Republic of India
Mumbai Metro Rail Corporation

# JICA Experts Study for the Operations and Maintenance Structure of Mumbai Metro Line 3 Project in India

# Final Report

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Japan International Cooperation Agency
(JICA)
Japan International Consultants for Transportation Co., Ltd.
PADECO Co., Ltd.
Metro Development Co., Ltd

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# Chapter 1 General issues for the management of urban railways

## 1.1 Introduction

### (1) Problems of urban transport

Concentration of population and economic activities into large cities poses confusion in housing, transport, medicine, welfare, education and environment across the world, against which action has been taken in various fields such as those of architecture, urban planning, environment, sociology, economics and transport.

In particular, problems related to urban traffic have become increasingly serious as motorization progresses to hinder normal urban activities while augmenting traffic congestion/accidents and degrading convenience in mobility simultaneously.

Problems of urban traffic are classified into the following four categories[1].

i) Traffic congestion

Crowdedness in public transport facilities in the morning/evening and traffic jams caused by road vehicles on urban roads

ii) (B) Traffic accidents

Collisions between (1) automobiles, two-wheelers, bicycles and other transport means, (2) such transport means and pedestrians, as a result of increases in the traffic volume, (3) trains and (4) trains and road vehicles on crossings.

iii) (C) Environmental deterioration by traffic

Air pollution, noise and vibration due to automobile emission, sights destroyed by viaducts and right to sunshine problems, etc.

iv) (D) Deterioration of public transport

(1) Losses in speed and punctuality/order of buses/street cars caused by congestion of road traffic, (2) resultant loss in reliability, (3) further increases in private automobiles, (4) decreases in public transport users, stagnation caused by decreases in revenue, lowered service level due to financial stringency, (5) further decreases in users in a vicious cycle and (6) increases in inconvenience of the traffic weaker who cannot own or drive private cars affected by the declined public transport.

### (2) Railway and road

A number of cities in developing countries, now standing at the initial stage of motorization, will see continued rapid increases in automobiles and increasingly stringent traffic problems in the future.

Having recognized in mind that it is impossible to maintain satisfactory service levels even though they construct roads to follow ever-increasing automobiles as a measure against urban

[1] Yoji Shintani, *Urban transport planning*, (Gihodo Shuppan, 1993)

transport problems, it has become the most fundamental and common trend in traffic policies among administrators in large cities over the world to suppress use of private transport means (private cars) and in return induce demands to public transport facilities[2].

In the background of this tendency, there is a large gap in transport capacity between private cars and public transport means. See Table 1.1 below.

Table 1.1 Comparison of transport capacity between railways and road transport means

| | Railway | Bus | Private automobile |
|---|---|---|---|
| Required width (m) | 9.3 | 24.4 | 24.4 |
| Passenger capacity (persons) | 1,000 | 40 | 4 |
| Headway (minutes) | 3 | 0.25 | 0.05 |
| Frequency of operation (times) | 20 | 360 | 1,800 |
| Transport capacity per hour per direction (persons) | 20,000 | 14,400 | 7,200 |
| Transport capacity per width of 1 m (persons) | 2,151 | 590 | 295 |

Note:

Width: Railways, double track, railways; buses and private cars, 4 lanes

Passenger capacity: Railways, 12 cars

Composition: Both railways and buses, with passengers assumed to be seated to capacity

Source: Hiroshi Kubota, *Railway Engineering Handbook* (Grand Prix Book Publishing Co.)

### (3) Status of Mumbai

Mumbai, the object of this survey and the largest economic and commercial city in India, has a population of 12.4 million[3] while recording 5% of GDP, 25% of industrial products, 40% of shipping and 70% of capital transaction of the total in the country[4].

In Mumbai, a bus network has developed to perform mass transport through Indian railways to enjoy a modal share as high as 45% of the total in the public transport facilities. See Table 1.2

[2] JICA, *Research on projects related to urban transport planning* (December, 2011)

[3] *Census India, population of Mumbai* (2011)

[4] JETRO, *Deli & Mumbai Style* (2011)

Table 1.2 Modal shares of the transport facilities in large cities

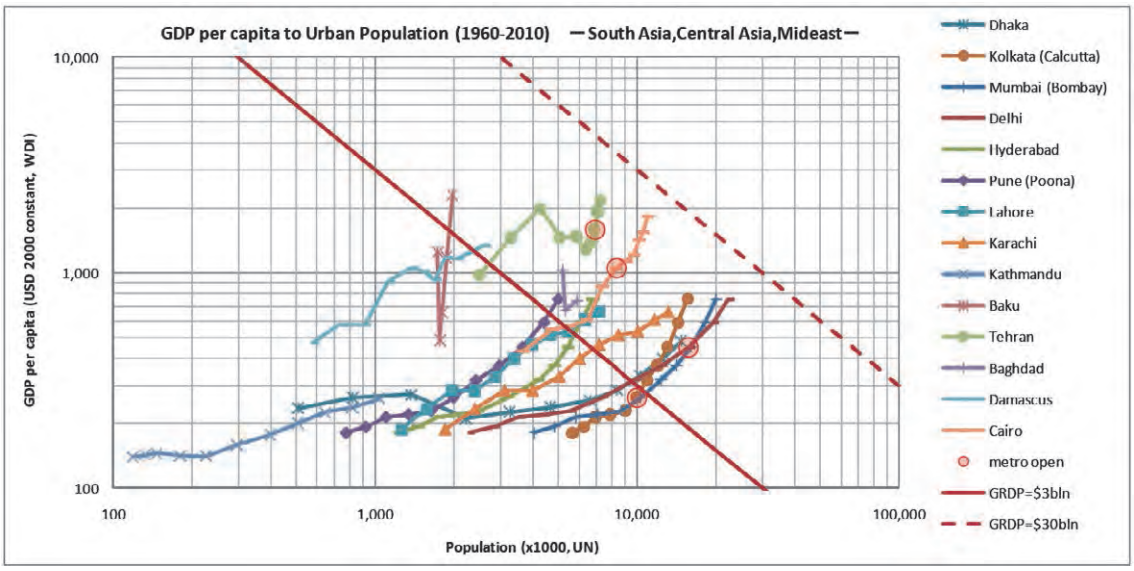
| | Population (mil.) | Land Area ($km^2$) | Modal Share (%) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Public | Walk | Private | Cycle | Others |
| Mumbai | 12.5 | 603 | 45 | 27 | 15 | 6 | 7 |
| Delhi | 11.0 | 431 | 42 | 21 | 19 | 12 | 6 |
| Bangalore | 8.4 | 226 | 35 | 26 | 25 | 7 | 7 |
| Ahmedabad | 5.6 | 281 | 16 | 22 | 42 | 14 | 6 |
| Paris | 6.5 | 762 | 62 | 4 | 32 | 1 | 1 |
| Tokyo | 8.8 | 622 | 51 | 23 | 12 | 14 | 0 |
| Singapore | 5.1 | 712 | 44 | 22 | 29 | 1 | 4 |
| New York | 8.2 | 790 | 22 | 39 | 33 | 0 | 6 |

Source: Singapore Land Transport Academy, *Passenger Transport Mode Shares in World Cities* as a part of *Journeys November 2011*

Timing to construct transport facilities in cities largely depends on the economic capability, style of land utilization and other social economic conditions. While assuming that the economic capacity of a city is the product of population and per capita productivity, Figure 1.1 illustrates the relation between the per capita income and the year of metro inauguration in different cities.

When we take logarithms of population and productivity, the state where the economic capability of a city is at a certain level is expressed with a rightward descending straight line. Figure 1.1 indicates that the metro of each city was constructed when the per capita income of the city had exceeded this line.

Mumbai, which is represented by a bottom right blue line, has already reached the state where it is entitled to construct a metro. As a matter of fact, a monorail and the Metro line 1 were actually inaugurated in Mumbai in the year of 2014.




Source: JICA, *Research on projects related to urban transport planning* (December, 2011)

Figure 1.1 Relation between inauguration of metro, population and per capita income in different cities

## 1.2 Management of urban railways

### (1) Transport service

The mission of urban railways is to run trains to transport passengers. The revenue from train operation is governed by the number of passengers. The larger the number of passengers is, the more crowded trains are; more efficient transport is and the more desirable it is for railway management. In contrast, the smaller the number of passengers is, the more difficult it is difficult to recover running costs. Therefore, railway operators are required to set train operation diagrams to meet users' demand and appropriately plan the number of cars in each train set.

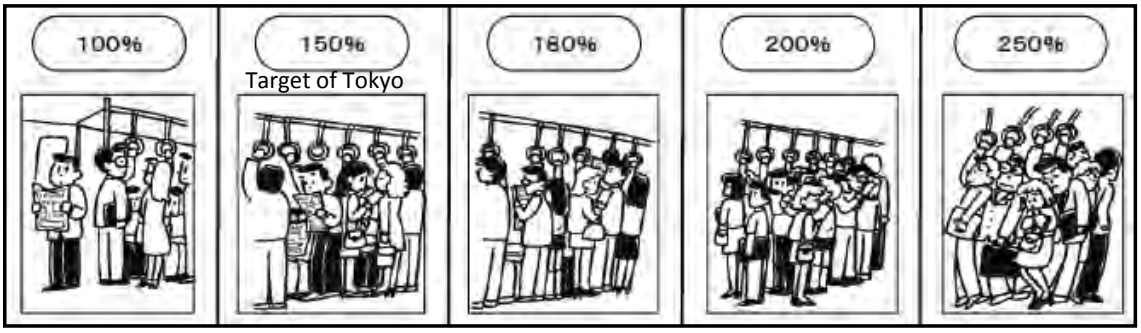
In this respect, however, transport demands fluctuate to a great extent in large cities, with passengers traveling in a particular direction concentrating into a particular morning/evening time zone in student/commuter transporting operation. If additional train sets were procured to relieve congestion, they would lie idle during the daytime. If the frequency of train operation is insufficient on the other hand due to shortage of train sets, it would fuel dissatisfaction of passengers on crowded trains. A rule of thumb for congestion rates is as follows.

150%: Passengers standing shoulder to shoulder can easily read newspapers.

180%: Passengers standing body to body can read newspapers.

200%: Passengers can read weekly magazines, though standing body to body with a sense of considerable degree of oppression.

250%: As their body leans progressively every time the coach pitches and rolls, passengers are crushed motion-less with even their hand remaining unmovable.




Source: Home Page, Ministry of Land, Infrastructure, Transport and Tourism

Figure 1.2 Rule of thumb for the rate of congestion

The average congestion rate during rush-hours in Tokyo and in major sections is 164% and 150%, respectively, with the maximum congestion rate set at 180% as a target.

Besides relieving congestion, what is keenly required by passengers is air-conditioning for trains. Tokyo Metro completed air conditioning for all cars by 1996, which was realized by the development of rolling stock featuring a small volume of heat generation during operation to minimize heat staying inside tunnels.

### (2) Working conditions and technological innovation in railways

The average working hours of railway workers is almost the same as that of workers in manufacturing industries. Workers specific to railways are those engaged in train operation/transport and track maintenance. As safety is important for train operation/transport, skilled workers are required therefor, who are supposed to engage themselves in service related to train operation together with conductors. Despite that track maintenance has been mechanized to a great extent on the other hand, it still involves heavy labor, while frequently requiring nighttime work in urban railways.

Table 1.3 compares the wage level in the railway industry with that in other industries. The wage level in railways is higher than that in general industries and road transport businesses but lower than that in the aviation industry.

Table 1.3 Wage level in the railway industry in Japan

| Industry | Fixed wage | Bonus and one-time allowance | Yearly wage |
|---|---|---|---|
| All industries | 100.0 | 100.0 | 100.0 |
| Total in all industries:<br>Industry size, 1,000 persons or over | 107.1 | 122.4 | 110.9 |
| Industry size, 100 to 999 persons | 96.4 | 94.1 | 96.0 |
| Industry size, 10 to 99 persons | 95.3 | 69.8 | 91.1 |
| Railway industry | 105.1 | 146.2 | 114.0 |

| | | | |
|---|---|---|---|
| Road passenger transport industry | 79.2 | 79.6 | 79.2 |
| Road freight transport industry | 89.6 | 52.8 | 83.8 |
| Aviation transport industry | 127.0 | 110.7 | 123.6 |

Source: Home Page, Federation of Labor Unions in Japan, comparison of wages between different industries

As the influence of strikes in the railway industry is severer than that in general enterprises, some constraints are imposed on the labor movement in railways[5].

In those days when railways made their debut, railways were referred to as a capital-intensive industry. In recent years, however, they make a labor-intensive aspect more conspicuous, affected by the advent of equipment industries. Nevertheless, technologies of train operation control and passenger services have made great strides in the wake of introduction of information technology and technological innovation in societies as a whole, in parallel with the improvement of safety and labor productivity. Table 1.4 summarizes the management indexes of the subway promotors in Japan.

Table 1.4 Management indexes of subway promotors in Japan

| | Transport passenger-kilometer | Route kilometer | No. of stations | No. of employees | Passenger-kilometers per employee | No. of employees per route kilometer | No. of employees per station |
|---|---|---|---|---|---|---|---|
| Tokyo Metro | 18,534,651 | 195.1 | 179 | 8,474 | 2,187 | 43 | 47 |
| Sapporo | 1,205,678 | 48.0 | 49 | 614 | 1,964 | 13 | 13 |
| Sendai | 270,922 | 14.8 | 17 | 423 | 640 | 29 | 25 |
| Tokyo | 5,971,671 | 109.0 | 106 | 3,595 | 1,661 | 33 | 16 |
| Yokohama | 1,628,659 | 53.4 | 42 | 831 | 1,960 | 16 | 20 |
| Nagoya | 2,746,795 | 89.2 | 96 | 2,696 | 1,019 | 30 | 28 |
| Kyoto | 640,893 | 31.2 | 32 | 590 | 1,086 | 19 | 18 |
| Osaka | 4,875,300 | 129.9 | 123 | 5,847 | 834 | 45 | 48 |
| Kobe | 954,044 | 30.6 | 26 | 603 | 1,582 | 20 | 23 |
| Fukuoka | 683,155 | 29.8 | 36 | 559 | 1,222 | 19 | 16 |

Source: Fiscal 2010 Annual Report on Railways

[5] Clause 8 and Clause 37, Labor Relations Adjustment Act,

(3) Operating cost

A number of subway business promotors in Japan make income and expenditure in their railway business balanced. See Table 1.5.

Table 1.5 Income and expenditure of subway business promotors in Japan

Unit: Billion yen

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka |
|---|---|---|---|---|---|---|---|---|---|---|
| Business income | 328 | 38 | 10 | 130 | 37 | 74 | 23 | 149 | 19 | 23 |
| Permanent way | 17 | 2 | 1 | 11 | 2 | 5 | 2 | 7 | 1 | 2 |
| Power supply line | 14 | 2 | 1 | 7 | 2 | 2 | 2 | 9 | 1 | 1 |
| Rolling stock | 17 | 2 | 1 | 9 | 1 | 4 | 1 | 9 | 1 | 1 |
| Train operation | 34 | 4 | 1 | 13 | 3 | 9 | 2 | 15 | 2 | 2 |
| Traffic service | 68 | 4 | 2 | 24 | 5 | 14 | 4 | 26 | 3 | 3 |
| Maintenance | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Transport | 3 | 2 | | 3 | 1 | 3 | 1 | 4 | 1 | 1 |
| Subtotal A | 161 | 16 | 0 | 67 | 14 | 37 | 11 | 69 | 9 | 11 |
| Management cost, etc. | 13 | 1 | 6 | 4 | 1 | 2 | 1 | 4 | 1 | 1 |
| Subtotal B | 174 | 17 | 6 | 71 | 15 | 39 | 12 | 73 | 10 | 12 |
| Tax, depreciation, etc. | 79 | 14 | 3 | 42 | 16 | 20 | 13 | 38 | 8 | 9 |
| Total operation cost | 253 | 31 | 9 | 113 | 31 | 59 | 25 | 111 | 18 | 21 |
| Operating profit and loss | 74 | 6 | 1 | 17 | 6 | 15 | -1 | 37 | 1 | 1 |

Note) As it is a sum of rounded figures, discrepancies may exist in the figures in “Total”.

Source: Fiscal 2010 Annual Report on Railways

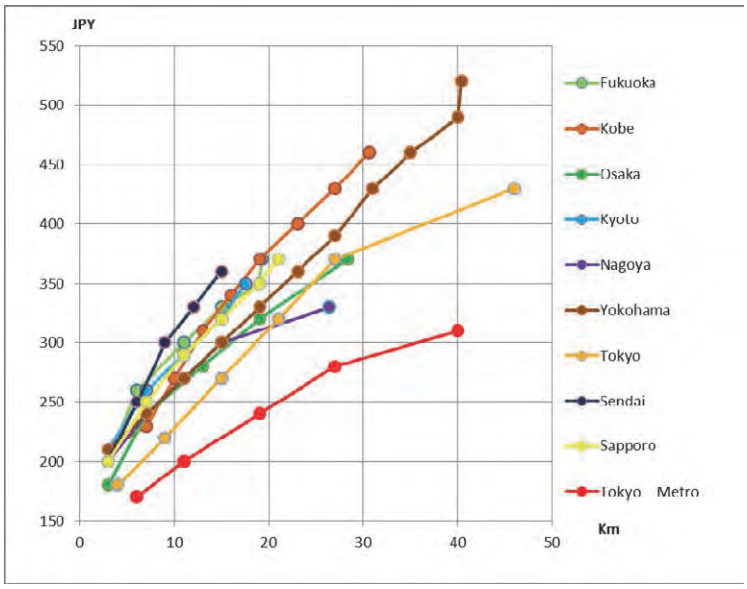
In the operating cost, the personal cost and the depreciation allowance account for 33 and 35%, respectively, with the latter reflecting the fact that subways feature comparatively new equipment/facilities. Inflation is advantageous for business promotors, as it reduces the

real-term burden stemming from the cost incurred in the past.

Subsides are input as non-operating income other than those for the construction cost. Subsidies account for approximately 10% of the operating income, which are gradually decreasing, however.

(4) Passenger fare

Subway fares are governed not only by the operation cost but also by competing transport facilities and users' ability to pay. Figure 1.3 illustrates the fares adopted by subway business promotors in Japan, which tend to increase as the traveling distance increases, but not to the extent strictly proportional thereto. The starting fare is approximately 200 yen irrespective of the traveling distance with different subway promotors. Passenger fares are low with Tokyo Metro and Tokyo Metropolitan subways and high with Sendai and Kobe subways. This presumably reflects the differences in the number of users and profitability between subways in mammoth cities and in small cities in local areas.




Source: Survey Team

Figure 1.3 Subway fares in Japan

The per capita GDP in 2013 is 38,467 US dollar in Japan and 1,510 US dollar in India. If we regard that the level of passenger fare strictly reflects the difference in GDP between India and Japan, the starting fare would be 8 yen or less in India. On the other hand, the DRP of this project assumes that the starting fare in 2017 is 10 Indian Rupees (approximately 15 yen) in India, which sounds to be comparatively high, given the corresponding figure in Japan, however.

There are two categories of passenger fares in Japan: one for ordinary tickets and the other for season tickets, with the level of the latter set approximately a half that of the former. The season

ticket fares have planted their roots in Japanese soil to superimpose (1) railway management purposes to induce transport demands and implement efficient transport and (2) public purposes such as industrial, social and educational policies.

In recent years, a majority of passengers are those holding season tickets, who concentrate in the rush hour time zone to determine the required maximum transport capacity. Mitigation of the congestion during peak hours entails an enormous amount of funds to be invested into equipment/facilities, which are born mostly by passengers who purchase comparatively expensive ordinary tickets.

According to the theory of peak load pricing, fares can be set high during peak hours and low at non-peak hours as a measure to suppress concentrating passengers, thereby leveling transport demands to cut investment funds into equipment/facilities. Although this theory has been introduced into power rates, its validity is dubious for the railway fare charging system, as it is difficult for commuters to change the time to go to their workplace, even though peak-hour fares are set high.

In addition to the above, there are a common passenger fare system and a relayed travel passenger fare system.

### (5) Management style

The subways in Japan except Tokyo Metro are directly managed by local autonomous bodies. Tokyo Metro, for which investors were the former Japanese National Railways and the Tokyo Metropolitan Government, is now in the transient process to privatization. Public organizations have been responsible for construction and management of subways in the past, only because it was extremely difficult for enterprises in the private sector to raise prohibitively large amounts of funds for subway construction[6].

As the subway construction spree has come to the end of the chapter in Japan, discussions on the subway management style is now to the fore. There are opposing opinions against changes in the management style, however, based on the problem-consciousness and directivities explained below.

i) Meaning of subway undertaking

The subway undertaking has been planned and promoted as one of the basic industries to solve urban problems such as traffic congestion and environmental disruption emerged during the period of high economic growth.

Subways have played the role to facilitate mobility of citizens and contributed to vitalization of regional economics through improvement of traffic convenience and systematic establishment of communities.

[6] The Ginza line, Tokyo Metro, was constructed as a private railway.

ii) Problems of management structure

It hasn't been clarified whether subways shall continue services even in deficit as the important capital assets for societies or maintain a minimum profitability level, with the directivity of their businesses not defined definitely.

Therefore, subway promotors lacked consciousness as the party responsible for a public undertaking, while continuing deficit operation without exerting autonomy.

As a result, excessive investment was implemented to victimize profitability, without drastic management innovation performed, which has led to a critical financial situation.

iii) Direction for change of the management structure

The ideal management style is a framework for business promotors to make management judgment by themselves and be rewarded in return therewith. Regarding the systems for personnel affairs, wages and services, funds raising and investment judgment in particular, they shall make their own judgment and take action accordingly.

At the moment, however, it is difficult for subway business promotors to perform autonomous and self-standing management, as they don't have a degree of freedom for management equivalent to that in the private sector. As the ultimate management style, therefore, changing to "a privatized or joint stock company" is preferable. However, a number of legal constraints and subjects would be piled up in regard to the status of employees and belongings of assets and debts in the way of management style innovation, if it were implemented too hastily. Therefore, local autonomous bodies shall take the initiative in drawing visions into the future, which shall be put in shape one by one thereafter.

### (6) Transmission of managing technologies from generation to generation

Widely-ranged know-how is required for the management of railways, which shall be accumulated and continuously improved in order to upgrade the quality of railways. In establishing a method to transmit technologies from generation to generation, it is important to make efforts to keep harmony with histories and traditions in societies. Despite that, however, it is also true that a hint is available in precedent cases in foreign countries.

Among the Japanese enterprises advancing into foreign countries, the importance of following policies is advocated.

i) Efficiency improvement: direct dialog between the top management and employees in the field, employee-participated activities and opportunities for activities outside the workplace.

ii) Prevention of leaving the workplace: Seniority-based treatment, clarification of chances for promotion, education of technologies and know-how by Japanese people

iii) Improvement of the degree of employee satisfaction: Opportunities to explain enterprise strategies and periodic reviews of the wage level

Japanese enterprises including railway companies are also promoting OJT and “Kaizen” (improvement) activities, which feature solving problems through a bottom-up process while exchanging wisdom between employees without relying on the instructions by the top management on such themes as guarantee of safety and improvement of working efficiency.

Typical themes dealt with in “Kaizen” activities include (1) measures against disaster, prevention of simultaneous accidents and accidents on platforms in the field of safe ant stable transport and (2) speedups, relieving congestion, introduction of barrier-free facilities and adoption of common tickets in the field of passenger services. It is thought that thinking such themes leads to the innovation of employee morale and further to a key toward the development of enterprise businesses.

OJT is for superiors and seniors at the workplace guide and make subordinates and juniors learn/acquire knowledge, technologies, skills and manners through concrete jobs intentionally, systematically and continuously, thereby aiming at raising service fulfilling ability and power at the workplace as a whole.

In the traditional apprentice system in contrast, apprentices should start training from miscellaneous jobs irrelevant to their purpose and assist the master/mistress thereafter in order to learn/acquire professional knowledge and skills while spending several years to decades. After starting in the US to cope with the shortage of fresh men/women training facilities during the period of World War I, OJT developed to the following programs for training within industry (TWI) and introduced into Japan in and after 1950.

i) Job Instructor Training (JIT), methods to teach jobs
ii) Job Relation Training (JRT), methods to treat people
iii) Job Methods Training (JMT), methods for improvement
iv) Program Development Training (PDT), methods to promote training plans

The above is supported by the fact that the theme “guarantee/raising of human resources and management of labor” is cited as a high-ranked subject for Japanese enterprises in advancing into overseas countries, together with “increases in the personal cost,” “changes in foreign exchange” and “complicated rules and legal systems.”

## 1.3 Construction of urban railways

### (1) Characteristics of transport facilities

Public transport facilities usable as a baseline for urban transport are metros, LRTs, existing railways, monorails or AGTs, BRTs and buses in passenger transport service (hereinafter referred to simply as "buses"), out of which the city administrator will select most appropriate ones in consideration of the economic level of the city, public transport demands for major object corridors, existence/non-existence of policies to promote public transport, spaces around existing roads and citizens' ability to pay fares.

Table 1.6 summarizes general specifications for public transport facilities.

Table 1.6 General specifications for public transport facilities

| | Metro | LRT | Existing railway | Monorail AGT | BRT | Bus |
|---|---|---|---|---|---|---|
| Exclusive or non-exclusive tracks/lanes | Dedicated tracks, grade-separated crossings with other transport facilities | Dedicated-track operation partly with mixed traffic | Inter-city transport mixed with commuter transport | Dedicated tracks, grade-separated crossings with other transport facilities | Dedicate- and non-dedicated-lane operation | Mixed traffic |
| Intervals between stations (km) | 1.5 | 0.8-1.5 | 3-15 | 0.8-1.5 | 0.4-1.0 | 0.2-0.4 |
| No. of seats (per unit car) | 50-80 | 65-85 | 60-90 | 30-75 | Standard car 40 Articulated car 65-85 | Standard Car 40 Articulated car 65 |
| Average speed (km/h) | 25-55 | 20-30 | 40-60 | 25-40 | 15-35 | 15-35 |
| Transportation capability (PPHPD) | -60,000 | -30,000 | -30,000 | -15,000 | -8,000 | -6,000 |
| Construction cost (million USD/km) | 60-100 (Underground) 30-50 (Viaduct) | 30-50 | 10-20 | 30-50 | 6-13 | - |

Note) PPHPD stands for passengers per hour per direction.

Source: Survey Team

### (2) Requirements for urban railways

Urban railways entail a huge amount of construction cost, which takes a long period of time for repayment. The construction cost becomes prohibitively high, as urban railways are imposed with the following requirements.

i) High-speed operation

To run trains at high speed, tracks shall be straight and flat as far as possible. In case the design maximum speed is 70 to 90 km/h, radii of curve shall be 250 m or over and gradients shall be approx. 3.5% or less.

In station yards, radii of curve shall be larger to minimize the gap between car body and platform edge and gradients shall be smaller to prevent cars from running away.

ii) Mass transit

Mass transit requires equipment/facilities to enable high-frequency operation of large-size rolling stock. The load on an axle (axial load) is approximately 18 t with 20 m-cars. The track layout and signals in the station yard shall be contrived to realize 2- to 3-minute headways.

Stations shall be equipped with passages, staircases and escalators, etc. to cope with the flow of a great number of passengers.

iii) Guarantee of safety

To perform mass transit safely, urban railways shall be equipped with dedicated tracks and shall cross roads and other railways through grade-separated crossings. To prevent invasion of third party people into the permanent way, the permanent way shall be structured to run on viaducts and/or in tunnels continuously.

### (3) Construction cost

To satisfy these requirements, the construction cost of urban railways of the underground type is approx. 60 to 100 million US dollars per kilometer. See Table 1.2. When this unit cost is applied to the 33 km-long line 3, Mumbai Metro, its construction cost amounts to approximately 3 billion US dollars. See the calculated construction cost in the Detailed Project Report (DPR).

The eventual construction cost is affected by the period from planning to inauguration of the projected railway. A carelessly drawn-up project plan will cause a cost overrun due to setbacks in land acquisition and/or in construction work. If the construction work delays, the construction cost will significantly be affected by price rises.

In constructing an urban railway, it often takes much time to adjust opinions between different public organizations. It will be required to analyze problems and actual work processes experienced in the construction of preceding Metro lines 1 and 2 and/or monorails in order to take countermeasures and institute a strong opinion adjusting organization.

### (4) Repayment of construction cost

Once a railway construction has been completed, its equipment/facilities endure transporting

service for long years, as seen with a number of railways across the world that are still active even now by transporting passengers and/or freights for more than 100 years after inauguration. Scrapped railways are those that have become unnecessary for societies as demands have shifted to other transport means in the wake of the progress of motorization. In other words, railways have a semi-permanent life as far as tracks are appropriately improved and provided with routine maintenance services.

In raising funds to construct a railway, therefore, it is difficult to set a period of repayment that would rival the length of its life. In planning urban railway construction, the administrator in the city cannot help but assume a case where the railway becomes useless affected by changes in social/economic conditions or the value of currency drops due to price fluctuations. He/she shall also assume the possibility of competition with transport means in other cities or the outbreak of a war. If the uncertainty into the future is seemingly a reality, the interest level will rise to retard railway construction.

Therefore, a consensus among citizens or users that the city will thrive in the future thanks to the constructed urban railway makes a key to start construction work for the railway, for the ground that, (1) after such a consensus has been established, it becomes possible to repay the construction cost with fares and taxes born by citizens and (2) it will also be easier to secure loans from other countries and private financial institutions[7].

Figure 1.4and Figure 1.5 Figure 1.2 and Figure 1.3 reproduce the O&M cost and revenue of the Mumbai Metro line 3 (MM3) after inauguration and the term-end cash balance stated in the Detailed Project Report (DPR). Figure 1.3 indicates that, although the balance of payment is in black every year, cash is short in the 7th year after inauguration when repayment of construction cost starts and for 29 years thereafter.

We hear that Mumbai Metro will rely on additional loans or assistance by the government during this period.

[7] Methods to raise funds are introduced in the “Annex X.”

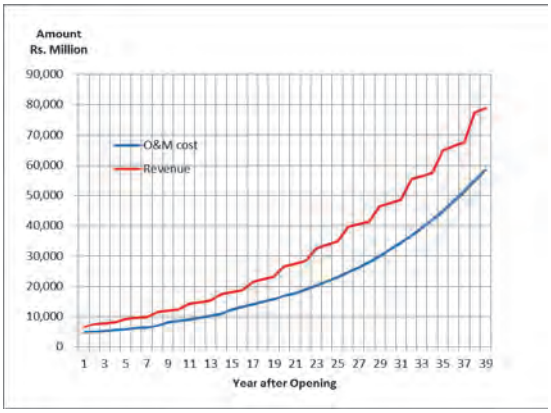



Figure 1.4 O&M cost and revenue of MM3 after inauguration


Figure 1.5 Term-end cash balance after inauguration

(5) Trend of transport policy

What has been a moot point for long years is what is called the equal footing theory, an attempt to optimize the distribution of resources from the social and economic viewpoint through competition in traffic markets between railways and roads while standing on the equalized conditions.

Railway business promotors are required to (1) prepare all inputs needed for railway transport by themselves, from lands, rails and other fundamental facilities to EMUs, other rolling stock, drivers, conductors and station members and (2) set fares to recover all expenses spent for such resources. In the case of road transport using trucks and buses that necessitates roads as a basic infrastructure in contrast, the financial sources for construction and maintenance of roads include not only the revenue from automobile taxes including the volatile oil tax but also the general revenue of the government and local municipalities. It has been a subject for long how to rectify this unfair right of way (permanent way and road) costs.

There is a case of Freiburg, Germany where subsidies are input not only into the right of way cost but also into railway management to prevent environmental disruption caused by automobiles, for which the automobile fuel tax is appropriated[8].

In the background of this discussion, there lies a fact that railways have lost monopoly to make management difficult amid the progress of motorization. Thus, policies now focus on the issue how to protect railways from competition.

As a concrete policy, therefore, regional monopoly has been approved for railways with a view that railways shall function as a network irrelevant of the state of affairs with individual lines. In other words, while restricting the entry of other business promotors into railways, it is intended

[8] Gen Hori, *Financial Problems of Public Transport in Freiburg, Germany*, (Ritsumeikan Univ. Legislation Theories, No.7, 2009)

to maintain railway networks while taking advantage of internal reliance between different divisions. This coordinating policy has misfired unfortunately, however, due to ever-intensifying competition between different transport facilities. Railways didn't resuscitate, but lost competitive power instead due to protective policies.

Under the circumstances, therefore, traffic policies have come to attach importance as a result to the improvement of competitive power in the fields where railway can exert their specific characteristics. As a means to strengthen competitive power, policies have been adopted to (1) approve open access and (2) separate management for train operation and that for other infrastructures[9].

This is to clarify the public burden on the right of way cost through separation of management and induce competition between plural operators on the right of way, thereby aiming at reinforcing the competitive power of railways. Setting aside light traffic lines, however, coordination will be extremely difficult between different operators who have started railway businesses in the open access system in the case of urban railways assigned with high-density high-speed mass transit. An alternative idea is to set the contract period in advance for an operator and give a chance of entry into railway operation to other candidate operators upon expiration of the existing contract, as already in practice in some cases.

