7TH WCTR SYDNEY AUSTRALIA 1995

TOPIC 34
URBAN PUBLIC
TRANSPORT

DESIRABLE URBAN RAILWAY SERVICE

MAKOTO ITO
Study and Research Division
Japan Transport Economics Research Center
3-18-19 Toranomon, Minato-ku, Tokyo 105, JAPAN

YOSHIHIRO AKIYAMA
Japan Railway Technical Service
4-8-13 Hongo, Bunkyo-ku, Tokyo 113, JAPAN

SHIGERU NAGASHIMA
Design Division
Teito Rapid Transit Authority
3-19-6 Higashi-Ueno, Taito-ku, Tokyo 110, JAPAN

Abstract

Towards the alleviation of the current state of serious congestion in Japanese urban railways in the peak rush hour, this paper reviews new service level goals for Japanese urban railways by comparing and analyzing congestion rates on urban railways in Japanese, European and American cities using common indices.

BACKGROUND AND AIM OF STUDY

In recent years, in Asia and other parts of the world, there has been an acceleration of population concentration in big cities. In order to make possible a standard of urban life appropriate to the 21st century, there are many problems that cities will have to resolve, in the areas of housing, land, environment, transportation, etc.

As regards urban transportation, improvements to urban railways, such as easing congestion, increasing commuting speed, etc, may be considered some of the most important factors in improving the quality of life of residents of large conurbations. Taking Japan's Tokyo as one example of a major conurbation, railway facilities are crammed beyond capacity at rush hours to the point that some commuters must take the next train. Therefore, it is necessary to take steps such as increasing the number of cars in train make-up, increasing the frequency of trains, rearranging schedules to meet the needs of passengers, and the construction of new lines as well as the upgrading of existing ones, etc, to be able to provide commuters with a more comfortable and convenient urban rail service.

As these improvements proceed, it is necessary to establish new levels for urban rail transport services that will be in keeping with the affluent standard of living in Japan in the 21st century. In researching these service levels, it is also vitally important to compare the rail service levels of major cities abroad (particularly America and Europe) which are of a similar scale to cities in Japan.

However, although there is no shortage in Japan of documented material on railways in other countries, and many transport operations and policies organizations have gathered and collected information in other countries, and in spite of the many on-site surveys conducted overseas, there is still a serious scarcity of data that can be used to provide strict comparisons. For example, the most important indicator of service levels in Japan is the "congestion rate" at rush hours in the most crowded sections. However, when one tries to compare the situation with that in other countries, one finds that the same kind of indicator is not used in other countries, and an accurate comparison is impossible.

Faced with this problem, one of the aims of this study was to research congestion situations in urban railways of four major European and American cities (London, Paris, New York, Washington D.C.), using the same methods that are employed in Japan, in order to make comparisons and to find out what levels of service urban railways in Japan should be aiming for.

TARGET CITIES AND THEIR RAILWAYS

New York, London and Paris were chosen as examples of large conurbations similar in scale to Tokyo, and Washington D.C. as an example of a typical provincial conurbation. The cities and their railways are outlined in Table 1.

London

London is composed of Inner London, which is the City of London, and 12 boroughs, and Greater London, including a further 20 boroughs. In a broad sense, the London metropolis can be considered that area falling within a 50 km radius of the center of the City of London.

The population of Greater London was 6,380,000 in 1991, and continues to decrease year by year.

London's railways are operated by London Underground, a subsidiary of London Transport, and British Rail. London Underground takes care of rail transport within the city, while British Rail's NSE (Network SouthEast) handles suburban transport.

Table 1 Comparison between major cities in Japan and in Europe and America

Item		London (Britain)	Paris (France)	New York (USA)	Washing ton D.C. (USA)	Tokyo (Japan)	Nagoya (Japan)	Osaka (Japan)
Population	Inner (1,000s persons)	6,380	2,150	7,310	610	7,980	2,100	2,510
	Greater (1,000s persons)	12,110	10,650	17,950	3,920	31,880	7,460	15,960
Area	Inner (km2)	1,579	105	800	159	618	326	221
	Greater (km2)	10,621	12,011	19,755	10,274	13,141	3,866	7,427
Population Density	Inner (persons/ km2)	4,041	20,476	9,138	3,836	12,909	6,442	11,357
	Greater (persons/ km2)	1,140	887	909	382	2,426	1,930	2,149
Operating railway	Underground (km)	394	315	398	144	230	77	107
	Suburban (km)	3,242	1,512	1,109	448	2,008	766	1,345

Source: (1) Population / area are from Japan Transport Economics Research Center (1994).
(2) Operating railway kilometerage are from Jane's Information Group (1994).

