail-East tracks, too, and Japan Rail has adopted this labor practice on its DMUs on this and selected others of its branch lines. The DMUs were modified for one-man operation.

Other Information

With this railway, the prefecture government connected remote fishing villages to industrial cities; one of the greatest values is that the village children can now enroll in the big-city schools. The progressive marketing effort resulted in a 99.5% farebox recovery rate for train services that did not previously exist in a mostly rural, low-density surrounding.

8.6.6 Tokyo's Tozai Line in the Kanto Region

Joint Use Pertinence

The Teito Rapid Transit Authority, Japan Rail-East, and the Third-Sector Toyo Rapid Railway at Tokyo provide an example of extending the reach of a city rapid transit service quickly and inexpensively relative to building an all-new line by employing the joint-use of track arrangement. The Tozai (pronounced "toe-zai," rhyming with sigh) project also afforded capacity relief to a crowded commuter rail service by diverting passengers from the inner section to rapid transit trains using the tracks of the less-congested outer section.

Rapid transit trains run over suburban commuter-rail tracks to distant suburbs and commuter/suburban trains run through the city on rapid transit tracks. Since the original two-operator arrangement was made, a newly-built interurban railway joined the array of service, operating over both the rapid transit and commuter-rail trackage. Freight and intercity passenger trains are in the mix as well.

The General Area

The Kanto region, embracing the cities of Tokyo, Yokohama, Kawasaki, and Chiba and their extensive urbanized commutershed, contains *many* rapid transit operators with lines radiating from all the mentioned cities except Kawasaki (which lies between Tokyo and Yokohama). Just as New York City is served by MTA New York City Transit, MTA Staten Island Railway, and the Port Authority Trans-Hudson Corporation, Tokyo itself is served by three rapid transit entities. The physical programs (but not the operations) of two have been guided by a succession of commissions and boards which have adopted and revised master plans since the end of World War II. Initially, subway lines were to reach every corner of the city – essentially replacing the streetcar lines. Then, with the outward spread of residential population, the planned lines grew longer – but only on paper. The realization that the passenger transportation needed by metropolitan Tokyo was unaffordable if accomplished by subway construction compelled the concept of reciprocal running. It provided means to expand the rapid transit service without having to make enormous investments in infrastructure.

During modern times, the public transportation system of Tokyo and vicinity evolved as:

- one of the world's largest street railway networks blanketing the dense core city;
- a far-reaching network of electrified commuter-rail lines operated by the national railroad system (Japanese National Railway – JNR) forming a loop around the city (the Yamanote Line), an east-west course through the middle (the combined Chuo Line and Sobu Line) and lines radiating on mainlines toward other cities;
- a web of interurban trolley lines running outward through suburbs and to satellite cities from the Yamanote loop line; and
- a gradually growing rapid transit network within the Loop.

This looked plausible on a map and in planners' minds. The interurbans and many of the JNR lines deposited their passengers at terminals located on the Yamanote Line. They were effectively distributed by loop line trains and the comprehensive street railway network, and – where available – by the few subways. Replacement of the streetcars with buses resulted in a plunge of inner city surface transit usage and overcrowding on the subways. Growth of the suburbs placed tremendous loads on the interurbans. What had once been regarded as a unique convenience – the exchange of passengers at loop line stations among interurbans, commuter trains, and streetcars, became intolerable instances of pedestrian congestion. Tokyo had outgrown its loop and the operating concept that had served well in the past. The notion was born of linking subways within the loop to the interurbans outside the loop. To do so still necessitated a massive subway construction program both to link with selected interurban terminals and to penetrate city and suburban areas not yet served by rail.

The Participants in Joint-Use

The participants in this joint-use situation are:

Teito Rapid Transit Authority (Teito Kosokudo Kotsu Eidan) (known locally as just "Eidan"; *Teito*=Imperial Capital–1067 mm (3'6") gauge, 1,500vDC catenary – a quasi-public entity.

East Japan Passenger Railway Company (Higashi-Nihon Ryokaku Tetsudo Kaisha) (Japan Rail-East) – 1067 mm (3'6") gauge, 1,500vDC catenary – one of six publicly-owned corporations comprising the lines of the former Japanese National Railways.

Toyo Rapid Railway (Toyo Kosoku Tetsudo) – 1067 mm (3'6") gauge, 1,500vDC catenary – a public/private jointventure Third-Sector railway.

The Components of the Joint-Use Facilities

The segments of the Tozai joint-use situation are as follows, west to east: (Please refer to the accompanying map Figure 8-7).

- Japan Rail-East's Chuo Main Line and Shinnoi Line, west from Takao for 245.0 km (152.24 miles) to Matsumoto and Nagano: This is a double-track electrified mainline carrying Japan Rail-East intercity passenger trains, Japan Rail-Freight trains, and Fujikyu interurban trains.

- Japan Rail-East's Chuo Line, east from Takao for 29.0 km (18.02 miles) to Mitaka: This is a double-track electrified commuter/suburban line carrying the Japan Rail-East local and express intercity passenger trains, Japan Rail-Freight's trains, the Fujikyu interurbans, and Japan Rail-East's intensive commuter/suburban services of both the Chuo Line (Japan's and perhaps the world's busiest railway service) *and* Sobu Line (Japan's third busiest line).

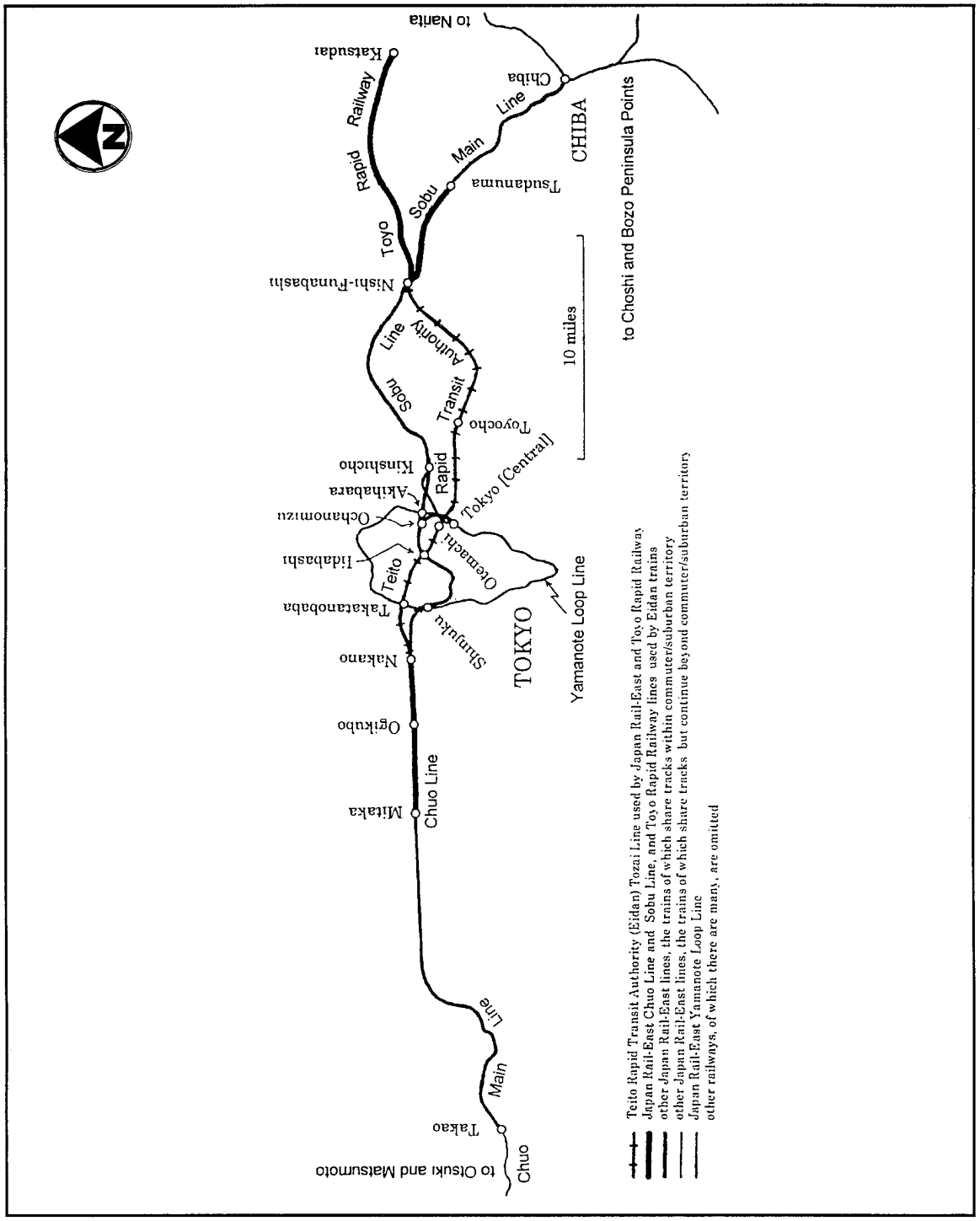
- Japan Rail-East's Chuo Line/Sobu Line, 9.4 km (5.84 miles) from Mitaka to Nakano: This is a four-track electrified commuter/suburban line, arranged as two abreast double-track railroads. One pair of tracks carries the Japan Rail-intercity passenger trains, the Japan Rail-Freight trains, the Fujikyu interurbans, and Japan Rail-East's Chuo Line commuter/suburban trains. The other pair of tracks carries the Sobu Line suburban/commuter trains, and Eidan rapid transit trains. The Chuo Line continues another 14.7 km (9.13 miles) via Shinjuku to Tokyo [Central] – see next item.

- Japan Rail-East's Chuo Line and Sobu Line continue from Nakano 12.1 km (7.52 miles) as side-by-side double track railways east through Shinjuku to Ochanomizu, where they separate.

- Japan Rail's Sobu Hon Line curves north, then east from Tokyo [Central] station mostly in subway for 4.8 km (2.98 miles) to meet the Sobu-sen at Kinshicho. Then, together they form a four-track railway (again, arranged as two juxtaposed double-track lines) east for another 15.8 km (9.82 miles) to Nishi-Funabashi.

- Eidan's Tozai Line, 30.8 km (19.14 miles) – this is the critical central link that makes the system work – from Nakano to Nishi-Funabashi: This double-track rapid transit line is mostly in subway west of and through the center of the city, but is on aerial structure for its eastern 14 km (8.7 miles).

Map of Tozai Line in Kanto Region - Figure 8-7



TOZAI LINE at TOKYO

G. Thompson 5-98

The Tozai Line was purpose-built to Japanese National Railway (JNR) standards of alignment geometry, clearances, electrification, and signaling. Tokyo's earliest subways were of standard-gauge and thirdrail electrification at low voltage. But the newer rapid transit lines use standard 1435 mm (4'8½") gauge, JNR 1067 mm (3'6") gauge, and Tokyo street-railway 1372 mm (4'6") gauge, and 1,500vAC catenary.

- Toyo Rapid Railway's Main Line, 16.2 km (10.07 miles) from Nishi-Funabashi to Katsudai.

- Japan Rail-East's Sobu Line, 6.1 km (3.79 miles) from Nishi-Funabashi east to Tsudanuma: This is a fourtrack facility (arranged as two juxtaposed double-track lines). One pair of tracks carries the Japan Rail-East local and express intercity passenger trains, the N'EX special express trains to Narita Airport, and the Japan Rail-Freight trains. The other pair of tracks carries the Sobu Line suburban/commuter trains, including those which are diverted through Tokyo's subway network on Eidan's Tozai Line, and Eidan rapid transit trains.

Services Operated

Omitting the intercity, interurban, airport, and freight services, this flattened-wye shaped track network, Takao to Chiba with the stem at central Tokyo, enables the operation of the following urban passenger rail services on the shared trackage, at headways ranging from 1½ to 5½ minutes:

- Chuo Line commuter/suburban trains every two to three minutes between Tokyo [Central] and Takao.
- Sobu Line commuter/suburban trains every three to 13 minutes between Chiba and Takao.
- Tozai Line rapid transit trains and Toyo Rapid Railway interurban trains between Mitaka and Nishi-Funabashi every two to ten minutes with the Eidan trains continuing to Tsudanuma and the interurban trains continuing to Katsudai.

Brief History with Emphasis on Joint-Use

The Chuo Line was opened in the commuter/suburban territory west from Shinjuku on the Yamanote Line belt line during 1885-1889 (although the last segment of the belt was not completed until November, 1925). The Chuo Line subsequently reached distant Nagoya as one of the early elements of a national railroad system.

Tokyo transportation entities adopted the reciprocal running policy in 1959 with principal emphasis upon linking the city's growing rapid transit network with the crowded suburban commuter railroads and interurban lines. The impetus for pursuing the reciprocal-running arrangement in metropolitan Tokyo came from the following stated intentions:

- to eliminate the inconvenience of changing trains
- to reduce travel time
- to balance the huge investment in subways with large-volume usage
- to reduce terminal congestion

By the time the reciprocal running policy was adopted, the two operating subway lines were too crowded, even by Japanese standards, to accommodate more trains. The first subway – the standard-gauge, third-rail Ginza Line, running since 1927, and the second subway – the Marunouchi Line, running since 1954, are operated by the private Teito Rapid Transit Authority ("Eidan"). Eidan was created by the government in 1941 to take over the three separate end-to-end companies that built and were jointly running the first subway

line. One-third control was granted to the City; the remaining ownership was among the national railway and private investors. The Hibiya Line, built by Eidan during 1959-1964, was especially designed to launch the reciprocal-running practice. Running through central Tokyo, it tapped Tobu interurban tracks in the north and reached Tokyu interurban tracks in the southeast. For this project, Eidan adopted the interurban's track-gauge of 1067mm (3'6") and current collection of 1,500vDC from overhead catenary.

