New Urban Transit Systems Reconsidered
A Better Transport Environment for the Next Century

Akira Nehashi

Introduction

Travelling was a hazardous undertaking in ancient times. Nevertheless, people travelled no matter how perilous, costly, or time-consuming the journey. With the progress of civilization, transport systems have grown to cover the world and are even looking space-wards. Not only is transport an essential part of business, it also offers a vital means for people to meet, make friends, and enjoy nature.

Although telecommunications, computers, and the Internet are rapidly making the world smaller, permitting instantaneous exchange of information, they cannot transport people or goods. This communications explosion is making people want to travel to see other countries and cultures, in turn creating a need for advanced transport systems.

This article describes public transport systems in cities from ecological methods like walking and using bicycles to shinkansen. Although inter-city and international transport are important major fields, they are not covered here.

The concept of automated guideway transit (AGT) systems was first discussed around 1970, becoming a hot topic at an international transport exhibition held near Washington D.C., USA, in 1972. Subsequently, many new urban transit systems have become reality in various countries of the world. At the same time, there have been remarkable improvements and innovations to traditional transport systems.

The issue of so-called 'transport gaps', or missing links in urban transport facilities, was first raised by G. Bouladon in 1967[1], which was published in Japan as *Innovating Urban Transport: New Urban Transit Systems*[2]. In 1975, a Japan National Railways (JNR) working group published a report on AGTs called *New Transport Systems*[3], which was the most detailed and easy-to-understand work on this popular topic at that time.

Today, as we enter the new millenium, the changing economic and technical background are creating a need for new transport systems. Therefore, it is appropriate to reconsider the issue of AGTs and other modern urban transit systems from the viewpoint of transport infrastructure as part of social capital, and making the best use of current transport systems.

Urban Transport Issues

Key problems

Many cities throughout the world have tried to improve their urban transport overall. Some advanced western countries have simply magnificent urban transport environments compared to the congested environment in Japan. They have city planning, citizen participation in decision-making, financing from public funds, etc. On the other hand, many cities in developing countries still lack sufficient public transport facilities. For example, in some SE Asian countries, rapid concentration of populations in cities and increasing use of private vehicles raise serious concerns. We should all be concerned about these issues and their global impact on the earth's environment.

Major issues in Japan

There are four major issues concerning the construction of urban transit systems in Japan:

- The transportation environment must be improved to deal with issues of congestion, safety, environmental conservation, comfort, and access for physically-handicapped passengers.
- Construction of transport infrastructure must be coordinated with city planning using a master plan and must be executed in a timely fashion.
- The public must be involved in the decision-making processes to smooth contentious issues of land procurement and ease construction.
- Financing issues must be solved because the days when the costs of building a transport system can be covered by profits from fares and tariffs are long over.

Poor accessibility and links

Japanese railways, airlines, and harbours are under the jurisdiction of the Ministry of Transport, while the cities, roads, rivers, etc., are under the Ministry of Construction. (It appears that these two ministries will be combined as one new ministry called the National Land and Transport Ministry in 2001 as part of the government's rationalization plans.)

At present, when a railway is planned over or under a road or land, complex formalities are required because more than one ministry has jurisdiction. The different viewpoints of the two ministries and transport operators have discouraged efforts to solve the problems.

The light rail transit (LRT) systems, monorails, AGTs, and other new transit systems discussed later, have not been exempted from this red tape. In Japan, these new urban transit systems are often built using publicly-owned roads, putting them under the jurisdiction of the Ministry of Construction. Consequently, since they are operated by different bodies and are not seen as true railways, there have been problems coordinating direct links with railways. Moreover, the railways themselves are notorious for not creating good links between existing lines, not to mention the new entrants.

Even though the many kinds of new transit system offer great advantages for the city by easing road congestion around stations, pollution, etc., it is difficult to imagine that priority will be given to public convenience, satisfaction and comfort, under the present circumstances.

Awareness of feeder service

Feeder transport to railway stations is currently served by buses, taxis, and private

automobiles, causing problems of road traffic congestion, unreliability, and pollution. Providing a monorail or AGT system as a feeder service for railways may be too costly and unprofitable. In the West, LRT systems are being reconsidered for this role and there are many good examples such as dedicated LRT lanes, direct connections with existing railways, etc. To be successful, the chosen feeder system must first match demand. When making the selection, it is imperative to understand the features and advantages or disadvantages of all candidate medium-capacity systems, including case studies from various countries.
Two years ago, the Japan Railway Construction Public Corporation (JRCC) formed a study group to discuss urban transit systems. The findings on the technical advantages and transport abilities were summarized in *New Urban Transit Systems*[4]. The rest of this article discusses the issues in achieving a better transportation environment for the next millenium.

Urban Transit Systems

Subways and existing railways

These transit systems meet the needs of many commuters, providing rapid mass transport at an average speed of 30 km/h in large cities.

Automobiles

Automobiles are a common, versatile and convenient door-to-door transport mode. Depending on road conditions, it is possible to travel long distances quickly but they are inefficient in terms of capacity and speed compared to public transport.