London Underground operates 11 lines, covering 394km, and carries around 730 million passengers a year. BR's NSE covers a wide area, from the center of London, radiating outwards to the south of England, and the exact range of its function as an urban railway is unclear. NSE operates a total of 11 lines on 3,242km of track, and carries around 500 million passengers a year.

Paris

The Paris metropolitan area comprises the Inner Ring, made up of the city center, and three surrounding departments, and the Outer Ring, made up of four departments outside the Inner Ring. Together, these areas are known as the Ile-de-France.

In 1990, the population of the Ile-de-France was 10,650,000, and while the population of the city itself is decreasing year by year, the population of the surrounding departments is increasing.

Paris' railways are operated by RATP (Régie Autonome des Transports Parisiens), and SNCF (Sociétié Nationale des Chemins de Fer Français). RATP operates the underground, while SNCF operates the intercity railway, including the urban railway. In addition, the RER (Réseau Express Régional), a local express service that runs through Paris, is operated jointly by RATP and SNCF.

RATP has 15 underground lines, covering 201km, and carrying 1.2 billion passengers yearly. RER has 4 lines, and covers 363 km (114km underground + 249km in the suburbs), and carries 370 million passengers yearly. SNCF's lines cover 1,263km in the suburbs, and carry some 540 million passengers yearly.

New York

The New York metropolitan area is defined by two concepts, the Standard Metropolitan Statistical Area, and the Standard Consolidated Statistical Area.

Firstly, the Standard Metropolitan Statistical Area (SMSA), centered around Manhattan consists of the 5 counties of Manhattan, Brooklyn, Queen's, Bronx, and Richmond in New York City, Rockland, Weschester, Putnam counties in New York State and Bergen county in the State of New Jersey. However, this definition of the SMSA was considered too small, and in 1960, the Standard Consolidated Statistical Area (SCSA) was established, comprising the 10 counties of New York State, and the 9 counties of New Jersey, surrounding the SMSA, and in addition, part of Fairfield County in Connecticut.

In 1980, the population of the metropolitan area was 9.12 million for the SMSA, and 16.63 million for the SCSA, and the extension of residential areas continues. The population of New York City was 7.35 million in 1988, and continues to increase year by year.

Practically all of New York's urban rail transport is managed by the MTA (Metropolitan Transportation Authority). Under this umbrella, the NYCTA (New York City Transit Authority) manages the underground, while the LIRR (Long Island Rail Road) and MNCR (Metro-North Commuter Railroad) operate the suburban railways. In addition, there is also a suburban railway run by the Port Authority of New York and New Jersey (PATH).

The NYCTA is mainly responsible for inner city rail in New York, operating 26 lines on 398km of track. Around 1 billion passengers are carried yearly.

Suburban railways are operated by LIRR, to the east of Manhattan, MNCR, to the north, and PATH to the west. The railways cover 1,109km, and carry 180 million passengers per year.

Washington D.C.

Washington's railways are operated by three bodies; WMATA (Washington Metropolitan Area Transit Authority), MARC (Maryland State Railroad Administration), and Virginia Railway Express.

WMATA operates the underground, with 5 lines and 114km of track, carrying 150 million passengers per year.

MARC makes use of Amtrak (National Railroad Passenger Corporation) lines, and operates three lines. The number of passengers carried is low; 4.5 million yearly.

Tokyo

The Tokyo Metropolitan Area is the largest conurbation in Japan, and is composed of Tokyo city itself, and surrounding prefectures; Kanagawa, Saitama, Chiba, etc The metropolitan area spreads to some 60 km from the center of Tokyo. The total population of this area is 31.88 million persons, with a continuous, slight increase. The population of Tokyo city itself is 7.98 million persons.

Tokyo's railways are run by 11 private railway companies, beginning with the East Japan Railway Company, which operate the suburban railways, and the Teito Rapid Transit Authority, and the Tokyo Underground, which operate the underground railways. Suburban and underground railways cover 2,008km, and 230km, respectively, and carry a combined total of 13.4 billion passengers yearly.

