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New Types of Guided Transport

Akira Nehashi

Monorails

Monorail cars run on rubber tyres that either straddle a single rail girder or hang suspended from it. The monorail offers a number of advantages, such as: small footprint of structural components on ground; ability to negotiate relatively steep gradients and tight curves; high ride comfort; and no level crossings because track entirely elevated.

The Monorail—From Early Days to Present

The monorail was invented much earlier than most people realize. The first record of a monorail was one patented in Britain in the 1820s, around the time the steam locomotive was first put to practical use. A motorized monorail line constructed in Ireland in 1888 carried passengers and freight over a distance of about 15 km and proved the feasibility of single-rail transport systems powered by an engine. The suspended monorail was invented in Germany and put into operation in Wuppertal in 1901. By 1957, it was clear that the basic design of the Alweg (straddle-beam) monorail was safe and effective. This was also true for the Safege (suspended) monorail by 1960.

Japan first gave serious attention to the monorail when a suspended type was opened in 1958 in Tokyo's Ueno Park. One purpose of the project was to test monorail technology and determine how it could be used for urban transit.

During the 1960s, monorails were developed and built in different parts of the world. A number of Japanese companies developed their own systems, and this resulted in considerable variety in Japan. In the early days, monorails were considered suitable only for amusement parks, but this changed in 1964 when the Tokyo Monorail began running along the edge of Tokyo Bay between Hamamatsucho and Haneda Airport. It was constructed to serve as an urban transport system. Research continued into making the monorail more suitable for urban transport and the basic design was standardized by 1967.

The straddle-beam monorail became a composite type that borrowed from a number of designs, especially Alweg, Lockheed, and Toshiba. The suspended monorail also evolved with improvements to the Safege design. See Table 1 for further information on monorail construction in different countries.

Tokyo Monorail serving Haneda Airport (Tokyo Monorail Co., Ltd)

Straddle-beam Monorails

Cars

Straddle-beam monorail cars have 2-axle bogies. The running wheels are rubber tyres filled with nitrogen. The bogie frame has two pairs of guide wheels on the upper side, while its lower side has one pair of stabilizing wheels. The electrical system is either 750 or 1500 Vdc.

Rail girders

Rail girders are generally made of prestressed concrete, although composite girders can be used when required. Supporting columns are generally T-shaped and made of reinforced concrete, but topographical or other conditions may dictate steel columns in the shape of a T or an inverted U. Figure 1 shows a typical example. At switches, the rail girder also serves as the turnout girder, with one end shifting to the other rail. The turnout girder is supported by a carriage that can be moved by an electric motor.

Suspended Monorails

Cars

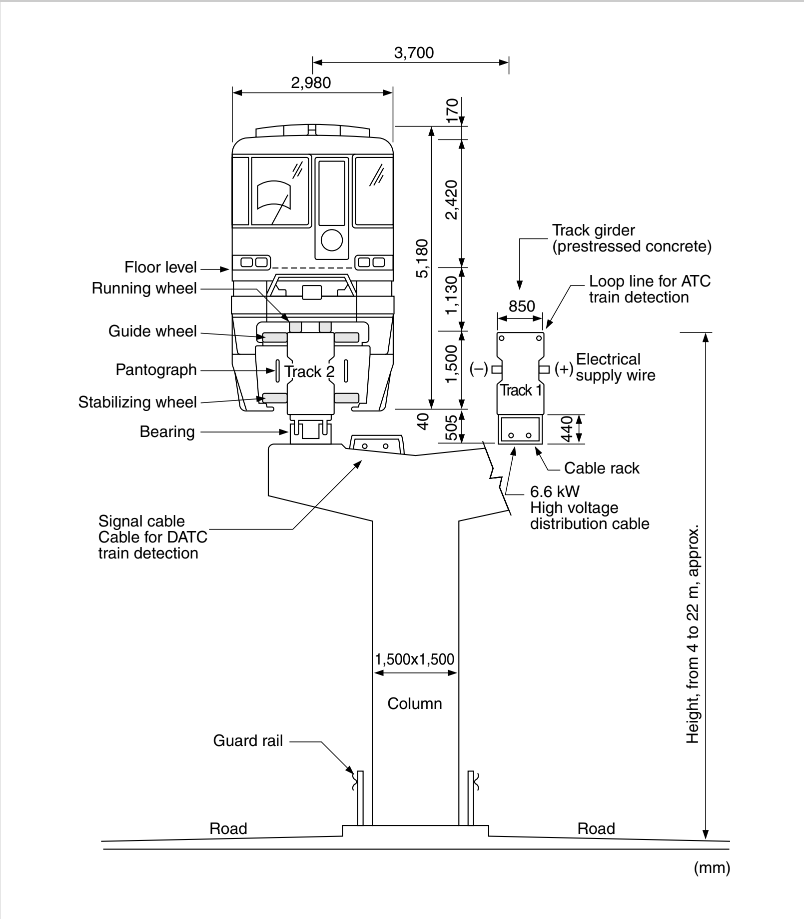
Suspended monorail cars have 2-axle bogies. Each bogie has four air-filled rubber tyres for travelling and guidance. Auxiliary wheels are also provided for each wheel as a safety precaution in case a tyre loses air. The suspension system uses air springs. The suspension joins the bogies to the body, and is composed of suspension links, safety cableways, oil dampers and stoppers. The electrical system is 1500 V.

