Railway Operators in Japan 4

Central Tokyo

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Overview of Tokyo Region

Japan's capital, Tokyo, is in the southern part of the Kanto Plain, almost in the middle of the Japanese archipelago. Tokyo is Japan's largest metropolis, and its population is amongst the highest of the world's major cities.

The area was sparsely populated marshes until 1457, when the warlord Dokan Ota (1432–86) built his castle in the small village of Edo. The village developed into an urban city after the *shogun* Ieyasu Tokugawa (1542–1617) occupied Edo Castle and established his shogunate in 1603. Edo became home to shogun's many vassals and retainers and a place of residence for the *daimyo* (lords), who were required by the shogun to spend alternate years in Edo. These military classes spent large sums of money maintaining their standard of living and Edo became a busy city of consumers, merchants and craftsmen. By the end of the 17th century, the number of the city's inhabitants had reached 1 million, requiring land reclamation and construction of the Kanda and Tamagawa aqueducts to support the burgeoning population.

After the fall of the shogunate and the Meiji Restoration in 1868, the city's name was changed to Tokyo (meaning Eastern Capital). For a short while, the economy of the new capital suffered a decline, because the government abolished the military class system on which the city had depended.

The subsequent 130 years have seen dramatic changes and Tokyo is now the political, financial and cultural centre of Japan.

The three branches of government—legislative (Diet), judiciary (Supreme Court) and executive (government ministries)—are all located around Tokyo's central Kasumigaseki district. The nation's commerce is also firmly anchored in central Tokyo, especially in the Otemachi and Marunouchi districts. Japan's major corporations have their headquarters in these districts, and many foreign companies have opened offices there as well. The nation's financial centre is situated in the core of Tokyo in and around the Nihombashi district. The Tokyo Stock Exhange is located close by in Kabutocho. Other core districts, especially Ginza, Asakusa, Ikebukuro, Shinjuku, and Shibuya, are famous commercial and shopping districts where department stores, retailers and restaurants are located in close proximity. The riverbank on Tokyo's eastern side has long been a working-class downtown district. During the Edo period (1603–1868), this part of the city flourished as a neighbourhood of merchants and craftsmen. Even today, three wards in this area—Chiyoda, Chuo and Taito—are wholesale districts supplying many products, ranging from food, electrical appliances and clothes to toys, miscellaneous goods and religious items. These districts supply both Tokyo and the various regions of Japan as well. Many small, family-owned workshops are also located in the area, supplying food products, textiles, furniture, items made of paper, leather and metal, and much more.

Tokyo is also the educational and cultural centre of Japan, with many universities and junior colleges, as well as the headquarters of publishing houses and the country's most influential radio and television broadcasting companies. The metropolis also has an excellent choice of other cultural facilities.

These extensive political, economic and cultural functions are supported by a huge and complex transportation network. Two of Japan's most important airports are located in Greater Tokyo—Tokyo International Airport (Haneda Airport) in Tokyo's Ota Ward handles mainly domestic air travel, and the New Tokyo International Airport (Narita Airport) in neighbouring Chiba Prefecture is used mainly for international flights. In 1999, 57.2% of all domestic air travellers used Haneda Airport.

JR and private railways operate an integrated transportation network within the metropolis. Major stations such as Tokyo Station are terminals for intercity trains, especially the Tokaido, Tohoku and Joetsu shinkansen. Most prefectural capitals have direct rail connections to Tokyo.

Shinjuku Station on JR East's Saikyo Line during rush hour (JR East)

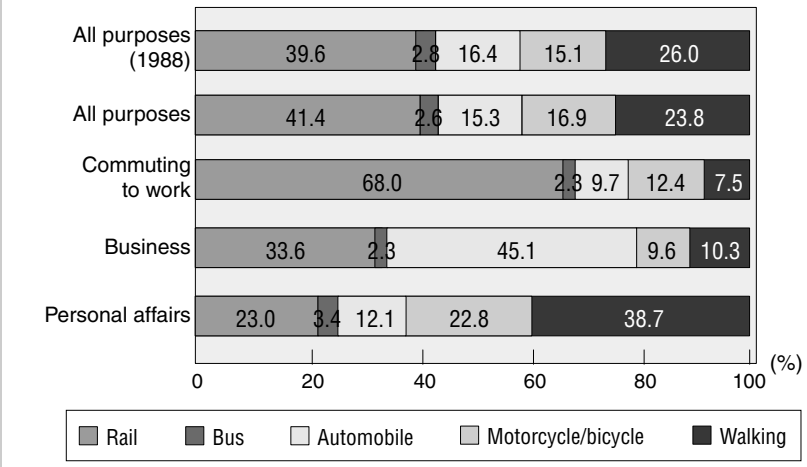
Table 1 Evolution of Central Tokyo Railways