For its investment in 20.3 km (12.61 miles) of rapid transit infrastructure, Eidan gained an additional 70.9 km (44.06 miles) of rapid transit service over the connecting interurban lines at both ends. Eidan and the city pursued this joint-operation concept vigorously, opening a succession of cross-city subways physically linked to Japanese National Railways commuter/suburban lines and private interurban lines.

The Teito Rapid Transit Authority commenced construction in 1962 of its Tozai Line (*tozai* = east-west). This new rapid transit line entailed considerable heavy construction, including the new and coordinated construction of an underground terminal for Japan Rail-East's Sobu Line and Yokusuka Line, which were to be linked here end-on-end. Eidan opened the basic Tozai Line in stages between December, 1964 and March, 1966.

After additional tracks were laid on the Japan Rail-East right-of-way, Eidan rapid transit trains began from downtown Tokyo to Ogikubo on the Chuo Line commuter-rail tracks in April, 1966, the first formal joint-use of track in this corridor. With track connections in place, on October 1, 1966, Japan Rail-East commuter-rail trains began using the rapid transit route via downtown Tokyo between Nakano and Otemachi – the first of reciprocal running in this corridor (for 14.7 km (9.13 miles). Completion of Eidan construction of the east leg of the Tozai Line resulted in opening of service east of Otemachi to Toyocho on September 14, 1967. The Tozai Line reached Nishi-Funabashi on Japan Rail-East's Sobu Line on March 29, 1969, heralding reciprocal running of Japan Rail-East commuter-rail trains the entire length of the Eidan rapid transit line.

Completing the last link of the March, 1972 master plan for this Tozai corridor, the Third-Sector Toyo Kosoku Tetsudo's line from Nishi-Funabashi to Katsudai was opened for service on April 8, 1996.

Notes on Implementation

By the time Eidan started construction of its Tozai Line in 1962, the complex jointuse/reciprocal running arrangement of Tokyo's other transit authority – Toei – on its Asakusa Line with two interurban companies and two Third-Sector railways, had been in operation for two years. Eidan was able to observe the problems of compatibility and how they had been resolved on Toei. The new Tozai rapid transit line was designed from the outset to Japanese National Railways physical standards in anticipation of joint use. Car design and performance was negotiated among Eidan and JNR and significant compromises were made. For operating compatibility, Eidan introduced with this project the region's first subway cars capable of running more than the previous rapid transit standard of 70 km/h (43.5 mph). Their cars were subsequently geared for up to 100 km/h (62.1 mph) so as to keep pace with the commuter trains, which have stations spaced farther apart than the urban subway. These were also the first rapid transit cars of 20,000mm (65'8") length, setting a new standard for future rapid transit lines. *In this way, joint use tends to drive upward standards and specifications.* The assigned Japan Rail-East fleet and the

Eidan's Tozai fleet are mechanically near identical except for car-appearance architecture. Train consist is identical – 8 motor cars and 2 trailers, comprised of two separable units of seven cars and three cars – to assure exactly the same performance characteristics in both the rapid transit sections of close average station spacing (lower speed, more rapid acceleration), and the commuter-rail sections (faster speed, longer runs between stations). To participate in the reciprocal running agreement, another joint use carrier, the Toyo Rapid Railway, contributed 24 tencar trains to the fleet mix.

A uniform ATC (automatic train control) system was adopted, but used only as an override in the event of human failure.

Other Information

The increase in rapid transit service route miles due to shared track is dramatic. While these are not, in all cases, new facilities or infrastructure, there are increases in services by complex overlapping of institutional and operating turfs.

The Tokyo region is very close to completing its 1985 rapid transit master plan. The latest score January 1, 1998) shows that Eidan- and Toei-owned rapid transit lines total 254.2 km (157.96 miles), but that Eidan and Toei trains run over 691.6 km (429.76 miles) of line – nearly three times as much trackage as Eidan's and Toei's own.

Prior to the completion of the Tozai Line, Eidan's three subway lines had a total of only 5.4 km (3.36 miles) of non-underground operation. The Eidan Line's eastern extremity added 14 km (8.7 miles) of elevated structure. To take advantage of the space beneath, Eidan established the Metro Elevated Rail Company in 1978 (now Metro Development Co., Ltd.) to develop revenue-producing activity. Eidan began as a private company, but became publicly-owned (hence "authority"), but it had a limited charter. So, somewhat like Japanese National Railways, it was unable to diversify as other corporations do in Japan. The government, however, re-established Eidan during the early 1990s. In exchange for agreeing to give priority to expanding the rapid transit network, Eidan was given the privileges of gaining interest-free loans and of diversifying its business enterprise (but with a limitation that it be transit related). Subsequently, Eidan created subsidiaries – a mutual aid foundation, a cleaning service, a construction company, a travel bureau, a land development company, a building maintenance and management service, food service (catering), and a railway car maintenance service. All serve the rapid transit system primarily and private customers secondarily.

8.6.7 Selected Other Japanese Examples

The following is a brief summary of selected Japanese shared track arrangements organized around eight key functions that rationalize joint use.

The 56 instances of reciprocal running found in Japan encompass as participants all six geographic Japan Rail Group corporations, four Japan Rail group interurban lines,[3] private interurban companies, private railway companies, Third-Sector railways, rapid transit companies and authorities, municipal transit systems, light-rail transit lines, and street railways. Represented are three track gauges, four voltages of electrification, and four systems of traction-power distribution, plus diesel propulsion. Twenty-one railway entities participate reciprocal-running arrangements *with more than one* other such entity.

Several of the private electric interurban railways and Japan Rail interurban lines maintain intensive freight services. Several

other private electric railways, such as Choshi Electric Railway's LRT line, maintain electric locomotives to haul freight cars over the company's tracks. These operations adhere to Japan Rail standards of dimensional clearances. But such freight operation is incidental to the passenger operation, which is the main purpose and reason for the railway. Their freight and passenger operations are under single management and therefore do not "compete" for track space.

In Japan, joint use of track can be categorized into several functions:

(1) to extend city rapid transit into the suburbs and/or to extend suburban train service to the city's core;
(2) to merge suburban rail services with city streetcar lines;
(3) to open new territory for development;
(4) to afford mainline access to off-line traffic generators;
(5) to offer access to major airports;
(6) to expand the influence of the high-speed rail network;
(7) combinations of these; and
(8) special advantageous circumstances.

A common factor is the preservation of passenger services which may otherwise have been discontinued or have withered – by putting rail infrastructure to additional uses and by linking it more directly with the transportation web – all in the context of major changes in rail institutions within Japan. Following is not a complete inventory of examples, but is a selection of those which might have applicability in North America.

To Expand City Rapid Transit to the Suburbs and/or to Extend Suburban Train Service to the City's Core

The counterpart of this category is the bringing of suburban rail services, such as commuter-rail, interurban, and light-rail transit to the hearts of cities via rapid transit lines if capacity permits and clearance problems can be overcome. Since rapid transit usually involves a more demanding signal system but more restrictive clearances, overlaying rapid transit on railroads is more facile than the reverse.

- In the Kanto Region of Japan, joint use/reciprocal running has been developed to the state of the art. Of Tokyo's thirteen rapid transit lines, only three do not participate in reciprocal running with Japan Rail-East or the private interurban railways. Yokohama's rapid transit lines do not yet participate, but future extensions will couple the heavy rapid transit lines to private interurban railways and purposebuilt Third-Sector railways. Chiba's rapid transit service is offered through the reciprocal running of the Keisei Electric Railway interurban and the gradually extending Chiba Express Electric Railway, which will soon reach and encompass a private non-electric railway currently served by railbuses.

- In the Kansai Region, half the Osaka, Kyoto, and Kobe heavy rapid transit lines participate in reciprocal running with area private interurban companies. Elsewhere in this report, the Hankyu interurban network's three examples of reciprocal running with city subway lines at Osaka and Kobe are described.

Each of Kyoto's reciprocal running rapid transit lines evolved separately. Kyoto's first subway was built in 1931, extended in 1963, and continues to be operated by the private Hankyu interurban system, providing that city with rapid transit service decades before the municipal subway lines were built.[4] The second subway, the

north-south Karasumaru Line, is a municipal venture, but was built to the dimensional standards of the private Kinki Nippon Railway interurban system with which it participates in reciprocal running. It opened in 1981 and was extended to meet the interurban line at Takeda in 1988. The third subway resulted from the grade-separation of the Keihan Electric Railway interurban line on its entry into Kyoto about 1985. Kyoto's fourth subway is a Third-Sector railway continuation of the Keihan interurban underground north to meet the private Eizan Electric Railway's LRT lines at Demachi-yanagi. The Third-Sector Kamogawa Railway was formed by Kyoto prefecture, Kyoto city, the private Keihan Electric Railway interurban company, and the private Keifuku Electric Railway (operator of LRT lines in Kyoto and Fukui), the project was implemented instead as a way to bring the Keihan interurban trains north to the LRT terminal at Demachi-yanagi. The 2.5-km (1.55-mile) railway is in a subway built in the bed of the former Biwa Canal – quite similar to the Newark City subway in the bed of the Morris Canal.[5]

Kyoto's fifth (second municipal) subway was recently completed with reciprocal running in mind, and will be extended at both ends to form a continuous loop through the suburbs. At the loop's northeast corner, a junction enables Keihan's light-rail vehicles to run in the rapid transit subway to Sanjo (where they heretofore terminated on the surface) and continue through the city to connect with other LRT and interurban lines.

Kyoto's municipal rapid transit line is 11.1 km (6.90 miles) long, but reciprocal running extends the influence of its trains to 27.1 km (16.84 miles). Together with the private Hankyu and Keihan subways and the Third-sector Kamogawa subway, the city's system increases to 36.1 km (22.43 miles). Construction and plans under way and the reciprocal running associated with the new line will increase this extent to 77.2 km (47.97 miles).

- In the Nagoya region, Japan's third largest conurbation, there are many examples of reciprocal running; more are planned for the future. The region contains three other city hubs, each of which has an electric railway network: Gifu, Toyohashi, and Yokkaichi. The two former places have their own examples of reciprocal running. In Nagoya, an ambitious rail-transit development program is being carried out by the Prefecture of Aichi, the City of Nagoya, and the principal private interurban railway – Nagoya Railway – to provide attractive rail transit alternatives.

  Somewhat like Boston, each of Nagoya's rapid transit lines has differing dimensional standards, preventing the lines from pooling or interchanging rolling stock. While other lines are of 1435mm (4'8½") gauge and employ third rail electrification (but suffer different clearances), Line 3-Tsurumai was specifically built during 1977-78 for reciprocal running, so it adheres to the 1067mm (3'6") and 1,500vDC catenary system of the private Nagoya Railway system. It therefore accommodates the private railway's interurban trains. Nagoya Railway built its new 15.2-km (9.45-mile) Toyota Line to the subway terminal from the automobile-manufacturing city of Toyota. Reciprocal running

began in 1979. Subsequently, the Line 3 subway was extended to Kami-Otai on August 11, 1993 to enable reciprocal running with Nagoya Railway's Inuyama Line, and through running via central Nagoya from the other end of the same subway. Interurban and rapid transit trains now run through from Toyota to Inuyama, 58.4 km (36.29 miles) combining three lines end to end.

Line 6-Sakuradori was built to 1067mm (3'6") and 1,500vDC catenary in order to be able to run reciprocally in the future with the prefecture's Aichi-Kanjo line to Toyota, and by way of a waterfront branch to run reciprocally with a City/Japan Rail Third-Sector railway to the port.

Nagoya already has 67.9 km (42.19 miles) of municipal rapid transit. Reciprocal running with Nagoya Railway expands this network to 105.9 km (65.81 miles). The city's ambitious construction and plans will increase the municipal network to 143.8 km (89.36 miles) and encompass another 139.2 km (86.50 miles) of reciprocal running. The future transit system will, therefore, contain 247.8 km (153.98 miles) of rapid transit operation – not counting hundreds more miles of commuter/suburban, interurban, and feeder lines. *The lesson learned is that joint ventures spawned by common business interests may not include joint use of track initially, but because of common stakes, these agreements spawn joint-use arrangements naturally.*

- At Fukuoka on the island of Kyushu, the city's rapid transit lines were built to Japan Rail-Kyushu track gauge, catenary voltage, and clearance envelope so that the track and subway could be shared by city heavy rapid transit trains and Japan Rail electric commuter/suburban trains to the downtown main railroad station. When the subway was extended in the other direction from the station to the airport, the Japan Rail trains, too, began serving Fukuoka Airport using the rapid transit tracks.

- At Nagano, site of the 1998 Winter Olympics, the city rapid transit line and the interurban network are under the single management of the Nagano Railway. Operation of rapid transit cars to the outskirts and interurban trains to downtown is now accomplished.

- At Sendai, the Sendai Transport Bureau in Northern Honshu decided to design its new rapid transit line to JNR physical standards, including track gauge, electrification voltage, and use of catenary and pantographs instead of third rail. Although the first subway line makes no connection with the Japan Rail, the standards prevailed so that the first line would be able to interchange rolling stock with a future second line.