Table 1 World Monorails

Year	Country	Location	Type	Length of line	Power source	Purpose	Notes
1824	UK	London	Elevated		Horse	Freight	Wooden columns. Said to be the world's first monorail.
1888	Ireland	Kerry County	Straddle-beam (Lartigue type)	15.0 km	Steam	Freight and passengers	Track: A-shaped support Speed: 30 km/h Operated until 1924
1898	Belgium	Brussels			Electric	Displayed at exposition	Said to be world's first electric monorail
1901	Germany	Wuppertal	Straddle-beam (Langen type) (C-type)	13.3 km	Electric	Passengers	Invented by Eugen Langen in 1893 and called Langen or Wuppertal type. Track: Supported on steel frame arches Speed: 25 km/h (still in operation)
1957	Japan	Toyoshima Park, Tokyo	Suspended (C-type)	0.19 km	Electric	Tourism	Single track; 33 seats; no longer in service
1952	Germany	Fuhlingen, Köln	Straddle-beam (Alweg type)	1.7 km	Electric	Development trials	Track: Reinforced concrete, 2/5 scale for research Precursor of Hitachi/Alweg type
1956	USA	Houston, Texas	Suspended	0.27 km	310 hp engine	Experimental	Track: Inverted J-shaped steel supports Max. speed: 80 km/h
1956	USA	Dallas, Texas	Suspended	0.49 km	Electric	Experimental	Track: T-shaped supports Speed: 94 km/h
1957	Japan	Ueno Park, Tokyo	Suspended (C-type)	0.33 km	Electric	To test potential for urban transit	Single track: two cars, fixed coupling; 31 seats
1959	USA	Disneyland	Straddle-beam	1.34 km	Electric	Tourism	3-car train; 82 seats
1961	Italy	Torino	Straddle-beam	1.16 km	Electric	Passengers	3-car train; 297 seats
1961	Japan	Nara Dreamland	Straddle-beam (Toshiba type)	0.84 km	Electric	Serving amusement park	Single track; 3-car train; max. 360 people
1962	Japan	Inuyama, Aichi Prefecture	Straddle-beam (Alweg type)	1.4 km	Electric	Passengers	Concrete single track Max. speed: 50 km/h Seating: 360 in 6-car train
1962	USA	Seattle	Straddle-beam	1.5 km	Electric	Passengers	From downtown to Expo entrance
1963	Japan	Yomiuri Land	Straddle-beam (Alweg type)	1.97 km	Electric	Serving amusement park	Track: Concrete Max. speed: 40 km/h Seating: 140 in 3-car train; no longer in service
1964	Japan	Haneda Airport–Hamamatsucho (Tokyo)	Straddle-beam	13.1 km	Electric	Passengers	Track: Concrete with some steel Max. speed: 80 km/h Seating: 95 per car; 6-car train
1964	Japan	Higashiyama Zoo	Suspended (Safege type)	0.47 km	Electric	Tourism	Abandoned because unprofitable; 150 people max. capacity; single track
1966	Japan	Mukogaoka Amusement Park	Straddle-beam (Lockheed type)	1.09 km	Electric	Passengers	Single track; max. 140 people; 2-car train
1966	Japan	Ofuna–Yokohama Dreamland	Straddle-beam (Toshiba type)	5.4 km	Electric	Passengers	Max. 265 people; 3-car train; not in service
1966	Japan	Himeji Station–Tegarayama	Straddle-beam (Lockheed type)	1.63 km	Electric	Passengers	Abandoned because unprofitable
1970	Japan	Ofuna–Shonan Enoshima	Suspended	6.6 km	Electric	Passengers	Seating: 79 per car; 2-car train
1970	Japan	Expo 1970, Osaka	Straddle-beam	4.3 km	Electric	Passengers	Dismantled after exposition
1971	USA	Disney World	Straddle-beam (TGZ)	4.4 km	Electric	Passengers	Max. 442 people; 6-car train
1976	Germany	Dortmund	Suspended (II-Baln)	0.9 km	Electric	Transport on university campus	Seating: 42; 1 car
1984	Germany	Ziegenhain	Suspended (C-Baln)	1.9 km	Electric	Transport within hospital grounds	Linear motor Seating: 12; 1 car
1985	Japan	Kita Kyushu	Straddle-beam	8.4 km	Electric	Passengers	Seating: 98 per car; 4-car train
1988	Japan	Osaka	Straddle-beam	21.2 km	Electric	Passengers	Seating: 99 per car; 4-car train
1988	Japan	Chiba Urban Monorail	Suspended	15.2 km	Electric	Passengers	Seating: 79 per car; 4-car train
1988	Australia	Sydney	Straddle-type (VON-ROLL)	3.6 km	Electric	Passengers	Max. capacity 170 people: 6-car train
1998	Japan	Tama (Tokyo)	Straddle-beam	16.0 km	Electric	Passengers	Seating: 104 per car; 4-car train
1995	USA	Las Vegas	Straddle-beam	1.2 km	Electric	Passengers	Seating: 244 per train; 6-car train
2003	Japan	Okinawa (under construction)	Straddle-beam	13.1 km	Electric	Passengers	Seating: 75 per car; 2-car train (4-car train planned)

Note: Track distances, January 2000

Figure 1 Track Structure (prestressed concrete girders)



Rail girders

All rail girders are made of steel. Each standard girder is a 3-span continuous girder. The inside is hollow with the lower part slit open. The inside of the girder has travel and guidance beams, electrical wiring and signalling equipment.