[9] Masamichi Hori, *The Equal Footing Theory in Contemporary Traffic Policies*, (Mita Shogaku Research, August 2000)

## 1.4 Governing Structure

### (1) Regulatory Organization and O&M (Operation and Maintenance) Organization

Organizations related to urban railway are classified into regulatory organization and O&M organization.

Regulatory organization assumes the regulator functions such as fare policy planning, the supervision of service level and safe operation, the railway use promotion planning, etc. Regulatory organization is generally the possessor of railway facility. Normally, the regulatory organization will be regulatory authority exercises jurisdiction over railway field at central government (Ministry of Railways, etc.) and local administration bureau (State Traffic Bureau, etc.). In addition, the regulatory organization related to safety often takes the shape of safety committee under the jurisdiction of the Ministry of Railways. The regulatory organization related to fare often takes the case of the Ministry of Railways or State Traffic Bureau but there may be the case of taking independent committee including user group.

O&M organization assumes railway operation and is consisting of secretariat department (plan, general affairs, safety, personnel affairs and financial), sales department and operation department (train operation, vehicle maintenance and facility maintenance). And the railway operation is performed while getting into synchronization or breaking each other.

### (2) Regulatory Organization

Permission and supervising systems required for administrative procedures based on legal regulation are required for the regulatory organization. In concrete terms, they accept notification and application from O&M organization, study the validity and supervise O&M organization. There are seven major control items, 1) Business license, 2) Grant money, 3) Operation plan, 4) Fare setting, 5) Design plan and maintenance plan, 6) Safety management and 7) Accident investigation, and an organization framework to satisfy the following functions is required;

i) Business license

Regulatory organization evaluates business plans and operation plans prepared by O&M organizations before opening. Emphases are placed on financial soundness for business plan and on safeness and passenger service for operation plan.

ii) Grant money

As for the delivery of grant money, form the budget for the central government or local government related to urban railway by regulatory organization side and put an execution department in place. In this case, there are many cases of establishing audit specialized organization such as the Board of Audit for the enforcement of grant money. In addition, as for

the government budge, a framework to correspond congress is also required since the budget is deliberated at the parliament and its burden is heavy.

iii) Operation plan

As for the operation plan, a notification is evaluated centered on the safety department and at the execution phase, implementation status is evaluated during periodical safety audit.

iv) Fare setting

There may be the case of requiring deliberation not only by regulatory agencies but also congress, etc. since the economic influence of price escalation went with fare modification has the profound effect. In addition, there may be the case of deliberation by the third-party organization such as consumer organizations, etc. If it is the case of deliberation by parliament and the third party organization, heavy load is accompanied on regulatory organization side.

v) Design plan and maintenance plan

The design plan of infrastructure and operation facilities should be confirmed that the design is valid based on related laws, regulations and technical standards. For the reason, it is often the case that a design manager is allocated in the organization which possesses the facility to clarify accountability framework. The department related to technical standard should mainly perform evaluation at regulatory organization side.

vi) Safety management

The safety department receives the report from O&M organization and audits implementation status as necessary.

vii) Accident investigation

Accident investigation is performed by the accident investigation committee by experts at regulatory organization side centered and recommendation for improvement is performed against O&M organization as necessary.

### (3) O&M organization

The railway operation business by O&M organization nothing changes between government operation and private operation. For the reason, the organization configurations are similar for both cases.

If O&M organization is not the possessor of infrastructure asset and operation asset, the asset maintenance management department becomes unnecessary. The possessor of asset is provided by related laws and regulations or the concession contract with private sector.

If O&M organization outsources rolling stock and facility maintenance, the organization of maintenance department becomes simple because their main job becomes ordering and acceptance test.

If O&M organization is operated by government, an independent organization from regulatory

organization is established and both regulatory organization and O&M organization are existed in the central government or local government but there may be the case of making O&M organization as public corporation or special-purpose holding company by the government.

At O&M organization, the framework to perform notification and application to regulatory organization and to receive audit by regulatory organization is required. If infrastructure asset and operation asset are possessed, the framework related to infrastructure and operation facilities is also required.

i) Business license

O&M organization should formulate a business plan and receive the approval by regulatory organization prior to open the business. In the business plan, objective descriptions on the validity of financial plan, safeness of train operation, technical validity of facility maintenance plan, etc., are required.

ii) Grant money

Frameworks of secure budget execution and audit receiving shall be arranged. In addition, O&M organization shall formulate business plan required to apply for grant money for the next fiscal year, submit the plan to regulatory organization and receive audit.

iii) Operation plan

Notification concerning to safeness for train operation speed, etc., should be performed prior to open the business and at the time of schedule revision. O&M organization should prepare documents required for notification centered on safety department and transportation department

iv) Fare setting

O&M organization shall construct a framework required to submit income and expenditure plan and demand supposition documents to be the reasoning of fare setting and receive audit. It is required to give the proof of fare modification validity at fare modification even if the fare modification was approved by concession contract in advance. If it receives the audit by the parliament or the third-party organization, load of O&M organization becomes heavy.

v) Design plan and maintenance plan

The facility maintenance plan should be formulated based on the related laws, regulations and technical standards, and executed but it is required to certify those are securely implemented.

vi) Safety management

There is the tendency of control becoming severe at each time of accident occurrence. In the most of cases, assign a safety management supervisor at O&M organization side, implement internal audit related to safety management by O&M organization itself and report the result to the regulatory organization.

vii) Accident investigation

Work cooperatively for smooth accident investigation centered on the safety department and take quick correspondence for improvement recommendation.

### (4) Points to consider

By separating regulatory and operation organizations, strained relations in a good sense are expected between both parties. Meanwhile, if the regulatory organization owns facility and the operation organization uses the facility, it is more likely to be the lack of communication between them.

In England, British National Railways was privatized in 1993 and the Railtrack owned and managed the infrastructure. The derailment accident at the outskirt of Hatfield in October 2000 revealed its chronical shortage of railway investment and the lack of governance. It is said that the problem was brought by the divergence of functions such as infrastructure, operation management, maintenance, etc., and the absence of supervisor due to privatization.

In the National Railways era, with the director-general as the head of organization, each department such as infrastructure, operation management, maintenance, etc., was placed under the director-general. “Train operation” was completed in a single organization, and top-down quick response in case of emergency enable to reduce train operation suspension, etc. easily.

While the political pressure was reduced by the privatization, the railway “service” was transformed to railway “business” which depended on the contract relationships instead of general supervising system, and the desire for profits became the maximal object. Under the new system that involved dozens of private companies to run a single train, the awareness of the notion “railway is a public service” was lost[10].

If reviewing the division of role with regulatory organization and operation organization, we shall pay utmost care and attention to prevent such a harmful effect.

[10] Hiromichi Kanayama, *What is observed from Wrecked British Railtrack Company*, PHP Policy Study Report, Vol. 6, No. 68, Feb. 2003

## 1.5 Business Model

"Fare revenue ownership" and "cost sharing" are the two most critical considerations in deciding on the selection of appropriate business models under the Public-Private partnership ("PPP") framework.

### (1) Fare Revenue Ownership

Either the public-sector entity (the regulatory authority) or the private-sector entity will have ownership of future fare revenues. If the public-sector entity is chosen as the owner, it will pay the private-sector entity to undertake O&M works, based on the written concession agreement between them. The fee level may vary according on the extent and/or quality of O&M services to be rendered by the private-sector entity.

If the private-sector entity is chosen as the owner, the private-sector entity will assume the demand risk (ridership risk) of the project. Under this situation, it may decide to forgo the O&M opportunity, as it may conclude that the risk-return profile of the project may not be economically viable.

### (2) Cost Sharing between Public and Private

The below are the factors to be discussed with regards to cost sharing between Public and Private.

- Initial investment cost
- Operational expenditures
- Replacement cost for existing operational assets
- Additional investment cost for new operational assets

If no private entities are willing to pay the entire initial investment cost which would be enormous, the public entities have to share the cost with the private entity. In metro projects, there are variations of cost sharing between Public and Private. One of variations is that, the public entity bears the cost of understructure (building infrastructure such as tunnels, tracks and stations), while the private entity funds the cost of E&M assets such as rolling stocks and signaling systems.

It would be ideal that operational expenditures can be recovered by farebox revenues from commuters without subsidies from the government, in either case that operation done by Public or by Private. Hence, it is necessary to carefully consider appropriate fare levels in consideration with commuters' affordability at the planning stage of projects.

Also, replacement cost and additional investment cost are important factors for Private to evaluate returns and project risks, since those costs are still significant. Therefore, it

would be necessary to examine how sharing such costs between Public and Private upon precisely estimating necessary costs at the project planning stage.

### (3) Other: Beneficiary Charge Principle

Apart from the aforementioned two considerations, there is another consideration that could affect the urban railway business model under PPP framework, called the "beneficiary charge" or "he-who-benefits-ought-to-pay" principle. It is based on the idea of having the beneficiaries of the urban railway assume the cost of the operating the said railway. Examples include the following: (1) have the private-sector O&M operator assume a higher proportion of the initial investment cost by offering the said operator the right to conduct businesses that are connected to or synergetic with railway operations, such as real estate development and advertizing within or around the railway land; (2) tax the residents who would benefit from the railway through transport cost and time savings as well as the increased likelihood of employers to have employees who are able to come to work on time consistently, and; (3) have the landowners who would benefit from the appreciation of land price appreciation as well as the increased ability to gain more customers assume a portion of initial investment cost.

Hong Kong's urban railway operator, MTR Corporation Ltd., (the "MTR") offers an example of conducting synergetic businesses. 12% and 10% of MTR's revenues are derived from advertizing and retail businesses within the railway areas that MTR operates, and lease income and management fees obtained from offices and shopping malls among other properties that it owns which are adjacent to its railways, respectively.[11]

The example of taxing residents and employers who have benefited from the railways can be found in France where since 1971, the state-owned public transport operator, Régie Autonome des Transports Parisiens has been given the power to increase the tax assessment on and tax collection from the railway beneficiaries in regards to property tax, resident tax and business facility tax.[12] Another example can be found in the State of New York in the United States, where employers are assessed the "metropolitan commuter transportation mobility tax" on account that businesses are benefitting from public transportation in Manhattan and its neighboring areas.

The example of the landowners assuming a greater portion of the initial investment cost can be found in Osaka, Japan. When the "Midosuji" metro line was being built in Osaka before World War II, residents and merchants within a 700m radius of the intended stations were asked to shoulder a portion of initial investment cost.[13]

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[11] MTR Corporation "2014 Annual Results" March 16, 2015

[12] Yoshitsugu Hayashi, "Social infrastructure funding in public transportation and give-back of the developers' profits" CRDRC 1993

[13] Hirotaka Yamanouchi, "Issues and prospects in transportation social infrastructure" IATSS Review Vol.33, No.1, April 2008

# Chapter 2 Present situation in metro projects

## 2.1 General

This chapter describes precedent cases of metro projects in the world, from the viewpoints of policies, legal restrictions, subsidies, fare, managing organizations and personnel.

As mentioned in Chapter 1, the recovery of invested capital is difficult because of the huge construction cost compared to the fare box revenue. To deal this problem, there are many ideas such as the division of roles and the share of expenses between the public and private sectors. These ideas aim to find the reasonable approach to the uncertain future ridership and fare revenue.

Following precedent cases mainly come from Singapore, Thailand, India and Japan.

## 2.2 Metro projects in the world

### 2.2.1 Singapore

(1) Policy

Policies for urban railway including funding and asset ownership have changed several times, the policy at that time was applied to formation of the project at that time. In 1987, when North-South and East-West Line (NSEW Line) commenced operation, the policy was that Public finances both civil infrastructure (tunnel, track, stations, etc) and E&M facilities (rolling stocks, signal systems, etc), Private bears operating expenses, as well as, replacement cost for existing assets and additional investment cost, through collection of farebox revenues.

At the time of the White Paper (Land Transport Plan) issued in 1996, the policy at the beginning was largely shifted. While Public sector finances both civil infrastructure and E&M facilities in the past policy, it was changed that, Private bears operational expenses, and not only purchase E&M facilities that Public owned after a certain time from the commencement, but also finance to replacement costs for those assets. As for additionally needed assets, Public take care of additional investment. This policy was applied to NSEW Line (SMRT), Circle Line (SMRT), North-East Line (SBS).

In “New Rail Financing Framework” announced in 2010, further policy change has been made based on lessons learnt from the experience in order for Public to make a properly decision for replacement and additional investment. Accordingly, transfer of E&M assets from Public to Private (i.e. asset ownership transfer from Public to Private), which was applied by the previous policy, has not been executed. In addition, replacement costs for existing assets and additional investment costs are included in license fees paid by operators to Public, eventually Public pays for it. This policy has

been applied for Downtown Line (SBS). Transition of role of financial burden can be summarized in the table below.

Table 2.1 Transition of MRT Financing Policy

| | At the beginning (from 1987) | Land Transport Plan (from 1996) | New Rail Financing Framework (2010) |
|---|---|---|---|
| Civil infrastructure | Public | Public | Public |
| E&M Assets | Public | Public→Private | Public |
| Operational expenditure | Private | Private | Private |
| Replacement (for existing facilities) | Private | Private | Public |
| Additional Investment | Private | Public | Public |

To develop high quality transport system, the Government of Singapore has introduced the principle of competition through introduction of competitive bidding in the mass transport market. When N-S-E-W Line as the first metro project in Singapore started operation, Singapore MRT Limited (later renamed SMRT Corporation) which was wholly invested by the Government was granted the license and had been carried out operation. Then after, the bidding was taken place for other lines, two operators (SMRT and SBS) competed in the bidding and a winner was selected for the operation of MRT.

### (2) Regulations

Legal basis for urban railway in Singapore is Rapid Transit Systems Act (No.29, 1995), and after several amendment, the final amend has been made in 25th March, 2014. The ACT consists of railway planning, construction, operation, safety management, asset and transfer of liability, fare and so on.

### (3) Subsidies

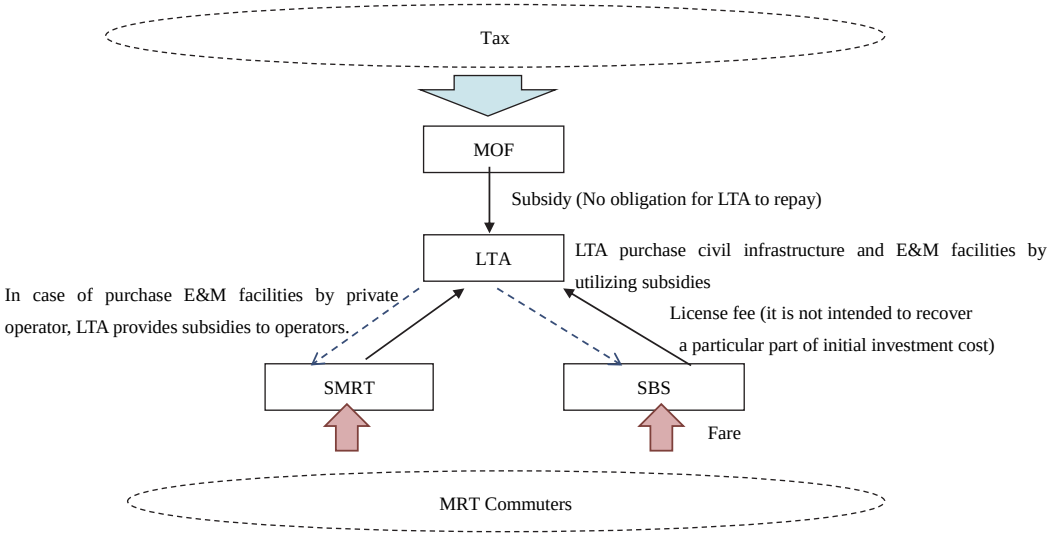
(Government to Regulatory Body)

Both civil infrastructure and E&M facilities are funded from general revenue source in the government, Ministry of Finance (MOF) provides a grant to LTA (Land Transport Authority). LTA is not obligate for repayment to the Government, and LTA finances and procures both civil infrastructure and E&M facilities. All grants from MOF are ear-marked, and MOF approves utilization of fund.

(Government/Regulatory Body to Private Operator)

As for policies for subsidies, basically the government doesn't provide direct subsidies to private operators. Except a case that subsidy for purchase costs for assets transferred from LTA to an

operator, no subsidies have been provided.




Source: JICA Study team

Figure 2.1 Funding sources for MRT and Subsidy

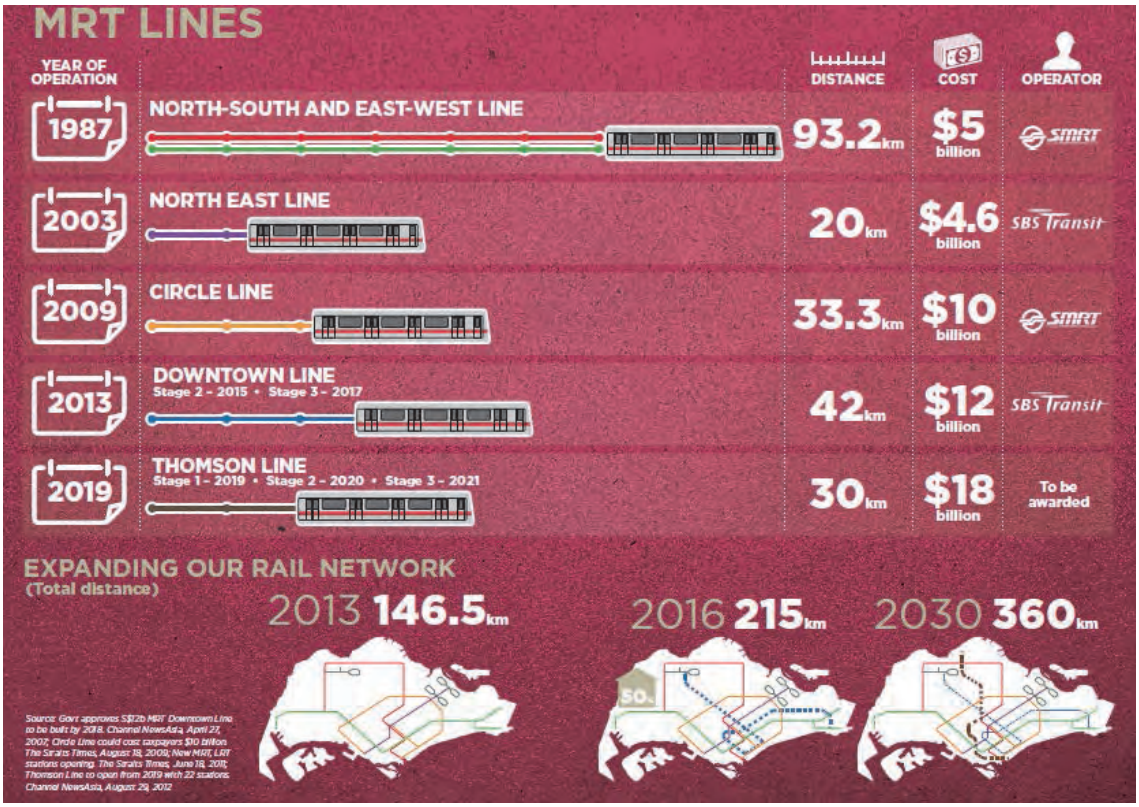
### (4) Fare

Private operators don't have authority to determine fare levels, PTC (Public Transport Council) regulates fares for trains. Fare levels are determined taking into consideration with balance of i) Affordability, ii) Quality, iii) Profitability. Since a metro as public transport is intended to provide users who don't have private vehicle, affordability is important factor. Also, maintaining high standard of services, at the same time, earning healthy profit in Private operator, have been required.

While direct subsidies from LTA to private operator are not practiced, there are systems of free-fare for commuters in early morning. This is subsidies from the Government to commuters, not for private operators.

### (5) Case Studies

MRT in Singapore has been currently operating by two national companies, SMRT and SBS. NSEW Line and Circle Line are operated by SMRT Trains Ltd as a subsidiary company of SMRT Corporation Ltd. North East Line and Downtown Line are running by SBS Transit.




Source: Centre for Livable Cities (CLC), Singapore, 2014

Figure 2.2 MRT in Singapore

As mentioned in the above, contents and scheme of License and Operating Agreement (LOA) have been slightly changed according to the policies at the time, and accordingly different concession schemes have been applied to the project by the project. It can be summarized in the table below.

Table 2.2 Summary of License and Operating Agreement

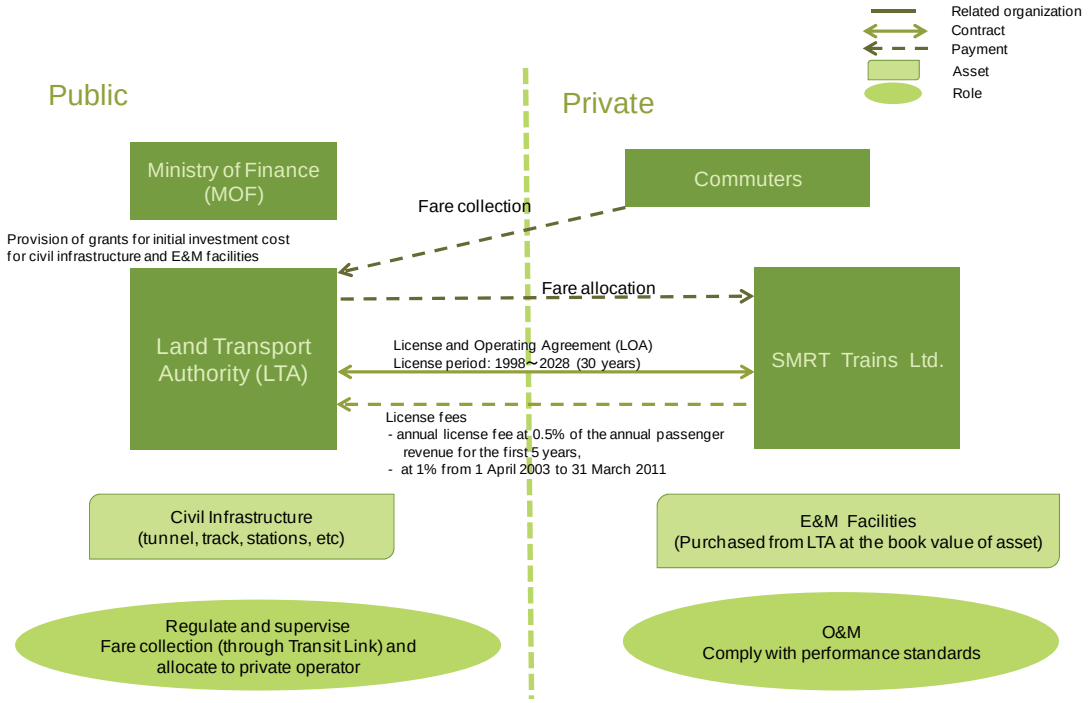
| | **N-S & E-W Line (SMRT)** | **N-E Line (SBS)** | **Circle Line (SMRT)** | **Downtown Line (SBS)** |
|---|---|---|---|---|
| Funding for Civil infrastructure | LTA | LTA | LTA | LTA |
| Funding for E&M Assets | LTA | LTA | LTA | LTA |
| Obligate to purchase E&M asset | Yes (done) | Yes (not yet) | Yes (not yet) | No |
| Operating expense | SMRT | SBS | SMRT | SBS |
| License fee | SMRT→LTA<br>Annual license fee | SBS→LTA | SMRT→LTA<br>Annual license fee<br>Annual non-fare revenue | SBS→LTA<br>License fee (fixed charge)<br>Revenue share charge |
| Ridership risk | SMRT | SBS | SMRT | SBS |

| | | | | |
|---|---|---|---|---|
| License period | 30 years | 30years | 10 years | 19 years |
| Fare level | by PTC | by PTC | by PTC | by PTC |

Source: JICA Study team

(5-1) (North-South and East-West Line

Since commencement of operation in 1987, Singapore MRT Limited, a wholly government company (later named SMRT Corporation), had operated under License and Operating Agreement (LOA). In 1st April, 1998, LTA and SMRT concluded fresh LOA.




Source: SMRT Annual report 2014

Figure 2.3 Project scheme for North-South and East-West Lines (NSEWL)

i) Financial Responsibility and Ownership of Assets

According to new LOA, E&M facilities were sold at the book value of assets from LTA to SMRT[14]. At the transfer of E&A assets, provision of subsidies from LTA to SMRT had been made. SMRT recovers operating expense, depreciation costs for E&M assets, replacement cost for existing assets and additional investment through farebox revenue.

14 According to LTA officers, LTA have been examining to buy back operating assets transferred to SMRC from SMRC. LTA has established asset management group to exam if LTA own all assets.

Table 2.3 Demarcation on asset ownership between Public and Private

| | Public (LTA) | Private (SMRT) |
|---|---|---|
| Civil infrastructure | ○ | |
| E&M Assets | ○ | ○(LTA sold at book value) |
| Operational expenditure | | ○ |
| Replacement (for existing facilities) | | ○ |
| Additional Investment | | ○ |

Source: JICA Study team

ii) Financial Structure (Money Flow)

In consideration for the license to operate, SMRT shall pay annual license fee calculated at 0.5% of the annual passenger revenue for the first 5 years, and at 1% from 1 April 2003 to 31 March 2011.

License fees has been determined through the process of biding (bidders provide price based on their financial projection). So, there are no clear intentions which part of initial investment cost should be recovered by license fee.

iii) Duration of license agreement

The license is for a period of 30 years from 1 April 1998. SMRT may request LTA to extend the license for a further period of 30 years whereupon LTA may, if it deems fit, renew the license for a further 30 years or such other period.

iv) Ridership risk

SMRT takes ridership risk. Through revenue from farebox, cost recovery for operating expense and depreciation cost related to SMRT owned assets is made.

v) Farebox

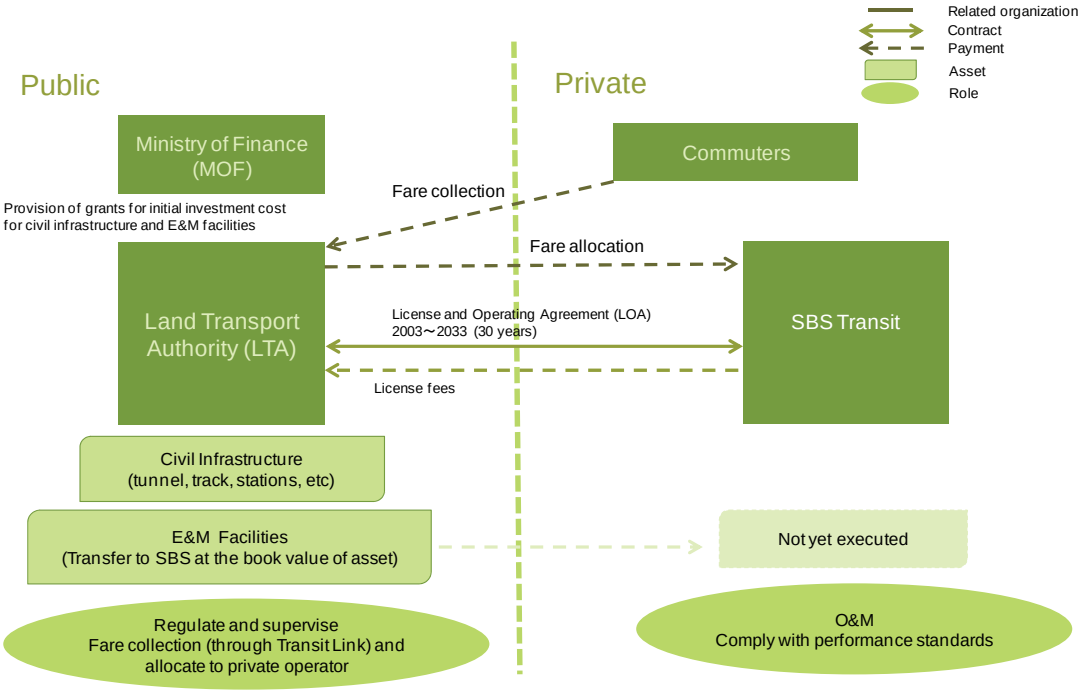
The maximum fares are determined by PTC. Same amounts are applied for the fare of private operators. Fare collection for the whole network has been done by Transit Link (an IC card ticketing company) as a subsidiary of LTA. Total fare revenue is allocated to each line in proportion to actual ridership on each line. And then LTA pays allocated amount to private operator.

vi) Commercial Development

SMRT Corporation Ltd is a group company, consists of several subsidiary companies. MRT is run by SMRT Trains Ltd, and commercial development (real estate, advertisement) is taken care by SMRT Investments Pte Ltd.

(5-2) North East Lines

A license was granted by LTA under which SBS is licensed to operate the North-East line which came into effect on 15th January 2003.




Source: SBS Transit Annual report 2013

Figure 2.4 Project scheme for North East Line (NEL)

i) Financial Responsibility and Ownership of Assets

LOA stipulates that SBS shall purchase the operating assets of the licensed systems at the net book value. LTA and SBS jointly review the viability on the fifth anniversary of the date of the contract (January 2008), upon consensus between two parties, LTA determines the dates of the SBS's purchase of the operating assets. As of today, LTA and SBS have not commenced the review. Its reasons are assumed that the policy has shifted for LTA to have to own all operating assets.

Table 2.4 Demarcation on asset ownership between Public and Private

| | Public (LTA) | Private (SMRT) |
|---|---|---|
| Civil infrastructure | ○ | |
| E&M Assets | ○ | Not yet transferred assets from LTA |
| Operational expenditure | | ○ |
| Replacement (for existing facilities) | - | - |
| Additional Investment | - | - |

Source: JICA Study team

ii) Financial Structure (Money Flow)

The license fee payable to LTA is prescribed under the subsidiary legislation of the Rapid Transit Systems Act during the License Term.

iii) Duration of license agreement

The license is for an initial period of 30 years commencing 15 January 2003. SBS may apply to LTA to renew the license for a further 30 years or any other period.

iv) Ridership risk

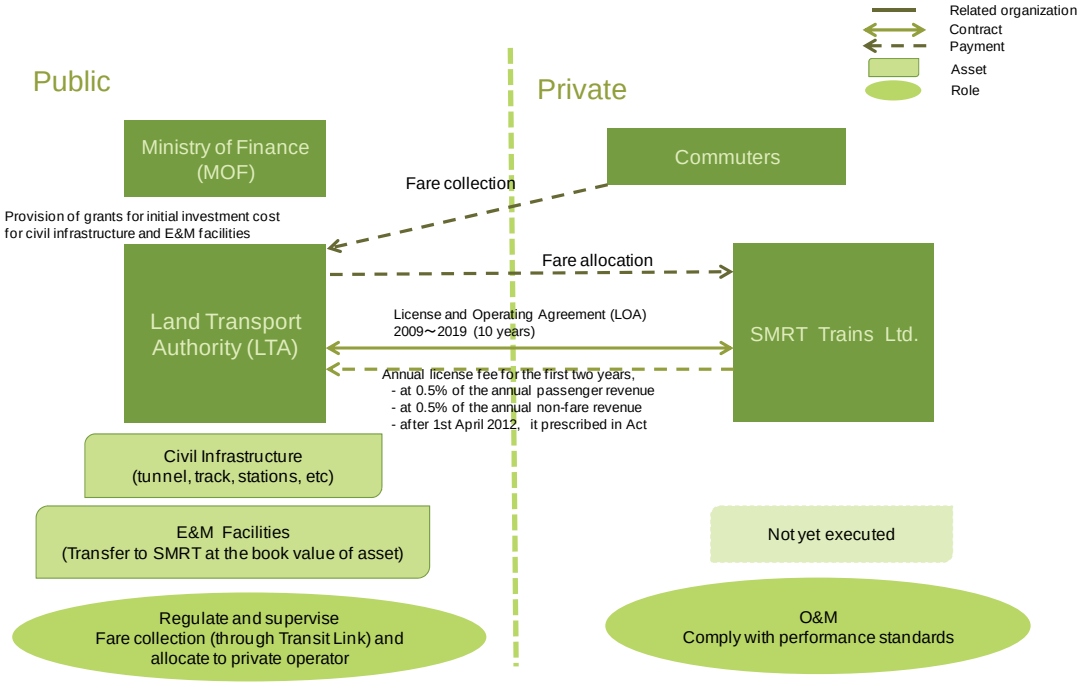
SBS takes ridership risk. Through revenue from farebox, cost recovery for operating expense and depreciation cost related to SBS owned assets is made.

v) Farebox

Same fare level as other lines is applied.

(5-3) Circle Lines

A license was granted by LTA under which SMRT is licensed to operate the Circle line which came into effect on 4 May 2009.




Source: SMRT Annual report 2014

Figure 2.5 Project scheme for Circle Line (CCL)

i) Financial Responsibility and Ownership of Assets

- It is stipulated in LOA that SMRT shall purchase the operating assets of the CCL System from LTA at book values on 4 May 2019 after 10 years from the date of contract. Also, it is stipulated that SMRT may apply for a grant from LTA for the replacement of eligible operating assets to be computed on the basis as set out in the LOA. However, since the policy has shifted for LTA to have to own all operating assets, it is assumed that a transfer of assets will not be realized.