Bicycles and walking

Wider sidewalks and more moving walkways, cycle paths and bicycle parking would allow many people to move easily over distances of up to about 2 km.

Buses and LRT systems

These services can carry several thousands of people each hour over relatively short distances of up to 10 km. In the past, their main role was to feed the metropolitan commuter train networks. In local core cities, they serve as the key transport mode.
However, the worsening traffic congestion in cities has adversely affected speed and regularity, resulting in lost passengers and forcing cuts in operation frequency or even closure of unprofitable routes. The lost passengers have turned to automobiles, aggravating city traffic congestion, pollution, etc.
These problems, coupled with the high cost of building underground railways, could be solved through use of lower-cost new urban transit systems.

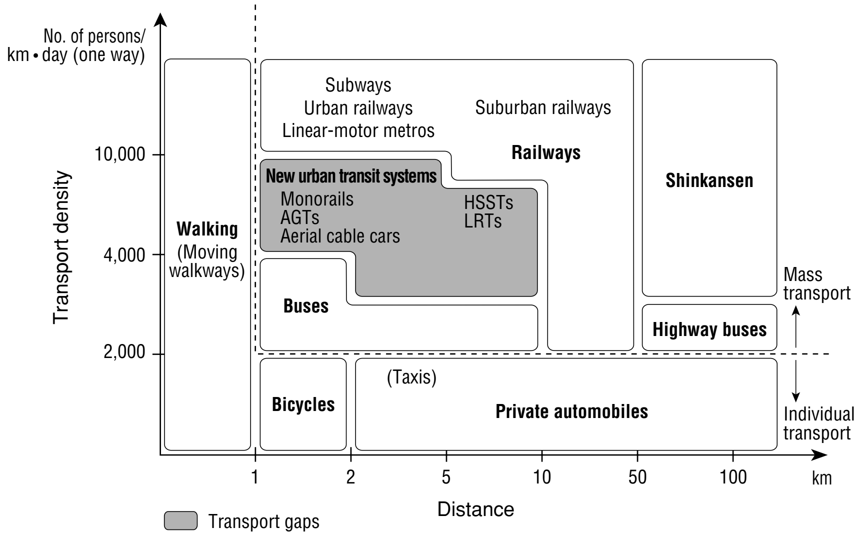
Transport gaps

Various figures that describe existing transport modes based on operation range, help identify transport gaps and visualize new transit systems. They usually show the transport density or capacity on the vertical axis and the distance on the horizontal axis. Some show the transport speed too.
Figure 1 gives an image of Japanese transport modes in an effort to find the ideal borderline separating mass and individual short-distance transport modes. The transport modes in the grey area are the new urban transit systems discussed here.
Shinkansen travelling a relatively short distance of less than 100 km, and highway express buses are included in this category. These medium-load transit systems are relatively new developments designed to meet the intermediate demand between mass transit railways and small-capacity buses. Some are already in operation. They include LRT systems, monorails, AGTs, linear-motor metros, high-speed surface transport (HSST) systems, and urban aerial cable-car systems, and a new bus transit system, an innovation of conventional bus services.

New Urban Transit Systems

The features and specifications of new urban transit systems are outlined in

Figure 1 Different Urban Transport Modes, and Transport Gaps in Japan



Tables 1 and 2 are summarized below. It should be noted that simple comparison of their advantages and disadvantages with other transport systems is not necessarily valid, because if they match the demand of a required service, they should be provided.

Table 1 Features of Urban Transit Systems

System	Features
Subways	• High-speed, mass-capacity
Buses	• Almost no fixed infrastructure • Flexible routing (easy additions and deletions) • Small- and medium-capacity
LRTs	• Use existing signal and operation systems • Simple and convenient • Low-cost construction and operation compared to AGTs or monorails
Monorails	• Space-saving • Can handle sharp curves and steep grades
AGTs	• Unmanned operation using fully-automatic system
Linear-motor metros (Small cross-section subways)	• Low-cost construction compared to conventional subways • Can handle sharp curves and steep grades
HSSTs	• Can handle sharp curves and steep grades • Almost no vibration noise • High-speed
Urban aerial cable cars	• Can handle long spans and steep grades • Space-saving • Low-cost construction compared to AGTs or monorails
Trunk bus systems	• Improved capacity, punctuality, and speed
Guided buses	• Flexible routing (can operate on ordinary roads in suburbs) • Facilities can be converted to AGT operation

LRT systems

The LRT system is a new medium-capacity tram system developed by re-evaluating an older concept and adopting the latest technologies. High-performance LRT cars run on rails in roads but are separated from automobile traffic, enabling them to maintain punctual, comfortable, and high-speed operation.

The capacity and speed are not as high as mass transit, urban railway systems and subways, but LRTs require much lower construction costs because infrastructure is built on the road surface. Therefore, LRTs are highly adaptable to local needs where population and transport capacity are not too high. LRT systems currently operating in Japan are shown in Figure 2.

Monorails

A monorail train travels along a single rail track on rubber tyres, and either straddles the track or is suspended from it. The first full-fledged urban monorail system in Japan was completed in 1964 linking downtown Tokyo and Haneda Airport, the capital's international airport at that time. Several urban monorail systems have been constructed since or are being developed or planned (Fig. 2).