Supporting columns are generally T-shaped, although topographical or other conditions may dictate an inverted-U shape or racket shape. The standard turnout is bidifferential. It is operated by a movable rail having both travel and guidance rails. The cross-section of the moveable rail forms an inverted-T shape.

Technical Similarities Between Suspended and Straddle-beam Monorails

Stations

Regardless of the monorail type, there are two common platform configurations—an island located between two guideways and two platforms on opposite sides of guideway(s). The chosen configuration depends on local conditions. Stations are generally located 300–1000 m apart. The distance depends on factors as such ridership, location, and connections with other transport systems.

Signalling and safety devices (ATC)

An on-board display indicates the permissible relative distance to the ahead train (the block section), and the permissible speed (which depends on guideway conditions). An Automatic Train Control (ATC) system also stops or slows the train when necessary.

Monorail tyres are rubber, so track circuits cannot be used to detect trains on the line. For this reason, signals indicating whether a train has entered or left a block are received at the trackside.

Centralized Traffic Control (CTC) devices

Centralized Traffic Control (CTC) is used to monitor traffic on all lines and control all signals and turnouts from a central location. The CTC equipment consists primarily of traffic boards, remote control consoles, television monitors showing operations, communications and alarm devices, other devices to transmit information, and peripheral equipment.

Automatic Train Operation (ATO) devices

Both types of monorail use automatic devices to ensure that all traffic follows uniform control standards and to provide a high level of safety and service.

See Table 2 for more detailed information on monorails in Japan.

Automated Guideway Transit Systems

Automatic Guideway Transit (AGT) systems can be defined as medium-scale transport using small, lightweight rolling stock running on rubber tyres on a dedicated guideway that is usually elevated. Unmanned AGT trains are controlled by computer. A number of AGT systems have been developed worldwide, the main differences being in the guidance, switching and braking systems.

Table 2 Straddle-Beam Monorails in Japan

	Straddle-Beam Monorails in Japan				Suspended Monorails in Japan	
	Tokyo Monorail	**Kita Kyushu Monorail**	**Osaka Monorail**	**Tama Monorail**	**Shonan Monorail**	**Chiba Urban Monorail**
Terminal stations	Hamamatsu cho –Haneda Airport	Kokura–Kikugaoka	Osaka Airport –Kadoma	Tachikawa-kita –Tama Center	Ofuna –Shonan Enoshima	Chishirodai –Chiba Minato; Chiba–Kencho-mae
Line length (km)	16.9	8.8	21.2	16.0	6.6	15.2
Number of stations	9	13	14	19	8	15
Average distance between stations (m)	2,110	680	1,630	770	940	960
Single/double tracked	Double	Double	Double	Double	Single	Double
Type	Straddle-beam (tyres)	Straddle-beam (tyres)	Straddle-beam (tyres)	Straddle-beam (tyres)	Suspended (tyres)	Suspended (tyres)
Switching system	Articulated switch	Articulated switch	Articulated switch	Articulated switch	Simple switch	Simple switch
Operations	ATC with driver and conductor	ATO with one driver	ATC with one driver	ATC with one driver (planned)	ATS with driver and conductor	ATC with one driver
Electrical system (Vdc)	750	1,500	1,500	1,500	1,500	1,500
Minimum curve radius (m)	120 (siding, 100)	80 (siding, 50)	100 (siding, 50)	100 (siding, –)	50 (siding, 50)	50 (siding, 50)
Max. gradient (per mill)	60 (siding, 60)	40 (siding, 60)	60 (siding, –)	58 (siding, –)	74 (siding, –)	60 (siding, 60)
Schedule speed (km/h)	43.5	28	35	25	29	26
Max. speed (km/h)	80	65	75	65	75	65
Car width x height x length (m)	3.02 x 2.92 x 16.55 (15.20)	2.98 x 3.49 x 14.80 (13.90)	2.90 x 3.74 x 14.80 (13.90)	2.98 x 3.75 x 15.50 (14.60)	2.58 x 3.69 x 12.75	2.58 x 3.73 x 14.80
Cars in train set; ( ) = number of sets owned	6 (19 sets)	4 (9 sets)	4 (8 sets)	4 (6 sets)	3 (7 sets)	2 (17 sets)
Seating per set	584	478	494	415	228	158
Time interval	4 minutes	6 minutes	6 minutes 42 s	7 minutes 30 s	7 minutes 30 s	4 minutes
Capacity (people/h)	8,760	4,780	3,952	4,200 (planned)	1,824	2,370
Located over	Sea/road	Road	Road	Road	Road	Road
Total construction cost (¥ billion)	21.1 (extension, 67.6)	68.1	115.3	242.2	5.3	133.7
Opened	1964 (13.0 km)	1985	1990	1998 (5.4 km)	1970	1988
Notes	Another extension now under construction from Haneda Kuko to Shin-higashi Terminal (0.9 km)		2.6 km line from Banpaku Kinen Koen to Handai Byoin-mae opened in 1998; 2 stations			