Merge Suburban Rail Services with City Streetcar Lines

Interurban trains reach central cities on local streetcar tracks at Gifu (a detailed description appears elsewhere) and the following other cities where joint use has been the means of accomplishment:

- At Fukui on Honshu's northwest coast, in addition to lines of Japan Rail-East, two interurban companies serve the region. The Fukui Railway's line runs south from the city. For most of its history, the company also operated a streetcar

line from the north end of town along the main thoroughfare. Fukui Railway's interurban trains continued from the south end; the interurban cars loaded from high platforms and ran on the streetcar tracks without making local stops. In 1972, the streetcar service was discontinued, but the interurban cars were outfitted with outward folding steps so they could load at curb-level platforms in city streets and began making all the street stops.

- At Hiroshima, the street railway network and the interurban line from the extreme west side of the city were operated separately, but with a convenient across-the-platform transfer at Koi near the East Hiroshima JNR station. Both were of 1435mm (4'8½") gauge and 600vDC overhead trolley wire and catenary. In 1958 a track connection allowed a few interurban trips to reach through the principal business district to the main Hiroshima station. Subsequently the interurban stations were rebuilt with both high car-floor-level platforms and low platforms, linked by steps, and through service began with articulated light-rail vehicles. High-floor interurban cars continued to run on the open-track section along with the light-rail vehicles. Customers would hover near the steps until they saw the train approaching, then move to the appropriate-level platform. The light-rail vehicle fleet, however, has wholly replaced the interurban cars, and the high platforms are now unnecessary.

- At Kitakyushu, the suburban Chikuho Electric Railway LRT line reaches a main railroad station over Nishi Nippon Railway street railway tracks. These are separate companies, but the newer LRT company chose to buy rolling stock identical to the street railway company's. The LRT line was purpose-built, and is not a former interurban line. This is an example of one carrier, for financial and operational reasons, specifying identical or compatible rolling stock, resulting from a joint-use situation.

- At Kyoto, a transition just being completed involves the light-rail transit line that has connected the satellite city of Otsu to the old city of Kyoto over an intervening mountain, and the new municipal east-west subway line. The city selected the trolley line's gauge, electrification system, and clearance envelope during construction of the rapid transit line – 1435mm (4'8½"), 600vDC catenary, and 2350mm (7'9.7") width at the door sills. (This breadth includes fixed extenders which are wider than the car bodies.) The city's rapid transit trains will turn from the main route and not run on the LRT line tracks, which continue to have street trackage in places. But the Keihan Electric Railway's light-rail vehicles will run through the subway to the far west side of Kyoto, rather than enter Kyoto on tracks in paved streets. A third-sector railway company was formed for the purpose of creating the LRT-rapid transit connection.

Concerns in early 20th Century U.S. over intrusion of interurban railways into railroad markets caused intentional variance from common standards to thwart interchange, much less through running.

The Japanese experience in these five regions has been to selectively integrate rail transit and railroads into coordinated networks within

metropolitan areas. The legacy left by these contrasting approaches has helped establish the destiny of rail transit in their respective areas.

Open Territory for Development

Like the early 20th Century U.S. streetcar suburbs, many of the newer Japanese rapid transit lines, interurban extensions, and Third-Sector railways have been built to open land for development. This includes whole new towns built simultaneously with the railways that serve them in the outskirts of Tokyo, Yokohama, Chiba, Osaka, Kobe, Kitakyushu, and elsewhere. This trend is fed by the growing demand for residential housing. *Joint use of track, particularly the linking of urban rapid transit and extra-urban/interurban lines, has been used to manage land development and achieve economic objectives quickly by national and prefecture governments:*

- The Abukuma Railway put to use an unfinished railway project of the former Japanese National Railways (JNR). Compatible with the railways with which it connects, Abukuma Railway is a 1067mm (3'6") gauge line electrified with 20,000vAC (50Hz) catenary (which is used by Japan Rail-East in this district). However, the Fukushima Transport light-rail transit (LRT) line which Abukuma interurbans use to enter Fukushima was electrified with 1,500vDC catenary. To resolve dual voltage conditions in the Fukushima terminal area, the catenary over one of the two LRT tracks was isolated and energized with 20,000vAC.

  Through electric service commenced on July 1, 1988. The new Marumori Line is 54.9km (34.11 miles) long with 23 stations. The interurbans enter Fukushima in a novel joint-use manner. About 5 km (3.1 miles) north of the city, they switch onto Japan Rail-East's electrified northeast mainline for about 4 km (2.5 miles) until a Fukushima Transport Bureau LRT line crosses on an overpass and swings alongside the mainline. Then Abukuma interurbans switch from Japan Rail tracks to one of the LRT tracks for the last stretch into Fukushima, where they share the LRT terminal. The light-weight interurban cars traversing this segment blend in with heavy mainline freight, intercity passenger, commuter/suburban, and freight equipment, and then with lighter-weight light-rail vehicles.

  The addition of 70.2 km (43.63 miles) of reciprocal running with Japan Rail-East extends Abukuma Railway service to a total length of 125.1 km (77.74 miles).

- The 5-mile Hokuso Development Railway grew into 50½ miles of electric railway operation. In order to open a new town in Chiba prefecture for development and in anticipation of a planned extension of the Tokyo subway network, the 7.9-km (4.91-mile) Third-Sector Hokuso Kodan line was built in 1979 to rapid transit standards. It was then 19.6 km (12.18 miles) from the nearest Tokyo subway terminal! Fully grade-separated and occupying the broad right-of-way originally reserved for a Tokyo-Narita Airport Shinkansen line, the new railway operated temporarily as a branch of the Shin-Keisei Electric Railway interurban line.

  Service began on March 31, 1991 on a new Hokuso extension west toward Tokyo, and Takasago. Takasago is a junction where Keisei Electric Railway interurbans and Tokyo Municipal Transport Bureau ("Toei")

Asakusa Line subway trains share track. This enabled Hokuso trains to run into the heart of (and through) Tokyo.

Train operation has become quite complex. If one stands in the Shimbashi subway station, they will see trains of five railways: one city-owned rapid transit system, two private interurbans, and two Third-Sector railways. Hokuso's railcars run over 81.2 km (50.46 miles) of line.

- To open the planned new town of Semboku in the suburban area south of Osaka, the Osaka Prefecture City Development Company Third-Sector railway built an all-new line to rapid transit standards through a new town, but at 1067mm (3'6") gauge, from a junction with one of the private Nankai Railway's interurban lines. Osaka Prefecture and Nankai Railways run trains over each others' tracks, offering a one-seat ride to Osaka mixing interurban and rapid transit rolling stock. This is the reverse of the usual scheme of interurbans entering central cities on city rapid transit lines. Here the rapid transit trains enter the city on an interurban line. The Third-Sector railway's cars, with four doublestream doors on each side, appear, as they are, to be city-subway cars.

- Tosa Kuroshio Railway: JNR opened a branch line along the south coast of the island of Shikoku on October 1, 1970 from a junction on what is now Japan Rail-Shikoku for 35.1 km (21.81 miles) to Nakamura on the remote southwesternmost point of the island of Shikoku. The line includes a spiral tunnel and a route atop the cliffs overlooking the Pacific ocean. Service was provided by DMUs, providing six local and five express round trips daily by 1980. At the time of the JNR breakup, Japan Rail-Shikoku decided to relinquish this branch.

  The peninsula communities joined with other investors to acquire the line and purchase a fleet of unique railbuses. The windows on the side of the railbuses that always faces the sea are panorama windows for views of the breakers. The company also acquired the unfinished infrastructure across the peninsula to Sukumo Bay. The structures, appearing like a Bay Area Rapid Transit District line with extensive modern aerial structure and tunnels, stood idle for more than twenty years. On October 1, 1997, the 23.6-km (14.67-mile) extension was opened. There are now 16 local and eight express round trips daily. The local railbus trips continue from the junction for 7.9 km (4.91 miles) on Japan Rail-Shikoku tracks.

Provide Mainline Access to Existing Offline Traffic Generators

A counterpart of this practice is affording rural railway passengers direct access to major cities by through running over the Japan Rail mainlines. The main thrust, however, is for Japan Rail limited express trains to turn onto the lesser railway and for limited express trains of interurban railways to turn onto the mainlines to reach main city stations. In this manner, the passengers of trains operated by four outlying interurban railways have direct access to central Tokyo and Tokyo residents have direct access to the mountains, hot springs, and the seashore. Similar arrangements exist in the Osaka, Kyoto, and Nagano areas.

- The Oigawa Railway is a special circumstance. It is an electric interurban line through a rural valley from the Pacific Coast on the Japan Rail Tokaido mainline into the interior. It hauled freight, primarily gravel from the valley's riverbed, and interchanged with Japan Rail-Tokai, hence, it was "narrow" 1067mm (3'6") gauge.

  The interurban company came into ownership by an individual who gathered a collection of cast-off locomotives, coaches, and interurbans which he ran in regularly-scheduled service, including a daily steam round trip. Because the railroad museum had become a popular sightseeing destination and the tourist train became a major attraction, Japan Rail-Tokai commenced direct service over the Oigawa tracks with commuter/suburban EMUs from Shizuoka 32.7 km (20.3 mile) north and Hamamatsu 44.2 km (27.5 mile) south.

Offer Airport Access

There are six instances of reciprocal running being the means by which fast, convenient train service has been provided to major airports. One has already been mentioned – at Fukuoka, where city rapid transit trains and commuter/suburban trains share tracks. At Tokyo, city subway trains reach Haneda Airport by traveling over the interurban mainline of the Keihin Express Electric Railway and one of that railway's branch lines. Among the trains following this route are those of the Tokyo Transport Bureau, the Keisei Electric Railway interurban company, and the Hokuso Third-Sector railway.

- Tokyo Narita Airport: This joint-use/reciprocal running example is fairly complex. The private Keisei Electric Railway interurban company, Japan Rail-East, and others formed a Third Sector railway to make use of extant trackage (including heretofore freight-only track and interurban railway trackage, and available incomplete railroad infrastructure to create a route that could be used jointly. The partners planned for Japan Rail-East dedicated 1067mm-(3'6"-) gauge airport trains and Keisei Electric Railway 1435mm- (4'8½"-) gauge dedicated airport and local-service interurban trains. All employ 1,500Vdc catenary. This merging of otherwise incompatible train services was accomplished by making use of the vacant double-track grading for a Tokyo-to-Airport *Shinkansen* line, removed from the high-speed rail master plan. Grading and culverts, a tunnel, and two underground stations beneath the airlines terminals had been completed.

  At its own investment, Keisei had built a line to the Airport, but for security reasons, its trains terminated at an underground station short of the airlines terminal. Rail passengers had to transfer to a Keisei shuttle bus through the tight-security no-man's land. JNR had a branch line through the city of Narita, to and from which it operated a connecting bus to the airport. One track on the vacant Shinkansen trackbeds was laid to 1067mm- (3'6"-) gauge and the other to 1435mm- (4'8½"-) gauge. Half of the four-track stations and one of the two island platforms was assigned to each railway system. In the airport, the tracks connect to the older Keisei Main Line and outside the airport, to Japan Rail-East's Narita Line.

  The dedicated Japan Rail "N'EX" airport trains run from Narita Airport to Tokyo partly on the Tozai corridor.

At Shingawa, the trains break into two parts – one continuing south to and beyond Yokohama, the other turning onto freight tracks clockwise around the Yamanote loop line's west leg. The dedicated Keisei "Skyliner" trains run non-stop on the interurban tracks to Ueno station in Tokyo. The Keisei local trains switch onto Tokyo Municipal Transport Bureau's Asakusa rapid transit line through Tokyo to alternate far-side terminals, a run of 75.0 km (46.61 miles). They continue from the subway over Keihin Electric Railway interurban tracks to Haneda Airport (a run of 80.4 km or 50 miles).

Because the services are pooled, these runs are duplicated by Toei rapid transit trains. Along the way, all of the dedicated "Skyliner," the local interurbans, and the rapid transit trains share track in joint-use/reciprocal running situations with three other Third-Sector railways (Hokuso Development Railway, the Residential Housing City Development Authority railway, and Chiba Prefecture-Operated Railway).

- New Kansai Airport: Osaka placed its third airport on a man-made island just offshore in Osaka Bay. Japan Rail-West and the private Nankai Electric Railway interurban company joined to bring convenient rail service to the new airport through a jointly owned new Third-Sector railway.

  Each railway has a mainline parallel to the coast from Osaka to Wakayama. It was judged that a single airport branch could be used by both. Both are 1067mm- (3'6"-) gauge and electrified with 1,500vDC catenary. The joint project entails a 4.3-km (2.67-mile) branch from Japan Rail's inland Hanwa Line, a 1.9-km (1.18-mile) spur from Nankai's Main Line, and a combined 6.9-km (4.29-mile) continuation from the junction to the airlines terminal – total line construction is 13.1 km (8.14 miles), mostly on aerial structure. The last leg to the airport is on a causeway bridge for 3.75 km (2.33 miles) over the water to the offshore airport. Each railway operates its own dedicated airport trains as well as frequent local trains, accumulating to frequent service by a mix of intercity, commuter/suburban, and interurban trains.