25 Jun 1882	Tokyo Horse Tramway starts service between Shimbashi and Nihombashi in Tokyo
28 Jul 1883	Nippon Railway starts service between Ueno and Kumagaya
1 Mar 1885	Nippon Railway starts service between Akabane and Shinagawa
11 Apr 1889	Kobu Railway starts service between Shinjuku and Tachikawa (extended to Hachioji in August 1889 and to Iidamachi in April 1895)
1 May 1889	Tokyo reorganized with a new municipal government
4 May 1890	Third Industrial Exposition opens at Ueno Park
22 Aug 1903	Tokyo Electric Tramway starts service between Shinagawa and Shimbashi
21 Aug 1904	Kobu Railway electrifies line between Iidamachi and Nakano
11 Sep 1906	Tokyo Electric Tramway, Tokyo City Tramway and Tokyo Electric Railway merge into Tokyo Railway
1 Oct 1906	Railway nationalization (The government buys private railways such as Kobu Railway, Nippon Railway, etc.)
16 Dec 1909	Yamanote Line starts electric operation service on Ueno–Ikebukuro–Karasumori section
1 Aug 1911	Tokyo City buys Tokyo Railway
18 Dec 1914	Tokyo Station opens
1 Sep 1923	Great Kanto Earthquake strikes
1 Nov 1925	Yamanote Line starts loop operation
30 Dec 1927	Tokyo Underground Railway starts service between Ueno and Asakusa
21 Jun 1934	Tokyo Underground Railway extends service to Shimbashi
1 Apr 1938	Execution of Land Transport Business Coordination Law (*Rikujo-kotsu jigyo-chosei-ho*)
15 Jan 1939	Tokyo Rapid Railway starts service between Shibuya and Shimbashi
4 Jul 1941	Establishment of TRTA
8 Dec 1941	Outbreak of Pacific War
1 Feb 1942	Tokyo City integrates all tramway operations in former cities
15 Aug 1945	End of Pacific War
1 Jun 1949	Inauguration of Japanese National Railways (JNR)
1 Jul 1952	USA returns Haneda Airport and renamed as Tokyo International Airport
20 Jan 1954	TRTA Marunouchi Line starts service between Ikebukuro and Ochanomizu
4 Dec 1960	TMG Asakusa Line starts service between Oshiage and Asakusabashi and through operation with Keisei Electric Railway
23 Jan 1962	TRTA Marunouchi Line starts full service between Ikebukuro and Ogikubo
31 May 1962	TRTA Hibiya Line starts service between Kita Senju and Minami Senju and through operation with Tobu Isezaki Line
29 Aug 1964	TRTA Hibiya Line starts service between Naka Meguro and Kita Senju
17 Sep 1964	Tokyo Monorail starts service between Hamamatsucho and Haneda Kuko (Haneda Airport)
10 Dec 1967	TMG Tramway abolished on Ginza Street
15 Nov 1968	Opening of TMG Asakusa Line between Oshiage and Nishi Magome
29 Mar 1969	TRTA Tozai Line starts service between Nakano and Nishi Funabashi
6 May 1976	TMG Mita Line starts service between Mita and Nishi Takashimadaira
31 Mar 1978	TRTA Chiyoda Line starts service between Ayase and Yoyogi-uehara
20 Mar 1978	New Tokyo International Airport (Narita) opens
1 Apr 1987	JNR Reform—establishment of JRs
8 Jun 1988	TRTA Yurakucho Line starts service between Wako-shi and Shin Kiba
19 Mar 1989	TMG Shinjuku Line starts service between Shinjuku and Moto Yawata
28 Nov 1990	TRTA Hanzomon Line starts service between Shibuya and Suitengu-mae
1 Nov 1995	New Transit *Yurikamome* starts service between Shimbashi and Ariake
18 Nov 1998	Keikyu starts direct service to Haneda Airport
26 Sep 2000	TRTA Namboku Line and TMG Mita Line extend services to Meguro and start through operation with Tokyu Meguro Line
12 Dec 2000	TMG Oedo Line starts full service

The concentration of development in Tokyo went hand-in-hand with population growth. In 1876, the population of the then Tokyo Prefecture was 873,646, but this had more than tripled to 2.67 million by 1908. In 2000, the Tokyo population stood at 11.74 million but the population of Greater Tokyo, which includes the neighbouring prefectures of Kanagawa, Saitama and Chiba, is far greater. In 1995, a total of 29.81 million people lived within 50 km of the former offices of the metropolitan government in Chiyoda Ward. Of these, only some 10% (3.23 million) lived in or close to the central business district. However, the daytime population in this core area increased every business day to an average of 7.15 million (220.8%). In other words, millions of Greater Tokyo residents commute from the suburbs to the inner city and many travel more than 90 minutes each way. The 1995 Metropolitan Transportation Census results showed that the average one-way commuting time to work or school was 69 minutes (a 5-minute increase over the previous 10 years). The census also showed that 24.5% of the area's 8.94 million commuters—more than 2.19 million workers and students—commuted more than 90 minutes each way, and that the number was increasing. Only 4.1% (370,000) of commuters travelled less than 30 minutes one way.

Considering the vast area and huge population of Greater Tokyo, railways are naturally a very important form of transportation. As shown in Figure 1, they are the major mode of transport for all travel purposes (41.4%) within Tokyo's 23 wards. This high usage rate rises to a staggering 68.0% when only

Figure 1 Purpose of Transport in Tokyo's 23 Wards (1998)



commuting is considered. This rate is far higher than in other Japanese cities and a 1992 survey found that the average national ratio was 13.6%.

Tokyo's commuter trains are infamously overcrowded, particularly during rush hour. For example, in 1998, JR East's Yamanote Line had a maximum congestion rate of 237% for trains from Ueno to Okachimachi. The ratio is well over 200%, which is assumed to be the threshold at which passengers are uncomfortably crushed against each other.

This article focuses on transportation in central Tokyo, with special emphasis on the Yamanote Line, subway lines operated by the Teito Rapid Transit Authority (TRTA) and the Tokyo Metropolitan Government (TMG), the Tokyo Monorail, and *Yurikamome*, an automated guideway transit system (AGT).

Development of Inner-city Rail Network

Early development

Cities and their transportation systems generally expand outward as people and industry move in, and then outward towards the newly developing suburbs. Until about 1890, Tokyo's railways were constructed to the capital from distant cities but the tracks stopped at terminals on the outskirts of built-up areas, rather than reaching the city core. These termini were located at Shimbashi (government railways), Ueno (Nippon Railway), Iidamachi—near Iidabashi—(Kobu Railway), and Ryogokubashi (Sobu Railway).

Nippon Railway constructed and opened (March 1885) the first line from Akabane to Shinagawa linking these termini. In these early days, the steam locomotives only played a small transportation role in central Tokyo. However, with time, the track became part of the busy Yamanote Line.

The Tokyo Horse Tramway was Tokyo's first urban transit system. When operations began in June 1882, the trams linked Shimbashi with Nihombashi, and by the following October 1882 they were running successfully in a loop through Shimbashi, Ueno, Asakusa, Asakusabashi, Hongokucho and Nihombashi.

In 1890, a demonstration electric tram was built for the Third Industrial Exposition in Ueno Park (Tokyo). This provided the impetus for development of an electric tram network for Tokyo. Three companies—Tokyo Electric Tramway, Tokyo City Tramway and Tokyo Electric Railway—began construction after obtaining the required licences. By 1906, the three companies operated a total of 919 trams on 143.3 km of track in the city. Average daily ridership was 352,225. In September 1906, the companies amalgamated under the name Tokyo Railway, after pressure from the high cost of fares when transferring from one tramway to another.

As the electric railway network grew, so did the consensus that a private, profit-seeking company should not control an essential public service. Reflecting this change in opinion, the Tokyo city government purchased Tokyo Railway's operations in August 1911. The new transit authority was owned and operated by the city, and named *Tokyo Shiden* (Tokyo Municipal Electric Railway). The name was changed to *Tokyo Toden* (Tokyo Metropolitan Electric Railway) in 1943 when the city was amalgamated with Tokyo Prefecture to form Metropolitan Tokyo. (The city was located in an area now generally encompassed by the current Yamanote Line.) Electric tramways remained Tokyo's main mode of urban transport until Tokyo Metropolitan Electric Railway ceased to exist in the late 1960s and construction of subway lines began in earnest.