Some characteristics of Japanese AGTs are listed below:

- Hourly capacity between 2000 and 20,000 passengers bridging capacity of buses and conventional trains
- Maximum speed of 50–60 km/h
- 60–70 seats per car
- 4–6 cars per train
- Computer-controlled headway

Development history

Research and development of AGTs first began in the USA in the 1970s and resulted in practical applications in the same decade. These achievements were prompted by amendments in 1966 to the Urban Mass Transportation Act and by a number of debates and reports addressing urban transport problems. Transpo '72, an exposition held at Washington Dulles International Airport in 1972, introduced four new types of transportation systems and the featured AGT attracted interest from around the world. Later, AGT technology was introduced to a number of American cities. One example is AIRTRANS, serving Dallas/Fort Worth International Airport.

AGT systems are being developed in Europe as well, particularly in the UK, France and Germany. The French VAL is well known.

Japanese research into AGTs began in 1968 with development of the Computer Controlled Vehicle System (CVS) completed in 1976. Different manufacturers of rolling stock, steel, heavy industrial products, motor vehicles, signalling devices and other products were conducting individual or joint R&D in the field. As a result, quite a few different AGT systems were proposed and some were developed. However, most AGT systems in Japan today have 4 to 6

Kobe *Port Liner* running through city centre (Kobe New Transit Co., Ltd.)

cars, with 60 to 70 seats per car. The first Japanese AGT urban transit system to enter service was the *Port Liner* opened in 1981 between Kobe and Osaka.

Japan's Ministry of Transport and Ministry of Construction established basic AGT specifications by 1983, and uniform technical standards were adopted.

AGT Structure

Standard basic specifications

Minimum basic specifications have been established within a range that ensures future technical innovations will not be impeded. These specifications can be summed up as follows:

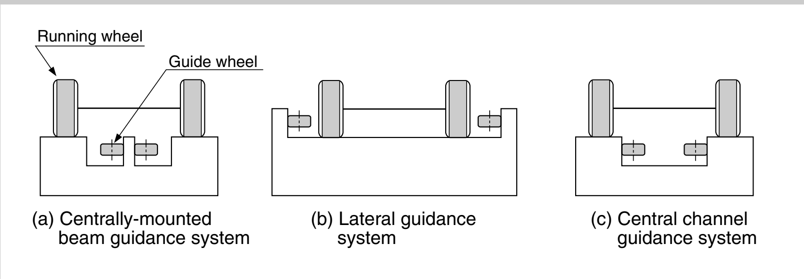
Basic concept:

- About 75 seats per car; unmanned operations

Other basic specifications:

- Guidance: Lateral
- Switching: Mobile horizontal
- Electrical system: 750 V dc (in principal)
- Rolling stock clearance: Height, 3300 mm; width, 2400 mm
- Gross weight: Under 18 tonnes
- Track and bed clearance: Height, 3500 mm; width, 3000 mm
- Lateral guidance spacing: 2900 mm
- Design load (Axle load): 9 tonnes

Figure 2 Guidance Systems



Rolling stock

Aluminium and fibre-reinforced plastic (FRP) are two common materials in carriage construction. The trains tyres are made of special rubber composites but auxiliary steel wheels ensure that the train can continue running for some distance if a rubber tyre fails.

Guidance and switching systems

Current specifications indicate that lateral and mobile horizontal guidance systems will become the future standard. Some previous guidance and switching systems include: a centrally-mounted beam guidance system; a central channel guidance system; a sink-and-float type switching system; a rotary switching system; and a horizontal rotary switching system. Figure 2 shows three guidance systems.

Automatic Train Operation (ATO) devices

Like the monorail, the AGT system can also use ATO devices. For more information on AGT systems in Japan, see Table 3.

Linear-Motor Subways

The small size and relative light weight of the under-floor linear motor permits smaller carriages than conventional cars. Linear-motor subways have been developed because the smaller subway cars permit construction of networks using smaller cross-section tunnels, which greatly reduces construction costs, particularly in urban areas. Actually, cars with an even smaller cross-section could be manufactured to meet tunnelling constraints if there is no need to transport a large number of passengers.