- Prior to MRT's purchase of the operating assets, SMRT is required to set aside annually the sum of S$30 million or 75% of the post-tax surplus derived only from the operation of the CCL System (whichever is lower) in a reserve fund account for capital expenditure.

Table 2.5 Demarcation on asset ownership between Public and Private

| | Public (LTA) | Private (SMRT) |
|---|---|---|
| Civil infrastructure | ○ | |
| E&M Assets | ○ | Not yet transferred assets from LTA |

| | | |
|---|---|---|
| Operational expenditure | | ○ |
| Replacement (for existing facilities) | - | - |
| Additional Investment | - | - |

Source: JICA Study team

ii) Financial Structure (Money Flow)

In consideration for the license to operate, SMRT shall pay annual license fee to LTA. An annual license fee is calculated at the sum of 0.5% of the annual passenger revenue, and 0.5% of the annual non-fare revenue during two years (4th May 2009 to 31th March 2011). After 1st April 2012, the license fee shall be the amount prescribed under the Rapid Transit System Act.

iii) Duration of license agreement

"The Initial License Term" is 10 years from the date of contract (4th May 2009). SMRT may apply LTA to renew for a further period of 30 years from the expiry of the Initial License Term.

iv) Ridership risk

SMRT takes ridership risk. Through revenue from farebox, cost recovery for operating expense and depreciation cost related to SMRT owned assets is made.

v) Farebox

Same fare level as other lines is applied.

(5-4) Downtown Lines

In 19th December 2013, LTA and SBS concluded LOA to operate the Downtown Line MRT system.

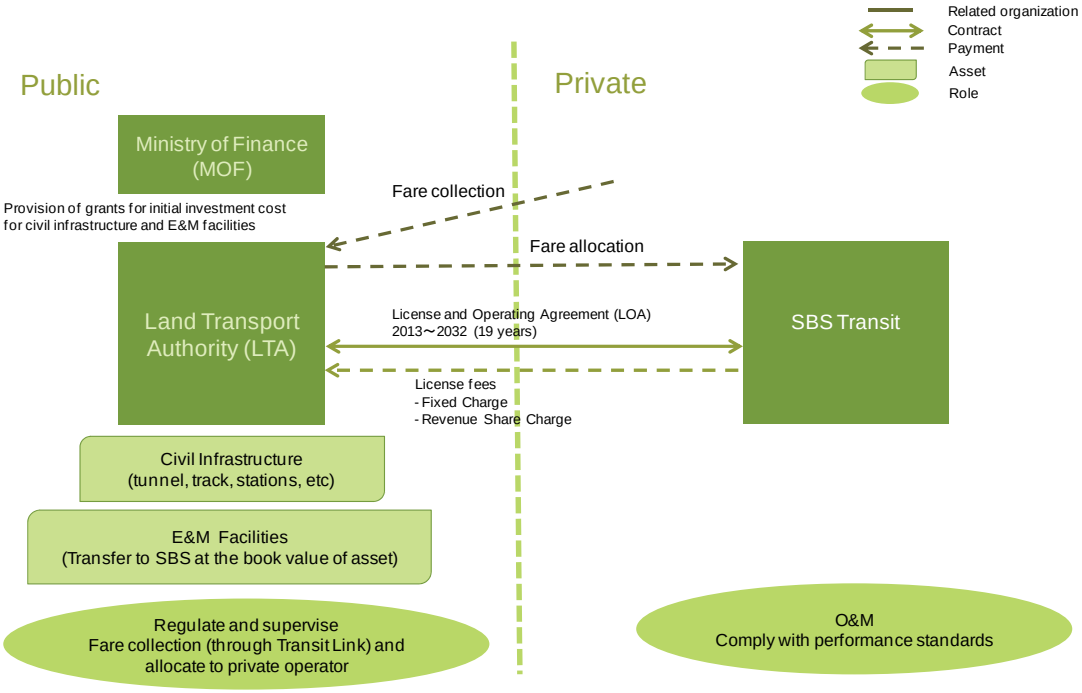



Figure 2.6 Project scheme for Downtown Lines

i) Financial Responsibility and Ownership of Assets

Whole assets are owned by LTA, SBS bears operating expense. There are no stipulations in the LOA that a private operator is obligated to purchase E&M assets, which has been stipulated in another lines.

Table 2.6 Demarcation on asset ownership between Public and Private

| | Public (LTA) | Private (SBS) |
|---|---|---|
| Civil infrastructure | ○ | |
| E&M Assets | ○ | |
| Operational expenditure | | ○ |
| Replacement (for existing facilities) | - | - |
| Additional Investment | - | - |

Source: JICA Study team

ii) Financial Structure (Money Flow)

In consideration for the license to operate, SBS shall pay LTA a license charge which consists of Fixed Charge and Revenue Share Charge. A yearly Fixed Charge is payable from financial year 2019 to end of license period. If the Operating Surplus minus the Fixed Charge for a financial year is more than the Threshold Profit, SBS shall pay Revenue Share Charge.

iii) Duration of license agreement

The license is for a period of 19 years commencing from 20 December 2013. LTA may renew the license for such further period with revised terms and conditions of the renewed license.

iv) Ridership risk

SBS takes ridership risk. Through revenue from farebox, cost recovery for operating expense and depreciation cost related to SMRT owned assets is made.

v) Farebox

Same fare level as other lines is applied.

### (6) Financial status on Private Operator

i) SMRT Corporation Ltd

SMRT Corporation Ltd is a public transport operator incorporated on March 6, 2000, as a result of an industry overhaul to form multi-modal public-transport operators in Singapore. The capital structure of SMRT as of 2014 is; Temasek Holdings (the largest investment company in Singapore owned by the Government) is a major shareholder with 54.2%, international/others with 41.5%, and other Singapore shareholders with 4.3% As a holding company listed on the Singapore Exchange since July 26, 2000, it operates bus, rail, taxi and other public-transport services. MRT is operated by SMRT Trains Ltd as a subsidiary company. Financial status in the segment of MRT has been positive during the past two years.

In addition, the Group leases commercial and advertising spaces within the transport network it operates and engages in operations and maintenance services, project management and engineering consultancy in Singapore and overseas.

Table 2.7 Profit and Loss for rail in SMRT

Unit: S$000

| | 2014 | | 2013 | |
|---|---|---|---|---|
| Revenue | | | | |
| Revenue from fare | 634,145 | 98% | 618,524 | 96% |
| Other operating income | 14,233 | 2% | 23,595 | 4% |
| Total | 648,378 | 100% | 642,119 | 100% |
| | | | | |
| Expenditures | | | | |
| Staff costs | (255,728) | 40% | (217,053) | 37% |
| Depreciation of property, plant and equipment | (101,735) | 16% | (86,103) | 15% |
| Amortisation of asset-related grants | 9,559 | -1% | 10,482 | -2% |
| Repairs and maintenance costs | (68,559) | 11% | (67,063) | 12% |
| Electricity and diesel costs | (113,087) | 17% | (118,378) | 20% |
| Other operating expenses | (117,766) | 18% | (104,292) | 18% |
| Total | (647,316) | 100% | (582,407) | 100% |
| | | | | |
| Profit from operations | 1,062 | | 59,712 | |

Source: SMRT Annual Report 2014

Revenues in segment of MRT consists of farebox revenues which accounts 96~98% and other revenues. Expenditures consist of labor cost (approx 40%), maintenance cost (approx 10%), power cost (approx 20%), and depreciation cost (approx 15%). And also, grants for asset transfer from LTA are amortized in the expenditure side. In short, farabox revenues have been able to recover total operating expense including depreciation cost.

ii) SBS Transit

SBS Transit Limited is a public transport operator in Singapore, which operates bus, rail, taxi and other transport services.The capital structure of SBS as of 2014 is; ComfortDelGro Corporation (the largest a private transport company in Singapore and the second large in the world) owns 75% of share of SBS, and other shares with less than 5% are owned by several minor shareholders. Currently, a segment of bus service is major segment of the company, which its revenue accounts 76%, revenues from MRT and LRT segment stands only 18%.

Financial status in the segment of MRT/LRT was negative in 2013, and surplus S$ 4.9 million in 2012. While revenues from the segment of MRT/LRT have steadily increased, it has been fall into loss due to start up costs for Down Town Line such as labor cost and maintenance cost. If excluding the start up costs, it is assumed that the segment of MRT/LRT earned profit S$13.6 million.

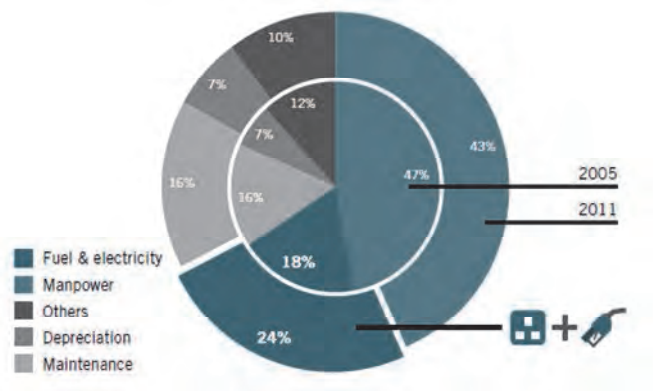
Table 2.8 Profit and Loss for rail in SMRT

Unit: S$000

| | 2013 | | 2012 | |
|---|---|---|---|---|
| Revenue | 148,138 | | 138,607 | |
| Expenditures | 153,912 | | 133,681 | |
| Profit from operations | (5,774) | | 4,926 | |

Source: SBS Transit Annual Report 2013

Cost breakdown of the segment of MRT/LTR in 2011 was labor cost (approx 43%), maintenance cost (approx 16%), power cost (approx 24%) and depreciation cost (approx 7%).




Source: SBS Transit Annual Report 2013

Figure 2.7 Breakdown of expenditure in 2005 and 2011

### 2.2.2 Thailand

#### (1) Policy

The national policy on public-private partnership in Thailand was made public through the legislation, “Private Participation in State Undertaking Act, B.E.2535 (1992)”, which has been in effect since April 1992. However, the main purpose of the act is to prevent corruption, and it is silent on the roles to be assumed by the private and public sectors in project phases such as asset financing and transfer.[15] Therefore, the roles to be assumed by the private and public sectors in urban railway projects is to be decided on an individual project basis, based on the individual projects’ profiles (especially ridership projection which can vary significantly depending on the intended locations) and accumulated experience.

The “Green line (original)” metro railway line, Thailand’s first Mass Rapid Transit (MRT) project which opened in December 1999, employs the scheme wherein the private sector finances both the construction of civil infrastructure (tunnel, track, station, etc.) as well as the procurement of electrical and mechanical (E&M) assets (rolling stock, signaling system, etc.). The private sector assumes the ridership risk, and it covers its operations and maintenance (O&M) expenses with the revenues it collects from commuters as train fare (this scheme is commonly known as the “Net Cost” scheme). Also, the costs of the refurbishment of existing and purchasing new operational assets are borne by the private sector. However, the project’s financial results ended up being below the forecast financial outputs, after seven years of operation in February 2006, the private sector filed the petition for business rehabilitation at the central bankruptcy court.

The Blue line, Thailand’s first underground MTR project which opened in July 2004, employs the "vertical separation" scheme wherein the civil infrastructure and E&M assets are financed by the public and private sectors, respectively. As with Green line (original), the Blue line operates under the Net Cost scheme wherein the private sector assumes the ridership risk, and it covers its O&M expenses from the revenues it collects from commuters as train fare. The cost of the refurbishment of operational assets is borne by the private sector. In the case of the cost of purchasing new operational assets, the private sector parties would discuss and then decide on which sector would shoulder the said cost.

The “Green line (Extension)” which commenced operations in stages from 2009 and 2013, employs

[15] Passanan Suwannoi, “Thailand’s Newly Proposed Public-Private Partnership Law”, August 17, 2012

the scheme wherein the public sector finances both the construction of civil infrastructure and the procurement of E&M assets. Although the O&M work is entrusted to the private sector, the public sector assumes the ridership risk (this scheme is commonly called “Gross Cost” scheme). The private sector receives a fixed management fee from the public sector as compensation for the O&M expenses it incurs. As with Blue line, the cost of refurbishment of operational assets is borne by the private sector. In the case of the cost of purchasing new operational assets, the private sector parties would discuss and then decide which sector would shoulder the said cost.

The Purple line, which is expected to commence operations in 2016, employs the scheme wherein both the civil infrastructure and E&M assets will initially be financed by the private sector. However, the ownership of civil infrastructure will be transferred to the public sector when the line opens, and the public sector will pay for the cost of transferring the assets in installments. Like the Green line (Extension), the Gross Cost scheme will be adopted as its operational scheme. As such, the O&M work will be entrusted to private sector while public sector will assume the ridership risk. The private sector will receive a fixed management fee from the public sector as compensation for the O&M expenses it will incur. Also, like Green line (Extension), the cost of refurbishment of operational assets will be borne by the private sector. In the case of the cost of purchasing new operational assets, the private sector parties will discuss and then decide which sector will shoulder the said cost.

It has been a trend for the public sector to assume more financial burden as well as more ridership risk. This is summarized in the following table.

Table 2.9 Transition of Financing Policy

| Line | Green line (Original) | Blue line | Green line (Extension) | Purple line |
|---|---|---|---|---|
| Year of commencement of operations | 1999 | 2004 | 2009~2013 | 2016 |
| Ownership of civil infrastructure | Private→Public | Public | Public | Private→Public- |
| Ownership of E&M assets | Private | Private | Public | Public |
| Burden of ridership risk | Private | Private | Public | Public |
| Burden of O&M expenses | Private | Private | Private | Private |

| | | | | |
|---|---|---|---|---|
| Burden of refurbishment cost of existing assets | Private | Private | Private | Private |
| Burden of cost of new assets | Private | Public/Private | Public/Private | Public/Private |

Source: JICA Study team

In Thailand, private sector operators have been chosen through competitive bidding processes. As the result, the MRT lines in Thailand are currently operated by two different private sector entities.

### (2) Background

The current urban railroad system in Bangkok, Thailand has its origin in "Master Transit Master Plan" that was proposed in 1994. Later, the legislation was updated as the "Urban Rail Transportation Master Plan in Bangkok and Surrounding Areas" that was proposed in 2004.[16]

### (3) Subsidies

(Government to Regulatory Body)

The public-sector authority with respect to the concession agreements for the Green line (Original) and the Green line (Extension) is the Bangkok Metropolitan Administration (the "BMA") Whereas, the Mass Rapid Transit Authority of Thailand (the "MRTA") is the public-sector authority with respect to the concession agreements for the Blue line and the Purple line. Information on the BMA's subsidies for urban railways under its jurisdiction is not available. In regards to the MRTA, the Ministry of Finance (the "MOF") provides both subsidies and loans to the urban railways under its jurisdiction. The MRTA will not need to repay the subsidies that are provided by MOF, but it will have to repay the loans.

(Government/Regulatory Body to Private Sector)

Private-sector operators have never received any subsidies directly from BMA, MRTA or other government entities. When the operator of Green line (Original) was in its bankruptcy proceedings, it did not receive any subsidies from the government as well.

[16] Association of oversees consultants, Nippon Koei Co., Ltd., "Analysis of light to medium volume transportation systems in Bangkok metropolitan area" February 2010

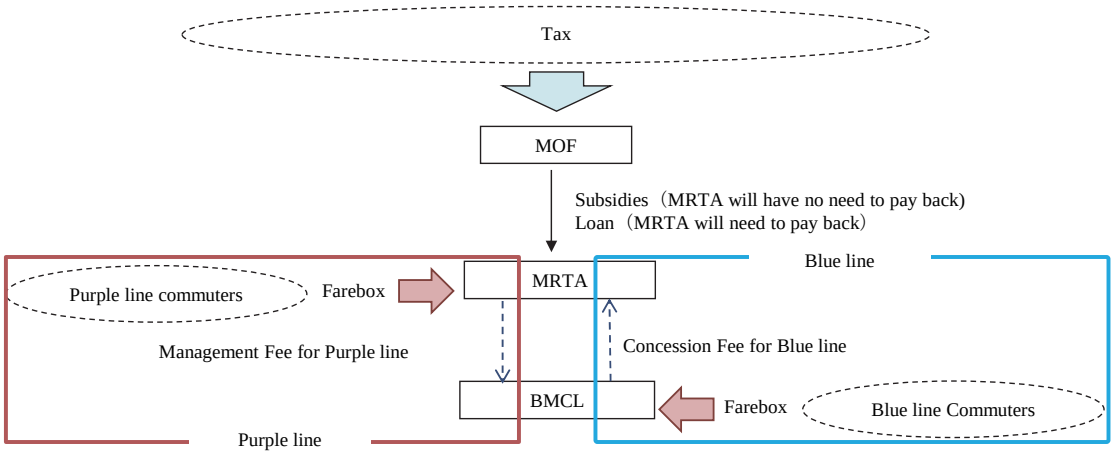



Figure 2.8 Funding Sources for Blue line and Purple line

### (4) Fare

The Office of Transport and Traffic Policy and Planning (OTP), the government entity responsible for submitting policies and formulating transport and traffic plans, determines the maximum farebox by considering factors such as as the commuters' financial ability to pay.

### (5) Case Studies

This section covers four lines: the Green line (Original), the Blue line, the Green line (Extension), and the Purple line. Both Green lines – original and extension – are operated by the Thai company, the Bangkok Mass Transit System Public Company Limited (the "BTSC"). The Blue line and the Purple line are operated by Bangkok Metro Company Limited (the "BMCL").

The below table summarizes the concession agreements for the four railway lines. As mentioned, the respective roles that are assumed by the private and public sectors are determined on an individual project basis, by considering the individual projects' profiles and accumulated experience.

Table 2.10 Summary of License and Operating Agreement

| | Green line (Original) | Blue line | Green line (Extension) | Purple line |
|---|---|---|---|---|
| Ownership of civil infrastructure | BTSC→ BMA[17] | MRTA | BMA | BMCL→ MRTA[18] |
| Ownership of E&M assets | BTSC | BMCL | BMA | BMCL |

[17] Civil infrastructure ownership was transferred from BTSC to BMA in order to reduce the property tax that would have otherwise been assessed on BTSC's possession

[18] The ownership of civil infrastructure will be transferred from BMCL to MRTA on the opening of the line, and the MRTA will pay for the transfer in 10-year installments.

| | | | | |
|---|---|---|---|---|
| Burden of ridership risk | BTSC | BMCL | BMA | MRTA |
| Burden of O&M cost | BTSC | BMCL | BTSC | BMCL |
| Concession payments | None | BMCL→MRTA Both fixed and floating payment | BMA→BTSC Fixed management fee payment | MRTA→BMCL Fixed management fee payment |
| Licensing period | 30 years (1999－2029) | 25 years (2004－2029) | 30 years (2012－2042) | 30years (2013－2043) |
| Farebox | Stipulated in the concession agreement | Stipulated in the concession agreement | Determined by BMA | Determined by MRTA |

Source: JICA Study team

### (5-1) Green line (Original)

In 1992, the concession agreement for the Green line (Original) between BTSC and BMA was signed. The concession period is 30 years from the commencement of operations. The Green line (Original) commenced its operation in December 1999 as the first MRT system in Thailand.

i) Financial responsibilities and ownership of assets

Civil infrastructure excluding land was developed under the BTO scheme, while the E&M assets were under BTO scheme. Upon the completion of construction, civil infrastructure was transferred to BMA, and as such, BTSC had effectively financed all the railway assets other than land. The BTSC covers the O&M and depreciation costs of the owned assets as well as the cost of refurbishment of existing operational assets and purchasing new operational assets from the farebox revenue it receives. However, the financial results were below the original forecast financial outputs, after seven years of operation in February 2006, the private-sector party filed the petition for business rehabilitation at the central bankruptcy court. The central bankruptcy court approved BTSC's rehabilitation plan as it deemed that BTSC's operation would be sustainable considering that the EBITDA since the second year of operations had been positive. Despite the above rehabilitation process, no modifications have been made to the concession agreement between BTSC and BMA.

Table 2.11 Demarcation on Asset Ownership between Public and Private

| | Public (BMA) | Private (BTSC) |
|---|---|---|
| Ownership of civil infrastructure | | ○ |
| Ownership of E&M assets | | ○ |
| Burden of O&M cost | | ○ |
| Burden of refurbishment cost of existing assets | | ○ |
| Burden of cost of new assets | | ○ |

Source: JICA Study team

ii) Concession payments

There are no payment flows during concession period.

iii) Licensing period

In April 1992, the concession agreement for Green line (Original) was signed. The concession period is 30 years from the commencement of operations. As the Green line (Original) commenced its operation in December 1999, the concession period will end in December 2029.

iv) Ridership risk

BTSC assumes ridership risk, and it covers the O&M and depreciation costs of the owned assets, as well as the costs of the refurbishment of its existing and new operational assets from the farebox revenue it receives.

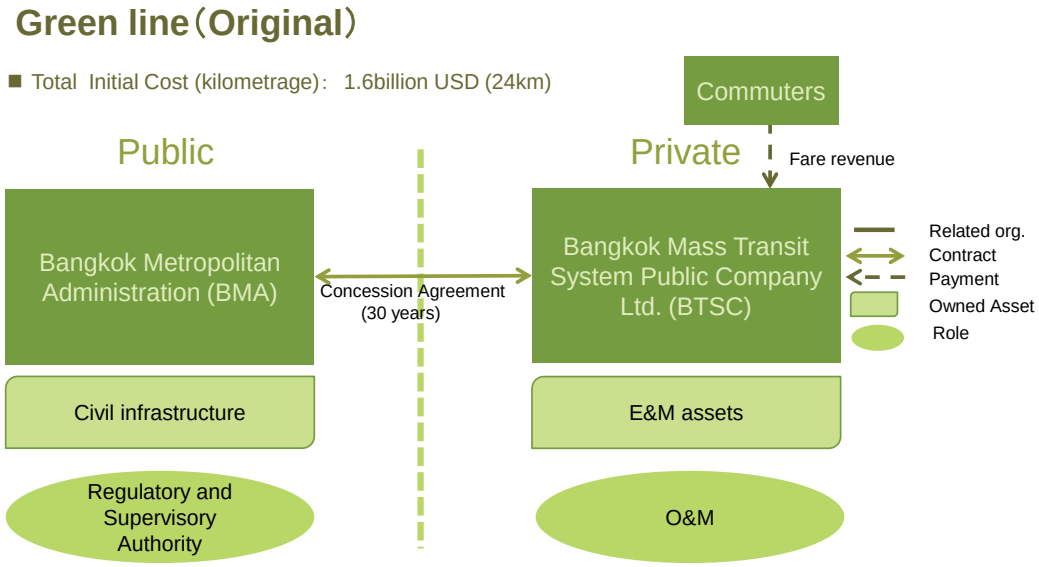
v) Farebox

The fare structure differs between the original line and extension line of the Green line. If a passenger travels within the Green line (Original), the minimum fare is 15 baht and the fare increases by 5 baht at every other subsequent station until the maximum fare of 42 baht is reached. If a passenger also travels on the Green line (Extension), the maximum fare will be 55 baht and the fare for the Green Line (Extension) will differ by zone.

The concession agreement allows for fare hikes every 18 months to cushion against inflation. However, due to the BMA's intention of keeping the fares low in order to make public transport convenient for Bangkok residents, BTSC has raised its fares only twice since commencing operations. As a result, the current fare level is below the maximum fare level allowed under the concession agreement.

vi) Commercial development

Under the concession agreement, the BTSC has the right to commercial development of the stations it operates. The BTSC has not employed the commercial development model wherein it owns and develops real estate adjacent to the railway lines it operates. This is because land acquisition would be unfeasible without the assistance of the public authority, and when the period of capital recovery from the land purchase phase to the development phase is too long.




Source: JICA Study team

Figure 2.9 Project Scheme for Green line (Original)

(5-2) Blue line

In August 2000, the concession agreement for Blue line between BMCL and MRTA was signed. The concession period is 25 years from the commencement of operation.

i) Financial responsibilities and ownership of assets

The Blue line commenced its operations in July 2004 as the country's first underground metro project. It employed the vertical separation scheme wherein the civil infrastructure and E&M assets are financed by the public sector and private sector, respectively. BMCL covers the O&M and depreciation costs of the owned assets (i.e., E&M assets), as well as the cost of refurbishment of existing and new operational assets from the farebox revenue it receives.

Table 2.12 Demarcation on Asset Ownership between Public and Private

| | Public (BMCL) | Private (MRTA) |
|---|---|---|
| Ownership of civil infrastructure | ○ | |
| Ownership of E&M assets | | ○ |
| Burden of O&M cost | | ○ |
| Burden of refurbishment cost of existing assets | | ○ |
| Burden of cost of new assets | ○ | ○ |

Source: JICA Study team

ii) Concession payments

During the concession period, the BMCL pays the concession fees that are linked to the farebox and commercial development revenues. Each type of revenue consists of a fixed amount as well as a floating amount that is linked to farebox revenue (commercial development revenue). The fixed amount payments are kept low in the initial years of operations – farebox-related fixed payments are exempt in the first 10 years, and the payments that are attributable to commercial development are 100 million baht in the first 8 years after the commencement of operations. It may be noted that the concession fee was determined at a level where the private operator could earn an IRR that is greater than 14%, and the said level is not calculated based on the recouping of the cost of the civil infrastructure that is financed by the MRTA .

iii) Licensing period

In August 2000, the concession agreement for Blue line between BMCL and MRTA was signed. Concession period is 25 years from the commencement of operation. As the Blue line commenced its operation in July 2004, the concession period will end in July 2029.

iv) Ridership risk

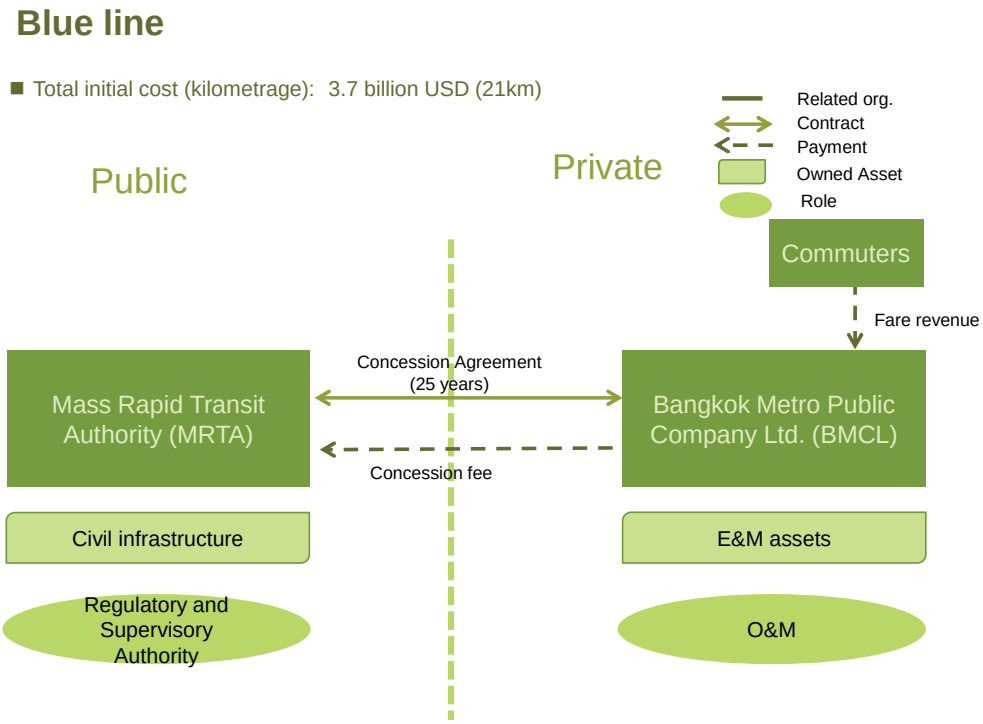
The BMCL bears the burden of the ridership risk, and it covers the O&M and depreciation costs of its owned assets as well as the costs of refurbishment of its existing and new operational assets from the farebox revenue it receives.

v) Farebox

The minimum fare is 14 baht, and the fare increases by 2 baht at each subsequent station until the maximum fare of 36 baht is reached. The concession agreement allows for fare hikes every 18 months in order to cushion against inflation.

vi) Commercial development

Under the concession agreement, the BMCL is allowed to advertize and lease space or property along the railways and stations that it operates.




Source: JICA Study team

Figure 2.10 Project Scheme for Blue line

### (5-3) Green line (extension)

The 30-year concession agreement for the Green line (Extension) was signed by the BTSC and the BMA. The Green line (Extension) commenced operations in stages from 2009 and 2013. The concession period is from May 2012 to May 2042.

i) Financial responsibilities and ownership of assets

Following the lessons learned from the Green line (Original) where the operator, the BTSC went through a financial rehabilitation process to relieve itself of all financial burdens other than land as well as ridership risk, the Green line (Extension) employs the scheme where the BMA which is the relevant public-sector authority, finances both the construction of civil infrastructure and the procurement of E&M assets. The PPP Gross Cost method is employed, and the BMA assumes the ridership risk although the O&M work is entrusted to the BTSC. The BTSC which is the relevant private operator entered into a long-term O&M contract whereby it receives a fixed management fee from BMA as compensation for the O&M costs it incurs. The cost of the refurbishment of operational assets is borne by BTSC. In the case of new operational assets, BTSC and BMA would discuss each individual case between them and decide on who would shoulder such cost.

Table 2.13 Demarcation on Asset Ownership between Public and Private

| | Public (BMA) | Private (BTSC) |
|---|---|---|
| Ownership of civil infrastructure | ○ | |
| Ownership of E&M assets | ○ | |
| Burden of O&M cost | ○ | |
| Burden of the refurbishment cost of existing assets | | ○ |
| Burden of the cost of new assets | To be discussed | |

Source: JICA Study team

ii) Concession payments

The monthly management fee is paid to the BTSC by the BMA during concession period.

iii) Licensing period

The contractual period for the long-term O&M contract is 30 years, starting from May 2012 and ending in May 2042. A short-term O&M contract was entered into at every staggered opening of the Green line (Extension) between 2009 and 2013. These contracts later were bundled together into one long-term O&M contract in May 2012.

iv) Ridership risk

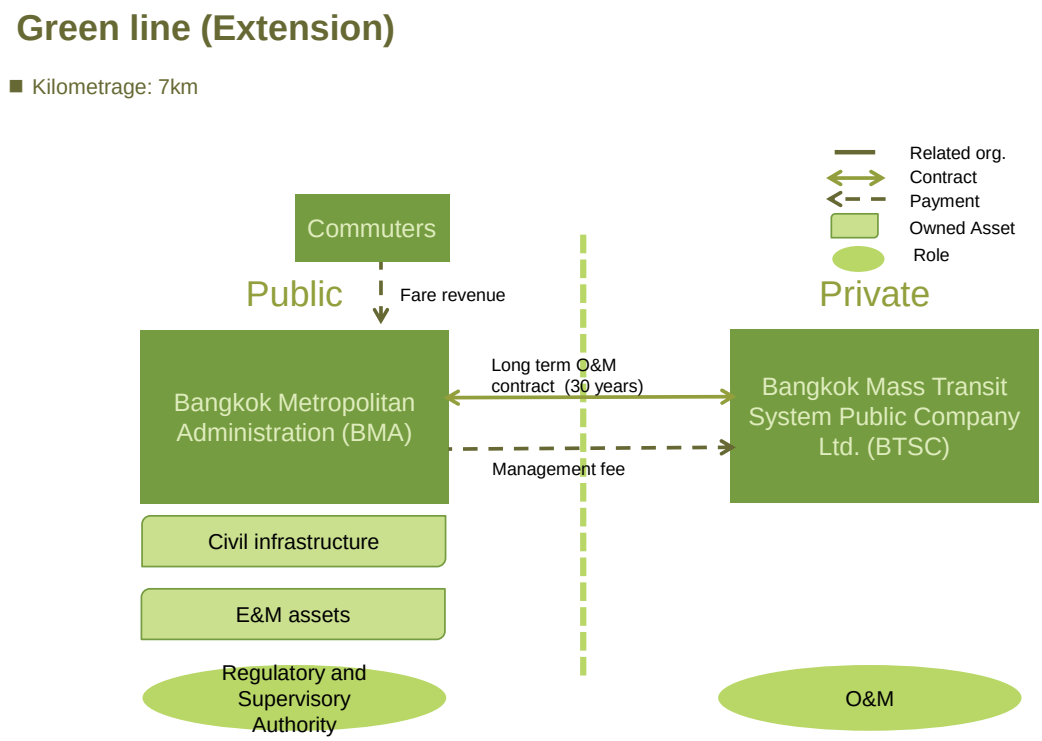
The BMA which is the relevant public-sector authority assumes the ridership risk. The BTSC which is the relevant the private operator, is compensated for the O&M cost it incurs through the monthly fixed management fee that is paid by the MRTA.

v) Farebox

The fare structure of the Green line's original line differs from that of its extension line. If a passenger travels within the Green line (Original), the minimum fare is 15 baht and the fare increases by 5 baht at each subsequent station until the maximum fare of 42 baht is reached. If a passenger also travels on the Green line (Extension), the maximum fare is 55 baht and the fare for the Green Line (Extension) will differ by zone. The BMA will revise the fares according to political and economic considerations, among others..

vi) Commercial development

BMA will conduct commercial development.