Provide Feeder Branch Lines One-Seat-Ride Access to Urban Hubs

There are many instances in which otherwise isolated private or Third-Sector railways run on Japan Rail tracks from their junctions with mainlines to the downtown stations of the closest principal city. In several of these instances, mostly operated with diesel railbuses, Japan Rail trains also turn onto the smaller railways – usually in the form of school trippers – served by DMUs. The institutional separation of the branch lines into separate managements was not a deterrent to implementation of joint use of track and reciprocal running.

Expand High-Speed Rail Influence

The Japan Rail Group operates two Shinkansen high-speed rail lines with joint-use arrangements. The employment of joint-use/reciprocal running arrangements enabled these lines to be implemented less expensively and more quickly; but they also necessitated accommodation of other kinds of rail service and reduced high-speed performance over portions of their route. It was possible to extend the extremely positive influence of high-speed rail to smaller cities to which it would otherwise have been regarded as unaffordable to add to the Shinkansen network. There will be

other such joint uses as the Shinkansen network continues to expand. This is similar to France's TGV trains running on conventional railroad infrastructure beyond the ends of the dedicated TGV lines to reach more remote cities, with the significant difference that France did not have to contend with a change of gauge.

- Yamagata Shinkansen: The new line from Fukushima to Yamagata was created by converting 87.1 km of the existing conventional mainline from 1067mm- (3'6"-) gauge track and 20,000vAC traction power to 1435mm (4'8½") track and 25,000vAC catenary. Because the railway already existed and had local stations for smaller communities along the way which the high-speed trains would not serve, Japan Rail-East installed a fleet of Shinkansen-compatible EMUs to run between high-speed train trips. Part of the Yamagata Shinkansen has three-rail track, with the additional rail to carry the 1067mm- (3'6"-) gauge trains. While this is an example of "railroad to railroad" joint running, the infrastructure and rolling stock are sufficiently different to warrant its consideration in shared track consist.

- Akita Shinkansen: The other high-speed instance is on the newer extension of Shinkansen service across the northern end of Honshu island. For much of the way, the older electrified 75.6-km (47-mile) cross-island line's track was converted from 1067mm (3'6") to 1435mm (4'8½") gauge, but electrification was kept at 20,000vAC instead of the Shinkansen standard 25,000vAC catenary (both at 50Hz). The line is single track with ten passing sidings at intermediate stations. For the rest of the way, for 51.7 km (32.13 mile) a west-coast mainline was used – a vital link in the 1067mm- (3'6"-) gauge network. This double-track main-line was rearranged as two single-track lines – one of 1067mm (3'6") gauge for continuation of the west-coast mainline traffic; the other of 1435mm (4'6½") gauge for the Shinkansen trains; both with the west-coast mainline's 20,000vAC catenary. Local commuter/suburban service is run on the former trans-island mainline with 1435mm- (4'8½") gauge EMUs (but outfitted for the 20,000vAC instead of the Yamagata-line's 25,000vAC). For 12.4 km (7.71 miles), the track is three-railed as a passing siding for the Shinkansen trains. For the slower and more-frequent west-coast mainline trains, there are passing sidings at five intermediate stations, at which places the high-speed track is detoured (not gauntleted) around the station on a widened right-of-way.

Combinations of the Above

There are a number of instances where one or more railways cooperating in joint-use/ reciprocal running arrangements in one location have similar arrangements with other railways in other places. Some of these have been described already. Following are a few examples that illustrate the versatility of the joint-use/reciprocal running practice.

- The Keisei Electric Railway interurban company participates in reciprocal running with the rapid transit lines of both Tokyo (where it is "tenant") and Chiba (where it is "host"), and in a dual-gauge circumstance with Japan Rail-East at Narita International Airport. The Chiba rapid transit line[7], which uses Keisei interurban track to reach central Chiba, is being extended

southward and will soon join the private diesel-operated Kominato Railway. Keisei further participates as conduit for Hokuso Development Railway, into Narita Airport with Japan Rail-East.

- The Odakyu Electric Railway, serving a large area south of Tokyo, runs through central Tokyo on Teito Rapid Transit Authority subway tracks in reciprocal running with both that Authority and Japan Rail-East in northern suburbs. At the far south end of its principal line, Odakyu runs reciprocally with the Hakone "Mountain-Climbing" Railway beyond its own terminal to a station at the toe of the mountains. The Hakone Mountain-Climbing Railway is a 1435mm- (4'8½"-) gauge interurban line on a constant 8% adhesion gradient up a volcanic spur of Mount Fuji with spirals, tunnels, and switchbacks. Because Odakyu is a 1067mm- (3'6"-) gauge system, it was necessary to lay a third rail for its trains to share Hakone's track. The novel dual gauge arrangement creates an offset which, when combined with narrow standard gauge cars, avoids gauntlets at high platforms (see Figure 8-8 and Appendix Figure E2).

Special Circumstances

There are a number of special-circumstance applications of joint use that do not necessarily provide lessons for us because they are tailored to local situations. They do demonstrate that local decision makers conceive unique solutions, within modest Japanese regulatory constraints. The Nagoya Railway's "North Alps Express" contradicts some imagined joint use of track taboos.

- North (Japanese) Alps Express: Perhaps Japan's most unusual example of reciprocal running is Nagoya Railway on the south coast of Honshu island cooperating with Japan Rail-Tokai, Japan Rail-West, and the Toyama District Railway interurban network on the north coast. The Japan Rail section of the 278.4-kilometer (173.00-mile) trip is not electrified, so Nagoya Railway uses DMUs typically running in six-car trains. Starting at a junction in the harbor area south of Nagoya, the trains run north under catenary *and in subway* through Nagoya on Nagoya Railway's mainline, then on surface interurban branch line trackage to Unuma where they switch to Japan Rail rails for a long run up and over the island's divide and down to the north coast city of Toyama where they switch to local street railway/interurban tracks to reach Tateyama, a resort city. The individual links in this rail journey using one set of equipment are as follows (Table 8-3).

8.7 OTHER PACIFIC RIM EXAMPLES

The search for examples of joint use of track/reciprocal running in the Pacific Rim outside of Japan was thorough, but there were few examples found. Most proved to be of marginal interest after more detailed examination. Two examples – Hong Kong and Seoul – were found to be useful in underscoring the value of joint use of track.

Hong Kong's Kowloon-Canton Railway is an especially inclusive example of joint use of track. Seoul's joint use among the metropolitan transit system and the national railway is of extraordinary geographic scope and especially rapid implementation.

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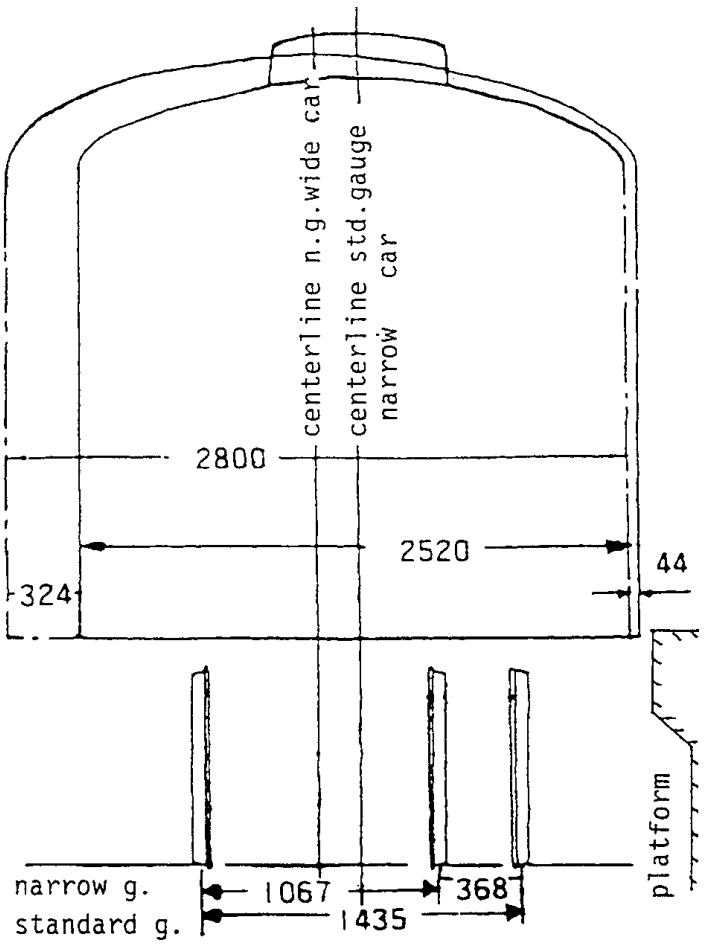
Hakone Ry. Dual Gauge Offset to Avoid Gauntlet Rails at High Platforms-Figure 8-8



Hakone-Tozan Ry. Dual Gauge. Smaller standard gauge cars (8'8.5") fit in envelope of wider narrow gauge cars (3'6") thus avoiding gauntlets at platforms. Also note photo (see Appendix J).

Table 8-3
Nagoya Railway Joint Use Links

Railway	Line	Shared with Modes	kilometers	miles	notes
Nagoya Railway	Nagoya Main Line	interurban	5.8	3.60	under catenary*
Nagoya Railway	Nagoya Main Line	interurban	2.7	1.68	under catenary*
Nagoya Railway	Inuyama Line	interurban and heavy rapid transit	27.4	17.03	under catenary*
Japan Rail-Tokai	Takayama Line	intercity passenger and freight	171.9	106.82	
Japan Rail-West	Takayama Line	intercity passenger and freight	36.6	22.74	some under catenary#
Toyama District Railway	Toyama Main Line	interurban	9.8	6.09	under catenary*
Toyama District Railway	Tateyama Line	interurban	24.2	15.04	under catenary*
Totals			278.4	173.00	

* = 1,500vDC; # = 20,000vAC

8.7.1 Hong Kong and New Territories, People's Republic of China

Joint Use Pertinence

Rapid transit trains are operated on the same tracks used by freight and intercity passenger trains. Although the rapid transit service is operated by the same Kowloon-Canton Railway (KCR) management that owns the railroad, intercity trains of the national Chinese Railways and provincial Guangdong Railway use the same tracks as 'tenants'. The KCR is an extreme example of wringing the greatest possible capacity from an investment in railroad rights-of-way and infrastructure. Hong Kong provides parallels in other intensive multiple uses of scarce land and resources.

The General Area

Hong Kong and New Territories, containing the major cities of Kowloon and Victoria, became a province of the People's Republic of China in 1997. Aggressive rail development was under way at the time, and the Chinese government has continued the progress, placing additional train volume on existing rail capacity.

From the start of British governance, a railway has run from the harbor to the border and to the next large urban center, Canton, in mainland China. This is the British financed Kowloon-Canton Railway. Although it was important for trade, the portion of the railroad in China was closed but not dismantled by the Chinese government. Hong Kong flourished, but Canton languished. Canton, in China, is now known by its Chinese name, Guangzhou; its population has grown to 2,914,281 (1990).

Participants in Joint-Use

Kowloon-Canton Railway Corporation (KCR) – 1435mm (4'8½"), 25,000vAC (50Hz) catenary and diesel (freight) – a private railway company.

Guangdong Railway (GR) – 1435mm (4'8½"), 25,000vAC (50Hz) catenary and diesel – a provincially-owned railway company.

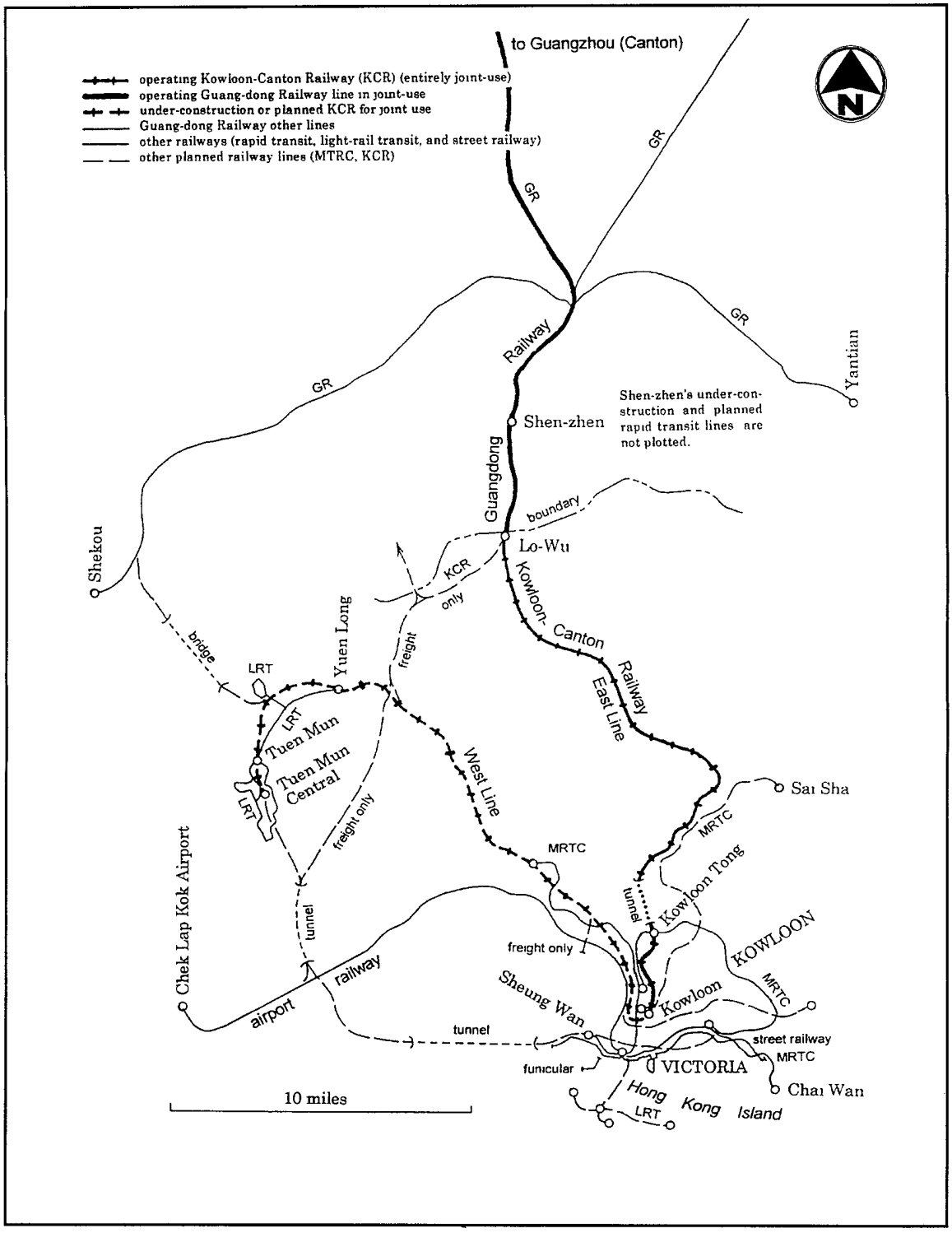
Chinese Railways (CR) – 1435mm (4'8½"), 25,000vAC (50Hz) catenary and diesel – a national railway system.