SURVEY METHOD

In order to gain a comprehensive understanding of the situation with regard to congestion and other railway service levels in European and American cities, surveys were carried out according to the following procedures. Further, in order to obtain international comparisons of congestion levels, the surveys targeted the most congested sections of the underground and suburban railways of each city.

Investigation of existing documentation

Statistical data and timetables obtained from past surveys were used to gain a comprehensive understanding of railway service levels.

Information from railway operators

Railway operators were asked in advance to provide details of the most congested sections, and the numbers of passengers during rush hours in those sections, frequency of trains, train floor plans, train make-up, etc In addition, permission was obtained for interviews with railway operators and counting numbers of passengers on station platforms.

Interviews with railway operators

Two survey teams (6 members each) were sent to Europe and America in order to conduct the urban railway surveys. They visited the offices of the railway operators and were able to confirm certain items necessary to the survey, and to ask additional pertinent questions.

Visual survey at stations

Team members conducted on-site (visual, photographic, video) surveys to count the numbers of passengers on platforms during peak rush hours in the areas of most crowded sections. The following three methods were used together in the survey.

a. On site counting

b. Counting from photographs

c. Counting from video tapes

Method a. was the basic method, verified and corrected by methods b. and c. upon the team's return to Japan.

INDICES TO INDICATE THE LEVEL OF CONGESTION

Method used to calculate congestion rates in Japan

In Japan, the "congestion rate" is the most common indicator use to express levels of congestion.

The congestion rate is found by dividing the transport volume by the carrying capacity of the congested section. The transport volume is the volume obtained by the survey of each train. Carrying capacity is found from the number of trains and the normal accommodation capacity, which is calculated from the train floor space by using the method set forth for each type of seating, as described in the "Urban Transport Annual Report in Japan".

Long seat: The area inside the carriage (excluding the driver's cabin, and machinery space, etc) is divided by the area per passenger ($0.35m^2$) to give normal accommodation capacity. Fractions are rounded down.

Semi cross seat: The area inside the carriage (excluding the driver's cabin, and machinery space, etc) is divided by the area per passenger ($0.40m^2$) to give normal accommodation capacity. Fractions are rounded down. In this case, if the total number of cross seats exceeds 80% of the total, then the standard for all cross seats shall be taken.

All cross seats: The number of seats gives normal accommodation capacity.

Congestion level indices in Europe and America

The same ideas for Japan's congestion rate are not necessarily used in Europe and America, and there are many ways of expressing the congestion level. For this reason, it is necessary to have a good understanding of these differences when comparing and analyzing data pertaining to levels of congestion in different cities.

Some of the different concepts showing levels of congestion are laid out here.

Train capacity

When expressing levels of congestion, it is not simply a matter of whether the Japanese style "congestion rate" is used or not, but also whether carriage capacity was used in the calculation, and indeed how carriage capacity is calculated. In other words, even if data from Europe and America are expressed in terms of a "congestion rate", if the concept of carriage capacity is different, a consistent comparison/evaluation is very difficult. Therefore, when comparing and evaluating congestion levels, it is necessary to universalize the concept of carrying capacity (calculation method).

Other indices

Besides the Japanese style "congestion rate", other means of expressing the level of congestion, such as "standing passengers per 1 m2 of standing space", or "floor space per standing passenger" are used. These are different from the indices usually employed in Japan, but are useful in providing a consistent index for comparison and analysis, where there are differences in the type of carriages, etc

Differences in time periods, etc

As a means of showing the level of congestion, "one carriage", "one train", or "one peak hour" can be set as the standard. In Japan, the usual value in new railway planning, transport capacity reinforcement, etc, is the congestion rate per peak hour on the line.

LOCAL SURVEY RESULTS

Local survey

Local, on-site surveys were conducted during weekdays in London, Paris, New York, and Washington D.C. from late October to early November, 1993.

Organization of data

The measured data were arranged in the following ways.

Testing of data

Video tapes and photographs were used to check whether there were any great discrepancies in the data, and used to check variations in the collected data. Also, by using the data obtained during interviews with railway operators, measured data were tested.

Transport volume

Transport volume was calculated as follows, based on the collected data.

a. Average passengers per train (per carriage)

   The data were used to calculate the number of passengers on a per-carriage basis for each train. The average data collected by the surveyors was used to find the average number of passengers per train, because of the possibility of there being variations between the congestion level of individual carriages.

b. Congestion analysis by time period

Because of variation in the congestion levels of each train, the congestion rate distribution was organized into average figures for 10 minute intervals.

c. Transport volume per 1 peak hour

The transport volume per 1 peak hour was calculated by multiplying the average number of passengers per carriage by the number of carriages in 1 peak hour, during the observation time period.