Source: JICA Study team

Figure 2.11 Project Scheme for Green line (Extension)

### (5-4) Purple line

In September 2013, the concession agreement for Purple line was signed between BMCL and MRTA. Concession period is 25 years from the commencement of operation. The concession period starts from September 2013 and ends in September 2043.

i) Financial responsibilities and ownership of assets

Both the construction of civil infrastructure and the procurement of E&M assets will initially be financed by the BMCL which is the relevant private operator. However, the ownership of civil infrastructure will be transferred to MRTA which is the relevant public-sector authority on the opening of the line. The MRTA will pay for the transfer, inclusive of the interest costs the BMCL will have accrued in order to finance the cost of civil infrastructure, and the payment will be in the form of annual installments for 10 years. The PPP Gross Cost method will be employed, and MRTA will assume the ridership risk, although the O&M work will be entrusted to BMCL. The BMCL which is the private operator, entered into the contract whereby it receives a fixed management fee from BMA as compensation for the O&M costs it incurs. The cost of the refurbishment of operational assets is borne by the BMCL. In the case of new operational assets, BMCL and MRTA will discuss each individual case between them and decide on who will shoulder such cost.

Table 2.14 Demarcation on Asset Ownership between Public and Private

| | 官（MRTA） | 民（BMCL） |
|---|---|---|
| Ownership of civil infrastructure | ○ | |
| Ownership of E&M assets | ○ | |
| Burden of O&M cost | ○ | |
| Burden of the refurbishment cost of existing assets | | ○ |
| Burden of cost of new assets | To be discussed | |

Source: JICA Study team

ii) Concession payments

The monthly management fee will be paid to BMCL by MRTA during the concession period.

iii) Licensing period

The concession period is 30 years, starting from September 2013 and ending in September 2043.

iv) Ridership risk

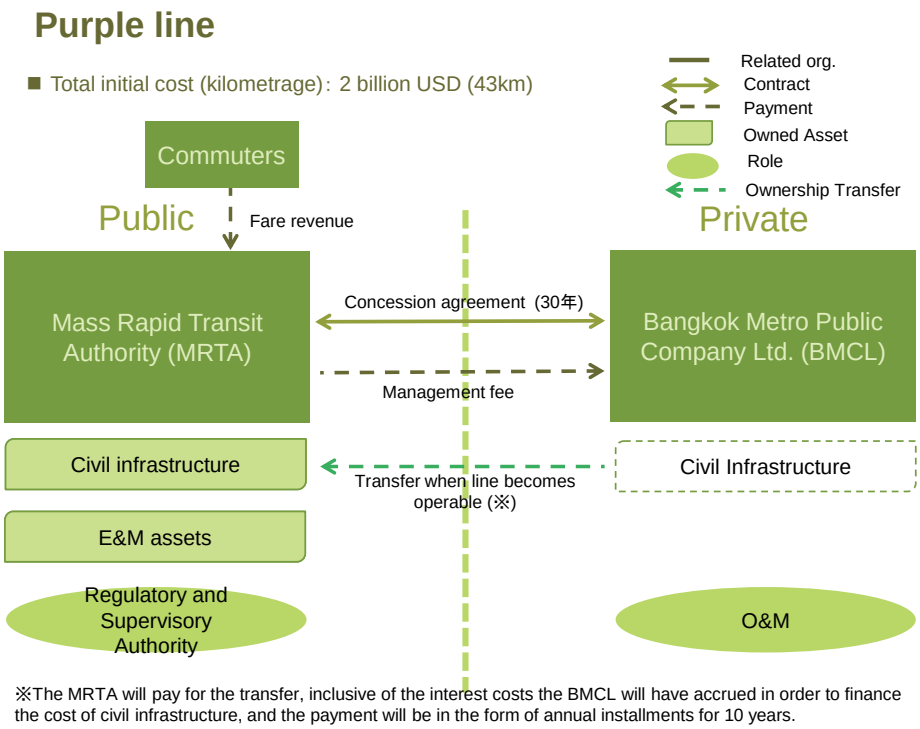
The MRTA which is the relevant public-sector authority will assume the ridership risk. The BMCL which is the private operator will be compensated for the O&M costs it will incur through the monthly fixed management fee to be paid by the MRTA.

v) Farebox

The MRTA, the relevant public-sector authority has the right to fare fixation. It is considering to set the fares according to zone, This is because, for a line laid out in a relatively less populated suburban area of Bangkok, this model is expected to generate more in fare revenue than the fare model in which the fare increases according to travel distance,.

vi) Commercial development

The MRTA, as the owner of the commercial development, is not bestowed the power to develop and advertize real estate.. However, the law is expected to change in 2015, whereby the MRTA will be given such power.




Source: JICA Study team

Figure 2.12 Project Scheme for Purple line

## (6) Financial Status of Private Operator

### i) BTSC

97.46% shareholder of BTSC is BTS Group Holdings Public Company Limited ("BTS Holdings"), listed on the Stock Exchange of Thailand with its market capitalization of 111.1 billion baht (3.4 billion US dollars). The largest shareholder of the BTS Holdings is the chairman of the same, Mr. Keeree Janjanapas, with 33% shareholding ratio. The second largest shareholding ratio is below 7% and no public entity owns BTS Holdings' shares in sizable amount[19].

The following summarizes the current operational results and financial positions of the BTSC's Green line including both the original and the extension lines, which have been carved out the BTSC's financial statements. Currently, the passenger numbers and farebox revenues have increased, while the financial positions are sound with positive EBIT and net income.

In 2013, in order to finance the further extensions of Green line as well as Pink line, it sold its right to future farebox revenues from the operation of the Green line (Original) to the infrastructure fund, the "BTS Rail Mass Transit Growth Infrastructure Fund" ("BTGIF"). The net consideration that the BTSC received from such sale was 61,399 million baht (1.86 billion US dollars).

Table 2.15 BTSC's Income Statements

**Income Statements**

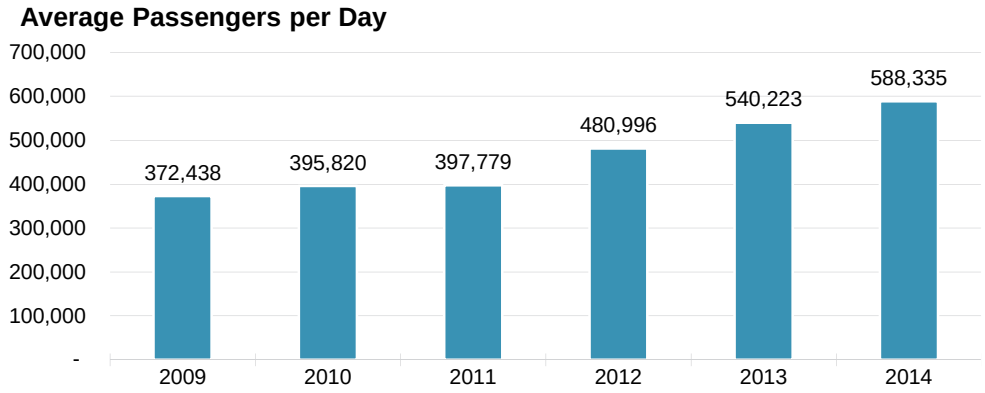
1USD=33THB

| | | THB (million) | | USD (million) | |
|---|---|---|---|---|---|
| | | 2011/3 | 2012/3 | 2011/3 | 2012/3 |
| **Revenues** | | | | | |
| Farebox revenues | | 3,545 | 4,297 | 107 | 130 |
| Other income | | 0 | 2 | 0 | 0 |
| **Total revenues** | | **3,545** | **4,299** | **107** | **130** |
| **Expenses** | | | | | |
| Cost of farebox | | 1,998 | 2,232 | 61 | 68 |
| Selling expenses | | 68 | 60 | 2 | 2 |
| Administrative expenses | | 456 | 357 | 14 | 11 |
| **Total expenses** | | **2,521** | **2,649** | **76** | **80** |
| **EBIT** | | **1,024** | **1,650** | **31** | **50** |
| Finace cost | | (745) | (812) | (23) | (25) |
| **Net income** | | **279** | **838** | **8** | **25** |
| | | | | | |
| **EBITDA** | Note | **2,025** | **2,905** | **61** | **¥ 88.03** |
| **EBITDA/Farebox revenues** | | ***57.1%*** | ***67.6%*** | ***57.1%*** | ***67.6%*** |
| **EBIT** | | **1,024** | **1,650** | **31** | **50** |
| **EBIT/Farebox revenues** | | ***28.9%*** | ***38.4%*** | ***28.9%*** | ***38.4%*** |

Note: Net income after adding depreciation and amortization and provision for long-term employee benefits

Source: BTS Rail Mass Transit Growth Infrastruture Fund Offering Memorandum, April 4, 2013

[19] Bloomberg




Source: BTS Group Holdings PCL Annual Report 2013/2014

Figure 2.13 Average Passengers per Day – Green line (Original and Existing)

Table 2.16 BTSC's Balance Sheet

**Balance Sheet** 1USD=33THB

| | THB (million) | | USD (million) | |
|---|---|---|---|---|
| | 2011/3 | 2012/3 | 2011/3 | 2012/3 |
| Cash | 360 | 68 | 11 | 2 |
| Other current assets | 85 | 135 | 3 | 4 |
| **Current Assets** | **445** | **203** | **13** | **6** |
| Project costs | 43,896 | 42,977 | 1,330 | 1,302 |
| Investments | 559 | 535 | 17 | 16 |
| **Non-current assets** | **44,455** | **43,512** | **1,347** | **1,319** |
| **Assets Total** | **44,900** | **43,715** | **1,361** | **1,325** |
| | | | | |
| Corrent portion of long term debt | - | 2,496 | - | 76 |
| Other current liabilities | 601 | 770 | 18 | 23 |
| **Current Liabilities** | **601** | **3,266** | **18** | **99** |
| Long-term debt | 11,907 | 9,444 | 361 | 286 |
| Loan from shareholder | - | - | - | - |
| Other long-term liabilities | 277 | 311 | 8 | 9 |
| **Long-term Liabilities** | **12,184** | **9,755** | **369** | **296** |
| **Net asset value** | 32,114 | 30,693 | 973 | 930 |
| **Total Liabilities and Net asset value** | **44,900** | **43,715** | **1,361** | **1,325** |

Source: BTS Rail Mass Transit Growth Infrastruture Fund Offering Memorandum, April 4, 2013

ii) BMCL

BMCL is listed on the Stock Exchange of Thailand with its market capitalization of 39.6 billion baht (approx. 1.2 billion US dollars). Three largest shareholders of BMCL are listed below. MRTA, the public sector entity and the regulatory / supervisory authority of the Blue line and Purple line, is its second largest shareholder. BMCL has no borrowing from public sector entity.

Table 2.17 BMCL's major shareholders

| | Shareholder's name | Business Description | Sector | Shareholding Ratio |
|---|---|---|---|---|
| 1 | Ch. Kanchang Public Company Limited | Provides construction services to public and private sectors including construction of expressways, public utilities, and industrial plants. | Private Sector | 25% |
| 2 | MRTA | Regulatory and supervisory authority of the Blue line and Purple line | Public Sector | 15% |
| 3 | Bangkok Expressway Public Company Limited | Undertakes construction and project management of expressways and other relevant projects in Bangkok under the 30 year concession agreement with the Expressway and Rapid Transit Authority of Thailand | Private Sector | 10% |

Source: JICA Study team

The following summarizes the current unconsolidated operational results and financial positions of the BMCL, which is the operator of the Blue line and the Purple line. Though the number of commuters is on an upward trend, the net income is negative due to the large financial cost. However, the EBIT (the earnings before income and tax) is positive.

The BMCL's financial position has been strengthened as it had raised 8.55 billion baht (260 million US dollars) through the allotment of new equity shares to its existing shareholders and the full repayment of a 4 billion baht loan (120 million US dollars) from its shareholder.

Table 2.18 BMCL's Income Statements

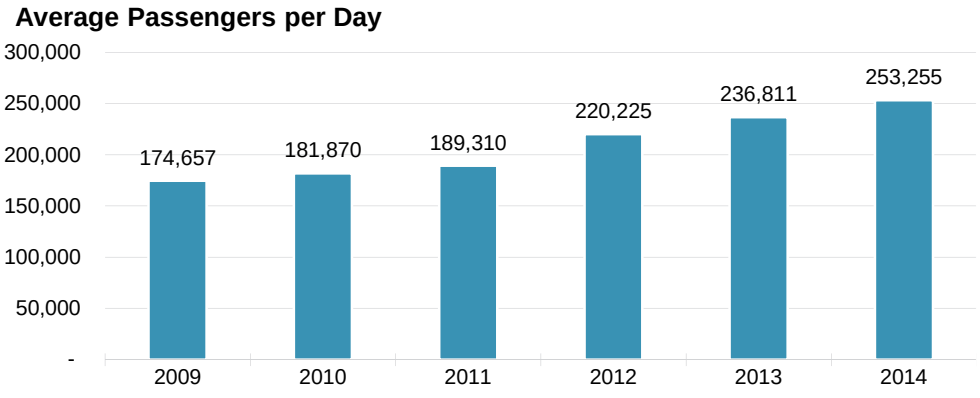
**Income Statements**

1USD=33THB

| | THB (million) | | USD (million) | |
|---|---|---|---|---|
| | 2012/12 | 2013/12 | 2012/12 | 2013/12 |
| **Revenues** | | | | |
| Farebox revenues | 1,979 | 2,106 | 60 | 64 |
| Commercial development revenue | 164 | 227 | 5 | 7 |
| Other income | 9 | 8 | 0 | 0 |
| **Total revenues** | **2,152** | **2,341** | **65** | **71** |
| **Expenses** | | | | |
| Cost of farebox | 1,369 | 1,316 | 41 | 40 |
| Cost of commercial development | 80 | 81 | 2 | 2 |
| Amortization of project costs | 324 | 348 | 10 | 11 |
| Selling expenses | 12 | 12 | 0 | 0 |
| Administrative expenses | 182 | 169 | 6 | 5 |
| **Total expenses** | **1,966** | **1,926** | **60** | **58** |
| **EBIT** | **186** | **414** | **6** | **13** |
| Finace cost | (1,168) | (1,210) | (35) | (37) |
| **Loss before income tax expense** | **(982)** | **(796)** | **(30)** | **(24)** |
| Income tax expense | 3 | 5 | 0 | 0 |
| **Loss for the year** | **(979)** | **(791)** | **(30)** | **(24)** |
| | | | | |
| **EBITDA** Note | **630** | **888** | **19** | **27** |
| **EBITDA/Farebox revenues** | ***31.8%*** | ***42.2%*** | ***31.8%*** | ***42.2%*** |
| **EBIT** | **186** | **414** | **6** | **13** |
| **EBIT/Farebox revenues** | ***9.4%*** | ***19.7%*** | ***9.4%*** | ***19.7%*** |

Note: EBIT after adding amortization and depreciation

Source:BMCL Annual Report 2013




Source: BMCL Presentation

Figure 2.14 Average Passengers per Day – Blue line

Table 2.19 BMCL's Balance Sheet

**Balance Sheet** 1USD=33THB

| | THB (million) | | USD (million) | |
|---|---|---|---|---|
| | 2012/12 | 2013/12 | 2012/12 | 2013/12 |
| Cash | 80 | 2,185 | 2 | 66 |
| Other current assets | 100 | 170 | 3 | 5 |
| **Current Assets** | **180** | **2,355** | **5** | **71** |
| Project costs | 17,547 | 17,202 | 532 | 521 |
| Investments | 334 | 508 | 10 | 15 |
| **Non-current assets** | **17,881** | **17,710** | **542** | **537** |
| **Assets Total** | **18,061** | **20,065** | **547** | **608** |
| | | | | |
| Construction payable | 516 | 495 | 16 | 15 |
| Corrent portion of long term debt | - | - | - | - |
| Other current liabilities | 105 | 131 | 3 | 4 |
| **Current Liabilities** | **621** | **626** | **19** | **19** |
| Long-term debt | 12,155 | 10,603 | 368 | 321 |
| Loan from shareholder | 3,981 | - | 121 | - |
| Other long-term liabilities | 299 | 72 | 9 | 2 |
| **Long-term Liabilities** | **16,435** | **10,675** | **498** | **323** |
| **Equity** | 1,004 | 8,763 | 30 | 266 |
| **Total Liabilities and Equity** | **18,061** | **20,065** | **547** | **608** |

Source: BMCL Annual Report 2013

### 2.2.3 India

#### (1) Policy

Up to now, the state governments (or city administrations) has independently planed metro projects without clear guidance from the central level, and preliminary project schemes have been determined by feasibility studies at initial stage. Funding availability was major factors to select the project schemes. Owing to increased needs for unified policies at the central level, currently the Ministry of Urban Development (MoUD) has drafted a new consolidated metro railway policy that focuses on both public-pri-vate partnership and gov-ernment funding models for the reference of state governments.

#### (2) Relevant laws and regulations

Major legislative framework for metro rail projects is the Metro Railway (Operations and Maintenance) Act, 2002. The law was first promulgated as an Ordinance on 29 October 2002. It was amended in 2009 to permit the Central Government to extend the Act to any metropolitan city or area, after consultation with the concerned State Government.

#### (3) Subsidies

Financial Structuring, including provision of subsidies from the central government or the state government, varies depending on the project scheme in each state. Please see case studies.

#### (4) Fare

According to Section 34 of the Railways (Operations and Maintenance) Act, 2002, the Metro Railway Administration (MRA) has the power to fix the first set of fares without any interference from another agency. Subsequently, revision of fares will be decided by a three-member Fare Fixation Committee headed by a retired or a sitting high court judge.

#### (5) Case studies

#### (5-1) Delhi Metro

i) Background

In order to decongest city transport, Government of National Capital Territory of Delhi (GNCTD) commissioned RITES in 1988 for a feasibility study of an Integrated Multi-Modal Mass Rapid System for Delhi. This was followed up with a DPR by RITES in 1995 for a 55.30 km of metro corridor Phase 1. Subsequent phases of Delhi Metro were also planned for a total of 293 km, thus taking the total network to 349 km.

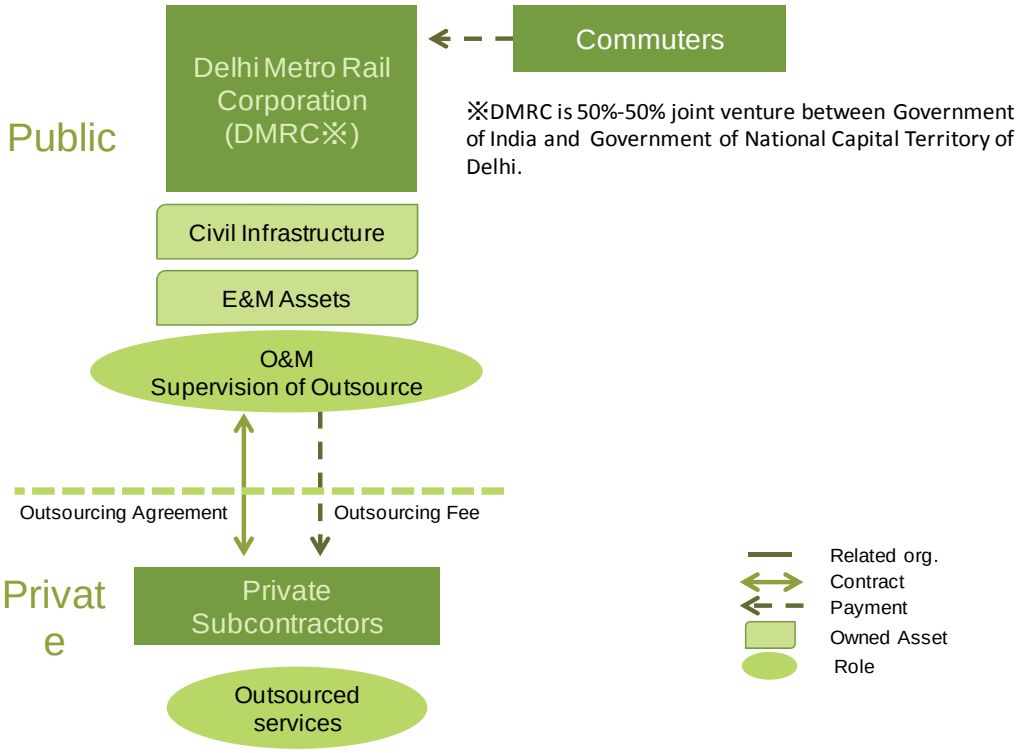
Since the provision of Yen loan from JICA was decided, other finance source seems not to be substantially required. Owing to this, the project was formulated based on public work scheme. Subsequently Delhi Metro Rail Corporation Limited (DMRC) as public sector entity was formed in 1995 for implementation and operation of Metro Project in Delhi. DMRC has internally retained core components of O&M and not outsourced owing to the following reasons:

- It provides better control over operation and flexibility in cost optimization to DMRC.
- Lower costs as private sector profit margins are excluded.
- It also mitigates the risks of aggressive bidding by private sector. Private sector often tends to bid aggressively during O&M biding in which case it will often not sustainable. It becomes expensive to take over midway when such arrangements fail.
- Savings in Service Tax liability.
- Outsourcing of manpower would have consequences since Indian labor laws will compel public sector to absorb labor hired by any contractor if they work for more than a particular period.

The project operation was started in 8 km stretch in 2002. The Phase –I comprising of 65.11 km and Phase -2 comprising of 124.93 km of the project was operational in 2006 and 2011 respectively. The Phase-3 comprising of 159.32 km is under construction presently which will cover the NCR part.

ii) Project scheme

The Delhi Metro project is operated under the direct management Scheme by Public Sector Entity DMRC. DMRC was formed as state owned special Purpose Vehicle Company with equal equity participation (50: 50) from GoI and GNCTD.




Source:
Study of PPP Project of Reliance Delhi Metro Airport Line, 14 June 2013, Sri Ravij Seth
Report of the sub-committee on operations and maintenance systems for metro railways, November 2013, Government of India/Ministry of Urban Development

Figure 2.15 Project scheme for Delhi Metro

iii) Financial Responsibility and Ownership of Assets

GOI and GNCTD undertook financial responsibility for financing the project through mix of equity contribution, proceeds from the property development and long terms debts from JICA. DMRC is the owner of the project assets.

Table 2.20 Demarcation on asset ownership between Public and Private

| | DMRC | Private |
|---|---|---|
| Civil infrastructure | ○ | |
| E&M Assets | ○ | |
| Operational expenditure | ○ | |
| Replacement / Additional Investment | ○ | |

Source: JICA Study team

iv) Ridership Risks

DMRCL takes ridership risks. The Delhi Metro Railway (Operation and Maintenance) Act, 2002 provides rights to DMRC to levy and collect the fare from the commuters.

v) Farebox

Section 33 of the Metro Act empowers the Metro Rail Administration (MRA) to fix the initial fare. Subsequent revisions in fare structure are to be made based on binding recommendation of three members Fare Fixation Committee. Such committee shall be headed by the sitting or retired High Court Judge and one member each of Additional Secretary level appointed by Central and State Government. As MRA of the project, DMRC has powers to fix initial fare, but not the revised fare. The fares were last revised in 2009 when the minimum fare was raised from Rs 6 to Rs 8 while the maximum fare was hiked to Rs 30 from Rs 22. Government has already set up fare fixation committee in February, 2015 and fares are expected to revise in near future.

vi) Financial Structuring

Project Cost for all three phases is estimated at Rs 704,330 million. GoI and GNCTD jointly financed 24.7% of this project cost through equal equity contributions. Further Governments have provided interest free subordinate loans of around 10% of project cost to cover land acquisition costs and central taxes. A total of 6.8% of the funds were internally generated through property development. A major portion of project cost (51.9%) was financed through long term JICA loan. JICA has provided loan @ interest rates of 1.2% to 1.4% with grace period of 10 years and payback period of 30 years for all three phases. Table below specifies the project cost and financing structure.

Table 2.21 Financial Structure for Delhi Metro

| Project Phase | Project Cost (Rs million) | Source of Fund (proportion of Project Cost) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Govt. of India | GNCTD | Property Development | Int. free Sub-debt towards land costs | Int. free Sub-debt for central taxes | JICA Loan | Grant |
| Phase -1 | 105710 | 14% | 14% | 7% | 5% | - | 60% | - |
| Phase -2 | 187830 | 16.39% | 16.39% | 5.59% | 3.83% | 2.73% | 54.47% | 0.59%* |
| Phase -3 | 410790 | 10.04% | 10.04% | 7.34% | 13.39% | | 48.57% | 10.62% |
| **Total** | **704330** | **12.3%** | **12.3%** | **6.8%** | **10.3%** | | **51.9%** | **6.4%** |

*Source: DMRC*

vii) Outsourcing (O&M)

The risks and responsibilities for Operation and Maintenance rest with DMRC. Operations are handled internally by a well trained staff. Maintenance related to core operations related functions such as signaling, track etc is also done in-house. However other maintenance activities such as

Power Systems are outsourced to OEMs. Facility related services, ITS, Housekeeping etc are outsourced too.

Table below specifies the Mode of O&M for core and non core activities.

Table 2.22 Outsourced works in O&M

| Item | Mode of O&M |
|---|---|
| **Operations** | Fully In-house |
| Train Operations | |
| Station Control Rooms | |
| Operation Control Center | |
| Depot Control Center | |
| Receiving Sub-stations | |
| Training Institute | |
| Station Management (Ticketing/House-Keeping/Parking/ Customer Facilitation Agents) and Security | Outsourced |
| **Repair and Maintenance** | |
| Track | Fully In-house |
| TVS | |
| Fire Protection and Fire Fighting Equipment | |
| Rolling Stock | In House after completion of Defect Liability Period |
| Signal & Telecommunication | |
| Traction Power System | |
| Automatic Fare Collection System | |
| Elevators, Escalator, ECS, Diesel Generator, Uninterrupted Power Supply | Partially Outsourced |

Source: JICA Study team

The past contracts with OEM suppliers have been with 2 years of Defect Liability Period (DLP) and 3 years of maintenance (with fixed cost replacements), so prices of spear parts are fixed for 5 years. However supplier begins to charge higher unit prices for replacement and maintenance after the 6$^{th}$ year. To avoid this, DMRC has considered working out maintenance plans at the time of procurement of systems, which is competed for costs of both supply and annual maintenance for the life cycle of the assets, and then quotes are evaluated on present value basis.

Also, it is envisaged that supply contracts should have provisions of transferable Warranties. DMRC has had the experience where a supplier refused to continue warranty when DMRC took over the operation from Reliance in Delhi Airport Metro because contract did not provide for such clause. Transferable warranties enable PPP in O&M since these warranties can be transferred to the private sector.

viii)Safety

Being MRA, the DMRC is responsible for safety during construction as well and Operation & Maintenance. Ahead of commencement of operation, the safety audit of the project was carried out by 3rd party safety inspector in UK. The System certification from the UK Company was provided to the Commissioner of Metro Rail Safety (CMRS). Driver competency certifications had been given internally by CMRS after conducing competency test.

### (5-2) Delhi Airport Metro Express Line (DAMEL)

i) Background

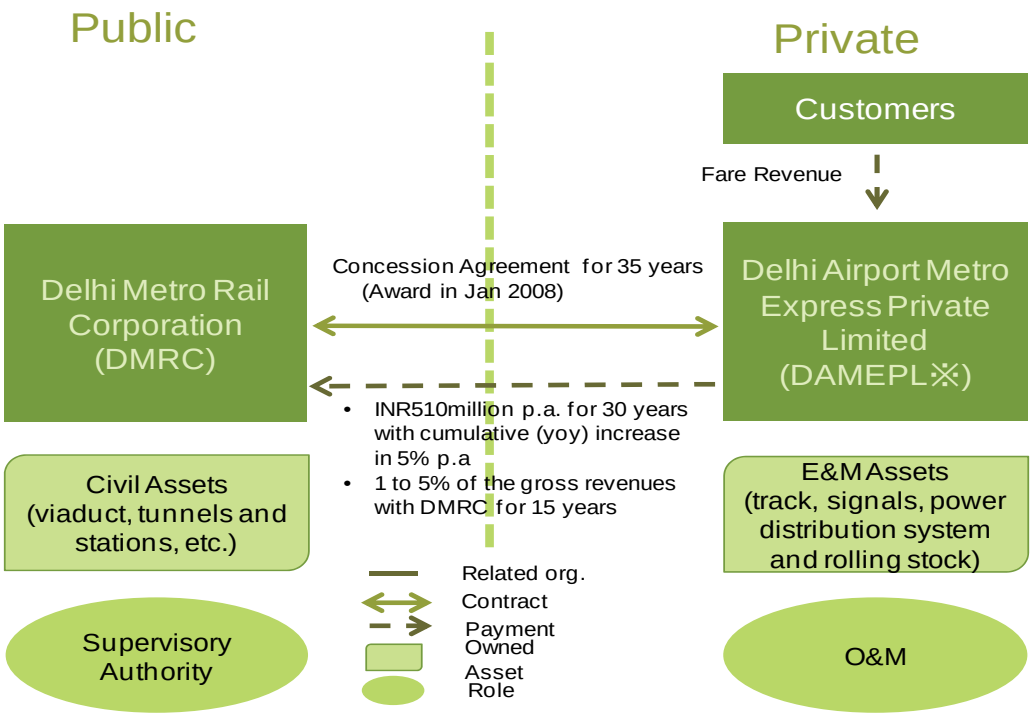
Prior to the Metro Rail Link from City to Airport in Delhi, Airport was accessed from the City largely through taxis and private cars, with only a limited number of passengers using buses. Situation worsened owing to steep rise in air traffic at IGI airport and was further expected to worsen during the commonwealth games. Moreover Origin Destination surveys revealed significant airport traffic originating from Connaught Place and vicinity. Thus a metro rail link between vicinity of Connaught Place and the airport was planned for a length of 22.4 km.

The project was structured innovatively. The project cost was divided in two parts. The civil part was constructed by the Delhi Metro Rail Development Corporation Limited (DMRC) employing proprietary construction contracts in EPC mode. Balance parts relating to electrical and mechanical works were responsibility of a PPP partner selected through competitive bidding. The operations and maintenance responsibility lay entirely with the private partner.

This manner of division of project cost in two parts stemmed from a need to limit burdening the private sector with the entire project cost since revenues were not sufficient to allow recovery of investment in full project cost. This structure also permitted sharing the investment and construction risks and facilitated the passing on of O&M risk to the private sector partner.

ii) Project scheme

The project was awarded to consortium of Reliance Infrastructure Limited and CAF, Spain for 30 years of contract in Jan. 2008, on the basis of their highest quote for annual concession fees to be paid to DMRC. The consortium formed an SPV called Delhi Airport Metro Express Private Limited (DAMEPL) for installing and operating the metro rail services. The equity contribution of Reliance Infrastructure Ltd and Construcciones y Auxiliar de Ferrocarriles, S.A. of Spain is 95% and 5% respectively in DAMEPL. The Project started commercial operations in Feb. 2011. However the passenger safety issues arising due to defects in civil structures, the services had to be suspended in July 2012 which again restarted in January, 2013. Disputes between the concessioner and DMRCL led to the former exiting the project whereby DMRCL took over the operations from 1st July, 2013. Figure below represents the Initial Scheme.




※DAMEPL owned by Reliance Infrastructure Ltd. (95%) and Construcciones y Auxiliar de Ferrocarriles, S.A. (5%) of Spain.

Source:
Study of PPP Project of Reliance Delhi Metro Airport Line, 14 June 2013, Sri Ravij Seth
Case Study 1 - The Delhi Airport Metro Express Project, November 2013, Indian Institute of Management

Figure 2.16 Project scheme for Delhi Metro Airport Express

iii) Financial responsibility and ownership on assets

Under the concession agreement, the DAMEPL as operator had obligations to design, finance, install and maintain the rolling stock, overhead electrification, tracks, signaling, telecommunication, ventilation and air conditioning and automatic fare collection. Its responsibilities also included day to day train operation and maintaining civil structures during the contract period. DAMEPL owns the system that it had installed during contract period which will be transferred to DMRC at the end of concession period or at a time of early termination.

Table 2.23 Demarcation on asset ownership between Public and Private

| | DMRC | Concessionaire (DAMEPL) |
|---|---|---|
| Civil infrastructure | ○ | |
| E&M Assets | | ○ |
| Operational expenditure | | ○ |
| Replacement / Additional Investment | | ○ |

Source: JICA Study team

iv) Ridership Risks

As per Concession Agreement, DAMPL took ridership risks. The Concession Agreement provided rights to DAMPL to levy and collect the fare from the commuters.

v) Farebox

The Concession Agreement provided initial fare structure which shall be fixed for first two years of operation. The revision on fare permitted at interval of every two years based on 90% of variation (increase) in WPI during the intervening period.

vi) Financial Structuring

As per scheme of division of project cost, of the total project cost of Rs. 58000 million, Rs.29150 million was borne by DMRC and the remaining Rs.28850 million by the Concessionaire.

Recovery of investments for the Concessionaire was envisaged through fare box collections, advertisement revenue, leases of commercial space built along the rail infrastructure, station retail outlets etc.