The Physical Components of the Joint-Use Facilities

- KCR's East Rail mainline from Kowloon for 33.9 km (21.07 miles) to Lo Wu on the Chinese border (Guangdong Province) – a double-track electrified intercity railroad. The topography is rugged, so the line contains long tunnels. But about one-fifth of the way is level along the coast of Tolo Harbour (a large arm of the Pacific Ocean). There are 13 stations. The line carries KCR rapid transit trains, KCR freight trains, and Guangdong Railway and Chinese Railways intercity freight and intercity passenger trains.

- Guangdong Railway's mainline from Lo Wu at the border to Shenzhen and Guangzhou, 147 km (91.3 miles), carrying Guangdong Railway's intercity and local passenger trains, Guangdong and KCR joint passenger trains, Guangdong freight trains, and Chinese Railway intercity passenger trains, express trains, and freight trains.

Map of Hong Kong & New Territories - Figure 8-9



HONG KONG AND NEW TERRITORIES

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- Chinese Railways' Beijing-Kowloon mainline for about 2,189 km (1,360.2 miles) from Guangzhou to Beijing, carrying Chinese Railways' intercity passenger trains, fast express trains, and freight trains.

Joint-Use Services Operated

Rapid transit service between Kowloon and Lo Wu is provided by 12-car KCR trains of EMUs running every 3 to 15 minutes. Intercity passenger and freight trains are fitted between them. As passenger traffic increased, freight became restricted to nighttime for capacity, not institutional or regulatory reasons.

Chinese Railways operates Guangdong freight and intercity passenger services from Kowloon to Guangzhou and Foshan (west of Guangzhou), and its own intercity and freight trains from Kowloon to points north of Guangzhou all the way to Beijing.

KCR and Guangdong Railway jointly operate high-speed trains between Kowloon and Guangzhou, and Chinese Railways operates high-speed passenger trains from Kowloon north to Beijing on both its older mainline and its new Jing-Jiu heavy-duty and high-speed railroad.

Brief History with Emphasis on Joint-Use

The British Hong Kong government built the Hong Kong section of the Kowloon-Canton Railway because the private British company to which China had granted a concession hesitated to begin work. The Hong Kong section opened in October 1910 as a single-track steam railroad. The British and Chinese [Railway] Corporation retained the rights from the border to Canton. Hence, it became, until 1983 the only government-owned and operated transportation facility in the New Territories.

Dieselization occurred during 1955-1961, but the new locomotives still hauled the original 1910 passenger coaches. Freight continued with some growth, predominantly in food from China. The railroad attracted planners, and its alignment figured into numerous plans. The emphasis was placed instead on introduction and expansion of the private Mass Transit Railway Corporation's (MTR's) rapid transit network. But by the 1970s, the government had designated several of the villages along the KCR as sites for massive new town development. A gradually-growing commuter-rail service proved to be inadequate. KCR embarked on a program of double-tracking, completed in 1977. A new, capacious terminal was opened in November, 1975 in Kowloon at Hing Hom, backed away from the former terminal at the water's edge. The single-track Beacon Hill Tunnel was replaced by a two-track bore in 1981. Stations were added, and catenary electrification progressed northward from Kowloon. Through passenger-train service, crossing the border into China with diesel locomotion, was restored beginning April 1979. First electric service began on 6 May 1982, and electric trains reached the border at Lo Wu on 16 July 1983.

The last diesel train ran seven days later, retiring the original passenger rolling stock. But diesel locomotives continue to pull the freight trains and the through passenger trains to Chinese destinations. Through trains are provided by Chinese Railways.

In 1975, the Mass Transit Railway Corporation began construction of an independent three-line 1432mm- (4'8-1/3") gauge fully-grade-separated heavy rapid transit network that is almost entirely underground. Although power was to be drawn from third rail, a last-minute judgment following examination of rapid transit lines elsewhere in the world resulted in 1,500vDC catenary. The first train ran on October 1, 1979. The network

opened in successive incremental sections, achieving its present 43.2-km (26.84-mile) length in August, 1989.

The present KCR Corporation was formed in 1982 and took over the railway and its operation from the government on February 1, 1983. The line carries almost 500,000 daily riders, but passenger loads have been as high as 668,466 in one day, putting it in league with Japanese interurban railways. The company also operates the isolated Tuen Mun light-rail transit network, which it opened in 1988, and many bus routes. KCR cargo amounted to 60 million metric-ton-kilometers (41 million metric short-ton-miles) annually in 1992, averaging 164,383 and 112,329 daily, respectively.

Both the political pressure and the potential growth of cargo moving toward Kowloon from a rapidly expanding rail network in nearby China persuaded Hong Kong to adopt and give priority to KCR's proposal for a "West Corridor". A construction start is expected in September 1998. KCR called for tenders for manufacture of 250 EMUs for both the old East and new West lines.

In November 1995, track laying was completed on the last link of the new Jing-Jiu trunk line (Beijing to Kowloon). China planned to start a new express passenger-train service from Shanghai to Kowloon before Hong Kong reverted to Chinese rule on 1 July 1997.

Guangzhou Railway leased a seven-car tilting *X2000*train from Adtranz for testing. The train was converted to 25,000Vac at 50 Hz for the purpose. Scheduled to arrive in March, 1998, the train will provide regular service at a premium fare between Kowloon and Guangzhou at speeds up to 200 km/h (124.3 mph), beginning by the end of 1998.

Notes on Implementation

KCR adopted MTR wide-bodied rolling stock dimensions both to provide wide clearances at high (car-floor level) platforms and to cope with anticipated high volumes of passengers. Each MTR car can carry 375 passengers, with all but 48 standing! They are 3200mm (10'6") wide, 22212.5mm (72'11.2") long and have five doors per car side. (KCR cars have three doors per side.) The KCR fleet of 354 cars is comprised of six-car trains that couple into 12-car trains in peak periods.

KCR uses the same zoned fare structure as MTR and uses identical ticket-vending machines, in an inter-system uniform fare structure. One of the world's largest multi-modal smart-card ticketing systems went into use in Hong Kong in September 1997. It encompasses riding on KCR East Rail, MTR, KCR Light Rail, City's bus, KB bus, and Hongkong & Yaumati Ferry.

Other Information

As this continuing history unfolds, a significant example of joint use of track and reciprocal running will have a pair of tracks carrying frequent KCR heavy rapid transit trains, jointly-operated KCR and Guangdong Railway local electric trains, Guangdong Railway intercity trains, Guangdong Railway high-speed trains, Chinese Railways intercity trains, Chinese Railways Jing-Jiu fast trains (and subsequently high-speed trains), and freight trains of all three railroads, on the route of the original Kowloon-Canton railway. This will be a dispatcher's nightmare until the new West Line is completed, *but the new line, too, will carry essentially the same diverse assortment of trains, but with a heavier volume of freight.*

8.7.2 Seoul and Inch'ön, South Korea

Joint-Use Pertinence

Between 1968, when streetcar lines stopped and 1974, when rapid transit was introduced, the large and fast-growing capital of South Korea depended upon buses for its mass transportation. When the City of Seoul opened its first rapid transit line, it was a mere 9.5 km (5.90 miles) in length, consisting mostly of subway alignment. But from day one, it offered service over 101.7 km (63.20 miles) of modern electric railroad lines. This was accomplished through the joint use of track. Since then, the network has grown and includes two more trunk lines over which the service territory is expanded through similar joint-use arrangements. At least two more such facilities are in construction, and the implementation of a rapid transit network for nearby Inch'ön will lead to more such arrangements. From the initial 8 km (5.0 miles) of underground rapid transit as anchor for the 101.7-km (63.20-mile) city-and suburban network in 1974, the joint-use network grew by 1998 to 435.4 km (270.55 miles), and is still growing.

The three operating examples of joint use of track combine urban rapid transit with suburban commuter rail in the forms of extant lines and purpose-built lines. The first of these includes freight trains and intercity passenger trains, in addition to the pooled rapid transit/commuter-rail trains. Korean National Railroad (KNR) commuter/suburban trains run through the central city subway, and Seoul Metropolitan Subway Corporation trains run to distant suburbs and satellite cities on KNR tracks.

The General Area

Seoul, capital of South Korea, is a modern, rapidly growing urban complex having a 1990 city population of 10,612,577. Seoul simply means "capital"; the real city name is Kyöngsong. The nearby port city of Inch'ön has grown to a metropolitan center in its own right, with 1,817,919 inhabitants.

Seoul made world news when it hurriedly completed three heavy rapid transit lines in time for the 1988 Olympic Games — it being the first city in the world to ever open as much as 105 km (65¼ miles) of new rapid transit at once.

Participants in Joint-Use

The participants in joint-use/reciprocal running are:

Seoul Metropolitan Subway Corporation (SMSC) – 1435mm (4'8½"), 1,500vDC catenary – the regional rapid transit authority.

Korean National Railroad (KNR) – 1435mm (4'8½"); 25,000vAC 60Hz catenary – the national railway system.

The Physical Components of the Joint-Use Facilities

Line 1 (south to north):

- KNR Kyöng-bu (Kyöngsong-Pusan) Line, 30.9 km (19.20 miles) from Suwön north to Kuro, a double-track electrified railroad carrying KNR freight, intercity passenger, and commuter/suburban trains, and SMSC rapid transit trains.

- KNR Kyöng-in (Kyöngsong-Inch'ön) Line, 29.7 km (18.46 miles) from Inch'ön on the coast southwest of Seoul to Kuro on the Kyöng-bu Main Line, carrying KNR freight, commuter/suburban, and rapid transit trains.

Map of Seoul and Inch'ön, South Korea - Figure 8-10

SEOUL and INCH'ÖN

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- KNR Kyöng-bu (Kyöngsong-Pusan) Line, 10.7 km (6.65 miles) from Kuro north to Seoul [Main] Station, a four-track electrified railroad carrying KNR freight, intercity passenger, and commuter/suburban trains, and SMSC rapid transit trains.

- SMSC Line 1, 9.5 km (5.90 miles) from Seoul [Main] Station east to Ch'öngnyangni, a double-track electrified rapid transit line mostly in subway, carrying SMSC rapid transit trains and KNR commuter/suburban trains.

- KNR Kyöng-wön (Kyöngsong-Wönsan) Line, 20.9 km (13 miles) from Ch'öngnyangni north to Puk-Üijöngbu, a double-track electrified railroad carrying KNR freight, intercity passenger, and commuter/suburban trains, and SMSC rapid transit trains.

Line 3 (southeast to northwest):

- KNR Pundang Line, 28 km (17.4 miles) from Pundang north to Susö, a double-track electrified railroad carrying KNR commuter/suburban trains and SMSC rapid transit trains.

- SMSC Line 3,39 km (24.2 miles) from Susö north, west, and north to Chich'uk, a double-track electrified rapid transit line mostly underground, carrying SMSC rapid transit trains and KNR commuter/suburban trains.

- KNR Ilsan Line, 11 km (6.8 miles) from Chich'uk west to Taehwa, a double-track electric railroad carrying KNR commuter/suburban trains, SMSC rapid transit trains throughout, and KNR freight and intercity passenger trains part of the way.

Line 4 (southwest to northeast):

- KNR Ansan Line, 19.4 km (12.1 miles) from Ansan on KNR's narrow-gauge coastal Su-in Line northeast to Kumjöng on KNR's Kyöng-bu Main Line, a double-track electrified railroad carrying KNR commuter/ suburban trains. This line was purpose-built as a suburban railroad, intended to temporarily run in joint-use through SMSC Subway Line #1 (as a branch of Line 1) until the following link was finished. It would then run in joint use with SMSC Line 4.

- KNR Kwach'on Line, 11.5 km (7.1 miles) from Kumjöng northeast to Namt'aeryong near Sadang, meeting end-on-end with SMSC Line 4, a purpose-built electrified suburban railroad carrying KNR commuter/suburban trains and SMSC rapid transit trains.