Spurred by the creation of Tokyo Municipal Electric Railway in 1911, tramway lines continued to be extended and ridership grew. In 1924, the system carried more than 496.27 million passengers over 155.8 km of track. This was the greatest pre-war ridership. Ridership declined sharply with the end of WWII, but picked up again as chaos gave way to order. Tokyo's postwar

golden age of tramways lasted from the 1950s until the early 1960s—during this time, more than 200 km of track was in operation and annual ridership peaked at more than 500 million. Only 8 of the 28 Yamanote Line stations did not offer direct connections with the municipal tramway system. The system criss-crossed Tokyo's core and monopolized public transport inside the Yamanote Line.

Construction of rapid railways—completion of Yamanote loop

Rapid railways came to Tokyo soon after electric tramcars began operating in the city. By the end of the 19th century, steam locomotives were linking Tokyo with major cities but policymakers did not seriously consider using the urban parts of these lines for mass transport. This was probably because the built-up area was relatively small and there was little need for an urban transit system at the time. But as Tokyo began growing steadily around 1890, the first suburbs sprang up within an area now mostly enclosed by the Yamanote Line. Then housing projects for white-collar workers became common outside the loop starting in the mid-1920s. These new suburbs prompted the development of electric railways carrying residents to terminals on the Yamanote Line.

The first rapid electric railway in Tokyo began running in August 1904 between Iidamachi and Nakano. The Kobu Railway had run a steam shuttle service between Iidamachi and Shinjuku that attracted many passengers and this section was the first one electrified to accommodate rapid services. Soon, electric trains were running between Nakano and Ochanomizu. When Kobu Railway was nationalized in October 1906, the section became the first electrified track under government ownership.

After the government nationalized many railways in 1906, it began planning to electrify the track connecting Tokyo's major rail terminals. By December 1909, electric trains were running from Karasumori (now Shimbashi) to Ueno in a circular route via Shinagawa, Shinjuku and Ikebukuro—today's Yamanote Line was starting to take shape. Another track section, between Ikebukuro and Akabane, was electrified at the same time. Then in March 1919, the Chuo Line was extended from Mansebashi to Tokyo Station, permitting through services to the Yamanote Line. In the early days, trains travelled easterly from Nakano to Shinjuku and Tokyo Station, southerly to Shinagawa, northerly back to Shinjuku and on to Ikebukuro, then easterly to Ueno. On a map, this path resembles the Japanese *hiragana* character 'の,' which is read '*no.*' Several years later, in November 1925, the elevated track section between Kanda and Ueno opened to wide acclaim, giving the Yamanote Line the general type of operations we see today.

Table 2 Changes in Line Length and Ridership Tokyo Trams and Subways

	Tramway		TRTA		TMG Subways	
	Route-km	No. of Passengers (1,000)	Route-km	No. of Passengers (1,000)	Route-km	No. of Passengers (1,000)
1911	103.4	138,317	—	—	—	—
1920	143.8	400,636	—	—	—	—
1930	173.3	369,739	3.9	n.a	—	—
1940	178.8	507,527	14.3	n.a	—	—
1950	212.8	478,946	14.3	119,309	—	—
1960	213.7	597,409	39.5	313,930	3.2	1,843
1970	47.7	134,954	104.9	1,147,712	28.7	182,137
1980	12.2	27,475	131.8	1,603,432	54.9	371,850
1990	12.2	24,198	155.9	2,136,971	64.3	539,787
1999	12.2	21,172	171.5	2,042,815	89.7	588,524

Subway construction

Tokyo's first subway line, running 2.2 km from Ueno to Asakusa, opened in December 1927. It was operated by Tokyo Underground Railway. This was the beginning of Tokyo's subway network and the inspiration of Noritsugu Hayakawa (1881–1942), Japan's pioneer of subway construction.

For a long period, the general policy was that only the municipal government should own and operate transportation infrastructure in the older part of the city (the part mainly within today's Yamanote Line). Due to this policy, private businesses were not given licences to build or operate railways in the inner city, explaining why even today private railway lines terminate at major stations on the Yamanote Line instead of continuing into the central business district. An exception was made for Tokyo Underground Railway, probably because the municipal government's poor finances prevented it building a large and costly subway. Even so, debate on construction and ownership of a subway system for Tokyo dragged on until after WWII.

Despite a long period of economic depression, Tokyo Underground Railway pushed on with construction and extended its Asakusa–Ueno line to Shimbashi (opened in June 1934). Meanwhile, another company called

Tokyo Rapid Transit Railway obtained permission for an 8.4-km line between Tokyo Station and Shibuya, and for a 7.3-km line between Shinjuku and Tsukiji. The subway line opened in January 1939 joined Shibuya and Shimbashi so both companies were operating one line terminating in Shimbashi. However, they disagreed strongly on how to link the lines. The lack of through services became a matter of public discontent, prompting the Ministry of Railways to step in and mediate a settlement. Finally, through services linking Shibuya and Asakusa were launched in September 1939.

The 1938 Land Transport Business Coordination Law integrated subways operation in Tokyo into TRTA—a public corporation—that would go on to construct a subway network. TRTA was funded and capitalized at ¥60 million by the national government (¥40 million), Tokyo's municipal government (¥10 million), and the private railways and the government railway's mutual benefit fund (¥10 million).

After WWII, the TMG wanted to see TRTA broken up, but the national government did not agree and subway construction proceeded under TRTA's direction. The first line constructed by TRTA was the 6.4-km Marunouchi Line linking Ikebukuro and Ochanomizu (opened in January 1954).

Government subway policy was clarified by the 1953 recommendations of the National Capital Construction Committee (an extra-ministerial body of the Prime Minister's Office). The recommendations to the Minister of Construction, Minister of Transport, and the Governor of Tokyo, called for:

- Through connections for suburban electric trains and urban subways
- Increase in TRTA's capital and large increase in TMG investment in capital
- TRTA to facilitate subway construction, TMG and other groups to construct any lines TRTA not intending to construct immediately

These recommendations opened the door for construction of subways by TMG itself—TRTA was no longer alone. The recommendations also noted that private railways should be permitted access to the inner city by providing through services to subway lines and such services soon became available on many lines.