Tram in Hiroshima *(Y. Akiyama)*

Construction of monorail systems was controlled by the Railway Enterprise Law, but the Law to Promote Urban Monorail Development, enacted in 1972, applies now.

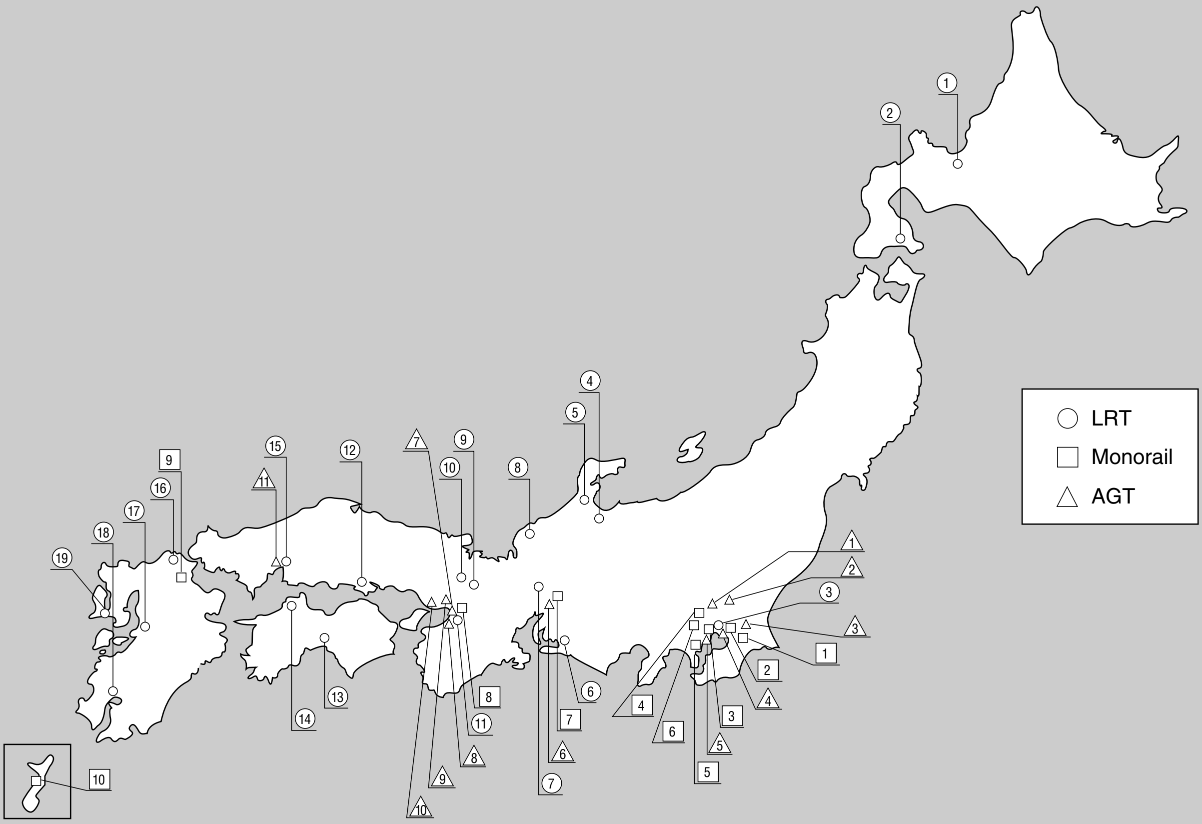
The advantage of monorails is that they use less land, can travel over steep grades and sharp curves, and the entire line can be built overhead. The first attempts to build monorails in Japan began in the late 1950s and the very first suspended monorail was completed in Ueno Park in Tokyo in 1958. At first, the monorail was a mere attraction, but by around 1965, there were many monorail development and construction projects; some foreign technologies were used and some Japanese companies developed their own technologies. Serious studies on their use in

Table 2 Specifications of Urban Transit Systems

Type	Construction costs [1] (including cars) (¥ million/km)	Schedule speed [2] (km/h)	Max. capacity [3] (passengers/h · one way)	Operating costs for standard schedule [4] (¥ million/km · year)	No. of passengers to cover operating costs (average fare: ¥150/passenger) [5] (passengers/km · day)
Subways	25,000 to 30,000	32	64,000	666	12,200
Buses	Approx. 0	12	2,500	41	700
LRTs	Approx. equal to guideway bus	20 to 25	14,000	113	2,100
Monorails	System: 3,000 to 7,000 Infrastructure: 3,500 to 7,500	30	26,000	221	4,000
AGTs	System: 3,000 to 6,500 Infrastructure: 3,500 to 10,000	27	18,000	233	4,300
Linear-motor metros (Small cross-section subways)	20,000 to 21,000	34	35,000	Approx. equal to conventional subway	Approx. equal to conventional subway
HSSTs	—	Approx. equal to conventional subway or linear-motor metro	15,000	—	—
Urban aerial cable cars	1,500 to 2,500 (Target)	23 (Target)	5,000 (Target)	—	—
Trunk bus systems	300	20	4,000	—	—
Guideway buses	3,300	20 to 25	4,000	—	—