Transport capacity

In order to match the method of expressing the transport capacity of the measured section in each country with that used in Japan, the following calculations were used.

a. Normal accommodation capacity

Normal accommodation capacity for each carriage is calculated according to the calculation method of Japanese congestion rates.

b. Transport capacity in 1 peak hour

The transport capacity is found by multiplying the normal accommodation capacity calculated above by the number of carriages and trains. The figures in a. and b. do not match the thinking of European and American railway operators as to the normal accommodation capacity or the transport capacity.

c. Standing floor space

The amount of standing floor space is also used to calculate the level of congestion, and the floor space is calculated for each type of carriage, using the Japanese method.

Survey results

Table 2 shows the survey results calculated by using the data collected on site, in the same way as is done in Japan. Table 2 is drawn up separately for underground and suburban railways.

Table 2 Outline of survey results

1 Underground railway

Item	London	Paris	New York	Washington D.C.
Operator	London Underground	RATP	NYCTA	WMATA
Line	Central Line	No. 13 Line	Lexington Avenue Line	Red Line
Most congested section	Bethnal Green-Liverpool St.	Saint-Lazare-Miromesnil	42nd St.-14th St.	Judiciary Square-Union Station
Peak rush hour	8:00~9:00	8:10~9:10	8:10~9:10	17:00~18:00
Train frequency	2 min.	1 min. 45sec.	3 min.	3 min.
Consist	8 carriages	9 carriages	10 carriages	4/6 carriages
Rolling stock type	Long seat Semi cross seat	Semi cross seat	Long seat	Semi cross seat
Average peak rush hour congestion rate	96%	164%	95%	68%
Maximum congestion rate	123%	222%	129%	104%

2 Suburban railway

Item	London	Paris	New York	Washington D.C.
Operator	BR	RATP	PATH	MARC
Line	Network SouthEast	RER A Line	No. 1, No. 2 Lines	MARC Penn Line
Most congested section	New Cross-London Bridge	Châtelet Les Halls-Auber	Exchange Place-World Trade Center	Union Station-New Carrollton
Peak rush hour	8:00~9:00	8:00~9:00	7:50~8:50	16:30~17:30
Train frequency	2 min.	2 min.	1 min. 50 sec.	15 min.
Consist	8/10 carriages	9 carriages	7/8 carriages	5~7 carriages
Rolling stock type	All cross seat	All cross seat	Long seat	All cross seat
Average peak rush hour congestion rate	149%	152%	71%	72%
Maximum congestion rate	175%	192%	94%	84%

Underground railways

Comparing London, Paris, and New York, overcrowding on trains is worst in Paris, topping 164% per hour average, with 222% in the worst case, close to Japanese figures. London and New York had almost the same levels of congestion. The worst congestion in Washington was around 100%.

Suburban railways

Suburban railways in Paris also exhibited fairly high congestion rates, at 152% per hour average, with the most crowded train having a 192% congestion rate. London had rather a similar congestion rate. Judging from these results, it would seem that New York is able to offer a comparatively more comfortable ride to work. Washington's figures were about the same as those for New York. One reason that America has a comparatively comfortable congestion rate is probably that it is normal for all passengers to be seated on the suburban railways.

However, considering the physical differences between Japanese and Westerners, and the fact that many trains in Europe and America have semi cross seats or all cross seats, there are many points to be paid attention to when making comparisons, and it is clear that future analysis will need to become even more detailed.

COMPARATIVE ANALYSIS OF CONGESTION LEVELS

International comparison of indices of target congestion levels

In order to compare the congestion levels of urban railways, the indices of the "congestion rate" in Japan, and the "number of standing passengers per 1 m^2 of standing space" are used.