Table 3 Automated Guideway Transit (AGT) Systems in Japan

	Yamaman Co., Ltd.	Saitama Shintoshi Kotsu Co., Ltd.	Seibu Railway Co., Ltd.	Kobe Shinkotsu Co., Ltd.		Hiroshima Kosoku Kotsu Co., Ltd.	Yokohama Shintoshi Kotsu Co., Ltd.	Tokadai Shin Kotsu Co., Ltd.	Osaka Municipal Government	Yurikamome Co., Ltd.
	Yukarigaoka Line	Ina Line	Yamaguchi Line	Port Island Line	Rokko Island Line	Astram Line	Kanazawa Seaside Line	Tokadai Line	Nanko Port Town Line	Rinkai Line
Terminal stations	Yukarigaoka –Yukarigaoka (loop)	Omiya –Uchijuku	Seibu Yuenchi –Kyujo-mae	Sannomiya –Naka Koen	Sumiyoshi –Marine Park	Hon-dori –Koiki Koen	Shin Sugita –Kanazawa Hakkei	Komaki –Tokadai Higashi	Suminoe Koen –Naka Futo	Shimbashi –Ariake
Line length (km)	4.1	12.6	2.8	6.4	4.5	18.4	10.8	7.4	6.6	11.9
Number of stations	6	13	3	9	6	21	14	7	8	12 (11 when line opened)
Average distance between stations (m)	683	980	1,400	800	1,125	920	815	1,230	940	1,000
Single/double tracked	Single; loop	Maruyama–Uchijuku, single Omiya–Maruyama, double	Single	Sannomiya–Naka Koen, double Other track, single	Double	Double	Double	Double	Double	Double
Guidance system	Centrally-mounted beam	Lateral guidance rails	Lateral guidance rails	Lateral guidance rails	Lateral guidance rails	Lateral guidance rails	Lateral guidance rails	Centrally-mounted beam	Lateral guidance	Lateral guidance rails
Switching system	Mobile track horizontal rotary system	Mobile horizontal guidance plates	Mobile guidance plates	Sink-and-float system	Mobile horizontal guidance plates	Mobile horizontal guidance plates	Mobile guidance plates	Horizontal rotary system	Mobile horizontal guidance plates	Mobile guidance plates
Operations	ATS; one driver	ATC; one driver	ATS; one driver	ATO; unmanned	ATO; unmanned	One driver	ATC; one driver	ATC; one driver	ATO; unmanned	ATO; unmanned
Electrical system	750 V dc	Three-phase 600 V ac	750 V dc	Three-phase 600 V ac	Three-phase 600 V ac	750 V dc	750 V dc	750 V dc	Three-phase 600 V ac	Three-phase 600 V ac
Minimum curve radius	40	25	60	30	60	30	30	100	70	45
Max. gradient (per mill)	45	59	50	50	58	45	40	60	25	50
Total construction cost (¥100 million)	21	304	39	437	419	1,760	650	313	420	1,661
Opened	1982	1983	1985	1981	1990	1994	1989	1991	1981	1995
Capacity (people/h)	1,630	3,480	–	3,840	972	5,720	4,320	965	4,428	7,200
Schedule speed (km/h)	24	31	25	22	27	30	26	30	27	31
Max. speed (km/h)	50	60	50	60	63	60	60	55	60	60
Time interval	8 minutes	16 minutes	–	3 minutes 20 sec.	4 minutes	3 minutes	5 minutes	12 minutes	2 minutes 45 sec.	3.5–4 minutes, morning & evening rush hours
Seating (one train)	215	375 (6-car train)	302	450	228	286	360	193	297	352

Development history

In 1979, Japanese researchers began examining ways to reduce the cross-section of subway tunnels. Technical development began in this field in 1981 and R&D continued until 1987 with the aim of constructing a commercial linear-motor subway. By 1988, it was clear that linear-motor technology could be used on a commercial line. Soon after, the decision was made to construct linear-motor subways in Tokyo and Osaka. Tokyo's first linear-motor subway was opened as the Line No.12 (later called Oedo Line) between Hikarigaoka and Nerima in 1993, reached Shinjuku in 1997 and was then extended to Kokuritsu-kyogijo in April 2000. It became Tokyo's first loop subway on 12 December 2000. Figure 3 gives more information on the linear-motor subway in Osaka.

TMG Oedo Line (TMG)

Figure 3 Comparison of Osaka Linear Motor Subway (Nagahori Tsurumi-ryokuchi Line) and Conventional Osaka Subway Line