- SMSC Line 4, 35 km (21.8 miles) from Namt'aeryong north and northeast to Tangkogae, a double-track electrified rapid transit line mostly underground, carrying SMSC rapid transit trains and KNR commuter/suburban trains.

Joint-Use Services Operated

Line 1 uses a pool of SMSC and KNR rolling stock to provide through services. This instance of reciprocal running increases the rapid transit distance from SMSC's 9.5 km (5.90 miles) to 101.7 km (63.20 miles) – eleven times over! The KNR tracks south of the city are shared with KNR intercity passenger trains, some going all the way to Pusan.

Line 3 uses a similar pool of SMSC and KNR rolling stock for through service. KNR provides overlapping service from Ori to Susö, then on its own tracks north

through the east side of the city to Söllüng on SMSC's Line 2.

Line 1 service operates every 1½ to six minutes. On lines 3 and 4, trains run every three to ten minutes.

Brief History with Emphasis on Joint-Use

Subway Line 1, opened in 1974 from the main railroad station through the center of the city to Ch'öngnyangi, 9.5 km (5.90 miles), is underground for 8.0 km (4.97 miles). From the start it accommodated Korean National Railroad (KNR) commuter trains. Continued rapid transit development was not only spurred by success of the first line, but by the expectation that the first line was going to quickly run short of capacity.

KNR had electrified its 10.4-km (6.46-mile) freight bypass around the south side of central Seoul between Yongsan on the Kyöng-bu Line to Ch'öngnyangi on the Kyöng-won Line for efficiency in 1974. But pressure for passenger transportation caused KNR to add stations and begin a regular passenger service with EMUs.

SMSC Line 2, started in March, 1978 and opened in stages. By May, 1984, it formed a continuous 54.3-km (33.74-mile) loop through the city, making no track connection with KNR. Lines 3 and 4, however, were specifically designed for reciprocal running with KNR. Also in 1978, a joint KNR/SMSC project was announced for a 42-km (26.10-mile) outer bypass route from the vicinity of Kumjöng on KNR's. It is intended to carry freight, KNR commuter/suburban, and SMSC rapid transit trains.

A bold 45-km (28.0-mile) project, Line 5 was started in June, 1990. Under construction in stages, it will connect Panghwa and Kimp'o International Airport at the west through the city to Kodok at the east with a 7-km (4.3-mile) eastern branch to Koyo.

Construction started in 1993 on Inch'ön's Line 1, north-and-south for 24.6 km (15.29 miles), all in tunnel, using 1,500Vdc and overhead conductor rail. It will open in 1998, initially feeding KNR's Kyöng-in Line at Pupyong station.

Seoul rapid transit lines 6 and 8 are under construction without joint-use/reciprocal-running implications. Planning for Lines 9 through 12 began in 1993. New lines are planned to satellite cities of Paju, Kuri, and Sangman.

Notes on Implementation

SMSC adopted KNR standards for clearances inasmuch as its rapid transit trains would have to run on KNR tracks used by freight and intercity passenger trains. As in Japan, the norm is high, car-floor-level station platforms which are critical for lateral clearances. But other features were compromised among SMSC and KNR, each having reasons for sticking with their own features.

For joint-use of track/reciprocal running, both the SMSC rapid transit trains and the KNR commuter trains are outfitted to operate under 1,500Vdc catenary in the subway and 25,000Vac/60Hz catenary on the KNR suburban tracks. Transition between the two voltages is accomplished automatically.

Both railways use ATC (automatic train control), but they are of different types. The KNR uses ATS (automatic train stop). The SMSC uses a continuous loop ATC.

Each railway has a different communication system. KNR had installed a space wave leaky coaxial cable circuit system. SMSC chose a two-way radio – inductive radio system. The same attitudes prevailed as for electrification. So, all

trains are equipped with both systems so that the operators can communicate directly to both the SMSC and KNR controllers.

The redundancy negotiated in the "compromise" has been costly – each operator keeping its own systems. The large fleets of railroad and rapid transit EMUs have had to be outfitted with two kinds each of electrification, train control, and communications systems. But, literature reveals no serious subsequent dispute nor dissatisfaction. *Such redundant systems are still considerably less costly than building duplicative railroad and subway lines.*

Other Information

Initially, it was intended that additional lines and branches be routed through the Line 1 central city subway. However, the volume of passengers grew quickly to such a volume that it became necessary to build closely parallel downtown subways to accommodate new rapid transit lines. *This is one of the few contemporary examples of a joint-use system outgrowing joint-use practices.*

The city, Seoul Metropolitan Subway Corporation, and KNR are engaged in an aggressive expansion program. Most of the new lines will be set up to participate in reciprocal running with KNR. By the end of this century, Seoul will enjoy a 585-km (363.5-mile) rapid transit network, reciprocal running, with KNR having added 242.0 km (150.38 miles) to the blend. In 1992, SMSC and KNR lines carried 21.5% of metropolitan travel. Seoul's goal is to have more than 400 km (248.6 miles) of these rail services carrying 75% by the Year 2000.

Neighboring Inch'ön is emulating the capital city. It is already a beneficiary of the joint KNR/SMSC service from central Seoul. Its first rapid transit line will open in 1998 and the second-line will go into construction. The third line is intended, and designed for, eventual reciprocal running with Lines 7 and 11 of the Seoul network. Lines 2 and 3 will bring the total to 80 km (49.7 miles) by 2007. A 125-km (77.7-mile) network is planned.

8.8 PACIFIC RIM LESSONS

The Pacific Rim case studies demonstrate at least ten varieties of shared track experience. LRT and freight mixes are uncommon in Japan but a large array of what would be classified in North America as non-FRA compliant rail transit rolling stock is operated jointly with railroad trains. The relatively minor role of freight railroading in Japan does not diminish the innovations of joint use between rail transit and railroad passenger entities. Sharing of track used by railroad freight and intercity passenger trains with lighter-weight rapid transit cars, light-rail vehicles, DMUs and railbuses is quite common throughout Japan and the Pacific Rim. The lessons that can be learned from Japanese and Pacific Rim experience with planning, designing, and implementing joint-use of track and reciprocal running are varied insofar as their applicability to the U.S. The central lesson is that common interests breed cooperation and an environment in which track sharing becomes a viable option. A corollary is that joint ventures and publicprivate partnerships generate innovative practices and must be supported by local decision making. A mixture of Pacific Rim and North American examples are offered as specific lessons in the following paragraphs:

Observations

- Achieving successful joint use is not the result of a single circumstance, but a combination of features negotiated by like-minded entities who feel they have a stake.

- Joint use of track/reciprocal running is useful as a means to inexpensively extend city rapid transit into the suburbs and useful for bringing commuter-rail to the heart of a city. This has been a prime motive in developing shared track proposals in Japan.

- The use of railbuses or other DMUs in joint use of track arrangements is an interim way for extending urban rail transit to the suburbs on existing railroad tracks. The railbus is a precursor for greater capacity vehicles while, for example, electrification is being contemplated (as on the Ise Railway), or ridership growth is being encouraged (as at Kuala Lumpur).

- Public-private joint Third Sector ventures are spawned when local jurisdictions are confronted with loss of service or a common economic interest emerges. The closest North American equivalent is the joint venture DBOM, or a short line operator taking over a branch line threatened with abandonment. Risk is tolerated in joint use where operating discipline and management culture embraces extraordinary safety practices.

Joint use of track/reciprocal running is primarily a means for reducing capital investment requirements by enabling proposed rail lines or extensions to make the utmost use of existing facilities. Attracting more patronage may result in shared track fulfilling an interim need until demand outruns capacity and separate parallel capacity becomes unavoidable.

Joint use of track/reciprocal running applied to very high density services in Japan may induce standardization of infrastructure and rolling stock as an unintentional result. Japan and Seoul, South Korea abound in purpose-built facilities designed and specified in anticipation of (not in response to) joint use, which also motivates common physical and technical standards.

Hong Kong has demonstrated that a variety of rail modes and initiatives can coexist on the same pair of tracks in a changing political environment. The electrified Kowloon-Canton Railway (KCR) tracks carry diesel freight trains, electric high-speed trains, diesel-locomotive-hauled intercity passenger trains, and electric heavy rapid transit trains – the latter being its basic use. This could be the northeast U.S. equivalent of Amtrak, Metro North, Conrail and MTA-NYCT rapid transit sharing track with NYCT as host. Through Hong Kong's densely-developed region, it was not necessary, nor was there space, to build a separate freight railroad, a separate intercity railroad, and a rapid transit line. As volume overwhelms capacity, KCR is building an all-new double-track railroad in a parallel corridor – not to separate modes, but to carry the same joint-use mix plus unit container trains. Adding parallel new capacity when existing capacity is reached need not require reverting to separate modes on separate facilities.

Basic Decisions by Joint Use Partners

There is no single model for pursuing joint-use of track or reciprocal running. Nevertheless certain practical considerations appear to pertain. Observation of the fundamental aspects among two (or more) prospective participants in joint-use of track/reciprocal running reveals the following:

- If both rail lines exist, but joint use is under consideration, compromises are negotiated no matter how similar the infrastructure or rolling stock might be (or be perceived to be).

- If one line exists and the other is merely planned and must be built, the new facility routinely complies with the older system's standards of design, dimensional clearances, etc., and compatible rolling stock. In some cases this can result in building new obsolescence.

- If one of the prospective participants in joint use is a railroad operator, the transit physical plant design will equal or exceed the railroad physical standards of weight, dimensions, and performance for that portion of the line used by joint service. The subject rail line will have two physical standards. For example, in North America, the Baltimore LRT lines can accommodate interline freight. However, the track connections used by Conrail and Canton Railroad – the freight operators – are at logical locations where the freight movements do not have to follow LRV standard steep gradients or go over aerial structure. The shared track sections are defined and built to a more generous geometry. Shared track can be isolated to specific segments of a system.

- If one of the prospective participants in joint use is electrified, its electrification standard will ordinarily prevail. However, this may necessitate modifications to the current-collection apparatus. Such modification might be as simple as a high-reach pantograph such as at San Diego and Baltimore, where freight trains run on tracks under LRT catenary. Or, it might be as complex as at Cleveland, where West Side Red Line heavy rapid transit and Waterfront Line light-rail transit tracks are crossed by Conrail freight sidings and the low catenary must be raised when freight movements occur.

- Though unlikely in North America of the 21st Century, if both participants are electrified, but with differing voltage and delivery systems, there are common means for resolving the incompatibility problem. Offset pantographs, dual wire, third rail/ catenary and overhead rail considerations are among the remedies.

- Railroads engaged in joint use will adopt, to the extent they are able, the equipment and labor practices of their rail transit partner, if the latter's economics are demonstrably superior. National railroads adopting rail buses is a prominent example.

There are some aspects of reciprocal running that had to be resolved by the Japanese, but ought not be problems in North America. Differences of track gauge are less of a problem, although it is inhibiting at New Orleans (broad gauge), Philadelphia (two gauges), Pittsburgh (broad gauge), San Francisco (BART's broad gauge), and Toronto (broad gauge).

Exceptions abound. Diversity is enhanced by local decision making. Standardization arises from the bottom up, not by national decree. Joint use of track over time and equipment replacement cycles drive a selective and evolutionary form of standardization.

Institutional Matters

It may prove necessary to tolerate the cost of some redundancy such as at Seoul, where both the Korean National Railroad and the Seoul Metropolitan Subway Corporation insisted on their own electrification scheme, train control system, and communications system. The rolling stock of both operators had to be outfitted

with redundant sets of systems. The tradeoff between capital cost of a redundant train control outweighed the capital cost of a duplicative parallel rail line in this case.

Cost sharing is negotiated. There are no established norms concerning what a prospective joint-use/reciprocal running participant might demand, tolerate, or yield. The case studies provide no optimal arrangement, just different ones based on local circumstances.

Whatever doubts the six Japan Rail group companies might have had with allowing private and Third Sector railway railbuses to share their tracks with their mainline trains were overcome by favorable experience. Japan Rail companies very quickly became the largest owners and operators of railbuses. Of the 782 railbuses running in Japan, 451 are owned and operated by regional Japan Rail companies. This is parallel to, but on a broader scale, Karlsruhe's successful use of dual-voltage light-weight LRVs to expand urban light-rail transit by running on Deutsche Bahn (DBAG) branch line tracks, resulting in DBAG acquiring its own fleet of LRVs to replace some locomotive-hauled and DMU assignments.

In addition to permanent joint-use of track arrangements, the practice has been employed as a temporary expedient. For example, during the gauge conversion and electrification modification for the Akita Shinkansen, special DMU trains filled in with through service inasmuch as the DMUs did not rely upon a continuous power supply from catenary. It was not necessary to halt rail service during this complex construction project.

Implementation of reciprocal running is often incremental in Japan, either to introduce new elements of service in sequence to acquaint operating employees with changes *or* to allow service to be introduced on completed segments while other segments were still under construction.

Aspects of corporate and railroad organization unique to Japan influence decisions to pursue joint use of track. When the railway corporation goal is to make a profit on investment and the railway goal is to expand ridership, these goals coalesce in the employment of joint use/reciprocal running as a means to cost effectively expand the market territory. Diversification of business and extension of rail service go hand in hand in the fields of land use development and economic development.

Research did not disclose a major incident or loss of life traced solely to joint use. No joint use sharing of tracks has ever been revoked because of incidents, misgivings, assumption of risk, or lapse of trust among partners. No litigation, insurance measure, or court action has been directed at joint use partners based on their shared track or other cooperative venture.