Standards for improving the level of congestion in Japan

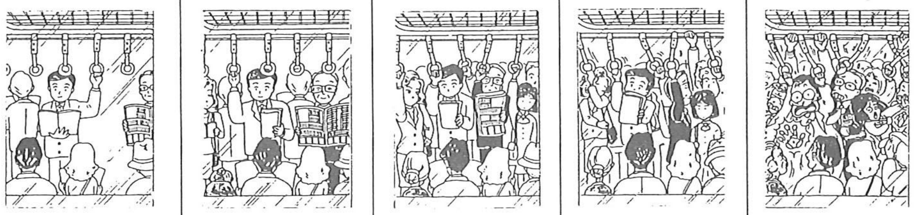
In Japan, the standard for improving service levels of urban railways in order to ease congestion is described as follows in the Council for Transport Policy Meeting's "Basic concepts concerning mid and long term railway improvements towards the 21st century" (Report No. 13, June 19th, 1992) (Figure 1).

Improvement levels for urban railways in order to ease congestion

When planning to make investment in order to ease congestion on metropolitan railways, the following levels should be used as targets for improvements.

a. An average congestion rate on major sections of each metropolitan urban railways during rush hours should be around 150% as a whole.

b. But, in the case of the Tokyo metropolitan area, for the next ten years, the target should be an average congestion rate of 180% on major sections during rush hours as a whole.



100%	150%	180%	200%	250%
With normal accomodation capacity. (Passengers able to choose whether to sit, or stand.)	Shoulder to shoulder, but still able to read a newspaper, for example.	Bodies touching each other, but still able to read a folded newspaper.	Closely packed, with feeling of being squeezed, but still able to read a magazine or book.	Body sways with movement of train. Unable to move freely, unable to move hands freely.

Figure 1 Congestion rate

Target congestion levels in European and American cities

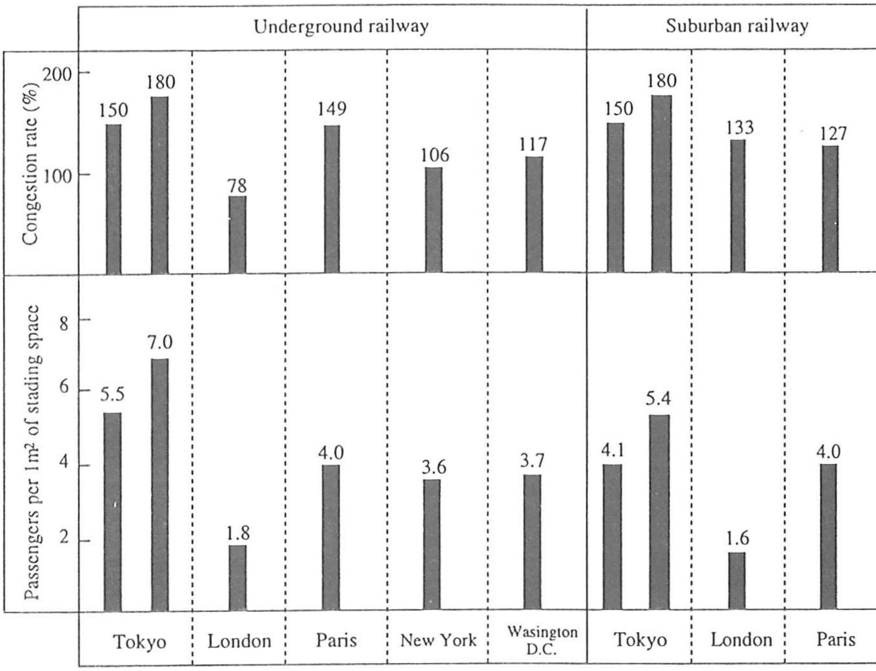
The target congestion levels for the underground railways, which are laid down by railway operators and governments in Europe and America are shown in Table 3. The target congestion level for the suburban railways are, in London—1 standing passenger for every 3 seated passengers—in Paris, the same standard as the Paris underground; and in New York and Washington D.C.— "all passengers seated" is regarded as the norm.

Table 3 Congestion standards on underground railways

City	Allowable congestion
London	The concept standard is that passengers should be able to stand without touching. Therefore, the capacity should be able to give a ratio of 1:1 of standing passengers to seated passengers.
Paris	Excluding floor space for seats, the number of standing passengers at peak hours should not exceed 4 persons per m^2.
New York	Standing space at peak hours should be 3 ft^2 per person. ($0.15m^2$ per person = 6 persons per m^2)
Washington D.C.	Standing space at peak hours should be 3 ft^2 per person. ($0.15m^2$ per person = 6 persons per m^2)

Comparison between Japan and Europe and America

The congestion levels in Japan and Europe and America are shown in Figure 2, using the same indices of the congestion rate and the number of standing passengers per 1 m^2 of standing space. As this graph shows, European and American cities have much more comfortable targets levels of congestion than Japan.