1 April 1993 prices
2 Estimated speeds indicated as range; otherwise average speeds, both including intermediate stopping
3 • Subways, 10 cars, 2-minute headway, 1424 passengers per train, 150% of capacity (load factor), 1424 passengers/train × 30 trains/h × 150% = 64,000 passengers/h
• LRTs
Two cars, 2-minute headway, 150 passengers per car, 150% of capacity, 150 passengers/car × 2 × 30 trains/h × 150% = 14,000 passengers/h
• Monorails
6 cars, 2-minute headway, 95 passengers/car, 150% of capacity, 95 passengers/car × 6 × 30 trains/h × 150% = 26,000 passengers/h
• AGTs
6 cars, 2-minute headway, 75 passengers/car, 130% of capacity, 75 passengers/car × 6 × 30 trains/h × 130% = 18,000 passengers/h
• Linear-motor Metros
8 cars, 2-minute headway, 780 passengers per train, 150% of capacity, 780 passengers/train × 30 trains/h × 150% = 35,000 passengers/h
• HSSTs
6 cars, 2-minute headway, 326 passengers per train, 150% of capacity, 326 passengers/train × 30 trains/h × 150% = 15,000 passengers/h
• Urban Aerial Cable Cars
Automatic shuttling, 10-second intervals, 15 passengers per car, 100% of capacity, 15 passengers/car × 360 shuttles/h × 100% = 5,000 passengers/h
• Route Buses
2-minute intervals, 81 passengers per bus, 100% of capacity, 81 passengers/bus × 30 buses/h × 100% = 2,500 passengers/h
• Trunk Buses
50 buses per hour, 81 passengers per bus, 100% of capacity, 81 passengers/bus × 50 buses/h × 100% = 4,000 passengers/h
• Guideway Buses
Estimated as about same as trunk buses: 4,000 passengers/h
4 Calculated according to standard operation schedule and unit expenses in Ministry of Transport *Annual Railway Statistics 1991*
LRTs based on trams, and buses based on *1991 Road Transportation Business Management Indexes*
• Subways
Length: 10 km, 13 stations, 8 cars, 17 hours per day (4 rush hours of 5-minute headway, 13 hours of 10-minute headway)
• Monorails
Length: 10 km, 13 stations, 4 cars, 17 hours per day (4 rush hours of 5-minute headway, 13 hours of 10-minute headway)
• AGTs
Length: 10 km, 13 stations, 4 cars, 17 hours per day (4 rush hours of 5-minute headway, 13 hours of 10-minute headway)
5 The number of passengers required to cover the operating cost was calculated at an average fare of ¥150 per passenger based on actual data obtained from current urban transport systems:
No. of passengers = Operating expenditure per day/Average fare per passenger
If the number of passengers falls short of this value, continuous financial aid will be needed to cover both the operating and construction costs.

Figure 2 LRT, Monorail, and AGT Systems in Japan



LRTs

No.	Company	Route km	Remarks
1	Sapporo City Transportation Bureau	8.6	Public
2	Hakodate City Transportation Bureau	10.9	Public
3	Transportation Bureau of Tokyo Metropolitan Government	12.2	Public
4	Toyama Chiho Railway	6.4	
5	Kaetsuno Railway	12.8	
6	Toyohashi Railway	5.3	
7	Nagoya Railroad	29.9	
8	Fukui Railway	3.3	
9	Keihan Electric Railway	25.2	
10	Keifuku Electric Railway	11.0	
11	Hankai Tramway	18.7	
12	Okayama Electric Tramway	4.7	
13	Tosa Electric Railway	25.3	
14	Iyo Railway	9.6	
15	Hiroshima Electric Railway	18.8	
16	Nishi Nippon Railroad	5.1	
17	Kumamoto City Transportation Bureau	12.1	Public
18	Kagoshima City Transportation Bureau	3.1	Public
19	Nagasaki Electric Tramway	11.5	

Monorails

No.	Line	Route km	Remarks
1	Chiba Toshi Monorail	13.5	Suspended, quasi-public organization
2	Ueno Zoo Suspended Monorail	0.3	Suspended, public
3	Tokyo Monorail	16.9	Straddled
4	Tama Urban Monorail	16.2	Straddled, quasi-public organization, under construction
5	Shonan Monorail	6.6	Suspended
6	Mukogaoka Playland Monorail	1.1	Straddled
7	Monkeypark Monorail	1.4	Straddled
8	Osaka Monorail	13.3	Straddled, quasi-public organization
9	Kita Kyushu Monorail	8.4	Straddled, quasi-public organization
10	Okinawa Monorail	13.1	Straddled, quasi-public organization, under construction

*1, 3, 8, and 9 are under extension.