In December 1960, the TMG opened its first line between Oshiage and Asakusabashi with through connections to the Keisei Electric Railway.

A new phase in subway construction had begun with TRTA and the TMG rushing to construct an underground network for the inner city. Before long, many suburban lines were offering through connections via subway lines to the central business district. Since the projects were handled simultaneously by two quite different entities, some problems occurred.

Subway construction requires huge capital. To take a recent example, the construction cost for the Namboku Line under the inner city (Akabane-iwabuchi–Meguro) averaged ¥23.8 billion/km.

Investment was made easier in 1951 by the issue of transport bonds and loans from the Trust Fund Bureau. Subsidies for subway construction were made available from 1962. The subsidy system introduced in FY1978 provided national and local government subsidies over a period of 10 years for up to 70% of the cost of eligible projects. In fiscal 1999, TRTA received ¥9.85 billion while the TMG received ¥32.86 billion. The subsidy level has risen over time and there are calls to increase it further for a longer period, because high construction costs are a severe burden on the finances of operators.

As the subway lines attracted more users, the tramways declined. At one time, trams were the mainstay of public transit in central Tokyo, but they were abandoned as road congestion increased and tramway finances worsened. Under a metropolitan financial restructuring plan approved in August 1967, trams were to be removed entirely from service between 1967 and 1971, but there is still one remaining line—the 12.2-km Arakawa Line between Minowabashi and Waseda. It survived mainly because most of its track is on its own right-of-way.

Through services linking subway and railway suburban lines

In line with the recommendations of the National Capital Construction Committee, many through services began between subway and suburban railway lines in Tokyo. The railway lines were operated by both Japanese National Railways (JNR—now the JRs) and private companies. Table 3 shows that most subway lines now offer through connections; the exceptions are TRTA's Ginza and Marunouchi lines, which were constructed in the early days, and the TMG's Oedo Line, which uses the latest linear motor technology. Perhaps no other subway system in the world offers such extensive through services to electrified suburban track.

Through services have several advantages: they permit suburban residents to travel easily into the inner city without transfer, and they reduce congestion on parallel lines and in terminal stations.

However, Tokyo's through services were provided only after a number of technical problems requiring coordination and massive investment were solved. The carriers had to adopt uniform standards not only for safety equipment but also for rolling stock size, function and structure. The cross-sections of some subway tunnels had to be enlarged for installing overhead catenary wires. Different track gauges between operators also required coordinated efforts, especially in the case

TMG's Series 10000 (left) and Keio's Series 8000 running side-by-side near Sasazuka Station in Shinjuku on Keio Line (Keio Electric Railway)

TRTA's Series 7000 (left and centre) and Tobu's Series 10000 (far right) standing at Wako-shi Station on Tobu Tojo Line (Tobu Railway)

of the TMG subway, which uses three different gauges. In fact, the gauge of TMG track is determined by the gauge of the private railway that the subway connects to. Consequently, the gauge of the Asakusa Line is 1435 mm, the Mita Line is 1067 mm, and the Shinjuku Line is 1372 mm. Furthermore, schedules must be coordinated and fare revenues apportioned fairly. In Japan, each operator has its own fare system. A passenger travelling on through services provided by different companies may have to pay separate fares, even for a relatively short journey. Discounts have been introduced to reduce the inequalities but better solutions are still required.

Planning for future

Finding ways to reduce congestion is one of the biggest challenges facing railway operators in Greater Tokyo. A policy statement of the Transport Policy Council

Table 3 Tokyo Subway/Railway Through Services

Subway	Connecting railway	Railway track section (31 Mar 2001)	Date started
TMG Asakusa Line	Keisei Line	Oshiage—Higashi Narita, Narita Airport	4 Dec 1960
	Keikyu Line	Sengakuji—Misakiguchi, Haneda Airport	21 Jun 1968
	Hokuso Kaihatsu	Keisei Takasago—Inba Nihon Idai	31 Mar 1991
TRTA Hibiya Line	Tobu Isezaki Line	Kita Senju—Tobu Dobutsu-koen	31 May 1962
	Tokyu Toyoko Line	Naka Meguro—Kikuna	29 Aug 1964
TRTA Tozai Line	JR East Chuo Line	Nakano—Mitaka	28 Apr 1966
	JR East Sobu Line	Nishi Funabashi—Tsudanuma	8 Apr 1969
TMG Mita Line	Tokyu Meguro Line	Meguro—Musashi-kosugi	26 Sep 2000
TRTA Namboku Line	Tokyu Meguro Line	Meguro—Musashi-kosugi	26 Sep 2000
	Saitama Railway	Akabane-iwabuchi—Urawa-Misono	28 Mar 2001
TRTA Yurakucho Line	Tobu Tojo Line	Wako-shi—Shinrin-koen	25 Aug 1987
	Seibu Ikebukuro Line	Kotake-mukaihara—Hanno	1 Oct 1983
TRTA Chiyoda Line	JR East Joban Line	Ayase—Toride	20 Apr 1971
	Odakyu Line	Yoyogi-uehara—Hon Atsugi	31 Mar 1978
TMG Shinjuku Line	Keio Line	Shinjuku—Hashimoto	16 Mar 1980
TRTA Hanzomon Line	Tokyu Den'en Toshi Line	Shibuya—Chuo Rinkan	1 Apr 1981

has set a benchmark for peak congestion rate of no more than 150% by 2015. To meet this goal, railway companies are quadrupling suburban lines into the inner city and increasing train lengths. More subway lines are being planned to offer more seamless links between the central business district and suburban lines. Through connections are important because they reduce transfers and shorten travel times.

Another partial solution is to move some services and functions from Central Business District (CBD). This is the goal of waterfront development projects in Tokyo Bay and redevelopment projects near terminal stations. A rail development project is now being planned for the Tokyo waterfront.

Transportation experts also predict a growing need to provide more convenient links for domestic and international travel. The focus here is on better access to airports and shinkansen stations. Development of a line connecting Haneda and Narita airports via Tokyo Station is now at the concept stage, and plans call for increasing the capacity of two lines offering direct access to Haneda Airport—the Tokyo Monorail, and the Keikyu Haneda Airport Line operated by Keihin Electric Express Railway.

More elevators, escalators and other aids are needed to increase accessibility for the disabled and growing number of elderly people. Rail and intermodal (rail–rail, rail–bus, rail–automobile) connections should also be easier. Some possible solutions are station modifications, fares based on total distance travelled rather than distance per carrier, and pre-paid cards for both train and bus fares.