The Concessionaire would pay the DMRC Rs.10,000 per annum as license fee in consideration of grant of site and right of way (ROW) under the project. The Concessionaire would also pay a Concession fee (bid parameter) of Rs.510 million to DMRC per year (to be escalated by 5% pa). In addition, the Concessionaire had to share a percentage of its revenue with DMRC as follows (First five years: 1%, next five years: 2%, $11^{th}$ to $15^{th}$ years: 3%, $16^{th}$ to 30th years: 5%).

vii) Duration of concession agreement

The Concession Agreement provided right to operate and Maintain the project for 30 years after system installation period of two years.

viii) Outsourcing (O&M)

The concession agreement permitted outsourcing to the private partner. Presently DMRC took over the operations from $1^{st}$ July, 2013 and retained many of the same vendors through re-negotiations of the contracts.

The system supply contract should have provisions of transferable Warranties. DMRC has had the experience where a supplier refused to continue warranty when DMRC took over the operation from DAMPL because contract did not provide for such clause.

ix) Safety

According to the Concession Agreement, commercial operation would be permitted to start only after CMRS issue clearance certificate stating that the project systems are capable of safe and reliable commercial operation by the concessionaire. It is also stated that the concessionaire shall engage services of Independent assessor as CMRS may require certifying that the project systems are ready and capable for safe and reliable operation.

CMRS was hesitant to issue safety clearance to DAMPL, but issued the clearance certificate to DMRC. This may be owing to the fact that DMRC is a MRA and as per the Metro Acts, MRA is responsible for safety compensations on occurrence of accidents/damage. While DMRC should act as MRA, as per the Concession Agreement, the Concessionaire is responsible for safety compensation if such event arises due to Concessionaire's breach of obligations. DMRC issued driver competency certificate to Concessionaire appointed train drivers/operators.

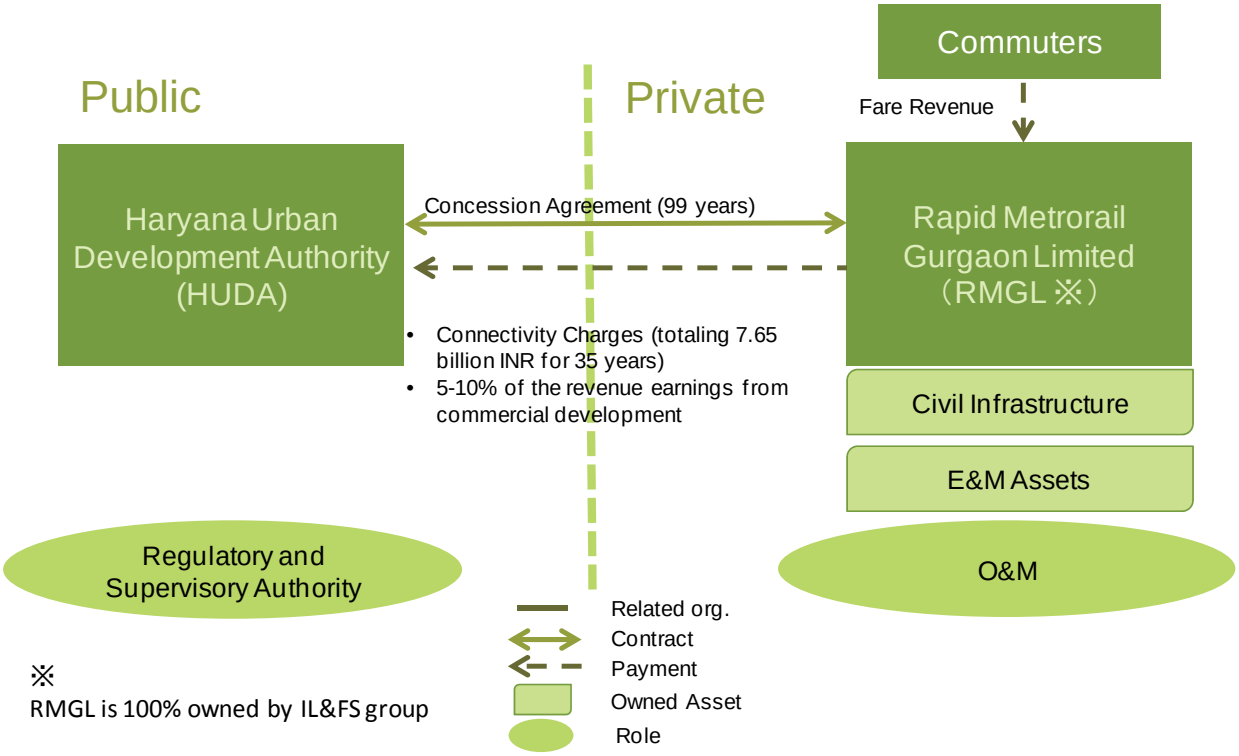
### (5-3) Rapid Metro Rail Gurgaon, Phase 1

#### i) Background

Information Technology and related Services business growth in India has driven emergence of number of towns and areas like Gurgaon, a town next to Delhi. This town has witnessed a 74% decadal growth in its population from 0.87 million in 2001 to 1.5 million in 2011 and fivefold rise in number of vehicles. Consequently, traffic congestion and pollution has soared. As one of the solution to these issues, Haryana Urban Development Authority (HUDA), an arm of the state Government of Haryana decided to develop 5.1 km metro system connecting Gurgaon to Delhi Metro Station Sikanderpur on full PPP Scheme considering the assumptions that higher ridership due to future development and higher advertisement revenue would make investment recovery possible. The system includes one elevated depot, six elevated stations and a fleet of five 3-car trains.

#### ii) Project scheme

HUDA awarded the project on a full PPP scheme without any subsidy to consortium of ITNL ENSO Rail Systems Limited (IERS) (Now known as ILFS Rail Limited), IL&FS Transport Networks Limited (ITNL) and DLF through competitive bidding process in July, 2009 for a 99 year concession, including construction period. A Special Purpose Vehicle Company (SPV), Rapid Metro Rail Gurgaon Limited (RMGL) was incorporated for implementation and operation of the Project. The consortium of IERS, ITNL and DLF subscribed equity stakes of 48%, 26% and 26% respectively in SPV. IL&FS group purchased DLF's stakes later from the SPV. Accordingly, effective shareholding of RMGL changed to IERS (65%), ITNL (35%) and DLF (0.01%). The project commenced operation in November, 2013.




Source:
Report of the sub-committee on operations and maintenance systems for metro railways, November 2013, Government of India/Ministry of Urban Development
RMGL annual report, IL&FS Rail Limited annual report

Figure 2.17 Project scheme for Rapid Metro Gurgaon

Along with the right to levy and collect the fares from Commuters, the Concessionaire has been granted rights to collect and retain advertisement rights and sale of commercial space on the stations.

iii) Financial responsibility and ownership on assets

Under the concession agreement, the RMGL as an operator has obligations to design, finance, construct, operate, own and maintain the phase -1 of the Project during the concession period of 99 years and transfer the ownership and assets at the end of the concession period. The asset ownership during the concession agreement belongs to the concessionaire. HUDA has provided land to the Concessionaire (RMGL).

Table 2.24 Demarcation on asset ownership between Public and Private

| | HUDA | Concessionaire (RMGL) |
|---|---|---|
| Civil infrastructure | | ○ |
| E&M Assets | | ○ |
| Operational expenditure | | ○ |
| Replacement / Additional Investment | | ○ |

Source: JICA Study team

iv) Ridership Risks

RMGL takes ridership risks. RMGL has been provided rights to levy and collect the fare from the commuters. Currently, revenue ratio is 50% from farebox, and the other 50% from advertisements (such as naming rights for each station). Revenues are much lower than projection since presently the region has one half less residential/commercial properties than originally planned due to a real estate slump and hence current ridership is one third of the original plan.

v) Farebox

RMGL being the MRA for the project, RMGL has powers to fix initial fare. RMGL increased its initial fare to Rs 20 as per act from promotional fare of Rs 12 in August 2014, taking the view that by July, 2014, all six stations have been operational.

vi) Financial Structuring

The total cost of the project is Rs. 10880 million, which will be funded by a combination of debt and equity in the ratio of 2.33:1, equivalent to Rs. 7616 million for debt and Rs. 3264 million for equity. The debt is provided by consortium of eight banks with Andhra Bank as the lead bank at a cost of borrowing of 10.5% (Floating rate). The loan is sanctioned for a grace period of 2 years and a total loan repayment period of 13 years. The project witnessed cost overrun at completion whereby the project cost increased to Rs 12390 million. This was mainly due to the delay in completion of project on account of non receipt of approvals in time from various authorities.

The Concession Agreement specifies connectivity charges of Rs. 50 million to be paid to HUDA within 60 days of signing the Concession Agreement and Rs. 400 million per year from the 17th to 35th year, totaling Rs 7600 million. Also, HUDA will have a revenue share on non fare annual revenues starting from 5% and going up to 10%.

vii) Duration of concession agreement

The Concession has been granted to RMGL for duration of 99 years including construction period of 2.5 years (30 months).

viii) Outsourcing (O&M)

The O&M Scheme followed by the RMGL is based on best practices followed in Metro systems across the world. Core operation functions are performed in house, whereas manpower intensive noncore operations such as security, ticket sale and cleaning are outsourced.

Since IL&FS group did not have prior operation experience of metro rail, they initially considered outsourcing operations to global players such as Serco and Veolia. However since they realized that these companies were going to recruit and train fresh manpower locally, they realized it could do so by themselves to lower financial burden to the extent of profit margin on outsourced companies and service tax. As first step of operation plan it organized the operation team – e.g., drivers and supervisors – by hiring Indian National Railway personnel. Thereafter all such personnel have been trained with DMRC and with suppliers at China. RMGL was able to create an operations team of 35 trained technical personnel prior to start of the operation.

Owing to small size of the system, in –house maintenance of system may not fit economies of scale, RMGL outsourced the maintenance of major systems such as Rolling Stock, Signaling system, Traction system and Depot Plant & Machinery including replacement part through 10 years maintenance contract with supplier Siemens. The performance in maintenance contract is measured through Key Performance Indicators. RMGL has also outsourced, to a large extent, maintenance of other systems such as telecommunication, automatic fare collection, track and building infrastructure.

ix) Safety

As MRA, RMGL is responsible for safety compensation during the construction as well as Operation period as per the Metro Act. Predefined and established procedures were followed for obtaining safety clearance certificate from CMRS.

### (5-4) Chennai Metro Rail Limited (CMRL)

i) Background

The idea of outsourcing operations and maintenance (O&M) had originally come from Chennai Metro Rail Limited (CMRL). CMRL had invited operators such as Serco, Veolia and SMRT from around the world to have an open discussion on operational models. All the operators at the discussion argued for the gross cost method, as they noted that the ridership risk would be too high to be assumed by them at the early stage of operation of the metro railway. Based on their suggestion, CMRL then called for a tender to select an operator from the private sector by using the gross cost method.

At the tender stage, the two best bids out of the three finalists were the ones whose prices were INR 15,070 million and INR 15,140 million. The International Finance Corporation (IFC), the financial advisor to CMRL, then compared the results with their Public Sector Comparator (PSC)[20], wherein their PSC had estimated the lowest possible price to be INR 15,080 million. Accordingly, the IFC recommended the acceptance of the bids, because it was in line with the lowest price as estimated by the PSC. CMRL then formed an external committee of directors to analyze the IFC's report. Representatives from Delhi Metro and Bangalore Metro were invited to sit in the committee, as both companies operated under the direct management model and shared the Indian Railways' practice of trying to do everything in-house due to the belief that the public sector can carry out tasks more efficiently than the private sector.

The external committee estimated the lowest price to be INR 12,940 million according to their PSC, in contrast to the IFC's estimation under their PSC, and it thus argued that it would be more efficient if the O&M function was not outsourced. The board of directors of CMRL then decided to cancel the tender and run the metro line itself in line with the practice of Delhi Metro and Bangalore Metro. Nevertheless, there are arguments against the external committee as below:

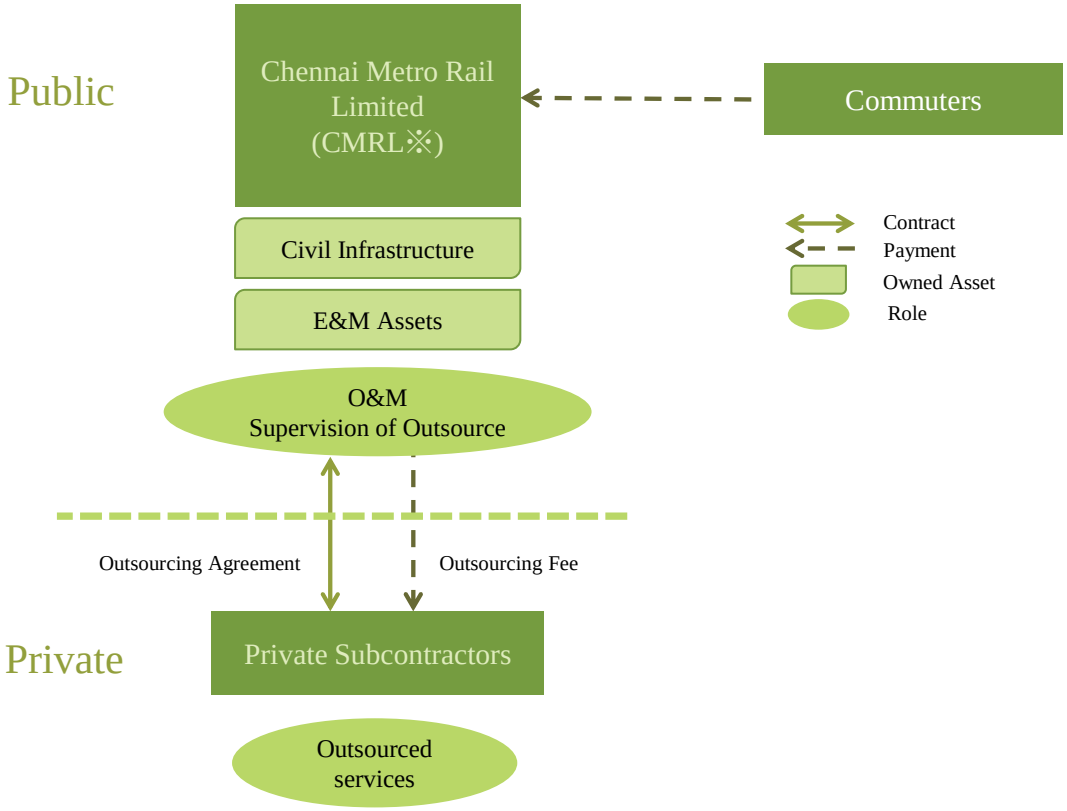
- The committee did not account for hidden costs such as the risk of poor maintenance and therefore not optimizing revenue
- The public sector needs to adhere to certain norms of recruitment (such as the "reservation" policy) and are restricted from laying off employees. Further, there is the issue of labor unions to contend with. These issues together will affect the flexibility in conducting operations, and thus, operational performance.

[20] PSC is a methodology used by a government to make decisions by testing whether a private investment proposal offers value for money in comparison with the most efficient form of public procurement

- The public sector may not be adept at innovative practices such as advertizing and scheduling trains flexibly (for example, extending train operation service times when there is late-night sports event at a nearby train station.)

ii) Project scheme

The Chennai Metro (Phase I) is operated under a direct management scheme, and CMRL is the Metro Rail Administrator (MRA) in this scheme:




Source:
CMRL Brochure
Report of the sub-committee on operations and maintenance systems for metro railways, November 2013, Government of India/Ministry of Urban Development

Figure 2.18 Project scheme for Chennai Metro

iii) Financial responsibility and ownership of assets

CMRL is the sole owner of the assets and will pay for operational expenditures as well as asset replacements and additions.

Table 2.25 Demarcation on asset ownership between Public and Private

| | Public | Private |
|---|---|---|
| Civil infrastructure | ○ | |
| E&M Assets | ○ | |
| Operational expenditure | ○ | |
| Replacement / Additional Investment | ○ | |

Source: JICA Study team

iv) Ridership Risk

CMRL will assume the ridership risk.

v) Farebox

CMRL, being the MRA, fixes the initial train fares. A consulting firm had conducted a study on fare fixation for CMRL by looking at various factors, including the local demand and possible ridership, among others. Committees outside of CMRL will determine subsequent fare revisions.

vi) Financial Structuring[21] [22]

Chennai Metro (Phase I) is a 43 km-long urban railway project of which 22.5 km is underground and consists of 2 corridors. Part of Corridor 1 will be operational in few months. The project, which was originally estimated to cost INR 146 billion, would cost around INR 200 billion as of March 2014. 59% of the project cost was to be financed by JICA.

vii) Outsourcing

Functions to be performed in-house are: maintenance of rolling stock, signaling, mechanical and electrical O&M and the automatic fare collection system. Functions to be outsourced are: cleaning, security, ticket operating. A portion of the maintenance work will be carried out by suppliers under 9-year contract in which there are 2 years of defect liability period and 7 years of annual maintenance. From the 10th year onwards, maintenance is expected to be done in-house.

viii) Safety

CMRL is assumed the responsibilities for safety and risks involved with safety.

[21] "Chennai metro project cost likely to rise 23%". Sify.com. 29 September 2010.

[22] "Phase-II Chennai metro project to cost Rs 36,000 cr". Business Standard (Chennai). 2 March 2014.

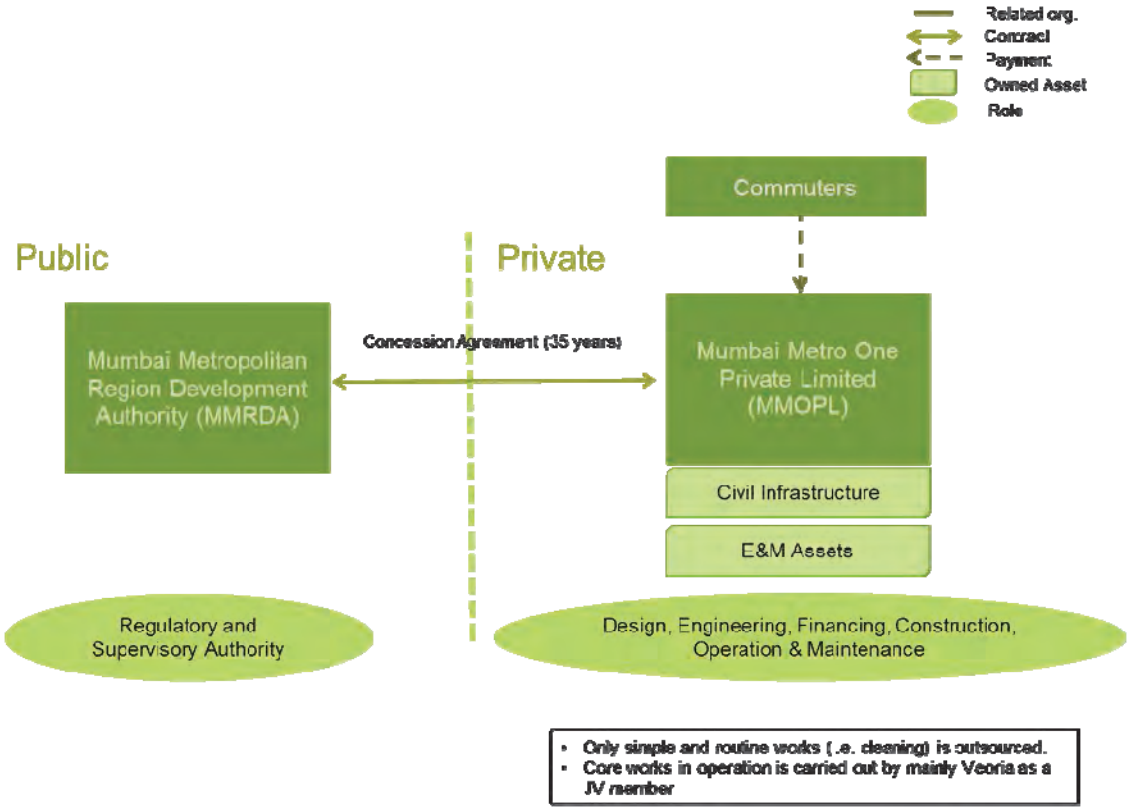
### (5-5) Mumbai Metro Line 1

i) Background

The Government of Maharashtra (GOM) through the Mumbai Metropolitan Region Development Authority (MMRDA) had planned a 146 kilometre long rail based Mass Rapid Transit System (MRTS) for Mumbai to address massive public transportation needs. MMRDA had been exploring the viability of various mass transit systems that are efficient and economically viable. In this context, a detailed feasibility study was carried out under the Indo-German technical co-operation. Upon examining a number of alternative corridors, the study concluded a mass transit corridor from Andheri to Ghatkopar is potentially bankable and economically viable. As a result of the study, it was decided to bid out the project on public private-partnership (PPP) basis. The project becomes the first project in mass transportation systems being implemented on a PPP basis in GOM.

ii) Project scheme

Through international competitive bidding process on PPP framework, MMRDA awarded to the consortium led by Reliance Energy Limited for the Mumbai Metro Line 1 (Versova-Andheri-Ghatkopar (VAG) corridor). The consortium has been formed with Reliance Energy Limited, Veolia Transport and MMRDA holding equity stakes of 69%, 5% and 26%, respectively. Then, a special purpose vehicle, Mumbai Metro One Private Limited (MMOPL) was incorporated for implementation of the project. The project commenced commercial operations on June 8, 2014.




Sources: Concession Agreement for Mumbai Metro Rail Project (Versova – Andheri - Ghatkopar Corridor)

Figure 2.19 Project scheme for Mumbai Metro Line 1

iii) Financial responsibility and ownership on assets

Under the concession agreement, the MMOPL as operator has obligations to design, finance, construct, operate, own and maintain the first corridor and transfer the ownership and assets at the end of the concession period. While public provides VGF (Viability Gap Fund) to the concessionaire, asset ownership during the concession agreement belongs to the concessionaire.

Table 2.26 Demarcation on asset ownership between Public and Private

| | MMRDA | Concessionaire |
|---|---|---|
| Civil infrastructure | | ○ |
| E&M Assets | | ○ |
| Operational expenditure | | ○ |
| Replacement / Additional Investment | | ○ |

Source: JICA Study team

iv) Ridership Risks

MMPOL takes ridership risks. The concessionaire is entitled to levy and collect the fare from the commuters.

v) Farebox

In line with the provisions of the Metro Railway Acts, 2002, MMOPL in the capacity as MRA is authorized to fix the initial fare for the project. The fare is examined as per the prevalent practice to ensure sustainability of operation and comparable with other existing modes of transport after considering the facilities that metro provides. However, the fare level was disputed. On a petition by the MMRDA on the revised tariff proposed by MMOPL, the Bombay High Court dismissed the plea and stated that MMOPL has the right to decide the fare for the initial opening until Fare Fixation Committee decides applicable tariff.

vi) Financial Structuring

The total project cost is estimated at Rs. 2,356 crores. VGF Rs. 650 crores as government cash support is provided to MMOPL. It is contributed by the Government of India (Rs. 470 crores being 20% of the project cost) and Government of Maharashtra (Rs.180 crores being 7.5% of the project cost).

The remainder is to be financed by 70% debt, 30% equity. The consortium (Reliance: 69%, Veolia: 5%) and MMRDA (26%) shall provide equity contribution of Rs. 466 crores in proportion of their equity stake. The private operator has also arranged debt of Rs. 1240 crores for the project. The loan has been tied up from a consortium of banks led by IDBI, Corporation Bank, Karur Vysya bank, Canara Bank, Indian Bank and Oriental Bank of Commerce. IIFCL (U.K.) is providing the foreign currency loan for the project. The cost of borrowing for the rupee component, which constitutes about 75 per cent of the total debt, is 12.25 per cent, while the foreign currency loan will be at 3.5 per cent above LIBOR (London Inter-Bank Offered Rate). The loan has been secured for a

moratorium period of 2 years and a total loan repayment period of 15 years.

Neither concession fees from the concessionaire to MMRDA nor management fees from MMRDA to the concessionaire are paid.

vii) Duration of concession agreement

Total concession period is 35 years, including a construction period of 5 years. MMOPL would operate and maintain the line for the remaining concession period of 30 years.

viii) Outsourcing

Basically core works in O&M has been carried out in-house. Particularly train operation is taken care by Veolia who has international experience in the metro sector under joint-venture framework. Comparatively simple works such as ticketing, security and so on is also done in house. Only cleaning is outsourced.

ix) Safety

As MRA, MMOPL is responsible for safety. Operation of the project was approved by Commissioner of Metro Rail Safety (CMRS). CMRS apprised MMPOL strictly because MML1 was a private sector initiative.

(6) Case studies Private-sector Operators in India

The private-sector operators of Indian metro railways are summarized in the table below. The two foreign private operators in the table are French companies.

Table 2.27 Summary of private-sector operators in India

Foreign exchange rates: USD 1 = INR 62.55; USD 1 = EUR 0.936

| | Reliance Infrastructure Limited | Infrastructure Leasing & Financial Services Limited (IL&FS) | Transdev | Keolis SA |
|---|---|---|---|---|
| Summary | Reliance Infrastructure Limited builds infrastructure for power generation, transmission and distribution; highways, roads and bridges; high-speed transport | IL&FS is an Indian infrastructure investment and finance company which develops infrastructure across the scale, from upstream to downstream sectors. Its major | In 2011, Veolia Transport of France and its market competitor, Trandev merged to form the current Transdev company. Transdev operates railways, buses, trams and | Keolis SA is a French company which operates railways, trams, buses, trolleys and other transport modals. Its |

| | | | | |
|---|---|---|---|---|
| | systems; and airports, among others. The company is part of the Reliance ADA Group which has business interests in finance, telecommunications, power, media, property and healthcare, among other sectors. | shareholders are the State Bank of India, the Life Insurance Corporation of India, ORIX Corporation and the Abu Dhabi Investment Authority, among others. | other transport modals across 20 countries. Its shareholders are the French savings deposit bank, Caisse des Dépôts and the French water management company, Veolia Environnement, and each holds 50% of the shares. | shareholders are the French national railway company, SNCF (70%) and the French savings deposit bank, Caisse des Dépôts (30%). |
| Credentials of railway operations in India | Operates Mumbai Metro Line 1 | Operates Gurgaon Metro | Operates Mumbai Metro Line 1 | Operates Hyderabad Metro[23] |
| Credentials of railway operations globally | N.A. | N.A. | France, the UK, Italy, Australia and 20 other countries | France, UK, Canada, China, the US, and 15 other countries |
| Country of incorporation | India | India | France | France |
| Market capitalization (as of March 2015) | 1,866 | Unlisted | Unlisted | Unlisted |
| Recent revenues (consolidated) | 3,120 | N.A. | 6,550 | 4,680 |

Source: JICA Study team

[23] Hyderabad Metro is the urban railway project for the city of Hyderabad, which is expected to commence operations in 2015. L&T (Hyderabad) Metro Rail Limited (the "LTHMRL") is the SPV incorporated to implement Hyderabad Metro project. In September, 2011, the LTHMRL entered into the 35 year concession agreement, extendable for additional 25 years, with the Government of Andhara Pradesh (GoAP). Over 40% of the equity contribution to the LTHMRL came from GoAP, and GoAP has management control over the LTHMRL in that the affirmative vote of GoAP is required for the passing of all any resolution of the same. The LTHMRL financed both civil infrastructure and E&M assets. In May 2012, LTHMRL has selected Keolis SA, as the O&M contractor.

### 2.2.4 United Kingdom

(1) Policy

Urban public rapid transit system in London has been developed since 19 century, and particularly the network of London Underground is considered the oldest rapid transit system. The most part of public transport in London is managed by Transport of London (TfL) as a division of the Greater London Authority (GLA). The role of TfL is to execute the transport strategy and to manage transport services across London. While a transport policy determined by the secretary of State for Transport and one in local authority must be consistent, in London as a capital of the U.K where mono-polar concentration has occurred, TfL has worked out their own transport policies. The mayor of London is responsible for developing transport strategy for London.

In 1990s British Rail was privatized and PPP was introduced. British Rail was separated into a body which is responsible for asset ownership & maintenance and a body which manage operation. Ownership of the track and infrastructure passed to Railtrack, and passenger operations were franchised to individual private-sector operators. On the other hand, a situation in London is a little complicated, two schemes (direct management by public and PPP) have taken a place in parallel. "Mayors Transportation Strategy" as a transportation policy in London was established in May 2010, and it is stated principles to realize the Strategy[24] as follows;

Value for Money (provision of the most valuable service toward money/payment)

Work in partnership (works under the most appropriate partnership)

Appropriate integration and phasing (ensure proper structuring)

Although operational schemes regarding urban rails aren't explicitly presented in the Strategy, a scheme which matches feature of each line (conditions of assets, and others) has been applied case by case in accordance with above principles in the Strategy[25].

Table 2.28 Operational schemes in London urban rail

| | Underground | Overground | Dockland Light Railway | Crossrail | Trams |
|---|---|---|---|---|---|
| Revenue Risk | TfL | TfL | TfL | TfL | TfL |
| Operation (Operating trains & stations) | TfL | Private (LOROL) | Private (Keolis Amey) | Private (MTR) | Private (First Grop) |
| Infrastructure Maintenace | TfL | TfL / Network Rail | Keolis Amey and other private | TfL / Network Rail | TfL |
| Fleet Maintenance | TfL | ROSCOs | Keolis Amey | Private supplier | TfL |

[24] Source: Mayor's Transport Strategy (2010), policy 27, pp 309

[25] According to an officer of TfL,

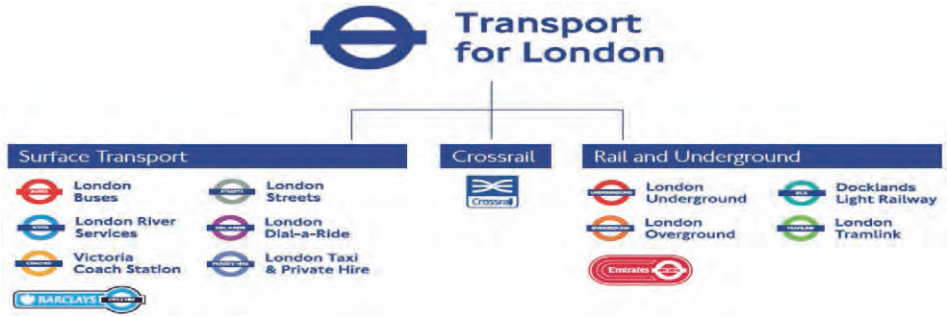
Source: TfL

Ridership risk is taken by TfL in all lines in common. Operation (operating trains and stations) is outsourced to private operators, except London Underground. Maintenance for infrastructure is carried out by in-sourced of TfL, except DLR. As for fleet maintenance, there are tendencies that maintenance works is outsourced to private sector.

(2) Relevant authorities in London urban rail

Transport for London: TFL

TfL carries out execution of the transport strategy and management of transport services across London. Management of TfL consists of the supervisory board appointed by the mayor, the mayor is chair. The Commissioner of TfL reports to the Board and leads a management team with individual functional responsibilities.




Source: Tfl

Figure 2.20 Organization chart of TFL

Department for Transport: DfT

DfT determines national transport strategy and works out high level transport policy. DfL is responsible for TfL's funding settlement. And also, TfL is co-sponsor of Crossrail.

Greater London Authority: GLA

GLA is established under GLA Act 1999, and TfL is a functional body of the GLA. GLA acts as a conduit for grants from the DfT to TfL. GLA consists of the Mayor of London and London Assembly

The Mayor

The Mayor acts as chair of TfL. The Mayor is responsible under the GLA Act 1999 for developing transport strategy for London. The Mayor has authorities of approval for TfL's borrowing limit (in consultation with TfL and the London Assembly), and setting fares within the context of a balanced budget.

London Assembly

London Assembly plays role of holding the Mayor and functional bodies democratically accountable, and oversight of the Mayor's budget.

(3) Finance of TfL

(i) Basic financial structure

Income

TfL's funds currently come from three key sources.

- Revenue
  - Generated primarily from bus and Tube together with growing Overground and DLR revenues
  - Other transport revenues including Congestion Charging, Cycle Hire and the Emirates Air Line
  - Commercial development income from TfL's estate, including advertising and property rental and development
- Grant
  - General Grant: subsidies for current expenditures as well as capital expenditures
  - Investment Grant: subsidies for capital expenditures
  - Business rates[26]: it is allocated from a tax on the occupation of non-domestic property in London
- Borrowing
  - Prudential Borrowing[27]

Expenditure

TfL's income is expended mainly to operational expenditures, capital expenditure and debt servicing.

- Operational Expenditure
  - Cost for operation & maintenance for tube, over ground and bus. Compensation for board member.
- Capital Expenditure

[26] Business Rate is a levy on non-domestic ratepayers to raise money for expenditure on projects expected to promote economic development". This funding is then passed to TfL as the functional body with responsibility for delivering the Crossrail Project.