AGTs

No.	Line	Route km	Remarks
1	Seibu Railway Yamaguchi Line	2.8	
2	Saitama New Urban Transit Ina Line	12.6	Quasi-public organization
3	Yamaman Yukarigaoka Line	4.1	
4	Tokyo Waterfront New Transit, *Yurikamome*	11.9	Quasi-public organization
5	Yokohama New Transit Kanazawa Seaside Line	10.8	Quasi-public organization, standard for later models
6	Tokadai New Transit Tokadai Line	7.4	Quasi-public organization
7	Osaka Nanko Technoport Line	1.3	Quasi-public organization, under construction
8	Osaka Nanko *Newtram* Line	6.6	Public
9	Kobe New Transit Rokko Island Line	4.5	Quasi-public organization
10	Kobe New Transit Port Island Line	6.4	Quasi-public organization, first AGT
11	Hiroshima Rapid Transit *ASTRAM* Line	18.4	Quasi-public organization

urban transit was started in 1967, and unified monorail design standards were established in an effort to promote them as valid urban transit systems.

AGT systems

The AGT is commonly defined as a medium-capacity transit system running compact, lightweight, rubber-tyred trains along an overhead guideway; the system can be computer-controlled for unmanned operation.

The systems currently operating in Japan (Fig. 2) are popularly called new transit systems. They are not all fully automated but are still regarded as AGT systems for our purposes. Other countries have adopted different guideways, controls, switching designs, etc.

Development in Japan started in 1968; many different AGT systems have since been developed in various fields. The trend now is for larger coupled cars.

Linear-motor metros

Japanese subways are key urban transport facilities. However, construction costs have soared due to higher land prices, deeper construction, prolonged construction time, and other adverse conditions. Reducing construction costs and maintaining profitability are vital in developing subways.

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

If large passenger capacity is not required, construction costs can be cut by reducing the tunnel cross section through use of linear-motor cars (Fig. 3). The linear motor drives the car without depending on adhesion between wheels and rails, permitting use of steering bogies, and enabling the train to manage sharp curves and steep grades. The smaller tunnel cross section also permits more flexibility in planning a route.

A subway tunnel for linear-motor cars is 23% less expensive to construct than a tunnel for conventional subway cars. This reduction is achieved by a 52% scaling down in the tunnel cross section although track foundation costs are slightly higher than for conventional subways. The costs of train cars, power sub-stations, and other systems are similar.

In Japan, linear-motor metros are already in operation in Osaka and Tokyo, and other systems are being constructed or planned for other cities.

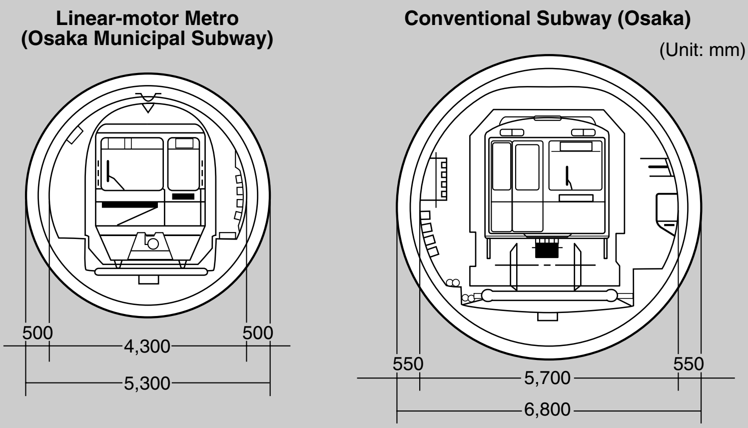
Magnetic levitation transit systems

In this system, the train is levitated by electromagnets and propelled by a linear motor. The major advantages are low noise and less friction permitting high-

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

Tokyo linear-motor metro Line No. 12 *(Tokyo Metropolitan Government)*

Figure 3 Cross Sections of Linear-motor Metro and Conventional Subway in Osaka



speed travel. A number of different systems are being developed, including: *Transrapid*, a repulsion-type system in Germany (*JRTR* 11, pp. 30–39), and the high-speed surface transport (HSST), an attraction-type system in Japan.

In Germany, full-scale development of *Transrapid* started in the late 1960s and one of the prototypes reached a top speed of 435 km/h in 1989. In Japan, a study on urban high-speed transit systems was started by Japan Air Lines in 1974 and development was subsequently taken over by the new HSST Development Corporation. An experimental line constructed in Nagoya over distance of 1.5 km with a minimum radius of 100 m and a maximum gradient of 70‰, has been in use since 1991. The HSST had a projected maximum speed of 200 to 300 km/h in the initial development stage, but recent tests suggest that a maximum speed of about 100 km/h is appropriate for urban transport. The introduction of urban HSST systems is being seriously studied in many parts of Japan.

Urban aerial cable-car systems

The aerial cable car, which is also called a ropeway or lift, runs on a cableway suspended overhead and has been a major tourist attraction at resorts throughout Japan. It uses minimum land and aerial space, is punctual, is low cost, can manage steep grades, which provides route flexibility, and is environment-friendly. Since these advantages are perfect for urban transit, its use as an economic, profitable, medium-capacity mode of transport is being evaluated.

However, in order to qualify as an urban transit system, further technical development is required to provide higher performance.

New bus transit systems

This is a new system being developed to improve the convenience and service of conventional bus systems. The improvements in Japan, range from simple bus priority lanes to development of trunk bus systems with extensive renovation of roads

HSST-100S on test track in Nagoya *(HSST Development Corp.)*

Shin Kobe aerial cable car *(Kobe City Urban Development Corporation)* for buses.