Notes:

1. Standing passengers per 1m^2 of standing space for Tokyo was calculated by using rolling stock type of Teito Rapid Transit Authority and East Japan Railway Company.
2. For New York and Washington D.C. suburban railways, the standard is seated passengers, and so these figures have been omitted.

Figure 2 **International comparison of congestion indices**

Comparative study of service levels

The congestion rate, as one example of a railway service level, is used to compare actual values and target values. The results are shown in Table 4. The values in this table were calculated, for each city and railway, by dividing "average congestion rate at most congested hour" by "target congestion rate".

This gave figures for 110% to 120% for London and Paris, with 60% to 90% for New York and Washington, illustrating a considerable gap between service levels in Europe and America.

Table 4 **Comparison of actual and target congestion rates**

	London	Paris	New York	Washington D.C.
Underground railway	123	110	90	58
Suburban railway	112	120	71	72

International comparison of congestion levels

Figures 3 to 6 show the results of comparisons made between levels of congestion on underground and suburban railways in Japanese cities and European and American cities. Photos 1 and 2 show the congestion levels of each city for underground and suburban railways separately.

Underground railways (Figures 3, 4)

With the exception of Paris, underground railways in other countries have much lower congestion rates than those in Japan, and even by comparing the number of standing passengers per $1m^2$ of standing space, there appears an obvious gap between the service levels at rush hours in Japan, and that in Europe and America.

Suburban railways (Figures 5, 6)

There is a considerable difference between congestion rates in Japan, and those in Europe and America, and the number of standing passengers per $1m^2$ of standing space is about half that of Japan.

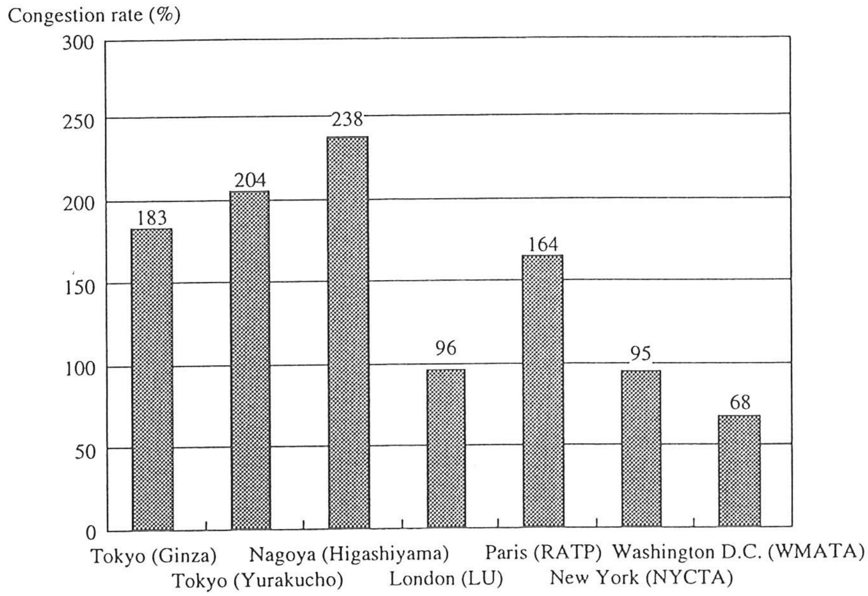


Figure 3 Congestion rate for 1 peak hour (underground railway)