Major Lines Serving Central Tokyo

The following section provides an overview of various railway lines in central Tokyo—JR East's Yamanote Line, TRTA's subway network, TMG 's subway system and Arakawa tramway, the Tokyo Monorail, and *Yurikamome*, an AGT system.

Yamanote Line

A large proportion of Tokyo's inner city is enclosed by the Yamanote Line and ridership on the line is very high, even for Japan. JR East officially regards the Yamanote Line not as a single line but as three entities: the 20.6-km Yamanote Line from Shinagawa through Ikebukuro to Tabata; a small section of the Tokaido main line between Shinagawa and Tokyo Station; and a small section of the Tohoku main line between Tokyo Station and Tabata. The total length of the loop is 34.5 km. Some stations like Tokyo, Shinagawa, Shibuya, Shinjuku, Ikebukuro and Ueno are terminals for a network of radiating lines. The Yamanote Line uses Series 205 commuter carriages. During the rush hours, trains run at a headway of 2 minutes and 30 seconds. Images of the awful peak congestion have been broadcast worldwide and JR East began operating 11-car train sets (EMU) in December 1991 to alleviate the problem. Some cars have six doors on each side and all seats on these cars are folded automatically into the vertical position until 10:00 to accommodate more standing passengers.

Teito Rapid Transit Authority subways

TRTA now operates eight subways with a total length of 171.5 km. Along with the TMG lines, they form a closely-knit network serving the inner city.

Ginza Line

The 14.3-km Ginza Line links Asakusa and Shibuya. It is Japan's oldest subway. Many of the 19 stations serve busy commercial districts, including Asakusa, Ueno, Nihombashi, Ginza and Shibuya. An average of 1.02 million passengers use the line each day (FY1999). During the rush hours, 6-car train sets run at headways of just 2 minutes. Electric power is supplied by a third-rail system, preventing through connections to other lines.

The name of Mitsukoshi-mae Station indicates its proximity to the famous Mitsukoshi Department Store; it is the only TRTA station named after a retailer. The station was named by Tokyo Underground Railway (TRTA's predecessor) in appreciation of Mitsukoshi's payment for the station construction.

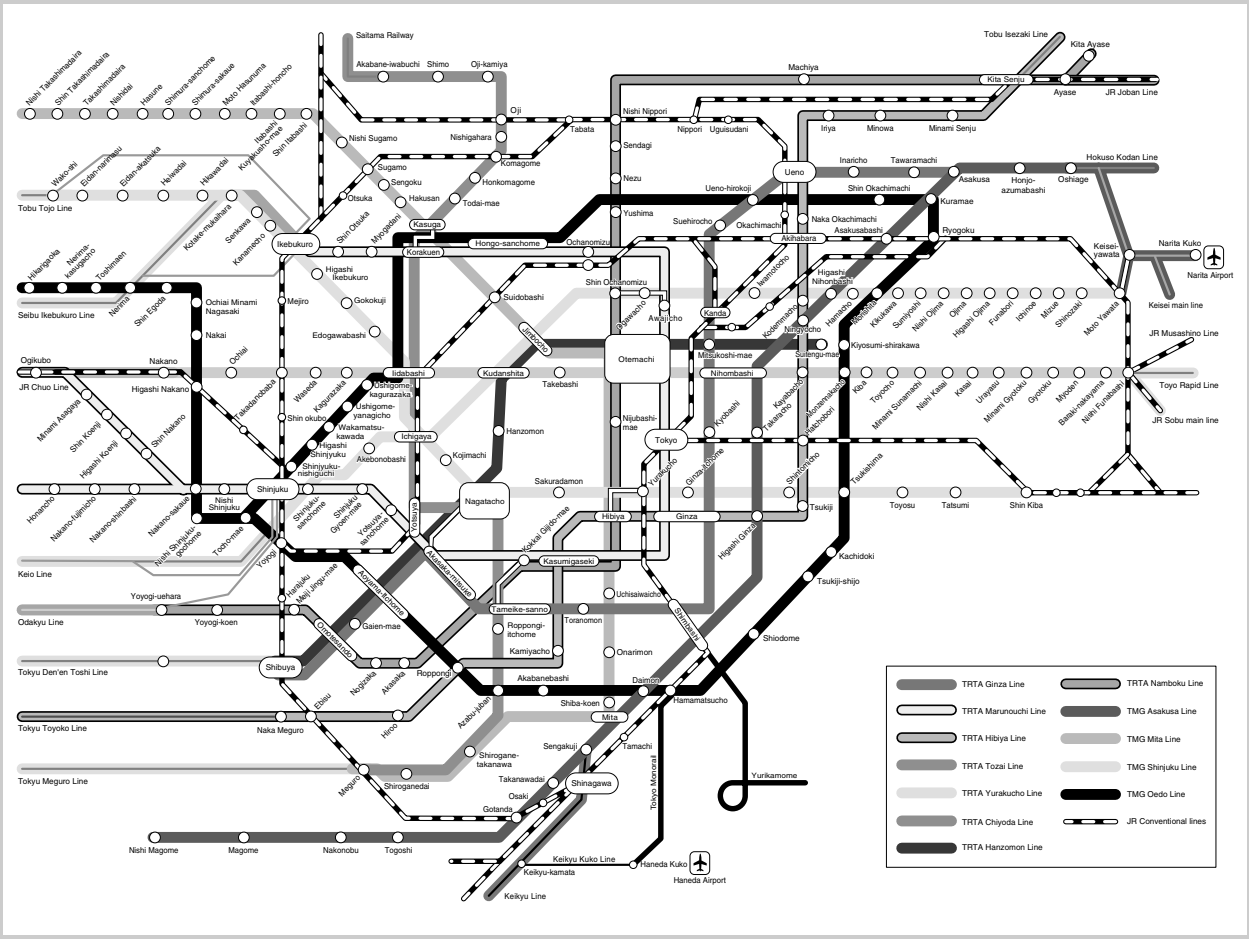
Marunouchi Line

This was the first subway constructed in Tokyo after WWII. The 24.2-km main line links Ikebukuro and Ogikubo, while a 3.2-km spur runs from Nakano-sakaue to Honancho. The main line passes under Kasumigaseki, the location of many government offices, and many important commercial districts, including Ginza and Shinjuku. An average of 1.11 million passengers use the line each day (FY1999). The line has 28 stations and during rush hours, 6-car train sets run at a headway of just 1 minute and 50 seconds. Like the Ginza Line, electric power is supplied by a third-rail system, preventing through connections to other lines.