Way Facilities, Structure, and Station Concerns

Construction of *new* rapid transit facilities in the larger metropolitan areas was designed to the higher JNR clearance standards or to area interurban railway company standards in anticipation of through running. The lesson: Don't undersize new rail facilities because of the attitude, "Joint use in the U.S. can never happen." There may, however, be other, valid reasons to build small, but specifying small dimensions to preclude joint use or other system integration is no longer practiced.

A variety of means of protecting the grade crossings of rail lines with public roads is available and, in Japan, there is no hesitation to run "subway" trains (which typically have grade-separated trackbeds) on suburban trackage that intersects roads at grade. Rapid transit cars in this service

are being retrofitted with steel pilots in recognition of vulnerability to collisions and deflecting objects at grade crossings.

In signaling, the most sophisticated system prevails and must be adopted by the other participant – not necessarily for en entire system, but at least for the joint-use trackage. Equipment is dedicated to specific trackage where expense prohibits installing ATO on the entire fleet.

Lack of subway or tunnel clearances for normal pantograph operation, or construction costs of increasing overhead clearances, are deterrents to pursuit of joint use of track/reciprocal running. Low cost alternatives exist. Use of low voltage, trolley bar instead of catenary, and double-sprung pantograph, direct-fixation track, or some combination of these, alleviate this problem. For possible extension of third-rail rapid transit trains from Philadelphia to Lindenwold, New Jersey, and beyond on railroad track, PATCO staff designed a car with a recessed pantograph pit so a locked-down pantograph would fit within clearances through the central city subway.

Although once common in some parts of the U.S., Japan does not contain a single example of the combination of power collection from catenary and third rail on the same line! Ample North American precedents overcame dual voltage/ collection complexities including Boston's Blue Line heavy rapid transit line (where the changeover takes place at a station) and Metro North's New Haven Line and Chicago's Skokie Swift line (where the changeover occurs while the trains are in motion).

Rolling Stock Compatibility

The locomotives, coaches, and other railcars employed in reciprocal running have compatible couplers for an active train to push or pull a stalled train to a safe haven.

The car body width at sills should be of the width of the wider of the participant's rolling stock. Existing rolling stock can be retrofitted with extended sills to reach the wider-body cars' station platforms. Or, if car width is limited by the physical plant of one participant, its cars must be fitted with retractable extenders.

Rolling stock compatibility requires sufficient uniform performance to function in a blended schedule. It extends to performance in another way. Because station dwell time is a very critical item in schedule making, the cars of each system must be able to load and unload passengers at stations in the same short (seconds) period of time. At Tokyo, where large volumes of passengers are handled, dwell time is especially critical and has brought about subway, commuter-rail, and interurban cars with four and five doors per side – typical of heavy rapid transit, but quite a change from commuter trains with doors at end vestibules or interurbans with quarter-point doors.

If doors have to be added to interurban and commuter stock, then speed has to be increased for rapid transit stock. New rolling stock for rapid transit service is designed to higher performance standards enabling blending of services and joint use with commuter-rail lines and interurban lines that generally had higher top speeds.

Where among participating railways there are segments with high (car-floor level) station platforms and segments with low (curb-level) station platforms, the adjustments to conform can be on the cars instead of wholesale rebuilding of stations. Folding steps interlocked with doors is the means for high-floor cars to load and unload passengers at low platforms as at Fukui and Gifu. Some North American examples are instructive in three ways: Pittsburgh uses different doors at the two kinds of platform; the low platforms are accommodated by separate doors with

step-wells. Buffalo uses outward-folding steps on its downtown transit pedestrian mall and high platform loading at all other stations; but the steps must be activated at each mall station. San Francisco uses internal elevator-type steps which in their up position provide the flat floor for use at high-platform stations; these need be activated only once on each trip while the train is in motion between the last of one type station and the first of the other type station. The choice of type of retractable step is critical, as it impacts dwell time at stations.

Merging different fare collection systems can result in changes that affect car design. Most of the diesel railbuses used in reciprocal running in Japan are equipped with fare collection apparatus that permits operation by one person and obviates the need for ticket agents or ticket-vending machines at stations or conductors on trains.

What Not to Emulate

North American transportation planners should not take example from some of Japan's rail system characteristics: lack of anti-climbers, incompatible couplers, general absence of "cowcatchers" (pilots), or different floor heights among rail vehicles, and conclude that these are unimportant.

Japan has a different response to wheelchair accommodation than does the U.S. There, employees are expected to assist disabled persons while boarding and alighting. Here, the physical requirements are legislated. It is the ultimate objective that the whole national rail system of Japan will be accessible. Among street railway operators, Kumamoto is trying low-floor LRVs. Unlike Europe and the trend in North America, low-floor car designs are currently not in general favor in Japan.

T'ai-pei, particularly by contrast to Seoul, is a useful example of the consequences of ignoring an opportunity for joint use of track. Commuter-rail service on the T'ai-wan Railroad Administration's (TRA's) T'am-shui Line was slated to be electrified. Instead, a political decision was made to replace it with a rapid transit line. To accommodate growing ridership, TRA replaced DMUs with trains of locomotive-hauled coaches. DORTS, the rapid transit construction agency, took over the line, TRA discontinued service, and DORTS dismantled it. At great cost, DORTS built a subway part way in a parallel street and part way on the T'am-shui right-of-way. DORTS continued with a continuously elevated aerial structure for most of the length of the line; it was not until the last few miles that the rapid transit tracks were actually laid on the former commuter-rail trackbeds. This time-consuming process was exacerbated by construction delays and quality problems, delays in delivery of rolling stock, and derailments during testing. By the time rapid transit trains began serving the public, it was ten *years* since commuter trains stopped running.

By contrast, the former Metropolitan Transit Authority in Boston converted the Boston & Albany Railroad's Highland Branch commuter-rail line to light-rail transit in 1959 and linked it to the Boyleston Street Subway for through running in ten *months.*

Other questions were pursued during research; who trains crews, who develops the joint schedule, how are maintenance and operating costs divided, who dispatches trains, and how is revenue divided. No single pattern or common procedure emerged from any of these issues, except that each was negotiated among participating interests on a local, metropolitan, or regional basis.

8.9 REGULATIONS AND AGREEMENTS

The railroad regulatory climate in Japan is quite different than in the U.S. or Canada. The reasons are obvious. The North American railroad network developed by private enterprise in an extremely competitive atmosphere, wherein any railroad company could build between any pair of cities. Granted, they needed to be chartered by state legislatures which often imposed limitations,[9] and in more modern times needed Interstate Commerce Commission (I.C.C.) consent as well. In Japan, initially only one railroad company was allowed to link any pair of cities, and subsequently the nationalized railroad built the newer lines on a justification basis – hence few parallel competing railroads. Japanese National Railways (JNR) became a powerful bureaucratic organization – a monopoly – that steered its own course.

When JNR was separated into six geographical-territory companies (and an overall freight operator), the Transport Ministry imposed JNR regulations and operating rules upon them as a means for assuring continuation of uniformity. The Ministry retains for itself a veto over fare decisions, but this appears to be done responsibly and cautiously inasmuch as it is national policy that the Japan Rail group of companies become sufficiently profitable to have their stock placed on the open market.

U.S. railroads that occur entirely within the bounds of a single state are within the jurisdiction of state regulatory commissions. Of course, to participate in interchange with interstate railroads, the state-bound railroads had to comply with I.C.C. regulations and accounting systems. In Japan, individual prefectures established rules to guide the smaller railways within their bounds. Historically, regulation has primarily focused on fare structures and fare rates, not market entry or equipment standards.

In Switzerland, *railroads* are nationally legislated to be of standard gauge – 1435mm (4'8½") – while *interurbans* are legislated to be of meter gauge.[10] Although Japanese National Railways and its successor Japan Rail Companies are of 1067mm (3'6") gauge, the Japanese interurbans are of several gauges. The institutional separation of the national railway system from the interurbans is, however, similar in Japan. *Hence, the JNR regulations and rules do not apply to the interurbans or smaller private railways, nor do these companies necessarily share the same regulations and rules with one-another.*

When two Japanese rail entities decide to introduce a joint use track arrangement, more than just a trackage rights agreement is on the table. They negotiate other terms in the agreement. In the case of the Sanriku Railway and its joint use of track with Japan Rail-East, it was necessary to compare the former JNR rules (imposed by the national Transport Ministry) with the rules established by Iwate Prefecture. What might seem the 'easy' course prevailed – to adopt for joint operation the more stringent of each pair of rules. In effect, this expanded the former JNR rules to encompass the operation of the Sanriku Railway.

Although forms of joint use of track and reciprocal running have a tradition in Japan, it was not until the breakup of JNR into the Japan Rail group of companies that attention focused on the combination of factors now at work throughout the nation. Somewhat similarly to Conrail not picking up all the Northeast and Midwest insolvent railroads' lines that were evaluated by USRA, the new Japan Rail companies did not take all of the JNR branch lines. Though these lines had no national purpose, they were regarded locally as valuable. This is similar to the circumstance in the U.S. where new shortline railroads were formed – often with municipality or county assistance – to

take over the lines omitted from the Conrail network. In the similar situation in Japan, the Third-Sector movement – private/public joint venture was launched.[11]

Joint use of track is not so much a national regulatory matter in Japan as it is a business matter of agreement among the participating rail entities. *There are no regulations at either national or prefecture level that prohibit joint use of track or reciprocal running.* There are, nevertheless, an assortment of conflicting operating rules and entity-to-entity differences with which negotiators must comply. The following model is offered as an example of a joint operating contract which (in Japan) tends to compensate for modest regulatory influence. A functional translation of Sanriku's joint use agreement(s) with Japan rail includes these elements:

- Reciprocal Running Contract
- Operating Agreement
- Agreement on Train Crew Exchange
- Amendment to Operating Agreement

Reciprocal Running Contract

This basic document is essentially an agreement, negotiated and signed by corporate executives of both railways. It sets forth the structure and spirit of the total agreement and subordinate agreements under its purview. It contains seventeen sections:

1. Rules that Apply – that trains will follow Japan Rail rules while on Japan Rail-East tracks and Sanriku Railway rules when on Sanriku tracks.
2. Reciprocal Running Train Name, Train Consist, Operating Days – An attached timetable gives train identifications, make-up (whether Japan Rail's or Sanriku Railway's equipment, single car, multiple-unit, or otherwise), and days of operation of each.
3. Operating Rules for Reciprocal Running – refers to separate agreement.
4. Responsibilities for Handling Trains – details the means of exchanging, making-up, and breaking-down trains at exchange points.
5. Points Where Train Operators Are Exchanged.
6. Communication About Operation – the need for each party to inform the other.
7. Taking Care of Disabled Trains – expresses the responsibilities for repairing and moving disabled trains.
8. Immediate Communication Upon Accident – stipulates accident-reporting.
9. Change or Repair of Facilities.
10. Electricity, Diesel Oil, Oil, and Other Articles of Consumption.
11. Train Use Fee – unequal rates are specified, based upon relative lengths of run on each other's tracks and other considerations.
12. Payment – dates for payments, late interest rate of 14.5%.
13. Division of "Damage" (Liability) – the railway that caused the damage will bear responsibility, but if damage occurs while both parties are involved, they must consult to ascertain division of responsibility. When rolling stock damage results in canceling a reciprocal running run, neither party will seek compensation. (This shared risk shared responsibility arrangement contrasts with "no fault," "hold harmless" provisions being negotiated in North America.)
14. Change of Train Use Fee.
15. Time Span of Agreement – the agreement was effective from March 16, 1991 until March 31, 1992, and is kept in force on a year-by-year renewable basis and as amended (currently still in effect six years later from the first operation).

16. Change or Dissolving – either party can dissolve or amend the agreement.
17. Settlement of Disagreement – for matters not covered or other disagreement, both parties must confer, otherwise referred to a settlement court.

Operating Agreement

This document contains eleven sections:

1. Reciprocal running will abide by specific Japan Rail rules of April 1987 concerning Safety Operating Model, Train Operator's Handbook, Operating Accident Reporting, Operator's Work Rules, Locomotive Maintenance Handbook, and Diesel Railcar Personnel Guide (covering DMU and railbuses).
2. Schedule for Reciprocal Running Trains (in separate agreement).
3. Meeting on Operation – responsibility for specified personnel of each railway to meet *daily* at specific location to confer on the next day's operation.
4. Handling of Signals – detailed instruction for abiding by signals.

5., 6., & 7
Handling Reciprocal Running Trains at interchanges and in the process of handing over a train.

8. Communication of Operating Conditions – each railway keeping the other informed of changes in operating conditions.
9. Taking Care of Unusual Conditions – both parties will confer on the unusual.
10. Change to This Agreement – both parties agree to confer upon changes.
11. Time Period for This Agreement – same as Reciprocal Running Contract.

Agreement on Train Crew Exchange

This agreement contains five sections:

1. Preserve Presence at Workplace–the conductor must be present prior to departure time from the exchange station.
2. Taking Over — the procedure for exchanging written or oral reports.
3. Division of Responsibility – when a conductor's responsibility is exchanged.
4. Delivery of Lost and Found.

Amendment to Operating Agreement

Matters that arose as a result of experience in operating the Sanriku Railway/Japan Rail-East reciprocal running service have been gathered into an amendment to the initial contract and agreements. Rather than new matters, this arrangement provides greater detail for existing rules and practices.