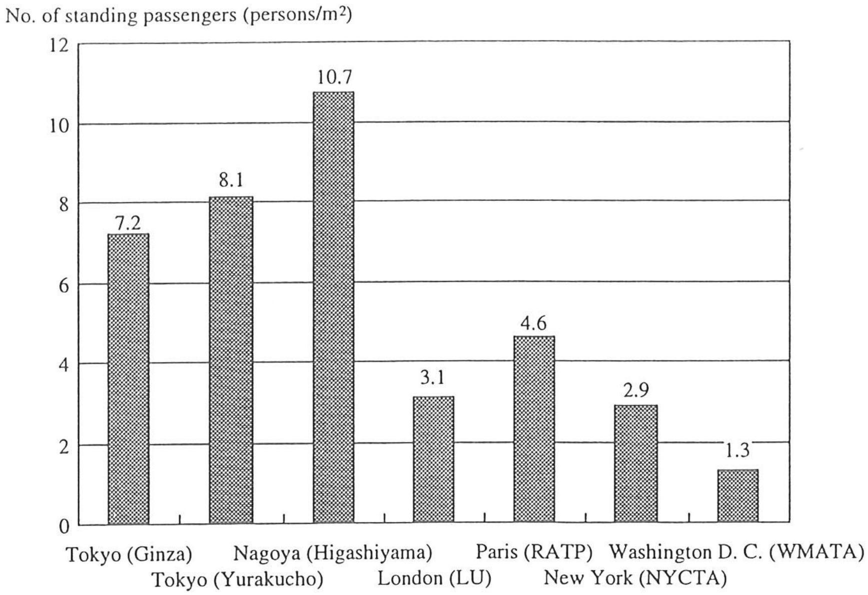


Figure 4 Number of standing passengers per 1m² of standing space in 1 peak hour (underground railway)

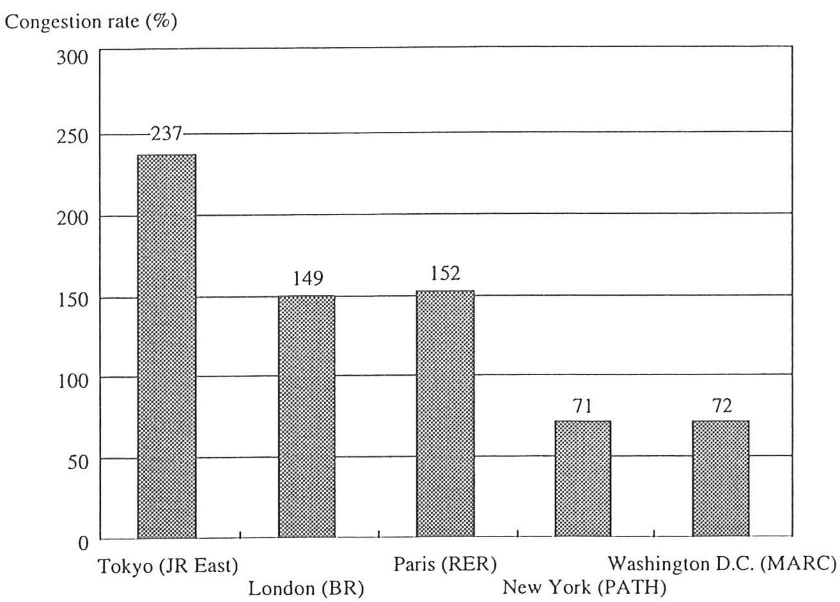
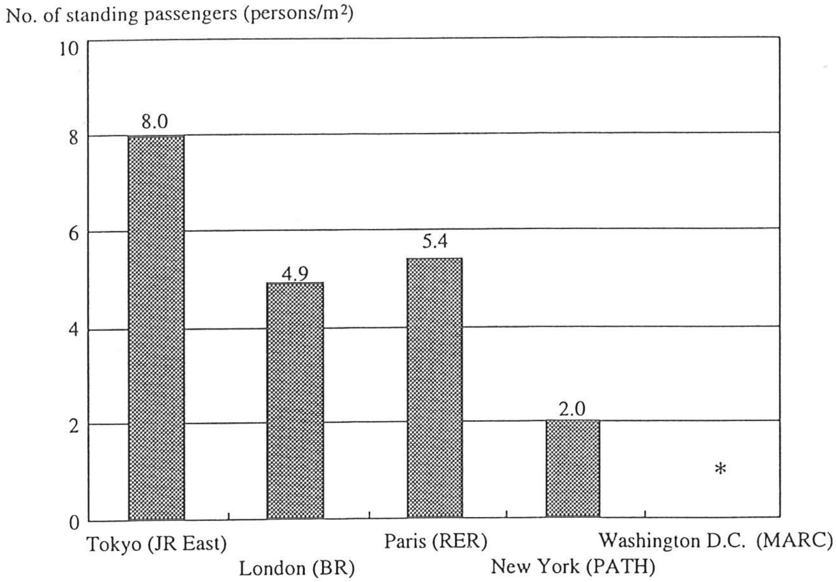
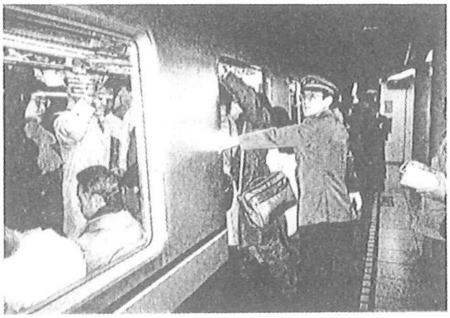