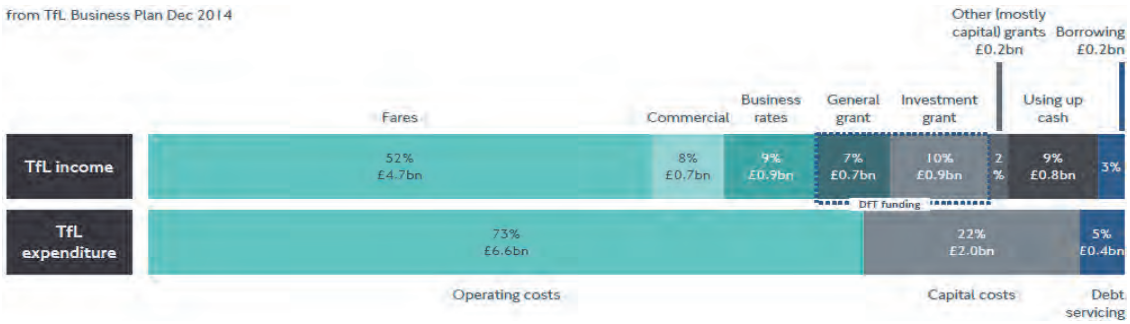
[27] Prudential borrowing is the set of rules governing local authority borrowing in the UK. Under prudential borrowing, the amount of debt and other liabilities most local authorities can incur is no longer capped by an upper limit. Instead borrowing must conform to the Prudential Code which (among other things) requires that borrowing be affordable and prudential.

- Cost for upgrading assets for tube, over ground and bus. Purchase of new rollingstock

- Debt service

- Repayment of principal + interest

The figure below (TfL's budget of 2015/16) shows basic financial structure of TfL. As for TfL's income, 50~60% comes from fare revenue, 20~30% accounts for subsidies, and portion of borrowing is exceedingly small. Regarding TfL's expenditure, 70% of total expenditure accounts for operating costs, around 20% for capital costs (excluding Crossrail), and 5% is for debt servicing.




Source: Tfl

Figure 2.21 Financial Structure of TfL

(ii) Current status of profit and loss in TfL

<u>TfL group finance: Operating income, expenditure and funding</u>

The table below shows a whole TfL's operating balance (fare revenue – operational expenditure) which includes both rail and bus business. In the past two years, operating balance was loss, the government expended grants/subsidies to TfL to fill a deficit. Current financial position indicates that income only from fare and bus is not able to satisfy to maintain TfL's business.

Table 2.29 Operating Balance of TfL in the last two years

Unit: million Pound

| TfL group (£m) | Full Year | |
|---|---|---|
| | Actuals, 2013/14 | Actuals, 2014/15 |
| Fares income | 4,095 | 4,281 |
| Other operating income | 646 | 720 |
| **Total income** | 4,740 | 5,002 |
| Operating expenditure (net of third-party contributions) | (5,875) | (6,152) |
| **Operating margin** | (1,135) | (1,150) |
| Interest income | 21 | 28 |
| Debt interest | (344) | (358) |
| Contingency and group items | 16 | 27 |
| **Margin** | (1,442) | (1,453) |
| **Finances sources** | | |
| General grant | 1,094 | 897 |
| Overground grant | 29 | 26 |
| GLA precept | 6 | 6 |
| Business Rates Retention | 803 | 828 |
| Other revenue grants | 43 | 8 |
| **Total revenue grants** | 1,974 | 1,766 |
| **Operating contribution to fund investment** | 532 | 313 |

Source: Tfl

Operating Balance for each segment of business in TfL

The table below shows operating balance for each segment of business in TfL in the year for 2014/15. Operating balance in London underground is positive. Fare income was able to covered operating expenditure, and surplus from operating balance is allocated to capital expenditure. London Overground occurred small deficit. Bus business resulted large deficit.

Table 2.30 Operating Balance for each segment of business

Unit: million Pound

| | Fare income | Other operating income | Operating expenditure | Operating margine |
|---|---|---|---|---|
| London Underground | 2,410 | 213 | 2,296 | 327 |
| London Rail | 336 | 15 | 372 | -21 |
| London Buses | 1,536 | - | 2,810 | -1,274 |

Source: Tfl

Capital Expenditure, Income and Funding

The almost 100% of capital expenditure is financed by the grant from the government. The expenditure for London Underground accounts the large part of the total expenditure. 1,241 million pound, which is 60% of 1,979 million pound in 2014/15, was expended for London Underground.

Table 2.31 Capital Balance of TfL in the last two years

Unit: million Pound

| TfL group | Full Year | |
|---|---|---|
| (£m) | Actuals, 2013/14 | Actuals, 2014/15 |
| Capital expenditure | (1,638) | (1,979) |
| Third-party contributions – capital | 67 | 25 |
| Sales of property and other assets | 41 | 47 |
| **Net capital expenditure excl. Crossrail** | (1,531) | (1,906) |
| Crossrail capital expenditure | (1,576) | (1,475) |
| **Net capital expenditure incl. Crossrail** | (3,108) | (3,382) |
| **Finance sources** | | |
| Surplus/ -deficit to fund investment | 532 | 313 |
| Crossrail funding sources | 2,066 | 1,702 |
| Investment grant | 895 | 909 |
| Metronet grant | 184 | 0 |
| Other capital grants | 110 | 124 |
| Working capital | (138) | (389) |
| Net borrowing and reserve movements | (543) | 722 |
| **Total** | 3,108 | (3,382) |

Source: Tfl

(4) Subsidies

Government to TfL

Both the central government and TfL recognize necessity and significance of subsidies. *Mayors Transport Strategy* states that significant taxpayer funding is committed to cover the costs of the essential investment that is underway to bring Tube assets to a state of good repair and to increase the network's capacity to support London's future economic and population growth.

The main source of grant income is the Transport Grant from the DfT. This comprises two elements: i) an investment grant, which supports delivery of the investment programme; and ii) a general grant, to support TfL's operating activities. Other key funding streams include specific capital grants from the DfT and the Greater London Authority for the Crossrail project.

TfL to Private operator

Subsidies aren't provided from TfL to private operators. In all lines where operation is outsourced to the private operators, TfL takes ridership risks, and make a fixed payment in compensation for O&M expenditures.

(5) Fare setting

Fare levels are set, according to Greater London Authority Act 1999, under responsibilities of the Mayor. In practice, TfL as an institution under direct control of the Mayor drafts fare level, and it is approved on the board of TfL. Basically, the fare level is revised one a year. In the lines where to the private operators carry out operation, the private operators don't have authorities for fare setting, the fare approved by the Mayor is applied for them. *Mayors Transport Strategy* states that fares have to be set at levels which allow TfL to sustain the operational delivery of public transport while maintaining affordability of users to the maximum possible extent.

(6) Case studies

(6-1) London Underground

(i) Background

The London Underground commenced its operations in January 1863, and now serves as the core public transportation network in the London metropolitan area. The network has expanded to 11 lines with 270 stations, carrying over 4 million passengers per day. In the beginning of 1990, after 130 years from the commencement of its operation, the network was facing the issue of frequent breakdowns and delays, which were caused by the decrepit infrastructure. This was due to the following:

- London Underground Limited (the "LUL"), being fully owned by the central government, did not have enough allocated budget to pursue investments, and;
- LUL was unable to manage and control infrastructure investments, resulting in chronically underinvested infrastructure (planned constructions were not completed within budget as a result of frequent cost overruns and delays)

The Tony Blair administration which began in 1997, called for government decentralization, and established the GLA which is a local administrative authority and also the TfL as one of the GLA's enforcement agencies, and as such, the TfL will administer matters related to public transportation in the London metropolitan area. Upon realizing that infrastructure refurbishments cannot be done effectively and efficiently if the TfL were to merely inherit LUL's functions, it was proposed that the infrastructure refurbishments of London Underground are to be done by using the PPP framework, and a working group was created and directed to consider the PPP models. The proposal made by the said working group is summarized as follows:

- The public sector would be responsible for train operations, while the

refurbishment and maintenance of the infrastructure would be outsourced to the private sector. This is due to the public sector's inability to manage the said assets.

- The costs of infrastructure refurbishment and maintenance would be shared between the public and private sectors, but in order to avoid monopolization by one private entity, the London Underground would be divided into 2 to 3 railway networks, and separate private entities ("Infracos") would be chosen for each railway network through tenders.

Based on the above proposal, the London Underground was divided to three separate networks as below, and the tender biddings were solicited for the Infracos for each network.

i) BCV (Bakerloo, Central, Victoria, and Waterloo & City lines)
ii) SSL (network consisting of 5 lines – i.e., Sub-Surface Lines: Circle, District, Metropolitan, East London, Hammersmith and City)
iii) JNP (Jubilee, Northern, and Piccadilly lines)

i),ii) The BCV and SSL networks were tendered to the Metronet Rail consortium (the "Metronet") which consists of 5 entities - Atkins, Balfour Beatty, Bombardier, EDF Energy and Thames Water, and iii) the JNP network to the Tube Lines consortium which consists of 3 entities - Amey plc, Bechtel and Javis plc.

With the 3 Infracos in place, London Underground commenced its operations in 2003 under the following operating model.

- Operator: LUL becomes a subsidiary organization of TfL and operates the London Underground, but outsources infrastructure maintenance and refurbishment to the Infracos.
- Infracos: Metronet establishes two companies – Metronet Rail BCV Ltd. and Metronet Rail SSL Ltd. which manage the BCV and SSL networks respectively, and Tube Lines establishes Tube Lines Ltd which manages the JNP network.
- Infracos and LUL come into a 30-year PPP contract. Under the contract, the Infracos are to procure new rolling stocks and maintain or refurbish the railway stations, signals, tracks and etc., and LUL is to supervise the Infracos (the Infracos are to receive the necessary funding from the public sector). The contracts are to be reviewed every 7.5 years based on past performances and also newly-set goals at the time of the reviews.

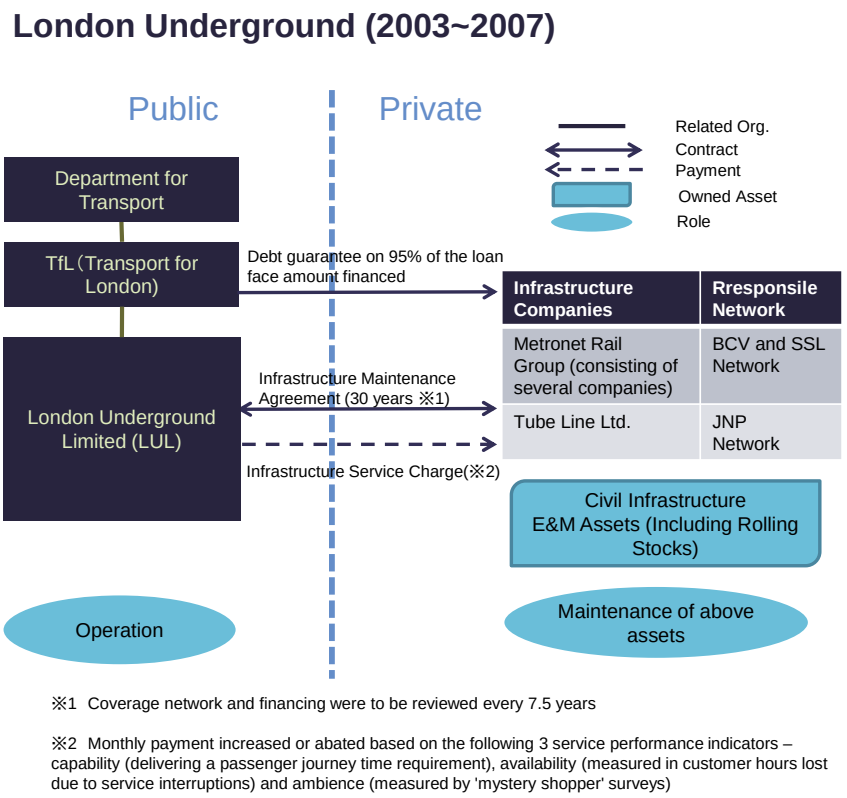



Figure 2.22 Operating model of London Underground in 2003

The operations of the London Underground under the above model were not without issues. Metronet became insolvent only after 4 years into its operation under this PPP model, and Metronet's assets were purchased by TfL in November 2007. The causes of Metronet's fortunes are as follows[28]:

i) **Flawed contracts resulting from the inability to define the assets that are to be maintained by the Infraco**: LUL was unable to define the assets to be maintained by Metronet under the PPP contract, and therefore the quality of the refurbishment and maintenance plans that were submitted to LUL by Metronet were inevitably poor, thus resulting in unanticipated refurbishment and maintenance costs. There were also frequent disputes between LUL and Metronet in regards to what to refurbish and maintain at what costs, resulting in cost overruns.

ii) **Insufficient monitoring**: Under the PPP contract, LUL retained the right to audit Metronet and its subcontractors, and LUL tried to exercise this right twice. However, LUL's audit team could only review the limited information Metronet

[28] Naoya Yamaguchi, "Issues under PPP/PFI Framework – London PPP Case", September 2012

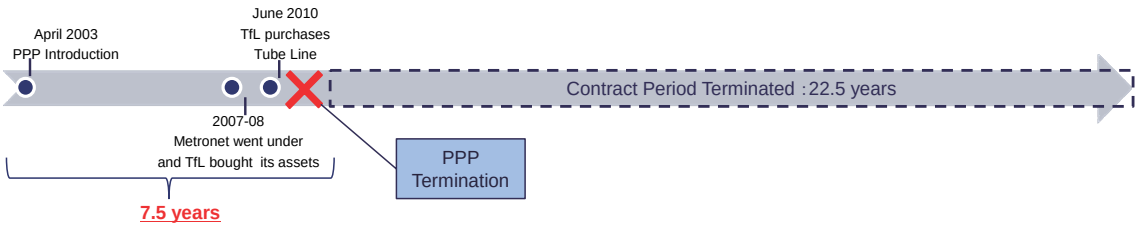
management had authorized to disclose in spite of its contractual obligations to allow LUL's auditors to access Metronet's documents and computer systems. Also, the information provided by Metronet had incomplete and conflicting information. As such, LUL was unable to effectively monitor Metronet's financial status.

The monitoring by Metronet's creditors did not function properly either - normally, in similar circumstances, creditors would be able to gain access to the assets the debtor was to maintain before the creditors provide the lending, but, because of the aforementioned reason, namely that LUL was unable to define the assets to be maintained by Metronet, LUL proceeded to guarantee 95% of the face amount of Metronet's debt which disincentivized creditors from monitoring Metronet's financial situation, and thus the monitoring by creditors ended up not functioning.

iii) **Flawed governance**: Corporate decisions at Metronet in many cases required the consent by the 5 of its shareholders. They did not set up the corporate board which would have acted for the benefit of Metronet itself, in order to reap the benefits of their being the subcontractors/suppliers of Metronet. As the result, Metronet was unable to contain opportunistic behavior by the shareholders.

Tube Lines also saw a similar ending with that of Metronet, due mainly to the aforementioned reasons i) and ii). Tube Lines faced a funding shortage and asked TfL for financial support. After deliberations, TfL moved to purchase all the shares of Tube Lines for 310 million pounds in May 2010. Upon learning of this, the Mayor of London left the following comment: "(We) are more than capable of delivering the improvements to London's transport network we need, on time and on budget"[29].

As with the Metronet case, all London Underground PPP projects were terminated by 2010, 7 years after the introduction of PPP framework in 2003.



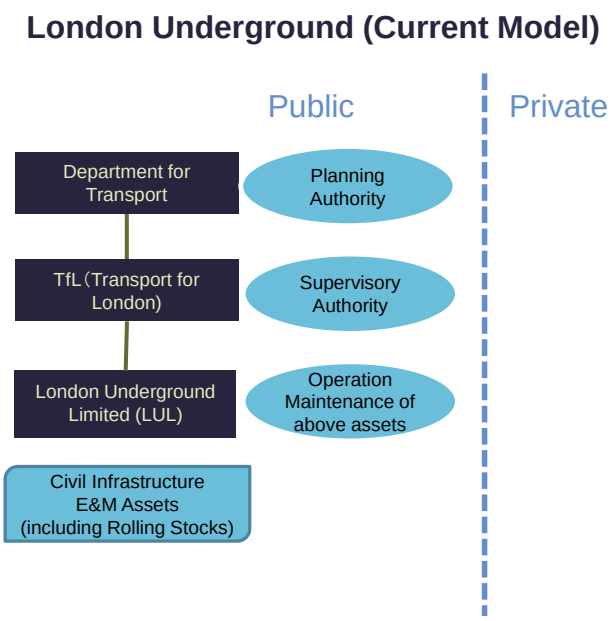

Source: JICA Study team

Figure 2.23 Chronology of London Underground since 2003 in a PPP framework

[29] BBC News, "Tube maintenance back 'in house' as new deal is signed", May 8, 2010

(ii) Project Scheme

The London Underground is currently being operated under a direct management scheme and all assets including civil infrastructure, E&M assets and rolling assets are owned and maintained by LUL which is a subsidiary organization of TfL. Below is its current operating model.




Source: JICA Study team

Figure 2.24 Current Operating Model of London Underground

(iii) Financial Responsibilities and Ownership of Assets

All assets including civil infrastructure, E&M assets and rolling assets are owned and maintained by LUL (TfL).

(iv) Ridership Risks

LUL (TfL) assumes the ridership risks.

(v) Farebox

The Mayor of London approves the fare revisions proposed by TfL under section 155 (1)(c) of the Greater London Authority Act 1999, which provides for the Mayor to be able to direct TfL to perform its functions. Fare changes proposed by TfL have generally tracked the changes in the Retail Price Index (RPI.)

Most of the transport modes under the control of TfL have a common fare and ticketing platform, and a journey, for example, using the DLR, Overground and/or Underground is treated as a single journey and not separately charged, so long as the switching is

done within a reasonable time frame.

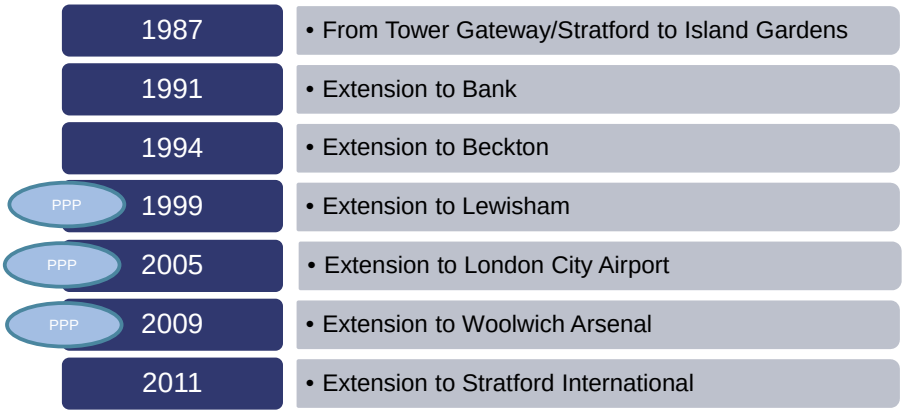
(vi) Commercial Developments

In regards to commercial development, TfL has a property development arm and a retail arm to best utilize the land TfL owns.

(6-2) Docklands Light Railway

(i) Background

Docklands Light Railway (DLR) was constructed as part of the redevelopment project of the Docklands area of London which was initiated in the early 1980s. Since the commencement of its operation in 1987, it has seen a series of extensions to the railways, and the now the network has expanded to 7 lines with 45 stations, carrying over 14 million passengers per day, and serves as the main transportation network in the Docklands area. The below summarizes how the network has expanded.




Source: JICA Study team

Figure 2.25 Network Extensions of DLR

(ii) Project Scheme, Financial Responsibilities and Ownership of Assets

DLR's project schemes vary according to railway extension, reflecting the circumstances at the time of planning. As for the financing of the construction, the public sector bore the majority of construction costs until the mid-1990s, and, through the introduction of PPP/PFI framework, the private sector bore the majority of the construction costs from the mid-1990s until the end of the 2000s. Thereafter, the public sector has borne all of the costs.

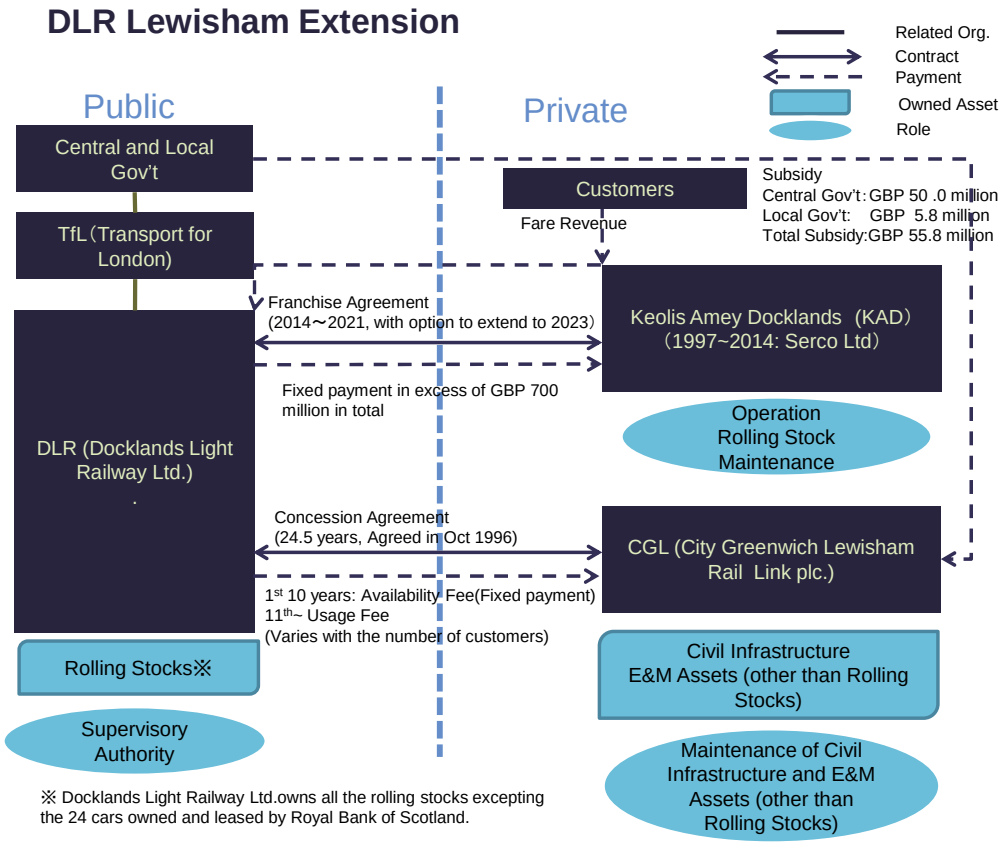
Along with the changing of the project financier, the post-construction maintenance scheme of the operating assets would also change with time.

Broadly speaking, two types of maintenance schemes exist in DLR, namely the first type having 3 railway extensions constructed under the PPP/PFI framework (namely, the Lewisham, London City Airport, Woolwich Arsenal extensions), and the second type being all other maintenance schemes. In the first type, the private sector builds, owns and maintains civil infrastructure and E&M assets (excluding rolling stocks) throughout the concession period, whereas in the second type, ownership

belongs to the public sector while the private sector maintains the assets that are owned by the public sector.

In either type, a single private sector operator obtains the operating rights to all the DLR lines through the "franchise" contract, and also operates and maintains rolling stocks[30]. In other words, there is no variation according to line extension in regards to the nature of operations.

The below summarizes the current operating model of the Lewisham extension, the first PPP project in UK transport sector.




Source: JICA Study team

Figure 2.26 Current Operating Model of Lewisham Extension

It may be noted that in November 2011, TfL bought all the assets of the London City Airport and Woolwich Arenal railway extensions that were held by the private sector operators[31] (however, the private sector continued to maintain the said assets, and as

[30] Under the franchise agreement between Docklands Light Railway Ltd. and the private sector operator, the main duties of the private sector operator are to operate and maintain rolling stocks and to maintain the assets Docklands Light Railway Ltd. owns.

[31] L - Finance and Policy Committee, "Docklands Light Railway Franchise Procurement", June 5, 2014

such the concession agreements were not terminated), which means that the public sector owned the civil infrastructure, E&M assets as well as the rolling stocks (excepting the 24 cars owned by the Royal Bank of Scotland).

(iii) Ridership Risks

The ridership risks are borne by the public sector. As mentioned above, a single private sector operator runs the entire DLR. Keolis Amey Docklands(KAD), the current private sector operator, obtained the operating rights from Docklands Light Railway Ltd., the subsidiary organization of TfL, through the franchise contract under the gross cost method.

(iv) Farebox

Please refer to the London Underground case for details.

(v) Concession Period

The franchise agreement between KAD and Docklands Light Railway Ltd. is a 7-year contract, extendable by an additional 2 years, totaling 9 years.

The concession agreements to maintain civil infrastructure and E&M assets (excluding rolling stocks) of the 3 railway extensions to be constructed under the PFI/PPP framework (namely, Lewisham, London City Airport, Woolwich Arsenal extensions.) were signed.

In the case of the Lewisham extension, the concession period is 24.5 years, and the private sector pays a fixed concession fee called "Availability Fee" for the first 10 years, and thereafter pays the so-called "Usage Fee" which fluctuates based on the number of the passengers (the private sector assumes the ridership risks) in replacement of the Availability Fee.

In the case of the London City Airport and Woolwich Arsenal railway extensions, the duration of the concession is 30 years and the private sector pays only the Availability Fee throughout concession period. This is based on the experience of the Lewisham extension concession that it would not be appropriate for the concessionaire maintaining only the civil infrastructure and E&M assets to be compensated for the fluctuations of ridership which it has no control over[32].

(vi) Commercial Development

The commercial development rights of DLR lie with the public sector. Please refer to

[32] Waterfront Auckland, "Public private partnership (PPP) case studies on private funding of transport infrastructure projects"

London Underground case for details.

### (6-3) London Overground

#### (i) Background

In 2006, the Department of Transport (DfT) handed over the franchising responsibility of the troubled North London Railway (NLR) (Silver line Metro) to Transport for London (TfL). Silverlink Metro ran a low quality service, marked by neglected stations, old rolling stock and low service levels. TfL took over Sliverline Metro appointed ***London Overground Rail Operations Ltd (LOROL)*** – a consortium of MTR (the operators of Hong Kong's metro) and Deutsche Bahn AG of Germany (DB) as a concessionaire[33] in 2007.

TfL set a dedicated program of enhancement of service levels which included new rolling stock, upgradation of infrastructure, station refurbishments, high standards of customer service and stringent monitoring of service levels set under the Concession Agreement.

Owing to above, Customer satisfaction (2007:71->2014:84) and reliability (2007: 92%, 2014:96%) improved remarkably. At present, LOROL manages 57 stations and operates 1,473 services daily on 104 trains and carries more than 520,000 passengers on 77 miles of track. The London Over ground Network is expected to host 100 stations by 2015. Overall, TfL has consolidated the fragmented overground urban rail routes into a comprehensive network linking 23 of London's 33 boroughs through a suburban network of passenger rail services.

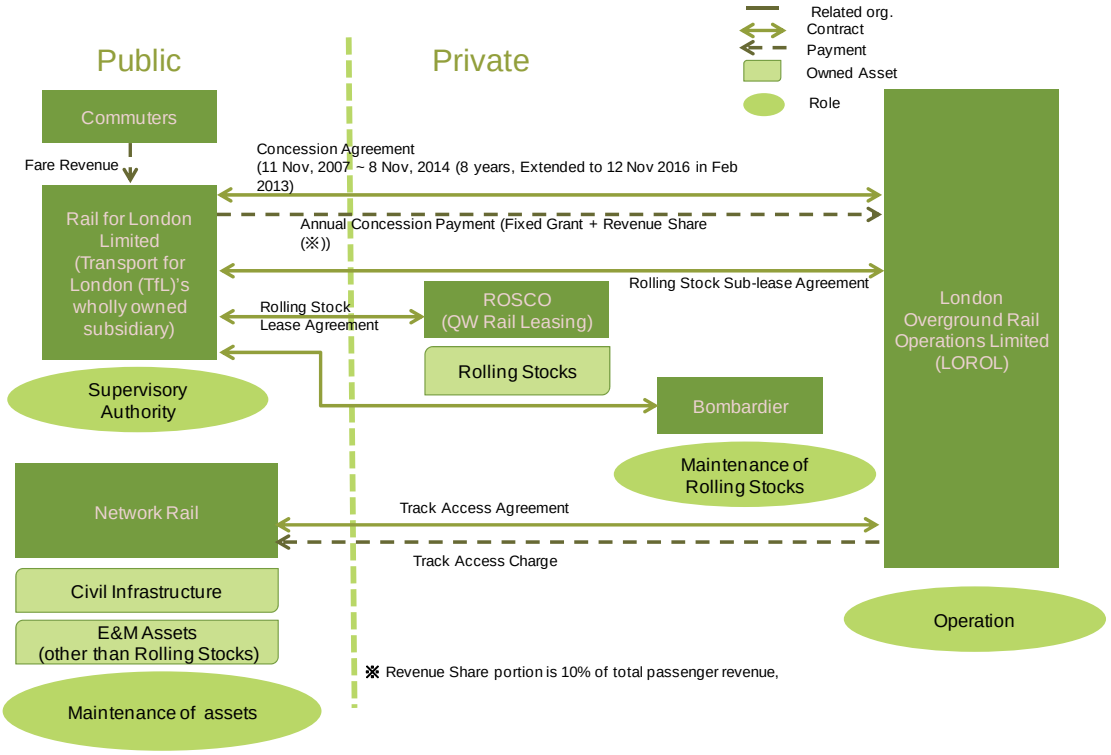
#### (ii) Project Scheme

TfL operates London Overground under through a Concession and not as a franchise. The important difference is that the concessionaire (LOROL) does not bear the ridership risk unlike in a franchise where the full responsibility for the network is handed over to the franchisee. This scheme is somewhat unique in the way that TfL, through its subsidiary Rail for London Limited (RfL), assumes most of ridership risk and plays an active role in management.

RfL is responsible for setting service standards, monitoring and enforcing service quality, investing and leasing in rolling stock, providing rolling stock to concessionaire

[33] LOROL is a Joint Venture between MTR Corporation (50%) and Deutsche Bahn AG of Germany (DB) (50%). DB's interest is managed by Arriva, the division responsible for regional passenger transport outside of Germany.

under a sublease, investing in ticketing infrastructure such as smart cards (Oyster), providing validators, ticket vending machines and setting fares. As against this, LOROL is responsible for operating train services, managing, maintaining and upgrading stations, staffing, collecting fare revenue for TfL, and customer interface services. In return for its services, LOROL receives a fixed annual concession grant and 10% of total passenger revenue. Pictorial representation of project scheme is provided below.




*Source: Concession agreement between Rail for London Limited and MTR Metro Limited, Annual Report 2014,LOROL .*

Figure 2.27 Operating model of London Overground

(iii) Financial Responsibilities and Ownership of Assets

All hard assets such as civil infrastructure and E&M assets other than rolling stocks are owned and maintained by Network Rail, the Public sector Company. For allowing LOROL to access this infrastructure, it charges track access charges to LOROL through a separate Track Access Agreement. (Track Access Charges in turn are set and regulated by Office of Rail Regulation, Govt. of UK).

Ticketing Infrastructure is owned and maintained by RfL where as rolling stocks are owned/leased by RfL through separate lease and maintenance agreements with QW Rail leasing and Bombardier respectively. LOROL does not own any asset rolling stocks, or any infrastructure such as stations, tracks and signals. It leases in the rolling stock through a separate Sub-Lease Agreement with RfL.

(iv) Ridership Risk

Ninety percent of the ridership risk is borne by TfL (through RfL) with fares and ticketing strategy set by the Mayor. LOROL, the current private operator, takes slightly a lower level (10%) of ridership risk while it receives considerable revenue through fixed annual grant through the concession contract under the Gross Cost method.

(v) Payment flow

The following table provides an insight into the payment flow to LOROL, RfL and Network Rail for London Overground Operations:

Table 2.32 Payment flow of London Overground

<table>
<tr><th>Entity</th><th>Payment Flow</th></tr>
<tr><td>LOROL</td><td>
<table>
<tr><th>Revenue Source /Payment Flow</th><th>Income in 2014 (£'000)</th><th>Proportion of Total Revenue</th></tr>
<tr><td>Annual Concession Grants from RfL</td><td>101460</td><td>77%</td></tr>
<tr><td>Share (10%) of Total Passenger Income</td><td>13826</td><td>10%</td></tr>
<tr><td>Performance regime income /Incentives for meeting Performance targets sets in concession Agreement from RfL</td><td>7623</td><td>6%</td></tr>
<tr><td>Station income received from other train operating companies for using and stopping at stations operated by LOROL.</td><td>4177</td><td>3%</td></tr>
<tr><td>Depot income received from other train operating companies for using LOROL operated Depot.</td><td>355</td><td>0.3%</td></tr>
</table>
Source : LOROL Annual Report ,2014
</td></tr>
<tr><td>Network Rail</td><td>• Annual Track Assess Charges of £14mn and £12mn paid to Network Rails by LOROL in 2014 and 2013 respectively[34].</td></tr>
<tr><td>RfL</td><td>• Passenger Fare Income<br>• Rolling Stocks Lease Payment to QW Rail leasing.<br>• Rolling Stock Maintenance Payment to Bombardier.</td></tr>
</table>

Source: JICA Study team

(vi) Duration of Concession Agreement

The duration of Concession is seven years extendable for another two years as per Concession Agreement. The Concession began from start of passenger operations on 11 November 2007 and was awarded a two year extension. Thus Concession will now

*34 Source: LOROL Annual Report,2014. This reference is also used for Concession Agreement Dates and Financial Status of the Project.*

end on 12 November 2016.