Promoting use of buses as convenient public transport requires suppressing use of private vehicles and attracting people onto buses. Bus routes and bus stops, schedules, convenience and comfort must all be improved.

Another improvement might be the introduction of guideway buses. Guideway bus systems use conventional buses fitted with simple, mechanical guides, and travel along a dedicated guideway. They have lower construction costs because they are much narrower than conventional elevated expressways. The Public Works Research Institute of the Ministry of Construction and private enterprises have been jointly researching the system since 1984. A prototype system operated for 6 months during the 1989 Fukuoka Exposition; a fully fledged system for commercial service has been officially adopted by Nagoya City and is now under construction.

Subsidies in Japan

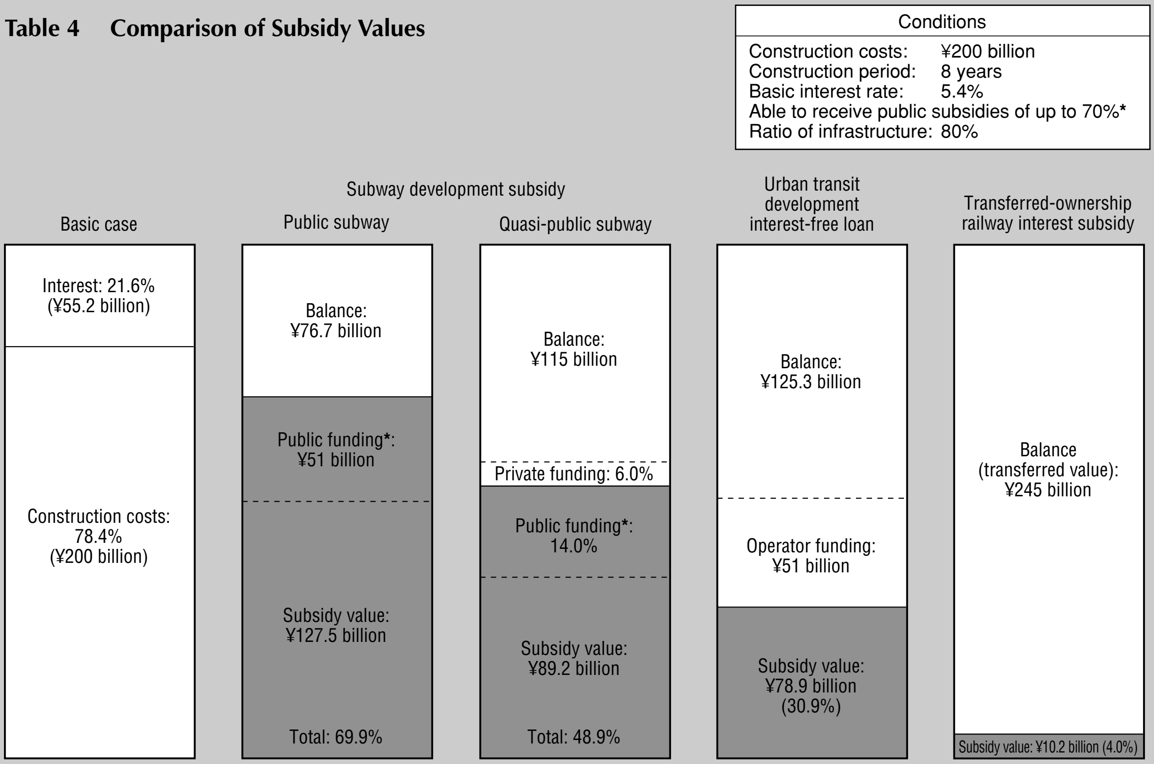
Japan has a number of systems for subsidizing railway development. A business planning to develop a railway can obtain subsidies from the national and regional governments if the plan fulfils the legal requirements. Table 3 lists the major available subsidies.

It is difficult to make simple comparison of subsidies because they are granted in various ways. One comparison (Table 4) converts the value of a subsidy into a value at the time of opening. (Subsidies received before opening are multiplied, subsidies received after opening are discounted, by the interest rate.) The comparison and calculation conditions are noted in the table. A public subway using the subway development subsidy scores the highest subsidy value of about 70%. In the case of a transferred-ownership line using the interest subsidy, which is applicable only to the portion the interest rate exceeding 5%, the subsidy value remains just 4%