Figure 5 Congestion rate for 1 peak hour (suburban railway)



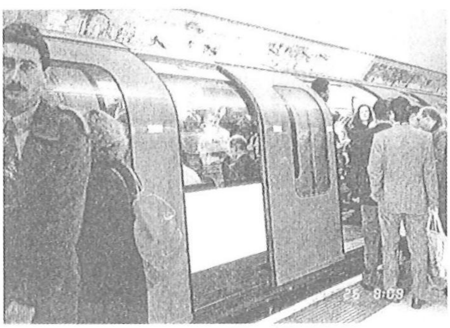
* In the case of Washington D.C., the number of passengers is less than the seating capacity.

Figure 6 **Number of standing passengers per 1m^2 of standing space in 1 peak hour (suburban railway)**



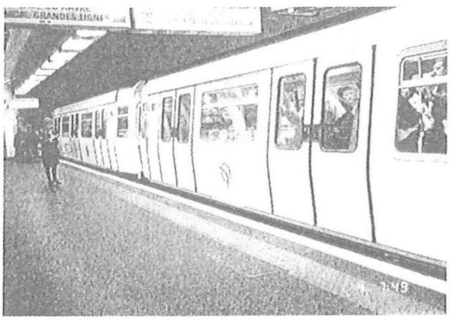
Tokyo (TRTA Ginza Line)

New York (NYCTA Lexington Avenue Line)



London (LU Central Line)

Washington D.C. (WMATA Red Line)



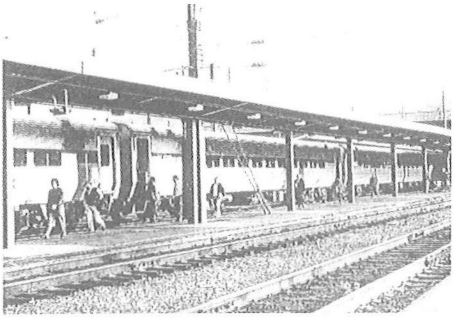
Paris (RATP No. 13 Line)

Photo 1 Congestion situation of underground railways

Tokyo (JR East Sobu Line)

New York (PATH)

London (BR Network SouthEast)



Washington D.C. (MARC Penn Line)

Paris (RER A Line)

Photo 2 Congestion situation of urban railways

DESIRABLE SERVICE LEVELS FOR URBAN RAILWAYS

This study used data gathered on-site, and looked at the comparative levels of congestion in urban railways of Japan and Europe and America, using the Japanese "congestion rate" as an index.

The results showed very clearly that there is a great difference between Japan and the West, in terms of both real congestion levels, and target levels. Further, when factors such as the duration of the congestion, and differences in physical constitution are considered, the difference becomes even more striking.

In the run up to the 21st century, while the railway is making a comeback worldwide, in order to promote this recovery even further, railway operators will also be faced with demands to provide more comfortable railway services.

Based on this first comparative study of the situation in Japan and Europe and America, we should like to study further the target service levels that Japanese railways should be aiming for. Also, it is our hope that the results of this study will be of use in the planning of future urban railway service levels in countries with large conurbations.

REFERENCES

Cook, T. (1993) *Thomas Cook Overseas Timetable* (Sept.-Oct.) Thomas Cook Publishing, U.K.

Council for Transport Policy (1992) *Basic concepts concerning mid and long term railway improvements towards the 21st century* (report No. 13, June 19th, 1992) Ministry of Transport, Tokyo.

Jane's Information Group (1994) *Jane's Urban Transport Systems*, Thirteenth Edition 1994-95, Jane's Information Group, U.K.

Japan Transport Economics Research Center (1993) *Urban Transport Annual Report*, Japan Transport Economics Research Center, Tokyo.

Japan Transport Economics Research Center (1994) *Urban Railway Congestion in European and American Cities—Survey of appropriate service levels for transport systems for the 21st century*, Japan Transport Economics Research Center, Tokyo.