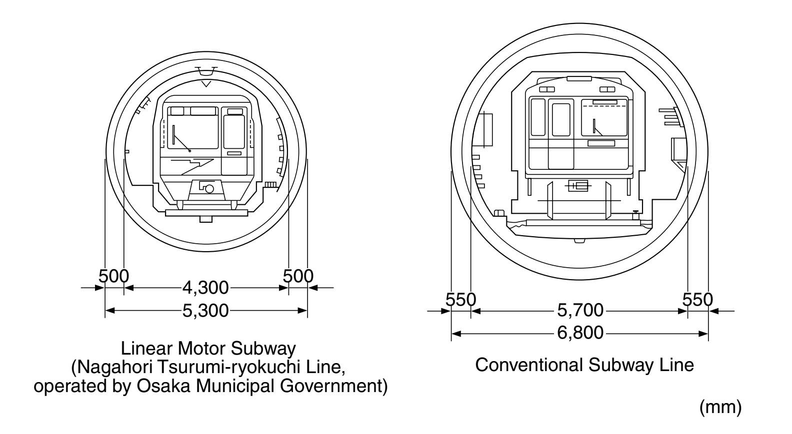
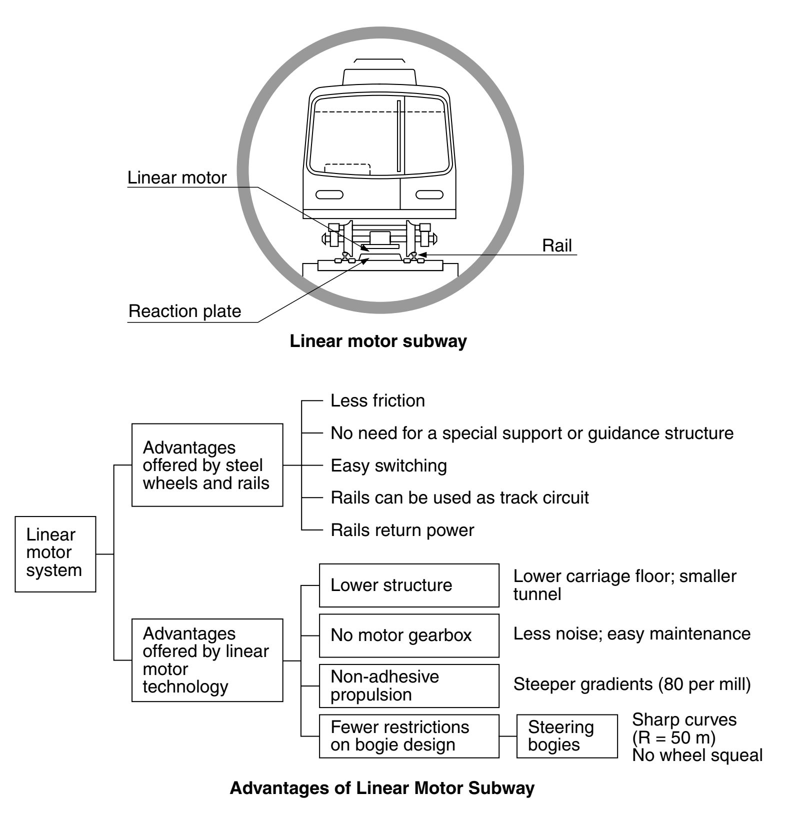


Figure 4 Linear Motor Subway



Structure of linear-motor subway

A linear-motor subway uses steel wheels and rails to support and guide the rolling stock. As a result, it enjoys the advantages of the track circuit control system and the linear motor propulsion system.

The linear motor permits construction of smaller tunnels and broadens the choice of where the line can be constructed because steering bogies can be used and because the non-adhesive propulsion permits use on steeper grades and sharper curves. This means that less land need be acquired to construct the line, reducing costs substantially. Some merits of this system are shown in Figure 4.

The following summarizes some of the major developments achieved in order to commercialize the linear motor subway.

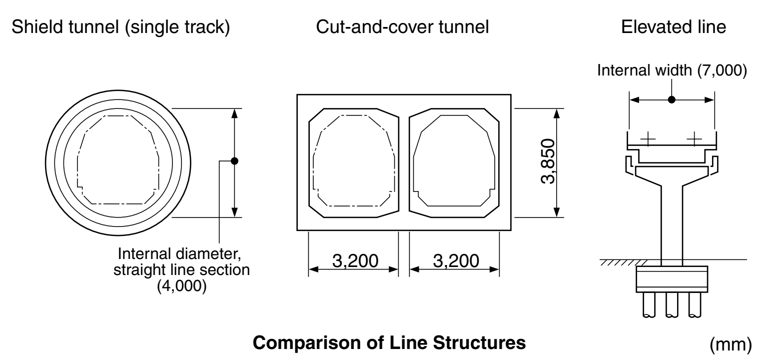
- Cars with smaller cross-section dimensions
  Vehicle floor height can be lowered to 700 mm by using smaller wheels and reducing the size of under-floor equipment. The result is a low-profile, lightweight car that can be used in tunnels with an internal diameter of just 4 m.
- Able to negotiate tight curves
  A bogie steering mechanism changes the axle angle, permitting cars to run smoothly on curves with a radius of only about 50 m.
- Able to run on steep gradients
  The linear motor provides non-adhesive propulsion that does not rely on the friction between the steel rails and wheels so cars can climb steeper gradients. It can also be used as a braking system for safer operations.
- Low noise levels
  The lighter cars generate less running noise and a bogie steering mechanism prevents wheel squeal on tighter curves.

Other developments

The principle of the linear motor generates

strong attractive and propulsive magnetic forces between the reaction plates on the track and the coils in the carriages. To overcome these forces, a new durable rail track was developed to attach the reaction plates to the sleepers. In addition, the motor (65-kW rated output) is mounted on the bogies using an innovative method of direct attachment and the system is controlled by a Variable Voltage Variable Frequency (VVVF) inverter. Safety is assured by four types of braking: service; emergency; security; and holding. Electrical wiring is routed to permit operation on tight curves.
Figure 5 compares the linear-motor subway with a conventional subway.