Table 3 Major Subsidies for Railway Construction

Subsidy (Recipient)	Applicable Transport System (1997 budget in ¥ billion)	Condition and System Outline
Interest subsidy for leased/transferred-ownership lines (Japan Railway Construction Public Corporation)	JRs and private railways (1.5)	• Condition: Reinforcement or improvement of JRs and private railways in metropolitan areas • Outline: JRCC arranges and transfers funds to company National and local governments bear interest exceeding 5%
Subsidy for subway development (subway companies)	Subways (68.3)	• Condition: Subway construction or improvement by Tokyo's Rapid Transit Authority (TRTA) or public or quasi-public (3rd sector) operators • Outline: Grants of up to 70% of construction costs
Subsidy for new-town railways (local government, quasi-public organizations, Housing and Urban Development Corporation)	New-town railways (2.7)	• Condition: Public or quasi-public new-town railways in metropolitan areas • Outline: Grants of up to 36% of construction costs (borne by national and local governments)
Subsidy for infrastructures (public or quasi-public organizations)	Monorails, AGTs, etc.	• Condition: Systems for which public or quasi-public organizations can obtain operators license covered by related regulations, etc. • Outline: Road authority constructs infrastructure and operator runs system. National and local governments bear up to 57% of infrastructure costs
Subsidy for waterfront railway facilities (railway companies)	Monorails, AGTs, etc.	• Condition: Facilities designated in waterfront development plans including reclaimed land • Outline: Port authority constructs infrastructure and operator runs system. National and local governments bear up to 57% of infrastructure costs
Subsidy for airport railway facilities (railway companies)	Airport access transit systems	• Condition: Airport facilities • Outline: Airport authority constructs infrastructure and operator leases and operates system
Interest-free loan for urban railway development (JRCC, TRTA)	Urban railways (37.6)	• Condition: Construction of new lines, double- or quadruple-tracking passenger railways in seven major cities of Japan • Outline: Government loan of up to 40% of costs, no repayments for first 5 years, and redeemed in 10 years. Interest-free top-up loans or subsidies available from local governments

Table 4 Comparison of Subsidy Values



- For urban transit development interest-free loan, amount equivalent to theoretical interest accrued for loan taken as subsidy value
- Local public funding considered part of subsidy

when calculated using an interest rate of 5.4%. However, the interest subsidy is losing its advantage because of the current low interest rates.

When these Japanese subsidies are compared with other countries, excluding public and quasi-public (new-town) transit systems, there are more private transport companies in Japan that develop their facilities without subsidies (Fig. 4).

For a Better Transport Environment

Suppressing automobile traffic

There are seven good reasons justifying suppression of urban automobile traffic:

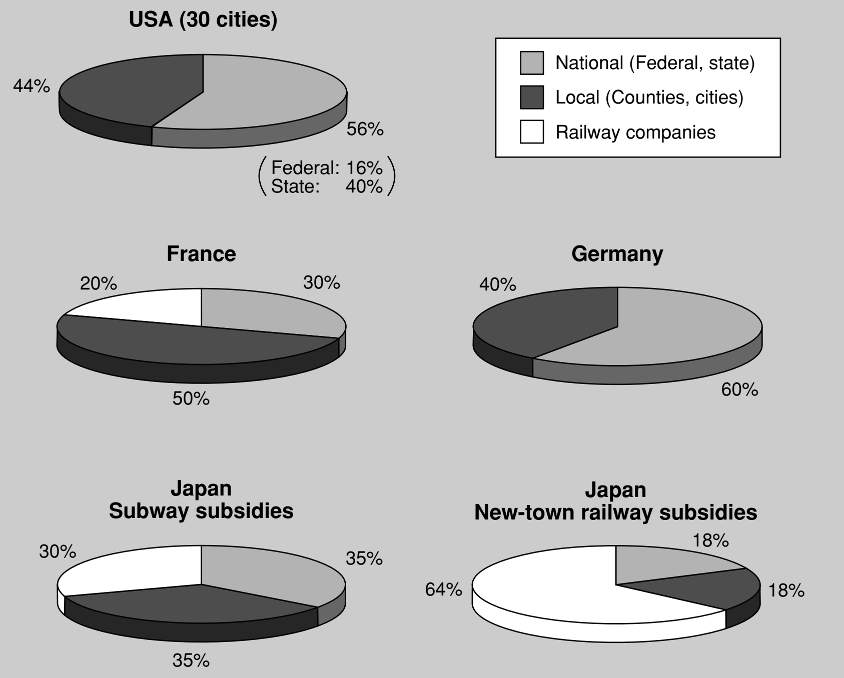
- Insufficient infrastructure to support sharply increasing numbers of vehicles
- Development of required infrastructure occupies vast areas of city centres
- Accidents, noise, and exhaust have negative socio-economic impact
- Traffic congestion adversely affects public transport for non-automobile owners
- Public transport is needed for efficiency and flexibility
- Private automobiles waste scarce resources
- Automobiles damage the environment of residential and commercial areas

The completion of LRT and subway systems in Los Angeles, underscores the pressing need for new urban transit systems in even the most automobile-oriented city in the world.

But to be realistic, since it is not possible to entirely abolish automobiles for private transport, construction of public transport to achieve a better environment must be tailored to the local needs. It is vital to take the following points into consideration:

- Construction and operating costs should be held as low as possible, but cheaper is not always better—future demand based on growth of the city should also be considered.
- The system must be easily accessible—links with existing transport modes as well as access to business and residential areas must be considered in determining the route and station locations.
- Acquisition of land and space must be carefully considered to maintain harmony with geography and city planning.

Figure 4 Urban Transport System Construction Cost Ratios



For the last 30 years, Japan has been in the habit of choosing the seemingly-economical automobile as its main transport mode without considering the problems of exhaust and noise pollution, accidents, etc. The reasoning is that roads are needed to solve the problem of traffic congestion and pollution will be minimized once congestion is solved. Development of roads is therefore mistakenly seen as meritorious from the viewpoint of protecting the environment.