Hibiya Line

The 20.3-km Hibiya Line traverses Tokyo's central district between Kita Senju (with through connection to Tobu's Isezaki Line) and Naka Meguro (with through connection to Tokyu's Toyoko Line). The line became fully operational with 21 stations in August 1964. Through connections to the Isezaki Line began in May 1962, establishing TRTA's first through service. Today, the Hibiya Line

Figure 2 Tokyo Subway Network (2001)



[Source: TMG Bureau of Transport]

offers through connections as far as Tobu Dobutsu-koen (Isezaki Line) in the north, and Kikuna (Toyoko Line) in the south. An average of 1.12 million passengers use the line each day (FY1999).

Rush-hour congestion at Kita Senju Station is legendary; before the Hibiya Line opened, many Tobu passengers transferred to JR East's Joban Line at Kita Senju, an inconvenient transfer because the Joban Line offers no direct access to the inner city (Ginza, Kasumigaseki, etc.). This access is provided by the Hibiya Line which has changed traffic patterns on the Isezaki Line. The Hibiya Line is one of TRTA's most congested lines and cars with 5 doors on each side were introduced in 1990 to help alleviate the problem.

Tozai Line

The 30.8-km Tozai Line traverses central Tokyo in an east–west direction. When it opened in March 1969, it was TRTA's first line to offer rapid services (with limited stops between Toyocho and Nishi Funabashi). The western end connects with Nakano on JR East's Chuo Line, while the eastern end connects with Nishi Funabashi on JR East's Sobu Line. There are through trains beyond each terminal, to Mitaka and Tsudanuma, respectively, relieving JR East's overcrowded Chuo and Sobu lines. Since April 1996, through services have operated from Nishi Funabashi to Toyo Katsutadai on track owned by Toyo Rapid Railway.

The Tozai Line has 23 stations. Six stations (Urayasu, Minami Gyotoku, Gyotoku, Myoden, Baraki-nakayama and Nishi Funabashi) at the east end of the line are in Chiba Prefecture—TRTA's first stations outside Tokyo. For example Urayasu City is just in Chiba Prefecture on the border with Metropolitan Tokyo; this area supported little more than fishing

Table 4 Size and Financial Status of Railways in Central Tokyo (1999)

	Route-km	Number of Employees	Number of Stations	Number of Rolling stock	Capital (¥million)	Operating Revenues (¥million)		Operating Expenses (¥million)		Operating Profits/Losses (¥million)		Ordinary Profits/ Losses (¥million)
						Railway	Non-railway	Railway	Non-railway	Railway	Non-railway	
JR East[1]	20.6	75,380	14	11,579	200,000	1,827,835	55,804	1,534,031	33,246	293,803	22,568	104,421
TRTA[2]	171.5	9,690	159	2,431	58,100	293,969	7,205	242,262	6,456	51,708	749	5,579
TMG[3]	89.7	3,809	108	845	914,137	88,087	48,434	91,270	53,185	-3,183	-4,751	-24,880
Tokyo Monorail	16.9	432	9	114	3,000	15,629	418	12,901	229	2,729	189	39
New Transit *Yurikamome*	11.9	157	11	36	11,000	8,887	-	6,746	-	2,141	-	229

[1] Route-km and No. of stations are for Sinagawa-Shinjuku-Tabata section only. Other data are for entire company.
[2] Hibiya Line (Route-km 20.3, No. of station 21), Ginza Line (14.3, 19), Marunouchi Line (27.4, 28), Tozai Line (30.8, 23), Namboku Line (15.6, 14), Yurakucho Line (28.3, 24), Chiyoda Line (24.0, 20), Hanzomon Line (10.8, 10)
[3] Asakusa Line (Route-km 18.3, No. of station 20), Mita Line (22.5, 24), Shinjuku Line (23.5, 21), Oedo Line (12.9, 12), Arakawa Tramway (12.2, 29)

Table 5 Passenger Volume and Density by Railway Company

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
JR East	No. of Passengers (1,000)	5,740,504	5,952,451	6,031,971	6,080,112	6,059,455	6,066,513	6,073,150	5,979,125	5,906,811	5,892,820
	Passenger Density*	45,011	45,885	46,923	47,078	46,798	46,833	47,362	46,381	45,834	45,668
TRTA total	Volume	2,136,971	2,154,118	2,159,991	2,139,664	2,112,726	2,090,298	2,095,524	2,084,295	2,084,955	2,042,815
	Density	283,083	278,696	271,310	271,269	268,248	265,960	257,555	255,065	255,650	250,935
Hibiya Line	Volume	457,102	457,119	454,004	447,109	441,651	438,115	432,533	424,465	421,556	410,675
	Density	333,002	333,321	329,736	327,710	323,951	321,454	317,326	311,886	309,804	302,739
Ginza Line	Volume	412,875	406,706	398,687	387,523	377,992	373,027	371,914	373,951	379,818	372,151
	Density	293,490	287,625	278,580	274,488	269,679	267,633	267,172	267,300	270,185	264,134
Marunouchi Line	Volume	448,223	447,635	441,531	433,512	427,062	419,758	422,593	417,580	413,899	406,892
	Density	242,268	240,121	235,464	232,847	228,789	224,363	223,432	219,823	217,949	213,140
Tozai Line	Volume	455,797	457,846	461,807	462,931	456,308	451,090	453,410	452,089	452,288	442,590
	Density	350,769	352,186	353,358	357,166	352,426	347,491	355,558	356,266	357,596	351,283
Namboku Line	Volume	-	2,469	8,201	9,157	9,580	10,012	32,681	43,282	53,694	55,872
	Density	-	9,694	10,997	12,210	12,750	13,667	35,141	43,124	50,761	53,963
Yurakusho Line	Volume	273,216	274,163	287,256	279,411	277,075	279,459	278,008	277,440	278,031	272,572
	Density	188,829	189,534	193,239	196,474	196,960	200,731	201,966	203,031	210,977	208,252
Chiyoda Line	Volume	440,230	442,399	442,963	4,382,272	433,791	426,291	421,359	415,693	410,988	402,278
	Density	342,926	342,185	341,960	336,991	331,918	326,432	321,027	314,997	312,822	304,349
Hanzomon Line	Volume	172,162	187,226	194,656	135,956	197,708	200,534	200,826	202,188	206,479	204,790
	Density	192,805	198,191	208,275	214,526	216,077	218,856	220,130	220,664	225,480	223,424
TMG total	Volume	565,239	593,726	605,437	607,975	605,569	587,816	579,560	580,363	597,774	588,524
	Density	128,804	133,391	132,306	133,557	133,516	130,031	129,803	126,930	124,128	123,222
Asakusa Line	Volume	208,029	222,483	224,489	223,983	223,195	217,009	214,590	213,094	213,346	210,129
	Density	154,466	165,772	168,981	169,055	168,595	164,595	164,471	163,161	162,571	161,105
Mita Line	Volume	182,732	186,466	186,425	186,049	184,028	177,009	171,815	170,719	172,260	166,857
	Density	146,980	150,008	150,852	150,165	148,783	143,419	141,028	139,880	140,170	136,546
Shinjuku Line	Volume	208,097	217,797	221,883	224,693	224,813	218,784	217,815	216,607	221,134	217,863
	Density	152,239	161,166	167,423	172,031	173,473	169,796	170,474	170,361	173,537	171,757
Oedo Line	Volume	-	2,260	8,419	9,225	10,057	10,559	10,740	17,451	40,315	43,855
	Density	-	17,378	20,249	22,366	24,547	26,147	26,798	39,241	59,169	64,277
Arakawa Tramway	Volume	24,198	24,605	24,818	24,517	23,586	22,620	22,523	22,411	21,695	21,172
	Density	14,129	14,327	12,899	12,782	12,300	11,776	13,302	13,240	12,818	12,475
Tokyo Monorail	Volume	44,574	47,127	51,081	57,013	61,394	62,006	64,693	65,208	63,148	53,905
	Density	110,472	116,467	121,246	121,455	188,657	117,530	119,312	121,026	117,613	102,715
New Transit *Yurikamome*	Volume	-	-	-	-	-	4,132	23,531	26,117	28,541	35,347
	Density	-	-	-	-	-	15,509	40,475	45,337	49,970	62,807