Conclusions Applying to this Research

There is nothing unusual or profound in the Sanriku Railway's reciprocal-running contract with Japan Rail-East or its supplemental memoranda of agreements. Perhaps the most significant point is a simple one: Item 3 of the Operating Agreement states: "Every day at 8:10 p.m. in the Miyako station, the Japan Rail station master and the Sanriku Railway operating manager must meet to formally agree upon the next day's operating schedule." This underscores person-to-person contact and designated individuals taking responsibility for actions and decisions as the hallmark of successful and safe Japanese railway operations. It is also evident that the key document is the employee rulebook – which every North American railroad and rail-transit agency has and uses as an instrument of operating-employee training, rules, examination, and discipline.

Risk and Liability are shared in the same measure as tracks are shared. No special acknowledgement was found in the agreements, which treats especially, the different sizes, weights and operating characteristics of rail buses and large consist locomotive hauled freight or passenger trains. No mention is made of personal injury or related litigation, which is subject to general laws and legal precedents in Japan.

8.10 PACIFIC RIM CONCLUSIONS

Employing joint use of track and reciprocal running has enabled Japanese transportation entities to carry out a variety of social and economic objectives, mostly expansion or preservation of rail services, for the purposes:

- In the major urbanized areas, of expanding services of urban rapid transit lines deep into surrounding suburbs by using existing tracks of the national railroad network or regional interurban railways instead of constructing costly duplicative infrastructure.

- In extra-urban and urban areas, to open new or renewed territory for residential or economic development.

The first set of cases accumulates to the greatest volume of riders while the second set accumulates to the greatest number of new rail miles. One of the greatest uses of joint use/ reciprocal running has been the cost effective, therefore, quick expansion of Japan's rapid transit systems and especially the system at Seoul and Inch'ön, South Korea, as portrayed in the following Table 8-4.

The point of Table 8-4 is to quantify the growth in rapid transit *(non FRA compliant type)* service over railroads attributed to joint use. The rapid transit **line** column contains the current (1 January 1998) extent of city rapid transit ("subway") lines. Not included are the subway or tunnel sections of commuterrail and interurban lines in Tokyo, Osaka, and Kyoto. The rapid transit **service** column contains the sum of the rapid transit lines *and* the additional tracks of other railways over which the rapid transit system's trains operate in joint use of track arrangements. This column quantifies the growth of one-seat service largely due to shared track. The **reciprocal running** column contains the sum of the rapid transit service total and the additional mileage over which the track-sharing trains operate. The last column adds the **planned** rapid transit joint use. It should be understood that the figures in this column do not represent the total of urban passenger rail mileage in any of the identified cities. There are many kilometers of existing and planned railways that are not or will not be involved in joint-use arrangements. But they are outside the scope of the following table and this report.

The following U.S. equivalent example is provided to help the reader on the use of the data in Table 8-4. In New York City, a rapid transit line extended from the former Hudson Terminal in lower Manhattan to Journal Square in Jersey City, the 3.22-mile distance would be entered into the rapid transit line column. If the rapid transit trains continued over the Pennsylvania Railroad's (PRR's) tracks for another 5.50 miles to Harrison, that distance would be added to the 3.22 miles and the 8.72 sum would be entered into the rapid transit **service** column. Suppose the rapid transit trains would have shared track with PRR electric commuter trains running from Exchange Place, Jersey City to and beyond Elizabeth. These trains continued beyond Harrison (and Newark) to New Brunswick another 23.25 miles and on a branch for 9.20 miles from Rahway to South Amboy; these mileages would be added to the 8.72 miles and the sum be entered into the reciprocal running column.

Table 8-4
Japanese Rapid Transit Expansion Attributable to Shared Track

region: core city	distances in kilometers and miles							
	now						master plan network with joint-use	
	rapid transit line		rapid transit service with joint-use		reciprocal running with joint-use			
	km	miles	km	miles	km	miles	km	miles
Kanto Region:								
Tokyo	254.2	157.96	691.6	429.76	974.9	605.80	1155.6	718.09
Yokohama	33.0	20.51	33.0	20.51	33.0	20.51	70.8	44.00
Kawasaki	0.0	0.00	0.0	0.00	0.0	0.00	31.7	19.70
Chiba	10.9	6.77	11.5	7.15	53.5	33.24	96.2	59.78
Kanto totals	298.1	185.24	736.1	457.42	1061.4	659.55	1354.3	841.57
Kansai Region:								
Osaka	140.5	87.31	196.3	121.98	271.4	168.65	299.6	186.17
Kyoto	23.8	14.79	45.7	28.40	68.7	42.69	97.0	60.28
Kobe	22.7	14.11	51.9	32.25	156.5	97.25	156.5•	97.25
Kansai totals	187.0	116.21	293.9	182.63	496.6	308.59	553.1	343.70
Other Cities								
Nagoya	78.0	48.47	135.0	83.89	143.7	89.30	277.9	172.69
Fukuoka	17.8	11.06	30.5	18.95	62.6	38.90	95.1	59.10
Nagano	12.5	7.77	12.5	7.77	46.1	28.65	n.a.	
Sapporo*	45.2	28.09	45.2#	28.09	45.2#	28.09	n.a.	
Sendai	15.8	9.82	15.8#	9.82	15.8#	9.82	68.3	42.44
Japanese total	654.4	406.62	1269.0	788.57	1871.4	1162.90	2348.7	1459.50
Seoul/Inch'ŏn	195.8	121.67	368.9	229.23	435.4	270.56	694.2	431.38

* = Sapporo rapid transit cannot participate in joint use of track because it is a rubber-tire system
# = no joint use in planning stage
• = The west rapid transit terminal is arranged so tracks can be extended as new towns are developed.

Note: Korean/Seoul shown for contrast.

The foregoing, of course, happens to be a real example from the past. The Hudson & Manhattan Railroad and Pennsylvania Railroad shared track between Journal Square and Harrison, with H&M trains taking power from low voltage DC third rail and PRR freight and passenger trains taking power from high voltage AC catenary, between 1911 and 1961. This busy double-track railroad handled the specially-designed H&M and PRR rapid transit trains, PRR EMUs, and trains hauled by PRR electric and steam locomotives. Today, it is exclusively the WTC-NWK mainline of the Port Authority of New York & New Jersey's PATH rapid transit system.

To avoid the appearance of exaggeration and distortion of the foregoing comparative data, the mileage added by long-distance trains that share the same tracks *is omitted.*

For comparison, New York City's three rapid transit operating entities have a sum of 443 km (275.3 route miles) of line, a bit more than Tokyo's. This represents the extent of the NYC system which is only 2/5 of the joint use/reciprocal running distance in Tokyo. Tokyo expanded its service network over 2½ times through joint use.

Rolling stock of varying types as seen on sections of track shared by two or more railways appears to have evolved into the same vehicle. This would suggest that there really is little or no mixing of incompatible types of rolling stock in Japan. To some extent, this homogeneity has evolved. For example, on the Tozai Line at Tokyo, the newest joint-use participant simply purchased cars identical to those already in operation by Japan Rail East and the Teito Rapid Transit Authority. Uniformity is also being achieved over time. As rolling stock comes up for renewal, refurbishment or replacement, rapid transit, interurban and commuter rail cars lose their individual corporate appearance and performance characteristics. In places where rapid transit is part of the joint-use mix, a new form of electric railway car has emerged blending the characteristics of each participant's rolling stock. In spite of a trend toward compatible or identical rolling stock induced by years of joint operation on rapid transit tracks, Japanese railroads continue to operate incompatible rolling stock on non-subway trackage shared with rapid transit trains.

While the following did not come to pass, an example of this incremental evolutionary process is noteworthy and illustrative of a U.S. equivalent situation.

Several Japanese railway practices deserve attention in North America as examples for transit agencies and the private sector considering expanding or introducing new passenger rail services:

- The Third-Sector process and institution; i.e., the use of public/ private joint ventures.
- The practice of private railways to diversify services, endeavors, and investments as a means to cross-subsidize passenger rail services.
- The operation of light-weight, economical diesel railbuses for lower-volume passenger rail services. Use of these vehicles on service that could not otherwise be feasible if higher capital investment or higher operating costs prevail.

These practices are useful individually or in combination. But, the definitive technique is that of joint use of track. It is prominent in a phase of transit project development that engages the tasks of planners and engineers in ascertaining project feasibility–achieving an affordable project cost. In Japan, this has obviously been a driving force in transportation decision making.

In North American experience, there is a popular notion among practitioners to separate and classify public transportation modes. Railroads are railroads, rapid transit is rapid transit, street railways are street railways, and buses are buses, with subdivisions between them. The rapidlyrising cost of underground construction long ago changed a similar attitude in Tokyo. A simple *value engineering* exercise challenge turned into policy–joint use of track is far less costly, even when numerous adjustments are made. Scarce financial resources for rail transportation can achieve far greater value if duplicative facilities are avoided, particularly if underground construction can be avoided. Tokyo concentrated on what were believed to be worth-the-cost subways in the densely-developed central city, and continued the service deep into the suburbs by leveraging the joint-use of track arrangement. Osaka, Nagoya, and other Japanese cities followed that example. Most of these cities had in place at least initial parts of subway systems and other elements to fashion a system.

Seoul, South Korea, however, started its all-new rapid transit planning from the outset with joint use of track and reciprocal running in mind. The rapid deployment of rail lines cooperatively by that city's transit authority and the national railroad system are perhaps the most dramatic demonstration of the value of joint use/ reciprocal running.

Japanese combinations of joint use/ reciprocal running with public/private joint ventures (the Third-Sector process) and diversity of endeavor and investment lend support to the *incremental approach* to transit system development. As capital funding flows, facilities are built in segments that can – one by one – be put into service at the earliest possible instance. These mixes have not tarnished the nation's reputation for railway safety, including 31 years of high-speed rail operation with no fatality or serious injury (yet encompassing the operation of slower commuter/suburban trains on the high-speed tracks of the Yamagata and Akita Shinkansen lines). The Japanese railways all boast very high rates of on-time performance.

A pair of questions from a North American perspective would be, "Why are lightweight railbuses allowed to mix with conventional heavyweight railroad trains?" and "Why are commuter-rail trains, rapid transit trains, and interurban trains of various lengths, weights, floor heights, and performance characteristics allowed to share tracks?" The answer lies in Japan's holistic view of transport. The cost and service benefits generated outweigh the potential risk to safety. The shared-track concept appears to be self perpetrating since, based on favorable experience, the practice is expanding.

In summary, the Japanese experience with joint use of track and reciprocal running has been favorable. The Japanese experience, widely spread geographically within the island nation, has found its way to other Pacific Rim countries.

Finally, some readers may assert that cultural differences drive attitudes to pursue joint-use, reciprocal running projects and unconventional operating practices in Japan. These outlined differences, while providing a climate in which joint use can flourish, translate to institutional and regulatory concerns for cost, physical, and operational feasibility and safety. Japan has no less regard for human life than North America.

ENDNOTES - CHAPTER 8

1. Sometimes termed as "Japan Rail-Central".
2. The bus design derived Mack FCD cars were used in joint service with freight trains on NYNH&H branch lines in Massachusetts and Rhode Island south of Boston, and regularly ran on the NYNH&H Main Line to reach the maintenance facility at Reading, Massachusetts.
3. Nine other Japan Rail group interurbans have their own trackage to downtown cores.
4. A unique temporary "reciprocal running arrangement occurred between Oyamazaki and Kammaki near Kyoto during 1961 while the Tokaido Shinkansen was being built and Hankyu's parallel Kyoto Main Line was being grade-separated. As part of construction staging the interurban trains ran on the high-speed tracks.
5. Or the former Rochester Subway & Industrial Railway in the bed of the Erie Canal, or the unfinished Cincinnati Subway in the bed of the Miami Canal.
6. Although on private right-of-way, the LRT tracks are not grade-separated.
7. The Chiba rapid transit line should not be confused with the shorter Chiba monorailway. This conventional railway line started with second-hand (built) interurban cars; these, in turn, were replaced by second-hand Tokyo subway third-rail cars outfitted with pantographs – until Chiba Kyuko's own transit cars were delivered.
8. Japan Rail-West employs 1,500Vdc catenary in the Osaka region and 20,000Vac on the north coast. So, the dual-voltage EMUs are able to run under the Toyama District Railway's 1,500Vdc catenary to reach the mountains.
9. In an early North American precedent, the New York State Legislature specified that the New York & Lake Erie Railroad (later Erie Lackawanna) had to find an alignment entirely within the bounds of New York State – a limitation that later was found to be impractical and was altered. This is the reason that the pioneer U.S. railway, because of topographic constraints, had to route through points in Pennsylvania.
10. As might be expected, there are exceptions to the rule. The Swiss Federal Railway's Brünig Line is of meter gauge and several Swiss interurbans are of standard gauge.
11. More than a decade after JNR was succeeded by the JR companies and the initial surge of Third-Sector railways occurred, the process continues. As recently as Spring 1998, as this report was being finalized, the Third-Sector Ibara Railway took over and completed the unfinished 41.7-km (25.91-mile) JNR line between Kannabe and Soja and opened it with a fleet of 110-km/h (68.4-mph) railbuses, bringing passenger trains to Ibara, a city of 38,346 – the last city of Okayama Prefecture to be without passenger-rail service. The new Ibara Railway has trackage rights over Japan Rail-West branch lines at both ends.