A similar trend is being followed elsewhere in Asia causing grave problems in those countries, as well as global-scale environmental problems. Development of clean, public transport would help solve both these local and global problems.

Supporting development of urban public transit systems

There are four major methods for supporting development of urban transit systems in Japan:

- Leasing public urban transit facilities to private companies
  This idea has been devised to cope with the poor incentive for private companies to make new expensive long-term investment in transport infrastructure. A project considered worth developing as part of the city planning is completed by the public authority and is then leased to a private operator. This minimizes the adverse effect of infrastructure costs on operating profits.
- Promoting joint ventures or integration with other transport or city facilities
  For better efficiency, comprehensive systems should be established that integrate conventional transport modes, new transit systems and local facilities into new medium-capacity feeder systems. Public initiatives should be taken.
- Providing subsidies for technological development
  A new subsidy system should be established to promote technologies for development of deep underground space and medium-capacity transport technologies, etc.
- Securing funding
  Traditionally, urban railways in Japan have long been regarded as profitable private businesses and have not received subsidies. But unlike private railways, private subways have received ample subsidies due to their very high construction costs.

Today, neither private nor public transport companies have any incentive to justify the huge investment in building a new transit system, due to the poor chance of acquiring sufficient new business to cover the costs. The railways face an interesting dilemma in that maintaining profitability relies on maintaining the status quo of overcrowded rush hours, rather than improving services. Therefore, it is essential to provide subsidies to revive their enthusiasm for investment. The transport budget may have to be reorganized in coordination with non-transport sectors in an effort to appropriate more to transport.

Against the background of environmental problems such as global warming, the rationale underlying European taxation systems favouring developments of railways over roads based on the need to protect the environment may be worth considering, but a political decision will be necessary. It may also be necessary to find a method of calculating the true costs of each transport mode, especially, the social costs of road accidents, pollution, etc.

Issues of construction cost and period

In order to accomplish future development of urban transit systems, there are five major points demanding substantial recognition.

First, efforts should be made right from the planning stage to reduce construction costs, coupled with thorough costing of every alternative route and scrutiny of all available new systems.

Second, efforts should be made to find ways to cut costs at the construction stage. Although new technologies can be a driving force behind a project, the duration of the construction , and hence cost, is greatly influenced by consultation with related organizations and communities. New technologies should be fully utilized whenever possible, but achieving a consensus based on past experience and trust is also a vital factor.

Third, a consensus should be reached as soon as possible to enable an early start. Any delay in launching a service adversely affects future operation. Shortening the construction period is as crucial as cutting the costs.

Fourth, proper services should be ensured for passengers. The basic specifications and standards should all be in accordance with future demand and maintenance requirements. The operator should have a variety of options to permit selection of the best business choice.

Lastly, efficiency should be ensured to achieve high productivity. To reduce construction cost and shorten the work period, efficient and quick decision-making procedures should be established.

Conclusion

The post-war development of public transport in Japan has been very successful in building national transportation systems, including shinkansen, expressways, and airports, as well as urban systems, such as subways, urban transit systems, and highways. However, recently voices claiming that railways are no longer needed in Japan due to the lack of funds and anticipated decline in the population are becoming more strident. But as a railway construction engineer, I sincerely believe that development of public urban transit systems, especially railway networks, is essential in preparing ourselves to tackle the serious problems facing the next century.

With the benefit of hindsight, perhaps railways have been too passive in the past, but the time has come for them to take the initiative in making a strong case for developing new urban transit systems in cooperation with regional planning and existing public transport, such as railways and buses, for the third millenium. ■

Notes:

1 G. Bouladon, 'The Transport Gaps', and 'Transport', published respectively in *Science Journal* by Associated Life Press. Ltd., London, in April and October, 1967.

2 Published by Japan Transport Economics Research Center, Tokyo, December 1970.

3 Published by Japan Railway Civil Engineering Association, 1975.

4 Edited by Urban Transit Study Group and published by Sankaido, Tokyo, 1997.

JRCC

The Japan Railway Construction Public Corporation (JRCC) is a national, public organization founded in 1964 with the aim of building the Japanese railway network. So far, the Corporation has constructed a total of 2348.1 km of railways on 93 different lines. Examples of the Corporation's work include the famous 53.8-km Seikan Tunnel under the strait between Honshu and Hokkaido, and the Joetsu Shinkansen, the first shinkansen line to cut through the heavy-snow regions of central Honshu. Moreover, the Corporation is currently constructing railways on 30 lines (808 km). Work is also underway on three new shinkansen lines, and *Maglev*.

The Corporation's mission is to build high-quality and safe railways as quickly and economically as possible. From time-to-time, it also assists in planning overseas railway projects.

Akira Nehashi

Mr Nehashi graduated in Civil Engineering from Tokyo University and joined JNR in 1970 where he worked in both the construction and shinkansen planning divisions. He is presently Deputy Director of Planning Department in charge of Project Research at JRCC.