Note: Passenger Density = Daily Passenger-km/Route-km

villages until the opening of line prompted large housing developments. Since this area was sparsely developed before construction, the subway line runs on elevated track for most of the 15.0-km section between Toyocho and Nishi Funabashi. An average of 1.21 million passengers use the line each day (FY1999). To alleviate congestion, cars with wider doors were introduced in 1991.

Chiyoda Line

When the Chiyoda Line opened in December 1969, it ran only from Kita Senju to Otemachi. It now extends 21.9 km from Ayase to Yoyogi-uehara,

with a 2.1-km spur from Ayase to Kita Ayase. There are 20 stations and the line offers through services for subways and trains. It connects with JR East's Joban Line at Ayase to continue on to Toride, and with Odakyu's line at Yoyogi-uehara to continue on to Hon Atsugi. Consequently, the Chiyoda Line offers through connections from the northeast and southwest suburbs to the inner city. It is TRTA's most congested line with a rate of 212% for trains travelling from Machiya to Nishi Nippori during the busiest hours (1998 survey). An average of 1.10 million passengers use the line each day (FY1999).
Rolling stock on the Chiyoda Line's was technically advanced for its time with Series 6000 thyristor-chopper-controlled EMUs and an on-board signalling system.

Yurakucho Line

The Yurakucho Line was the fifth subway line constructed by TRTA. It stretches 28.3 km from Wako-shi to Shin Kiba. The first section began operations from Ikebukuro to Ginza-itchome in October 1974. One of its initial purposes was to reduce congestion on the Marunouchi Line. When the Eidan-narimasu/Wako-shi extension opened in August 1987, through services to the Tobu Tojo Line became possible and now extend as far as Shinrin-koen. The last extension of the Yurakucho Line to Shin Kiba was completed in June 1988. Through services are also offered to the Seibu Ikebukuro Line at Kotake-mukaihara after a new section from Ikebukuro to Kotake-mukaihara was opened in December 1994 where the track was quadrupled. An average of 744,000 passengers use the line each day (FY1999). Another extension under construction, now called Line 13, will link Ikebukuro to Shibuya.

Hanzomon Line

The 10.8-km Hanzomon Line runs from Shibuya to Suitengu-mae. When it opened in August 1978, it ran only from Shibuya to Aoyama-itchome (2.7 km), but was later extended to Nagatacho, Hanzomon and Mitsukoshi-mae. One reason for the construction was to reduce congestion on the Ginza Line. It offers through services for both a subway and private railway, connecting with Tokyu's Den'en Toshi Line at Shibuya. Ongoing construction of an extension from Suitengu-mae will lengthen the line to Oshiage. Once this section is completed, subway carriages will offer through services to Tobu's Isezaki Line. An average of 559,000 passengers use the Hanzomon Line each day (FY1999).

Namboku Line

TRTA's newest line, the 21.3-km Namboku Line, runs north–south through central Tokyo from Akabane-iwabuchi to Meguro. It offers through services for both subways and trains, connecting with Saitama Railway's line at Akabane-iwabuchi, and with Tokyu's Meguro Line at Meguro. The Namboku Line shares track with TMG's Mita Line between Meguro and Shirogane-takanawa. The line and rolling stock are billed as a new rail transport system for the 21st century—innovations include platform doors and TRTA's first driver-only operation.

Transit systems operated by TMG Transportation Bureau

Tokyo's subway network is unusual in that two groups operate their own respective parts of the system—TRTA and TMG. This arrangement permitted the network to take shape quickly but the disadvantage for passengers is that each company sets its own fares and requires payment at transfers between systems.
Most TMG lines do not pass through the CBD and its inefficient management has placed its finances in difficulties with a FY1999 deficit of ¥24.9 billion.

Asakusa Line

TMG's oldest line, the Asakusa Line, began operations in December 1960. In the early days, it only ran 3.2 km from Oshiage to Asakusabashi. The southern section between Nishi Magome and Sengakuji opened in November 1968, completing the 18.3 km between Nishi Magome and Oshiage. One reason for

Platform doors to improve passenger safety on the TRTA Namboku Line (TRTA)

the line's construction was to reduce congestion on JR East's Sobu Line. Through services to and from the Keisei main line at Oshiage were another measure to reduce congestion. The track connects with the Keihin main line at Sengakuji to provide through services linking Chiba Prefecture to Kanagawa Prefecture through Tokyo.