Figure 5 Linear Motor Subway



Safety evaluation

Construction of a commercial line could not have begun without determining whether the technology was sufficiently safe for a commercial railway system. Trial runs and tests were conducted to check the major safety factors as follows:

Unique features and performance of system

- Factors affecting car clearance and track clearance in small-section tunnels
- Separation of tracks; emergency procedures
- Performance on sharp curves—measures to prevent derailing at tight curves; bogie steering
- Performance on steep slopes—starting, acceleration and braking on relatively steep slopes

New technology factors

- Linear motor technologies
- Steering bogies with small-diameter wheels
- Reaction plates—track structure, start-up strength, attachment to track

Other factors

- Linear motor undercar clearance—flexibility of reaction plate and other components; dynamic gap change
- Safety of lighter cars
- Safety of non-adhesive linear propulsion systems

Trial runs on the Osaka Nanko Test Track examined the above items and verified that the linear motor subway system was completely safe.

Flexible Intelligent Transportation System

The extensive system of expressways, shinkansen trains, and other advanced surface transport modes has dramatically boosted the Japanese economy, raised the standard of living and expanded travel opportunities. However, there are still serious problems, including road congestion in cities, rush-hour overcrowding on urban railways, widespread air pollution, etc.
To counter these problems, Japan has developed and constructed the various urban transit systems described in this article. Strides are also being taken in other areas, including more efficient buses and promotion of 'park and ride' systems. But these measures are still not enough to solve the problems.
As a result, some quite futuristic systems have been proposed in the last few years. They aim to combine the advantages offered by tracks—speed, large capacity and accurate scheduling—with the door-to-door convenience of the car. The last part of this article examines one proposal called the Flexible Intelligent Transportation System (FITS).

What is FITS?

Although they are not physically coupled, FITS vehicles run something like a train in a dedicated lane at high speed in single file (Figure 6). The FITS concept envisions an intelligent transportation system that is safe and reliable, can carry large volumes of passengers at high speed, and operates in accordance with demand. Passengers may transfer at points that correspond to today's stations, or may proceed without making a transfer to a place close to their destination. Such a system would offer flexibility and expanded choice.
The basic concept proposes a system that will:

- Span wide areas and increase mobility

Figure 6 Illustration of FITS

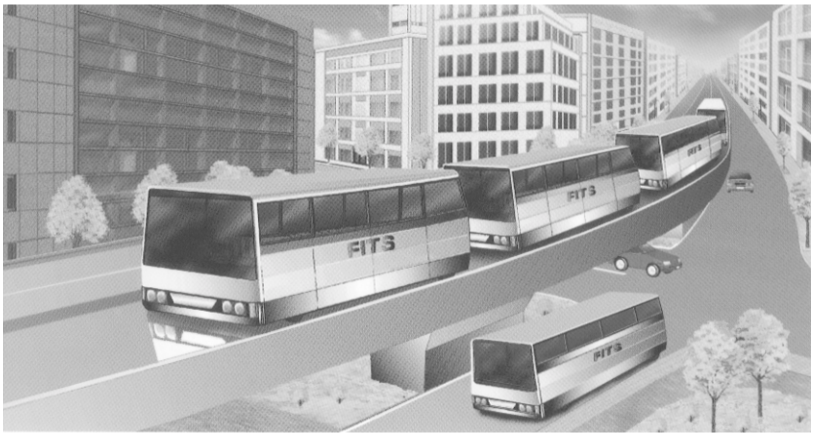
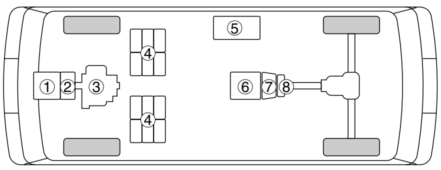


Figure 7 FITS Specifications

Vehicle structure



① Generator
② Speed gear
③ Generator engine
④ Batteries
⑤ Inverter
⑥ Motor
⑦ Speed reducer
⑧ Transmission brake

Specifications

Engine	Displacement Output	1,500 cc 25 kW
Motor	Type Output	AC Induction 70 kW
Batteries	Type Weight Capacity	Sealed lead (24) 500 kg 60 Ah/3h
Measurements	Length Height Width Minimum road clearance	10,520 mm 3,340 mm 2,490 mm 145 mm
Minimum turning radius		8.3 m 2.5 m
Vehicle weight	Dead weight/ Loaded weight	11,940 kg/15,625 kg
Axle load	Front/ Rear	5,675 kg/9,950 kg
Climbing capability		43‰
Braking performance	Braking distance	19 m (50 km/h)
Vehicle entry/exit and door position		Stepless front and mid-car entry
Auxiliary wheels/ Ground side structure		Automatic housing system/ Concrete guide walls
Extent of impact on auxiliary wheels		Max. of 4G on front and back (left and right)

for all, especially the elderly
- Permit passengers to travel directly and easily to their destinations
- Be responsive with reasonable fares
- Complement existing local and inter-regional transport systems, ensuring mutually profitable operations
- Benefit local economies
- Have low construction, maintenance and management costs
- Be environment friendly

Transport method

The envisioned dedicated lane will serve as a main line on which vehicles will operate at high speed in single file, much like a train, but at a fixed distance from each other. At nodes (stations), some vehicles may leave the file and enter an expressway or ordinary road to carry passengers to their destinations like a bus serving a local route. Capacity will be from 8000 to 14,000 people per hour, one way, with a service every 3 minutes.