(vii) Fare box

The Mayor of London approves the fare revisions proposed by TfL under section 155 (1)(c) of the Greater London Authority Act 1999, which provides for the Mayor to be able to direct TfL to perform its functions. Fare changes proposed by TfL have generally tracked the changes in the Retail Price Index (RPI.)

Most of the transport modes under the control of TfL have a common fare and ticketing platform, and a journey, for example, using the DLR, Overground and/or Underground is treated as a single journey and not separately charged, so long as the switching is done within a reasonable time frame.

(viii) Commercial Development (if any)

No Commercial development rights grated /provisions involved in London Overground with LOROL .

(ix) Financial status of a project

Financial Status of LOROL for last two years is placed in the table below.

Table 2.33 Financial Status of LOROL

| | | Amount in £'000 |
|---|---|---|
| | **2014** | **2013** |
| **Turnover** | **131715** | **126829** |
| *Concession Grant* | *101460* | *98507* |
| *Passenger Income* | *13826* | *12881* |
| *Performance Regime* | *7623* | *7912* |
| *Station Income* | *4177* | *4093* |
| *Depot Income* | *355* | *403* |
| *Other Incomes* | *4274* | *3033* |
| Cost of Sales | 114643 | 107531 |
| Administration Expense | 16003 | 12857 |
| Operating Profit | 1069 | 6441 |
| Net Interest Receivable | 1193 | 644 |
| Profit Before Tax | 2262 | 7085 |
| Tax | 1010 | 1812 |
| Profit after Tax | 1252 | 5273 |
| Profit Margin (Operating Profit/Turnover) | 0.8% | 5.1% |

Source: LOROL Annual report

Key Observations are as follows:

- Turnover in 2014 increased 4% by £4.9 million, of which 20% was on account of strong passenger revenue growth. This indicates successful ridership growth, when some other operators are just breaking even or suffering.
- Concession Payments from RfL increased by £2.0m primarily as a result of indexation and projects income.
- Operating profit decreased by £5.4m compared to the previous year owing to introduction of management fees by both Joint Venture members in 2014.
- LOROL earned considerable performance incentives in both 2013 and 2014. The performance is measured through Public Performance Measurement (PPM) during the period. PPM represents 12 months moving average of the percentage of timetabled passenger services arriving at their scheduled destination within five minutes of the published arrival time. LOROL registered PPM of 96.41% as against target of 96.32% in 2014 indicating punctual and reliable services.

(x) Others (Outsourcing, Safety)

- **Safety**: LOROL will be responsible for safety issues arising due to deficiency in Operation/its role. However Network Rail is responsible for safety issues arising due to deficiency in provision of Civil and E&M Infrastructure (except Rolling Stock).
- **Outsourcing:** Facility maintenance and Security is LOROL's responsibility. It has outsourced facility maintenance such as cleaning and fixing as well as security functions. However Transport Police also sends security staffs at its own cost to ensure public safety.
- **Staff Employment:** If another operator wins next concession agreement of London Overground, staff will be transferred from LOROL to the new operator, as mandated by law .
- **Coordination with Network Rail:** LOROL's role also includes coordination with Network Rail and any other entity involved in London Overground in order to facilitate safe and timely operations. As part of its duty it works closely with Network Rail in order to reduce delays arising from infrastructure issues. For Example the infrastructure near London Bridge is not stable, causing delays and hence impacting LOROL's performance.

(6-4) Crossrail Project

(i) Background

Historical Background

The idea of Cross Rail Link was conceptualized in 1904 when the Royal Commission Study suggested east-west rail link in London. Subsequent London Transport Studies in 1965, 1974 and Central London Rail Study in 1989 proposed an east-west Cross Rail link. Owing to huge capital costs, considerable land requirements and its impact on large number of private interests, large authorization and powers were required for development of the project. These powers were sought through the Cross Rail Bill introduced in British Parliament which was rejected in 1994. However UK Government issued safeguarding directions to protect its alignment and to ensure no development would take place which would prevent Crossrail from being built in future.

Few events in 2000 further favored development of Crossrail, For instance, record level of congestion experienced by Underground and National Rail networks, publication of 10 year Transport Plan by Deputy PM and subsequent London East-West Rail Study, which suggested requirements for extra passenger capacity to and through London, recommended that a Crossrail scheme should be developed to construct the east-west route. In order to develop and promote Crossrail Scheme, a 50/50 Joint venture company, Cross London Rail Links Ltd, between Transport for London (TfL) and the Department for Transport (DfT) was formed in 2001. The Company became fully subsidiary of TfL in 2008 and was renamed Crossrail Ltd (CRL).

Parallely many business cases were developed for project development, funding scheme and Value for Money assessment. The socio economic benefits were studied to justify the project. It was estimated the project investment of £14.8bn in Crossrail Project would bring £42 bn of Net Benefits to UK GDP, £9.9bn of passenger time savings and help in creating enormous additional jobs (55000 jobs supported in London with 14000 direct, on site jobs), with estimated reduction of 57,000 tonne in carbon emissions and 50% reduction in train noise.

Further it was envisaged that the Crossrail project would bring enormous environment benefits to London. The project would enable 57000 new homes and overall contribute in creating 3 million sq ft of commercial, retail and residential space. The project is expected to transport 1.5mn people within 45 minutes through London[35] . After establishment of significant socio-economic benefits of Crossrail Project , the Crossrail Bill was further introduced in February 2005, approved in October 2007, and received Royal Assent in July 2008 and became Crossrail Act, 2008.

[35]*Source : Presentation by Technical director of Crossrail Ltd , Mr.Chris Sexton*

Project details and Operation stages

The Crossrail Project is UK's (and Europe's) largest Public project with a total project cost of £14.8 billion and infrastructure design life of 120 years. It will deliver a 118 kilometre rail line that will link Maidenhead and Heathrow in the west with Shenfield and Abbey Wood in the east including 21 km of twin tunnels under London (a total of 42 km). There will be 40 Crossrail stations including 7 new underground stations. Crossrail Line is divided into following three parts based on ownership.

- New section between Abbey Wood and Paddington (Crossrail) station ("Central Operating Section") being built and owned by Crossrail Ltd a subsidiary of TfL.
- Existing mainline infrastructure between Paddington and Reading stations and Liverpool Street and Shenfield stations owned by Network rail. The Train and station services on this line has been part of the Greater Anglia and Great Western franchise agreements until recently which has been transferred by DfT to TfL.
- Heathrow spur line owned by Heathrow Airport Holdings Limited (HAL).

The construction of new Central Operating Section between Abbey Wood and Paddington (Crossrail) station started in 2009 and it has been planned to be completed in 2018. When completed, Crossrail Project will increase the capacity of London's rail based public transport network by 10 per cent.

(ii) Project Scheme

Crossrail Ltd, a fully owned subsidiary of TfL, is mandated to develop the Crossrail Project infrastructure. Further Sponsor's Agreement between TfL and DfT authorizes TfL to procure the operations of the Crossrail train and station services by grant of a concession. With this Authorisation, TfL appointed MTR Corporation of Hongkong under the PPP scheme for *Crossrail Train and Station Services* concession on Gross Cost Contract in July 2014. The Concession Agreement was signed between Rail for London (RfL), a subsidiary of TfL, and MTR Corporation, the Crossrail Operator for the following scope:

i) Operations of the new train and station services on the new Crossrail infrastructure ("Central Operating Section") owned by Crossrail Ltd.

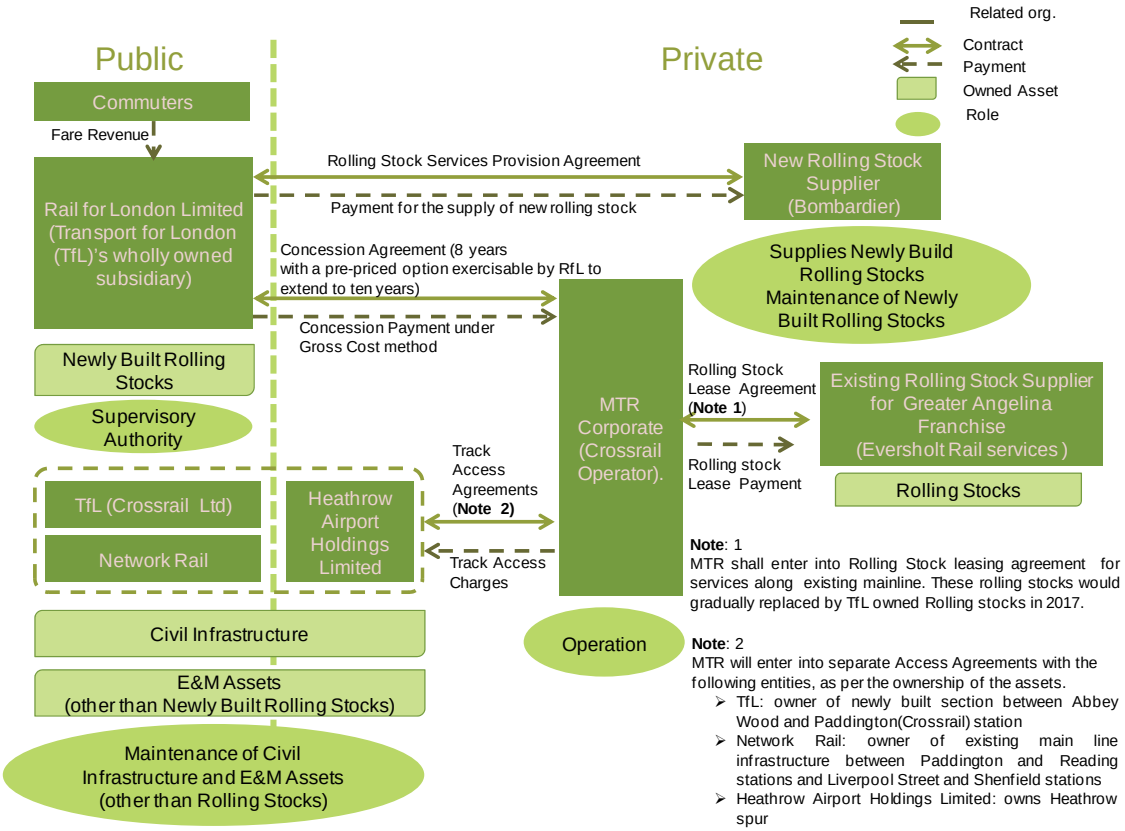
ii) Exiting train and station services existing currently under the Greater Anglia and Great Western franchise agreements (services between Liverpool Street and Shenfield) which have been transferred by DfT to TfL. MTR Corporation shall take over and use 44 class 315 rolling

stock units from Eversholt Rail services existing on the route. Existing rolling stocks will be gradually replaced in 2017 by TfL. The Station and E&M Infrastructure except rolling stocks along this line is owned by Network Rail .

iii) Train Operation along Heathrow spur line.

Under this scheme RfL assumes ridership risk and play an active role in management similar to the London Overground Concession. The Crossrail Operator (i.e. MTR Corporation) will receive fixed annual concession payment which is adjusted against performance regime/service levels. The concession payment is indexed to the Retail Price Index. The Concession agreement also provides flexibility to Crossrail Operator to earn additional return should they perform but also provides a means by which the public sector can claw back excess returns. This permits RfL to receive 50 percent share of the Crossrail Operator's profit over a predetermined threshold of 30 percent above the level of profit provided in Crossrail Operator's financial model as part of bid[36]. RfL is responsible for setting service standards, monitoring and enforcing service quality, investing and leasing in new rolling stock, providing rolling stock to concessionaire, investing in ticketing infrastructure such as smart cards (Oyster), providing validators, ticket vending machines and setting fares, Train Timetable development and Marketing. As against this Cross-rail Operator is responsible for operating and staffing Train and Stations, fare collection for RfL, and customer interface services. Operator's responsibilities also include cleaning and aesthetic improvements of stations, low level repairs, fault identification and reporting. TfL has contracted Bombardier for supply and maintenance of new rolling stocks. Original intention was to have Crossrail Operator procure the rolling stocks but there were little interest because of financial crisis. Pictorial representation of project scheme is provided below.

[36] *Source: Finance and Policy Committee of Transport for London Paper dated 17th July,2014*




*Source : Finance and Policy Committee of Transport for London Paper dated 17th July,2014.*

Figure 2.28 Operating model of Crossrail

(iii) Financial Responsibilities and Ownership of Assets

The Funding Package for the Crossrail Project was agreed and approved as part of comprehensive spending review (CSR) in 2007. Following the CSR in 2010 again the funding package of project cost of £14.8bn has been agreed for crossrail scheme, according to which, 21 km underground section in central London would cost £12.5 bn where as over ground section is expected to cost £2 bn including upgradation of existing stations owned by Network Rail. Subsequent to CSR, UK PM announced that Crossrail's cost will be met by Government, the Mayor of London and London businesses. The Contribution of each are placed in table below.

Table 2.34 Contribution to Crossrail

| **Entity** | **Contribution Towards Project Cost** | **Remarks** |
|---|---|---|
| **Mayor of London (A)** | **£ 7.15 bn** | |
| *Transport for London* | £ 2.7bn | • Direct Contribution : £1.9bn<br>• Land and Property : £500m |

| | | |
|---|---|---|
| | | • Developers Contribution: £300m |
| *Greater London Authority(GLA) through own source and London Business* | £4.4bn | • Crossrail Business Rate Supplement (BRS) and Direct Contribution: £4.1bn[37].<br>• Mayoral Community Infrastructure Levy £300m[38] |
| **Government through DfT (B)** | **£ 5.20bn** | |
| *Direct Contribution from DfT* | £4.8bn | |
| *Heathrow Airport Holding Ltd (HAL) , City of London Corporation and Others* | £0.4bn | • HAL Contribution : £70m<br>• City of London Direct Corporation : £200m. |
| **Network Rail and Other (C )** | **£ 2.45bn** | |
| *Network Rail* | £ 2.3bn | |
| Other | £ 0.15bn | • Canary Wharf Group has agreed to contribute £150m towards the costs of the new Canary Wharf Crossrail station .<br>• Berkeley Homes has agreed to construct a station box for a station at Woolwich. |
| **Total (A+B+C)** | **£14.8bn** | |

*Source : Presentation by Technical director of Crossrail Ltd , Mr.Chris Sexton and Crossrail Ltd website : http://www.crossrail.co.uk/about-us/funding*

Further TfL will be responsible for any cost overrun. The ownership of civil infrastructure and E&M assets are placed below. Each owner will maintain the civil and

[37] *The BRS is rate applicable on most non-domestic premises meaning Building or part of it used for the Business. having ratable value of more than £55,000. The Business Rate Supplements Act 2009 gives the Greater London Authority (GLA) the power to levy a supplement (a BRS) on business rates in order to finance part of the Crossrail project.*

[38] *Mayoral Community Infrastructure Levy (CIL) is a charge on all new development in London. Its purpose is to contribute to the cost of additional infrastructure required as a consequence of new homes, offices and other buildings. All Mayoral CIL revenues are currently being used to fund Crossrail.*

E&M assets that it owns.

**Transport for London :** TfL is the owner of all Civil Infrastructure and E&M assets of newly built section between Abbey Wood and Paddington (Crossrail) station ("Central Operating Section") through its subsidiary Crossrail Ltd. It is also owner of new rolling stock.

**Network Rail (Public Sector Company) :** All Civil Infrastructure and E&M assets of existing main line infrastructure between Paddington and Reading stations and Liverpool Street and Shenfield stations is owned by Network Line.

**Heathrow Airport Holding Ltd (HAL):** Heathrow spurline is owned by HAL.

Crossrail Operator shall enter into track access agreements with the above entities which shall permit it to use track against payment of track access charges (Track Access Charges are set and regulated by Office of Rail Regulation, Govt. of UK).

Ticketing Infrastructure is owned and maintained by RfL Further Crossrail Operator shall have station access agreement with other train operating companies at Shenfield, Slough, Maidenhead stations and with HAL at Heathrow. All these entity shall permit Crossrail Operator to use stations against payment of station access charges. The Crossrail Operator does not own any assets.

(iv) Ridership Risks

Complete ridership risks are borne by TfL (through RfL) with fares and ticketing strategy set by the Mayor.

(v) Payment flow

The following table provides an insight into the payment flow to key stakeholders of Crossrail.

Table 2.35 Payment flow of London Overground

| Entity | Payment Flow |
|---|---|
| Crossrail Operator (MTR Corporation) | • Annual Concession Grant from RfL (The Contract is awarded to MTR Corporation for cumulative value of £1.4bn over the base 8-year concession term before performance adjustments (bonuses and penalties)).<br>• Incentive for meeting Performance Target from RfL.<br>• Sharing of 50 percent share of operator's profit over a predetermined threshold of 30 percent above the level of profit provided in Crossrail Operator's financial model to RfL.<br>• Rolling Stock lease and maintenance payment to Eversholt Rail services and Greater Anglia franchises respectively 315 rolling stock for running services |

| | |
|---|---|
| | between Liverpool Street and Shenfield, initially until it is gradually replaced by new rolling stock provided TfL in 2017.<br>• Station access charge to other train operating companies at Shenfield, Slough, Maidenhead and to HAL at Heathrow.<br>• Track Access charges to TfL, Network Rail and Heathrow Airport Holding Ltd. |
| Network Rail | • Annual Track Assess Charges from Crossrail Operator for existing main line between Paddington and Reading stations and Liverpool Street and Shenfield stations. |
| RfL | • Passenger Fare Income.<br>• Track access charges for Central Operating Section from Crossrail Operator.<br>• New Rolling Stocks purchase and maintenance payment to Bombardier.<br>• Annual Concession payment to MTR Corporation |
| HAL | • Track Access Charges for Heathrow spur line and station access charges for Heathrow Station from Crossrail Operator. |

Source: LOROL Annual report

(vi) Duration of Concession Agreement

The duration of Concession is Eight years extendable for another two years as per Concession Agreement. The Concession was awarded in 2014.

(vii) Fare box

The Mayor of London sets and approves the fare revisions proposed by TfL under section 155 (1)(c) of the Greater London Authority Act 1999,. Fare changes proposed by TfL have generally tracked the changes in the Retail Price Index (RPI.).

(viii) Commercial Development (if any)

No Commercial development rights grated /provisions are involved in Crossrail Operation Concession Contract. However 12 major property developments above stations comprising of 3 million sq ft of commercial, retail and residential space have been planned. The property development is targeted to generate approx. £500m. TfL through its property development arm shall undertake utilization/leasing/selling of property.

(ix) Financial status of a project/Operator

Since Operation on existing main line between Paddington and Reading stations was planned to start in 31st May, 2015, the financial status of operator is not available. However sources of finance of this project is placed in point no 3 above.

(x) Others (Outsourcing, Safety)

Safety

- Railways and Other Guided Transport Systems (Safety) Regulations 2006 ("ROGS") requires Operator to obtain the Safety Certification and the Infrastructure manager (TfL or its subsidiary Crossrail Ltd and Network Rail) to obtain Safety Authorization from Office of Rail Regulation (Regulator) prior to start of the operation.
- Crossrail Operator will be responsible for safety issues arising due to deficiency in Operation/its role. However Network Rail and TfL as Infrastructure owner and manager, shall be responsible for safety issues arising due to deficiency in provision of Civil and E&M Infrastructure.
- As per Concession Agreement , Operator shall have to put in place Safety Management System which should be a suitable and sufficient to support safe (and reliable) operations . Further Operator shall have to participate in wider safety governance arrangements with key stakeholders and monitor and manage certain safety related metrics across the railway.

Coordination with Infrastructure Managers (i.e TfL or its subsidiary Crossrail Ltd and Network Rail) and Rolling Stock Supplier:

- The Concession also requires interfacing amongst Crossrail Operator, Infrastructure Owner and Rolling Stock Providers by creating a performance regime which incentivized performance arising from coordination and interfacing. For instance, Track Access Agreement between Crossrail Operator and Network Rail not only governs the level of access and associated charges but also, inter alia, sets benchmarks and financial incentives in relation to Network Rail's performance.
- Crossrail Operator will also be required to work very closely with the Rolling Stock Provider to train the drivers and develop the operational protocols necessary to ensure the effective day to day operation of the fleet.

### 2.2.5 Japan (Tokyo Metro, Tokyo Metropolis, Yokohama, Nagoya, Osaka, Fukuoka)

(1) Summary of subway undertakers

Table 2.36 summarizes the leading subway undertakers in Japan.

Table 2.36 Leading subway undertakers in Japan

| | First section opened | Route length (Km) | Number of lines | Number of stations | Number of enployees | Train crew | Service hours | Fare system | Ridership (million) | Track gauge (mm) | Power | Power collection | Minimum headway | Number of rollingstock |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tokyo Metro | 1927/12 | 195.1 | 9 | 179 | 8,433 | D/C & D | 5:00-0:48 | distance | 2,321.77 | 1,435/1,067 | 600V DC/ 1500V DC | third/ overhead | 1'50'' | 2,665 |
| Tokyo Gov. | 1960/12 | 109.0 | 4 | 106 | 3,481 | D/C & D | 5:00-1:07 | distance | 852.98 | 1,435/1,372 /1,067 | 1500V DC | overhead | 2'30'' | 1,094 |
| Yokohama | 1972/12 | 53.4 | 3 | 42 | 902 | D/C | 5:08-0:51 | distance | 197.90 | 1,435 | 750V DC/ 1500V DC | third/ overhead | 4'20'' | 282 |
| Nagoya | 1957/11 | 89.1 | 6 | 96 | 2,640 | D/C | 5:30-0:30 | distance | 427.52 | 1,435/1,067 | 600V DC/ 1500V DC | third/ overhead | 2'00'' | 762 |
| Osaka | 1933/5 | 129.9 | 8 | 123 | 5,605 | D/C & D | 5:00-0:39 | distance | 859.74 | 1,435 | 750V DC/ 1500V DC | third/ overhead | 2'00'' | 1,280 |
| Fukuoka | 1981/7 | 29.8 | 3 | 36 | 585 | D | 5:30-0:25 | distance | 104.57 | 1,435/1,067 | 1500V DC | overhead | 3'00'' | 212 |

Source: JICA Study team

With two or more service routes in operation, all subway undertakers in Japan have their own assets under their own upkeep and operation, thereby efficiently raising the power of transporting service of their railway networks. They are transporting passengers under a passenger fare system to charge fares proportional to travel distance for passengers, which is a convention prevailed in Japan. Although track gauges or current collecting systems aren't necessarily the same with all subway undertakers, they have adopted mostly the track gauge of 1,067 mm and the power supply voltage of DC 1,500 V in case they are implementing through-operation with other private railway undertakers, to guarantee continuity with the railway belonging to the other party. Trains are running at approx. 2- to 4-minute headways during peak hours, with the minimum headway being one minute and 50 seconds adopted for Marunouchi Line, Tokyo Metro. To run trains at such small headways during commuter transporting hours, all subway undertakers have large fleets of rolling stock.

(1-1) Tokyo Metro

Financier: 53.4%, Government of Japan (Minister of Finance) and 46.6%, Tokyo Metropolitan Government

Capital: 58,100 million yen

Infrastructures/assets for operation: Proprietary

Fare system: Distance-based fare charging system (section-wise cumulative-kilometer-dependent fare charging system)

History: Tokyo Metro is a successor of the Tokyo Subway Co. that started revenue service for the 2.2 km-long Ueno-Asakusa section (part of the current Ginza Line), the first one of its kind in Japan, in December 1927. Thereafter, Tokyo Subway extended the line from Ueno to Shimbashi. In parallel, the Tokyo High-Speed Railway Co. constructed the Shibuya-Shimbashi section. In January 1939, these two companies were merged into one to start passenger transport service for the 14.3 km-long Asakusa-Shibuya section (currently the Ginza Line).

As it entails an enormous amount of funds to construct underground railways, however, it was extremely difficult for private companies to construct a subway by themselves. Under the circumstances, the Land Transportation Business Coordination Act was enacted in April 1938, based on which the Teito Rapid Transit Authority (Eidan subway) was set up in July 1941 to succeed and operate the above Asakusa-Shibuya section.

The Teito Rapid Transit Authority had constructed and inaugurated nine lines during the period from July 1954 (inauguration of the Ikebukuro-Ochanomizu section, Marunouchi Line) to June 2008 (inauguration of the Kotakemukaihara-Shibuya section, Fukutoshin Line). When inauguration of the Fukutoshin Line had become a reality, the Teito Rapid Transit Authority was privatized as Tokyo Metro in April 2004, for the reason, among others, that inauguration of the Fukutoshin Line would put a period to the series of subway construction in Tokyo to mean that one of the purposes to have instituted the Teito Rapid Transit Authority has been attained.

Tokyo Metro is now implementing through-operation to/from other railway companies with its seven lines out of the nine belonging thereto, to claim a service route as long as approx. 530 km in total including the sections of other railway companies under through-operation therewith.

(1-2) Bureau of Transportation, Tokyo Metropolitan Government

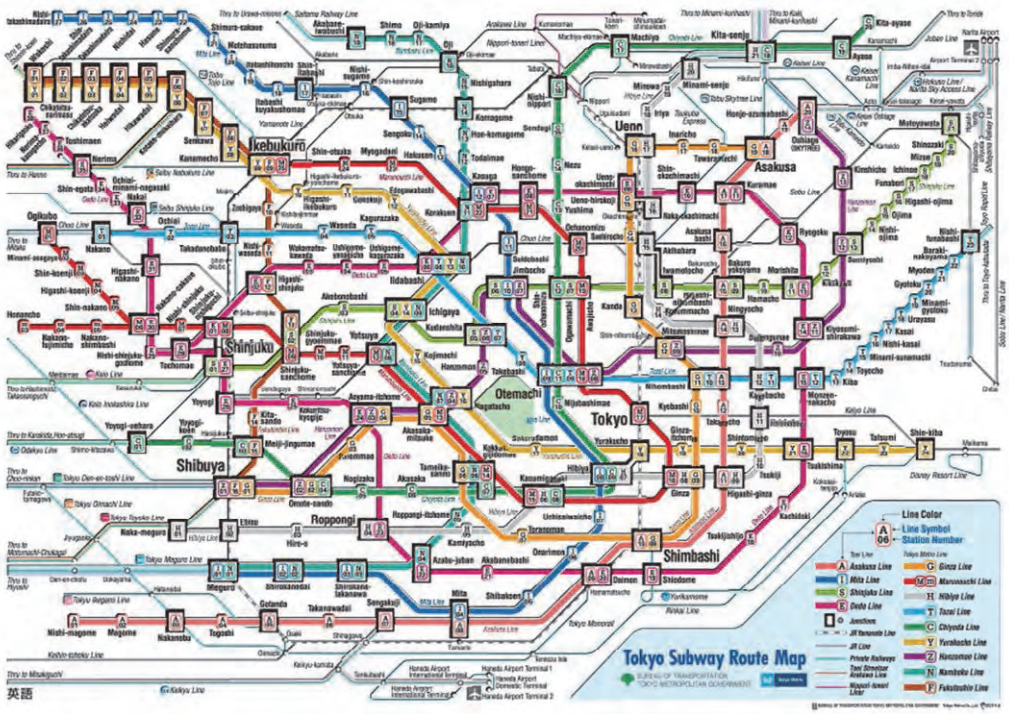
Financier: Tokyo Metropolitan Government

Capital: 992,991 million yen

Infrastructures/assets for operation: Proprietary

Fare system: Distance-based fare charging system (section-wise cumulative-kilometer-dependent fare charging system)

History: To quickly construct a number of subways in Tokyo, in order to cope with the rapidly increasing population in the capital city in the wake of World War II, it was determined that the Tokyo Metropolitan Government participate in subway construction with a license granted therefor, which had hitherto been limited to the Teito Rapid Transit Authority alone. Thus, the Metropolitan Government constructed and inaugurated the 3.1 km long Oshiage-Asakusabashi, Asakusa Line, in December 1960, the Mita Line in December 1968, Shinjuku Line in December 1978 and the Oedo Line in December 1991 to subsequently hold four subway lines under its umbrella, of which three lines, except the Oedo Line, are in through-operation to/from other railways.




Source: Home page, Tokyo Metro

Figure 2.29 Subway route map,
Tokyo Metro and Bureau of Transportation, Tokyo Metropolitan Government

(1-3) Yokohama

Financier: City of Yokohama

Capital: 509,505 million yen

Infrastructures/assets for operation: Proprietary

Fare system: Distance-based fare charging system (section-wise cumulative-kilometer-dependent fare charging system)

History: The City of Yokohama worked out in 1966 a plan to construct four subway lines, based on which the 5.2 km-long Kamiooka-Isezakichojamachi section, Line 1, was inaugurated first in December 1972. Then, a section to extend Line 1 was inaugurated in September 1976, together with the Kannai-Yokohama section, part of Line 3. Thereafter, Lines 1 and 3 steadily continued extending to eventually constitute a 40.4 km–long corridor called Blue Line encompassing the erstwhile separated two lines. Furthermore, the 13.0 km-long Hiyoshi-Nakayama section, Line 4, started revenue service under the name of Green Line.


Source: Home page, City of Yokohama

Figure 2.30 Subway route map, Transportation Bureau, City of Yokohama

(1-4) Nagoya

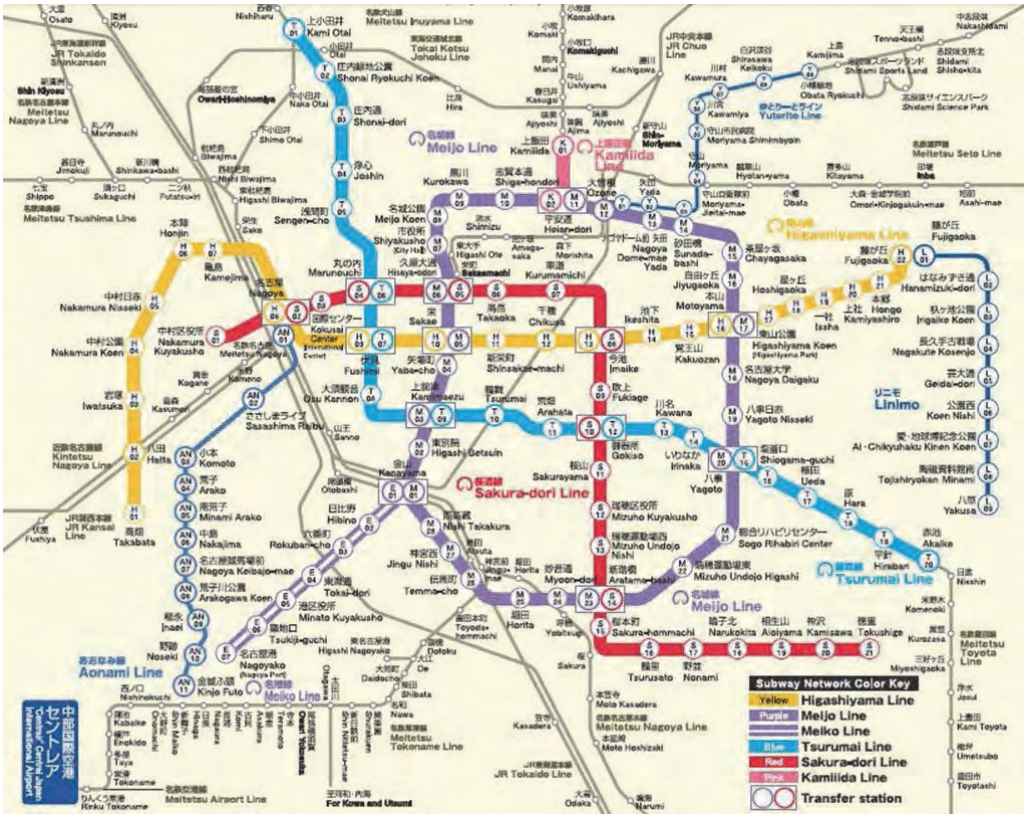
Financier: City of Nagoya

Capital: 661,770 million yen

Infrastructures/assets for operation: Proprietary

Fare system: Distance-based fare charging system (section-wise cumulative-kilometer-dependent fare charging system)

History: The City of Nagoya adopted an urban planning policy to aim at restoration after World War II (Post War Urban Reconstruction Plan of Nagoya). As a means thereof, The City of Nagoya worked out a subway network construction plan in 1947, based on which subways were constructed in succession to start passenger transporting service for six lines, including the 2.4 km-long Nagoya-Sakae section, Higashiyama Line (inaugurated in November 1957), the Sakae-Shiyakusho (City Hall)-section, Meijo Line (1965), the Nonami-Tokushige section, Sakura-dori Line (March 201). Two lines of these six are implementing through-operation with other railways, and one of which was constructed and is now owned by the Kamiiida Link Line Co., a semi-public/private sector company, with funds invested by The City of Nagoya and Nagoya Railroad Co. The City of Nagoya is now operating the Line by paying a rental fee to the Link Line Co.