The Asakusa Line bypasses the CBD, so ridership was lower than on many other lines for some years (average of 574,000 passengers each day in FY1999). But it was given a new role in November 1998 when Keikyu trains began through services from Haneda Airport. This has made it possible to provide 4 daily return direct services between Haneda and Narita airports using the *Airport Express*. Demand for convenient airport-to-downtown access will undoubtedly grow and there are plans to connect the Asakusa Line to Tokyo Station, creating a single line linking the two airports and the shinkansen terminus.

Mita Line

The 26.5-km Mita Line between Meguro and Nishi Takashimadaira links Takashimadaira New Town in north Tokyo with the inner city. The first section to open (December 1968) runs 10.4 km from Sugamo to Takashimadaira. The line was later extended in both directions and measured 22.5 km in May 1976 when it began operations between Mita and Nishi Takashimadaira. An average of 455,000 passengers use the line each day (FY1999).

The newest section from Mita to Meguro was opened in September 2000. As mentioned above, the line shares 2.3 km of track with TRTA's Namboku Line between Meguro and Shirogane-takanawa, making the TMG a category-2 operator. Subway trains from both the Namboku Line and the Mita Line now join Tokyu's Meguro Line at Meguro, offering through connections to the south.

Shinjuku Line

The 23.5-km Shinjuku Line from Shinjuku to Moto Yawata was opened in March 1989 and traverses central Tokyo in an east–west direction. Keio trains and TMG subway cars can use each other's tracks at Shinjuku and most subway trains offer through connections to Keio stations. The Shinjuku Line makes it possible for commuters from Tama New Town in west Tokyo to enjoy direct services to the inner city. The west end of the line runs almost parallel with JR East's Chuo Line. The eastern section was constructed parallel to JR East's Sobu Line to alleviate congestion. An average of 595,000 passengers use the line each day (FY1999).

Oedo Line

The Oedo Line opened to full service in December 2000. It links Hikarigaoka in northwest Tokyo to Nerima and Shinjuku and then loops through the inner city. It offers convenient access from Hikarigaoka New Town in Nerima Ward to Shinjuku. The loop line has connections to many older JR East and subway stations in the inner city, making commuting easier. The tunnels were constructed with a small cross section to reduce costs. The linear-motor powered trains boast the latest technology.

TMG Arakawa Tramway

Despite the plan to abolish all tramway lines by 1972, the Tokyo Metropolitan Assembly decided in 1973 that the 12.2-km Arakawa Line between Minowabashi and Waseda should remain in operation in perpetuity. The two main reasons were because the trams were popular with local residents and much of the track is on its own right-of-way.

Trams run at intervals of 2 minutes and 30 seconds during rush hours and every 5 minutes during other daytime hours. There are 29 stops.

The line goes back to August 1911 when Oji Electric Railway began operating trams between Asukayama and Otsuka. The entire line was completed in January 1932. In 1942, Oji amalgamated with Tokyo Municipal Tramway and the section between Minowabashi and Oji Eki-mae was called Line 27, while the section between Arakawa Shako-mae and Waseda was called Line 32. After the decision to retain the service, Lines 27 and 32 were consolidated to form the Arakawa Tramway.

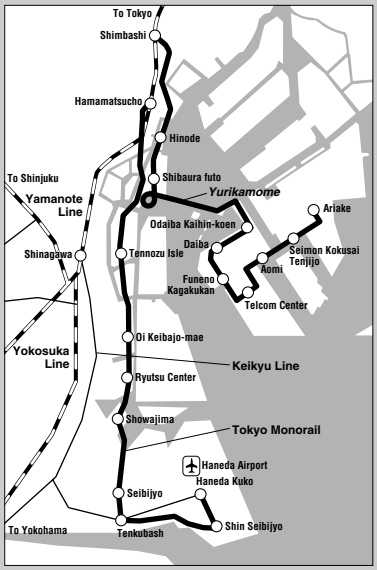
To rationalize costs, the trams have used single-driver operation since 1977. Air-conditioning was installed from 1984, platforms were raised above ground level from 1996 and slopes have been installed to eliminate steps between platforms and ground level. An average of 57,000 passengers use the line each day (FY1999) but ridership is declining gradually.

Tokyo Monorail

Tokyo Monorail's 16.9-km line links Haneda Airport with Hamamatsucho. The line was opened in September 1964 by Hitachi Un'yu Tokyo Monorail. Operations were transferred to a new group in 1981 and renamed Tokyo Monorail. The system is an early example of a straddle-type monorail in Japan. The initial purpose was to offer fast connection between the airport and Hamamatsucho, close to the inner city so almost no intermediate stations were constructed. Seven new stations were added later because of trackside development and the need to attract more users.

Haneda Airport's terminal building was relocated and opened in September 1993, creating the need to construct a new station and new track from Haneda Seibijyo. When the new section opened, the old section between Haneda Seibijyo and the former Haneda Station was abandoned. The New East Terminal is

Figure 3 Tokyo Monorail and *Yurikamome* Netwok



Tokyo Monorail's Series 1000 running along Tama River near Haneda Airport (Tokyo Monorail)

now being constructed and when it is completed, the monorail line will be extended 0.7 km from Haneda Airport Station to the new terminal.

The travel time from Hamamatsucho to Haneda Airport is 22 minutes with trains at every 3 minutes and 20 seconds during rush hours, and about 4 minutes during other daytime hours. As a result, the service has earned the nickname, 'No-Wait Monorail.' An average of 147,000 passengers use the line each day (FY1999).

The monorail was the main link to the airport for many years, but in November 1998, Keikyu began its own services to the airport, robbing the monorail of part of its role. The percentage of airport users taking the monorail has declined in recent years, dropping to 37.3% in 2000. On the other hand, more commuters are using intermediate monorail stations, especially Tennozu Isle, Oi Keibajyo-mae, and Ryutsu Center. The company plans to refurbish its Hamamatsucho Station in order to increase capacity.

Tokyo Monorail is now under JR East's control since buying 70% of the shares in February 2002.

Yurikamome—Tokyo's new waterfront transit system

The *Yurikamome* AGT was built to satisfy demand for a better link between the inner city and waterfront. The operator is a public–private joint partnership between TMG and business interests. The 12.0-km line started operations between Shimbashi and Ariake in November 1995. (A 2.8-km extension from Ariake to Toyosu is now under construction.) An average of 97,000 passengers use the line each day (FY1999).

The medium-capacity AGT is computerized and trains and stations are unmanned. The line cost ¥170.2 billion to construct but received ¥115.1 billion in new-transit-system subsidies from the national and metropolitan governments. ■

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