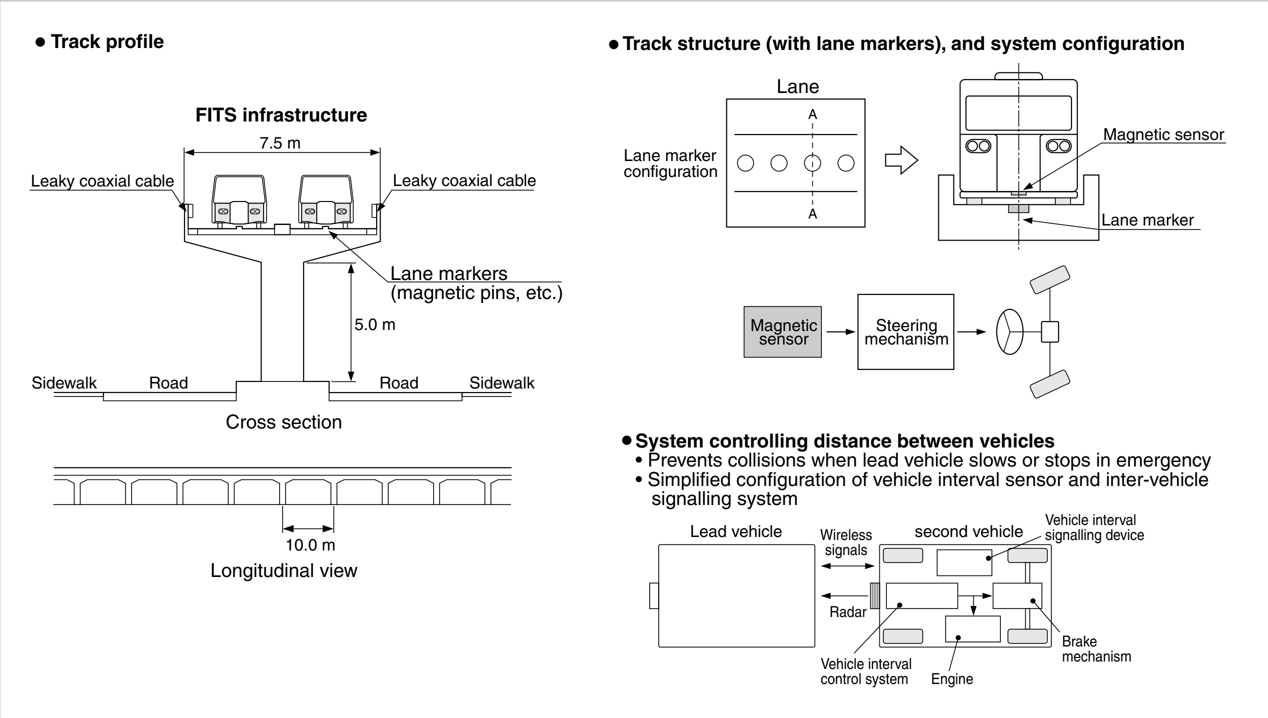
Vehicles

As presently envisioned, a gasoline engine will drive a generator to store electricity in batteries. This electricity will power the vehicle's two electric motors. The low-floor vehicle will follow a dedicated lane marked by magnetic pins. Sensors on the vehicle will detect the magnetic pins to control the steering. Switching the polarity of the magnetic lane markers will permit control of vehicles leaving and entering the dedicated lane. The distance between vehicles will be controlled by a front radar and vehicle interval control system that can apply the brakes when necessary. At high speeds, the distance between vehicles will be about 15 m. Figure 7 shows a diagram of the vehicle and the proposed specifications.

Lane structure

A single row of columns will bear the lane girders at a height of 5 m. The proposed concrete or asphalt road will have a width

Figure 8 FITS Infrastructure Concept



of 7.5 m and the construction methods will take durability, maintenance, and cost effectiveness into consideration. The vehicle wheels will be strengthened with steel fibers or other materials. There will be no need for special electrical or signalling equipment, nor for a vehicle shed. Figure 8 shows some more details.

The future

Once FITS is operational, it could spread to many areas; it offers great promise not only for conventional transport industries but also for new types of industry. The Society for New Transportation Systems is presently examining various issues with a view to promoting FITS.

The Japanese government has restructured its ministries and agencies this year. The Ministry of Land, Infrastructure and Transport has jurisdiction over all land, sea and air transport. Hopefully, this new administrative environment will make it easier to develop systems (like FITS) that exploit the advantages of both road and rail, and to propose, develop and construct new transportation systems based on new technologies.

With new technology, the transport sector can help society serve aging populations, combat global pollution, and develop even better lifestyles for all. ■

Kanji Wako

Mr Kanji Wako is Director in charge of Research and Development at the Railway Technical Research Institute (RTRI). He joined JNR in 1961 after graduating in engineering from Tohoku University. He is the supervising editor for this series on Railway Technology Today.

Akira Nehashi

Mr Nehashi is Director of Corporate Planning Department in Taiwan High-speed Railway Headquarters at Japan Railway Technical Service (JARTS). He joined JNR in 1970 after graduating in civil engineering from the University of Tokyo and worked both in the construction and shinkansen planning departments. He also held many positions at, National Land Agency and Japan Railway Construction Public Corporation before assuming his present post at JARTS.