Source: Home page, City of Nagoya

Figure 2.31 Subway route map, Transportation Bureau, City of Nagoya

(1-5) Osaka

Financier: City of Osaka

Capital: 997,049 million yen

Infrastructures/assets for operation: Proprietary

Fare system: Distance-based fare charging system (section-wise cumulative-kilometer-dependent fare charging system)

History: With World War I as a momentum, the City of Osaka developed into a commercial and industrial city known all over the world. The city adopted a plan in 1925 to construct four subways lines extending to 54.5 km in total as its new transport means and opened the 3.1 km-long Umeda-Shinsaibashi section, Line 1 (current Midosuji Line), which is the first municipal subway constructed in Japan and the second subway put into commercial service after the forerunner Ginza Line in Tokyo. Thereafter, the city promoted subway construction to establish a network in a lattice pattern at the city center and radially spreading in peripheral areas to require hopefully only one-time changing trains for passengers in traveling to any destination. The City of Osaka is now operating eight lines including three where through-operation is in practice with railways owned by other railway promoters.


Source: Home page, City of Osaka

Figure 2.32 Subway route map, Osaka Municipal Transportation Bureau

(1-6) Fukuoka

Financier: City of Fukuoka

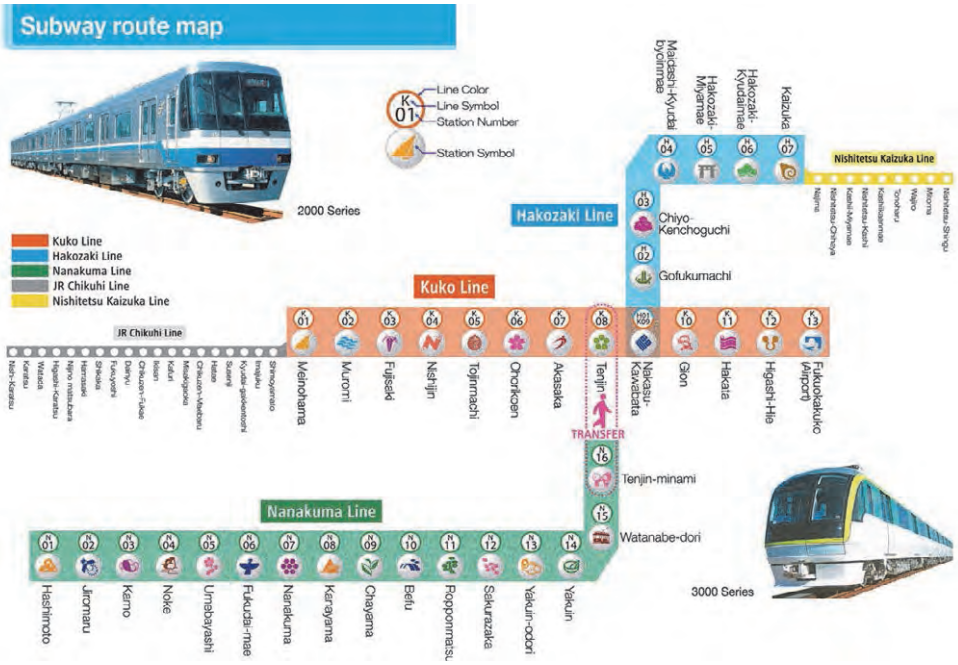
Capital: 320,308 million yen

Infrastructures/assets for operation: Proprietary

Fare system: Distance-based fare charging system (section-wise cumulative-kilometer-dependent fare charging system)

History: In 1974, the City of Fukuoka made a subway construction plan to construct the 9.8 km-long Meinohama-Hakata section, Line 1 (current Kuko (Airport) Line) and 4.7 km-long Nakasu-kawabata-Kaizuka section, Line 2 (current Hakozaki Line) under its responsibility for construction and operation. The 5.8 km-long, Muromi-Tenjin section, Kuko Line, was opened in July1981 as the first step, with the inauguration of the whole Hakozaki Line following suit in November 1986. The City of Fukuoka determined construction of the 3.3 km-long Hakata-Fukuoka Airport section as an extension of the Kuko Line same year and put the total route of the Kuko Line into commercial service eventually in March 1993 to run trains directly beneath the Airport terminal, which is an epoch-making event experienced for the first time in Japan. This made the Fukuoka Airport gain reputation that it is the most convenient airport in Japan.

In February 2005, the 12.0 km Hashimoto-Tenjin-minami section, Line 3, (current Nanakuma Line) made its debut for passenger transport service. The construction of the 1.4 km-long Tenjin-minami-Hakata section, Nanakuma Line, is now underway for inauguration scheduled for 2020.



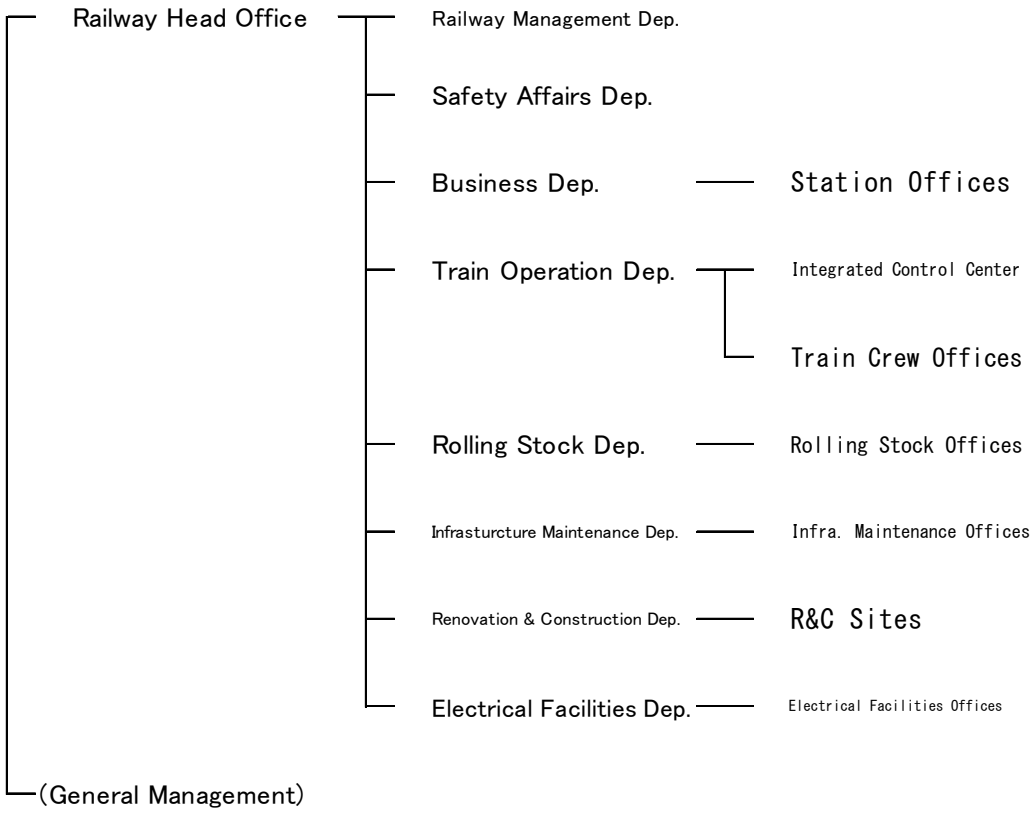

Source: Home page, City of Fukuoka

Figure 2.33 Subway route map, Fukuoka City Subway

(2) Organization and employees

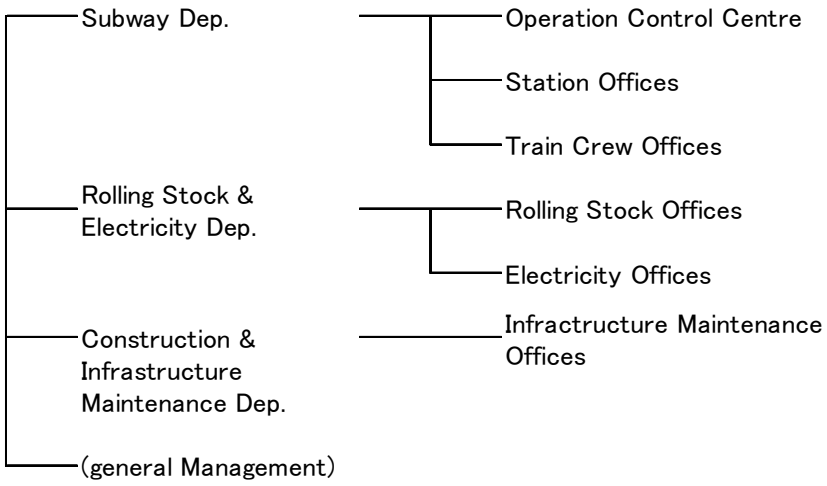
Though it depends on the business scale, the organizational structure is almost the same with different subway undertakers, which can broadly be divided into two: one being the Head Office division that adopts business polices and implements management of operation and the other the work-site division in charge of operation and upkeep of railways. Though some variations are seen in the work-site division, it has stations and organizations for train operation, rolling stock, engineering work (tracks and structures) and electricity.

Figures below represent concrete organizational charts of some subway undertakers.



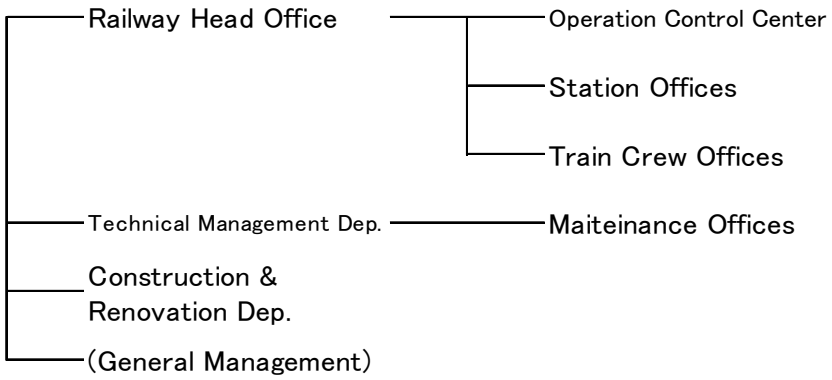

Source: JICA Study team

Figure 2.34 Organizational chart (Tokyo Metro)



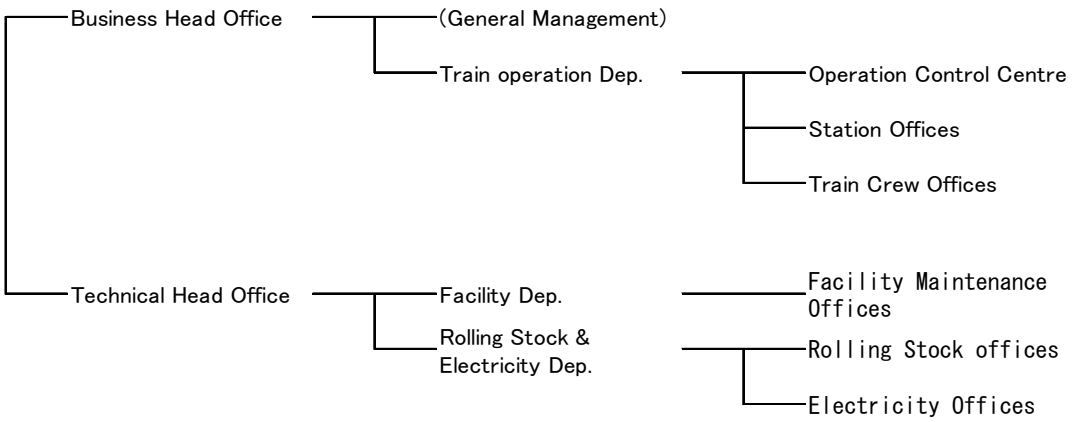

Source: JICA Study team

Figure 2.35 Organizational chart (Bureau of Transportation, Tokyo Metropolitan Government)



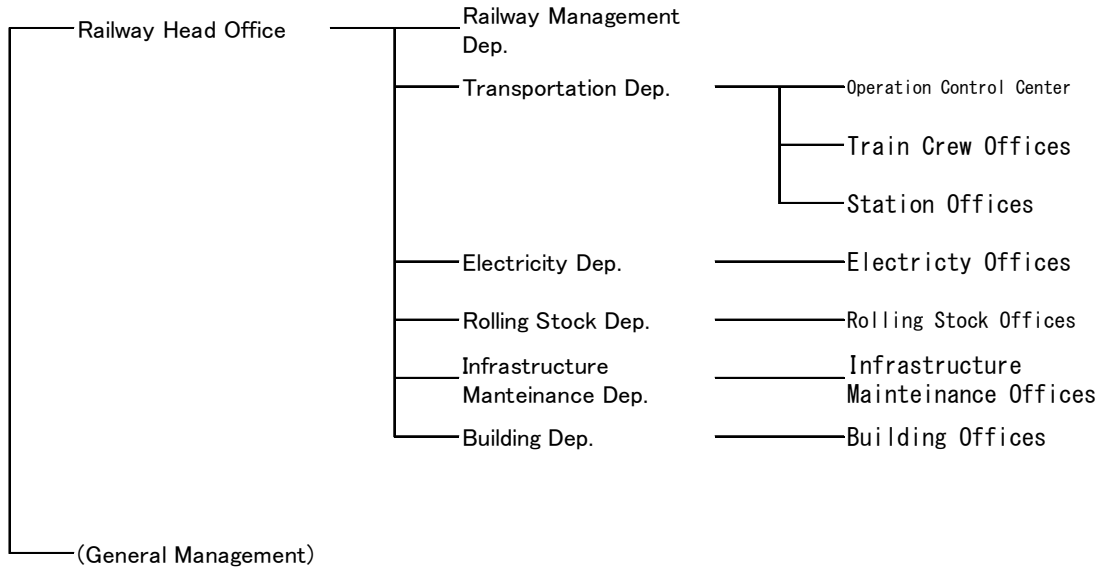

Source: JICA Study team

Figure 2.36 Organizational chart (Transportation Bureau, City of Yokohama)



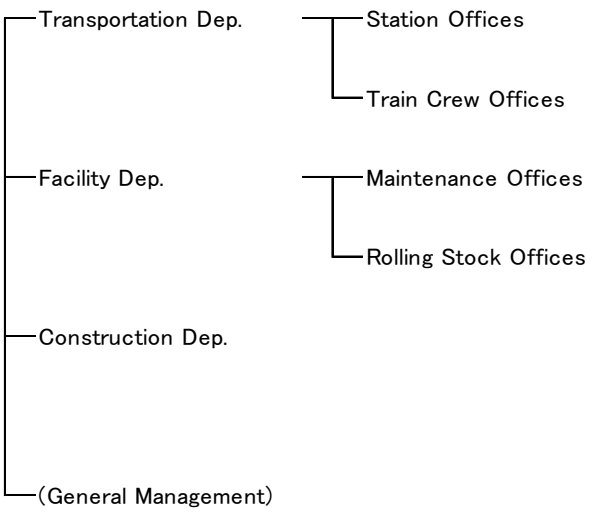

Source: JICA Study team

Figure 2.37 Organizational chart (Transportation Bureau, City of Nagoya)




Source: JICA Study team

Figure 2.38 Organizational chart (Osaka Municipal Transportation Bureau)




Source: JICA Study team

Figure 2.39 Organizational chart (Fukuoka City Subway)

The Table below summarizes the division-wise No. of employees of six subway undertakers in Japan.

Table 2.37 Division-wise Number of employees of six subways in Japan

| | | Tokyo Metro | Tokyo (Metropolitan) | Yokohama | Nagoya | Osaka | Fukuoka |
|---|---|---|---|---|---|---|---|
| Head Office | General Management | 406 | 159 | 30 | 168 | 406 | 43 |
| | Transpotation | 208 | 68 | 19 | 50 | 218 | 32 |
| | Rolling Stock | 61 | 31 | 11 | 16 | 52 | 6 |
| | Infrastructure Maintenance | 92 | 97 | 35 | 10 | 58 | 25 |
| | Electrical Facilities | 72 | 44 | 14 | 8 | 58 | 20 |
| | Construction | 93 | 0 | 20 | 138 | 134 | 24 |
| | total | **932** | **399** | **129** | **390** | **926** | **150** |
| Field Offices & Sites | Station | 2,918 | 1,129 | 223 | 424 | 1,981 | 139 |
| | Driver | 1,295 | 703 | 161 | 392 | 804 | 113 |
| | Conductor | 850 | 246 | 0 | 204 | 459 | 0 |
| | Transpotation (others) | 672 | 219 | 113 | 635 | 0 | 85 |
| | Rolling Stock | 855 | 350 | 42 | 314 | 616 | 35 |
| | Infrastructure Maintenance | 335 | 204 | 66 | 203 | 362 | 14 |
| | Electrical Facilities | 586 | 326 | 76 | 154 | 463 | 27 |
| | Construction | 57 | 0 | 0 | 0 | 61 | 0 |
| | total | **7,568** | **3,177** | **681** | **2,326** | **4,746** | **413** |
| Total | | **8,500** | **3,576** | **810** | **2,716** | **5,672** | **563** |

Source: Annual Report on Rail Statistics 2011

(3) Financial status

Below explained is the financial status of six leading subway undertakers in Japan based on their balance sheets and profit and loss statements.

The three important points revealed from the balance sheets are the facts that: (1) the fixed assets account for a lion's share in their total assets to reflect the railway facilities of all categories under their possession required for railway operation; (2) they have long-term liabilities in particular, related to heavy investment burdens stemming from subway construction and (3) these subway promoters except Tokyo Metro are burdened with prohibitively high amortization cost to cope with a variety of fixed assets under their possession, which has subsequently lead to a large amount of accumulated deficiency due to continued operation in the red.

In contrast, however, the profit and loss sheets prove that they all maintain a surplus in the railway business. Even those suffering from the amortization cost that has

snowballed since inauguration are now enjoying black-ink figures on the single-year basis.

Following Tables represent the balance sheets and profit and loss statements of six typical subways in Japan.

Table 2.38 Balance sheet

(Unit: million yen)

| | Tokyo Metro | Tokyo Metropolitan Government | Yokohama | Nagoya | Osaka | Fukuoka |
|---|---|---|---|---|---|---|
| Current assents | 81,850 | 174,974 | 12,227 | 9,414 | 56,400 | 878 |
| Fixed assets | 1,181,738 | 1,776,962 | 705,565 | 824,201 | 1,330,215 | 466,329 |
| Total assets | 1,263,589 | 1,951,936 | 717,794 | 833,616 | 1,386,663 | 467,208 |
| Current liabilities | 167,570 | 85,181 | 8,063 | 23,288 | 39,100 | 30,310 |
| Long-term liabilities | 720,723 | 536,123 | 156,885 | 328,419 | 46,738 | 105,972 |
| Total liabilities | 888,293 | 621,305 | 164,948 | 351,708 | 85,839 | 136,282 |
| Capital | 58,100 | 992,991 | 509,505 | 661,700 | 997,049 | 320,308 |
| Statutory surplus | 62,167 | 658,723 | 282,939 | 177,161 | 350,849 | 150,403 |
| Surplus | 255,009 | △321,082 | △239,598 | △356,953 | △47,075 | △139,785 |
| Total net assets | 375,295 | 1,330,631 | 552,846 | 481,908 | 1,300,823 | 330,925 |
| Total debts and net assets | 1,263,589 | 1,951,936 | 717,794 | 833,616 | 1,386,663 | 467,208 |

Source: Annual Report on Rail Statistics 2011

Table 2.39 Profit and loss statement

(Unit: million yen)

| | Tokyo Metro | Tokyo Metropolitan Government | Yokohama | Nagoya | Osaka | Fukuoka |
|---|---|---|---|---|---|---|
| Business income | 332,008 | 171,229 | 57,200 | 92,269 | 162,947 | 23,997 |
| Business expenses | 261,363 | 158,890 | 49,398 | 82,448 | 140,350 | 21,338 |
| Operating profit and loss | 70,645 | 12,339 | 7,802 | 9,821 | 22,596 | 2,659 |
| Non-operating income | 2,341 | 8,055 | 7,030 | 10,156 | 13,076 | 3,977 |
| Non-operating expenses | 18,030 | 15,402 | 10,767 | 16,923 | 23,283 | 5,858 |
| Recurring profit and loss | 54,956 | 4,992 | 4,065 | 3,054 | 12,390 | 778 |
| Extraordinary income | 6,875 | 68 | 0 | 297 | 936 | 1 |
| Extraordinary loss | 5,875 | 1 | 28 | 285 | 5 | 4 |
| Income before taxes | 55,956 | 5,059 | 4,036 | 3,066 | 13,321 | 775 |

Source: Annual Report on Rail Statistics 2011

A tremendous amount of funds are required for railway construction and much more to construct subways. Therefore, it is the case that local autonomous bodies, owners of respective subways, grant subsidies to support the management of subways under their umbrella (except Tokyo Metro).
Besides the above subsidies, subway undertakers are entitled to the following subsidy-granting systems.

Subsidies for underground high-speed railway construction project cost *
To facilitate the construction of underground railways primarily for the purpose of transporting students and commuters, this system provides undertakers belonging to local autonomous bodies who construct such railways with subsidies to support part of the costs for construction and large-scale remodeling work. Objects of subsides include construction of new railways, work to reinforce structures against earthquakes and large-scale remodeling work to introduce barrier-free facilities. The Government of Japan (through the Japan Railway Construction, Transport and Technology Agency (JRTT)) and local autonomous bodies grant subsidies, 30% or less the cost of the object construction project, for subway undertakers. Table 2.40 represents subsides granted by JRTT in fiscal 2013.

Table 2.40 Subsidies for the underground railway construction project cost (fiscal 2013)

(Unit: million yen)

| | |
|---|---|
| Tokyo Metro | 2,050 |
| Tokyo Metropolitan Government | 1,258 |
| Yokohama | 2 |
| Nagoya | 32 |
| Osaka | 574 |
| Fukuoka | 446 |

Source: JRTT website

* Railway Subsidies Guide Book, JRTT

### 2.2.6 The typical subways in the world

Table 2.41 summarizes particulars of 12 subways in different cities in the world. The cities which is mentioned above and the big cities in the world are compared in this table.

Table 2.41 Summary of the typical subways in the world (No. 1)

| | First section opened | Route length (Km) | Number of lines | Number of stations | Number of enployees | Train crew | Service hours | Fare system | Ridership (million) | Track gauge (mm) | Power | Power collection | Minimum headway | Number of rollingstock |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tokyo Metro | 1927/12 | 195.1 | 9 | 179 | 8,433 | D/C & D | 5:00-0:48 | distance | 2,321.77 | 1,435/1,067 | 600V DC/ 1500V DC | third/ overhead | 1'50" | 2,665 |
| Fukuoka | 1981/7 | 29.8 | 3 | 36 | 585 | D | 5:30-0:25 | distance | 104.57 | 1,435/1,067 | 1500V DC | overhead | 3'00" | 212 |
| Beijing | 1969/10 | 198.9 | 8 | 123 | 16,000 | D/C | 5:10-23:40 | flat/ distance | 1,500.00 | 1,435 | 750V DC | third | 3'00" | 1,770 |
| Hong Kong | 1979/10 | 171.3 | 11 | 81 | 8,540 | D | 6:00-1:00 | distance | 1,309.00 | 1,435/1,432 | 1500V DC /25KV AC | overhead | 2'08" | 1,919 |
| Bangkok (BMCL) | 2004/7 | 20.0 | 1 | 18 | 1,000 | D | 6:00-0:00 | distance | 62.00 | 1,435 | 750V DC | third | 3'10" | 57 |
| Singapore (SMRT) | 1987/11 | 98.4 | 4 | 58 | 3,000 | D | 5:30-0:30 | distance | 510.20 | 1,435 | 750V DC | third | 2'00" | 636 |
| Kolkata | 1984/10 | 28.3 | 1 | 24 | 3,163 | D | 7:00-21:45 | distance | 114.80 | 1,676 | 750V DC | third | 7'00" | 144 |
| Delhi | 2002/12 | 90.7 | 3 | 78 | 4,805 | D | 6:00-23:00 | distance | 255.50 | 1,676 | 25KV AC | overhead | 4'00" | 320 |
| London | 1863/1 | 408.0 | 12 | 270 | 13,400 | D | 4:40-1:30 | zonal | 1,073.00 | 1,435 | 630V DC | third/ fourth | 2'00" | 4,070 |
| Paris | 1900/7 | 201.8 | 16 | 300 | 9,967 | D & Less | 5:30-1:15 | zonal | 1,472.50 | 1,435 | 750V DC | third/ bilateral rail | 1'35" | 3,561 |
| Moscow | 1935/5 | 292.2 | 12 | 177 | 37,401 | D/2C | 5:45-1:15 | flat | 2,572.90 | 1,520 | 825V DC | third | 1'30" | 4,504 |
| New York | 1904/10 | 374.0 | 27 | 468 | 27,967 | D/C | 24hours | flat | 1,623.00 | 1,435 | 625V DC | third | 2'00" | 6,183 |

Source: JICA Study team

Table 2.42 summarizes particulars of the subways having a scale similar to that of Mumbai Metro Line 3.

Table 2.42 Summary of the typical subways in the world (No. 2)

| | First section opened | Route length (Km) | Number of lines | Number of stations | Number of enployees | Train crew | Service hours | Fare system | Ridership (million) | Track gauge (mm) | Power | Power collection | Minimum headway | Number of rollingstock |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fukuoka | 1981/7 | 29.8 | 3 | 36 | 585 | D | 5:30-0:25 | distance | 104.57 | 1,435/1,067 | 1500V DC | overhead | 3'00" | 212 |
| Incheon | 1999/10 | 29.4 | 1 | 29 | 955 | D | 5:30-0:40 | distance | 71.50 | 1,435 | 1500V DC | overhead | 4'30" | 200 |
| Nanjing | 2005/9 | 27.7 | 1 | 16 | 1,120 | D | 6:30-22:00 | distance | 36.50 | 1,435 | 1500V DC | overhead | 5'00" | 114 |
| Bangkok (BMCL) | 2004/7 | 20.0 | 1 | 18 | 1,000 | D | 6:00-0:00 | distance | 62.00 | 1,435 | 750V DC | third | 3'10" | 57 |
| Kolkata | 1984/10 | 28.3 | 1 | 24 | 3,163 | D | 7:00-21:45 | distance | 114.80 | 1,676 | 750V DC | third | 7'00" | 144 |
| Delhi | 2002/12 | 90.7 | 3 | 78 | 4,805 | D | 6:00-23:00 | distance | 255.50 | 1,676 | 25KV AC | overhead | 4'00" | 320 |
| Nurnberg | 1972/3 | 33.0 | 3 | 44 | 450 | D & Less | 5:00-1:00 | zonal | 170.00 | 1,435 | 750V DC | third | 1'40" | 186 |
| Lisbon | 1959/12 | 41.0 | 4 | 52 | 1,705 | D | 6:30-1:00 | zonal | 125.30 | 1,435 | 750V DC | third | 3'00" | 338 |
| Roma | 1955/2 | 36.5 | 2 | 49 | 2,700 | D | 5:30-23:30 | flat | 273.00 | 1,435 | 1500V DC | overhead | 3'00" | 450 |
| Budapest | 1896/5 | 30.8 | 3 | 42 | 861 | D | 4:28-23:24 | flat | 289.50 | 1,435 | 600V DC/ 750V DC | third/ overhead | 1'40" | 299 |
| Los Angeles | 1993/2 | 32.1 | 2 | 16 | 657 | D | 4:30-0:54 | flat | 46.90 | 1,435 | 750V DC | third | 5'00" | 104 |
| Rio de Janeiro | 1979/3 | 36.8 | 2 | 33 | 1,832 | D | 5:00-0:00 | flat | 154.00 | 1,600 | 750V DC | third | 4'20" | 182 |

Source: JICA Study team

## 2.3 Summary

The above sections describe precedent cases of metro projects in the world. O&M models which have been applied for the precedent cases can be classified five models. O&M models are distinguished mainly by three factors; i) asset ownership of civil infrastructure/E&M facilities, ii) risk takers of ridership risk, and iii) burden of O&M costs.

### (1) Direct management

Direct Management Method means that, Public sector finances both civil infrastructure/E&M facilities, owns all assets, takes ridership risk, and implements O&M.

Fukuoka city subway, Tokyo metro, Delhi metro and Chennai metro are implementing metro project by direct management method.

### (2) PPP Gross Cost Method

PPP Gross Cost Method means that, Public sector finances both civil infrastructure/E&M facilities, owns all assets, takes ridership risk, and collects fare from commuters. Private sector implements operation by their own expenditures. Public sector makes a payment for a certain amount of management fees to Private sectors toward operation done by Private.

PPP Gross Cost Method has been applied for Green Line Extension and Purple Line in Thailand.

### (3) PPP Net Cost Method (1)

PPP Net Cost Method (1) stands for, Public sector finances both civil infrastructure/E&M facilities, owns all assets. Public sector grants a right of utilisation for facilities to Private sector, Private implements operation. Private sector takes ridership risk and collects fare from commuters, and O&M expenses will be recovered by farebox revenue.

PPP Net Cost Method has been applied for Downtown Line, North-East Line, and Circle Line in Singapore.

(4) PPP Net Cost Method (2)

PPP Net Cost Method (2) is variation of PPP Net Cost Method (1), and it differs in terms of funding source and asset ownership. Public sector finances civil infrastructure and owns assets of under-structure. Public sector grants a right of utilisation for under-structure to Private sector. Private sector constructs E&M facilities, owns, and implements operation. Also, Private sector takes ridership risk and collects fare from commuters, and O&M expenses will be recovered by farebox revenue.

Blue Line in Thailand, Delhi Metro Airport Express in India, and North-South and East-West Line are implemented under PPP Net Cost Method (2).

(5) BOT Method

Private sector finances and constructs for both civil infrastructure and E&M facilities, own them, and implement O&M. Assts will be transferred to Public sector at the completion of BOT contract period.

BOT method has been applied for Green Line in Thailand, Rapid metro Gurgaon in India.

Table 2.43 O&M Models in metro projects

| Project Scheme | 1. Direct Management by Public | PPP Scheme (Note) | | | |
|---|---|---|---|---|---|
| | | 2. Gross Cost Method | 3. Net Cost Method ( 1 ) | 4. Net Cost Method ( 2 ) | 5. BOT Method |
| Operator in Charge | Public | Private | Private | Private | Private |
| Demand Risk | Public | Public | Private | Private | Private |
| Ownership of Assets | | | | | |
| Civil Infrastructures | Public | Public | Public | Public | Private |
| E&M Assets | Public | Public | Public | Private | Private |
| O&M Cost | Public | Private | Private | Private | Private |
| Replacement and Additional Investment | Public | Public | Public | Private | Private |
| Example | ・Fukuoka City Subway<br>・Tokyo Metro<br>・Delhi Metro<br>・Chennai Metro | ・Green Line (extension) in Bangkok<br>・Purple Line in Thailand | ・Downtown Line,<br>・North East Line<br>・Circle Line in Singapore | ・ Blue Line in Bangkok<br>・ North-South and East-West Line in Singapore<br>・ Delhi Metro Airport Express (Original Scheme) | ・ Green Line in Bangkok<br>・ Rapid Metro Gurgaon<br>・ Hyderabad Metro |

Source: JICA Study team

# Chapter 3 Mumbai metro line 3

## 3.1 Operational background and challenges

### 3.1.1 Development of India

In recent years, India has sustained high economic growth rates. Following 9.8% in 2006, the economic growth rate reached 9.5% in 2007. Despite a respite in 2008 and 2009 at 7.5% and 7.0%, respectively, due to the Global Financial Crisis, it recovered to the rate of 8.6% in 2010; this promising trend of high economic growth is expected to continue for some time.

In India, major urban areas supporting the national economy have experienced significant population growth, surpassing the nation-wide population growth rates. Furthermore, the urbanization rate is expected to reach 41% in 2030.

However, most urban areas lag behind in infrastructure development; unable to catch up with increasing transportation demands derived from population and economic growths, exacerbating traffic congestion, deteriorating traffic safety, aggravating air pollution, and increasing inconvenience in accessing urban services, etc.

### 3.1.2 Urban transportation in Mumbai

Mumbai, the largest city in India, has a population of 12.48 million with the population density at 20,694/km2 as of 2011, is one of the most densely populated cities in the world. The city marked significant increases in the number of registered automobiles; from 1.03 million vehicles in 2000 to 1.77 million vehicles in 2011. It suffers from chronic traffic congestion with the average vehicle speed of 15km/h in its major roads, which is a deplorable situation, compared with Tokyo (20km/h) and New York (30km/h). In the meanwhile, public transportation means play a primary role. They carry 11 million people a day, 52% of which is by train, and 26% is by bus.

At present, the city has railway services provided by the Western Railway and the Central Railway, both of which are managed by Indian National Railways. The total length is 465km, all of which are electrified at DC 1500 V or AC 25 KV, and run on the broad gage of 1,672 mm. There are three operational lines available in the city; the Western Line, Central Line, and Harbor Line, which are utilized, in total, by 7.3 million passengers a day. At peak hours, some lines operate 15-car trains at two-minute intervals. Rush-hour congestion is excruciating, sometimes causing fatal accidents due to people boarding a jam-packed car forcibly or walking within tracks.

Under these circumstances, various efforts are made to develop and improve the railway network. The monorail was opened on February 1, 2014 with the total extension

of 8.3 km. The construction is now underway to extend it by 11.2 km to the south. Mumbai Metro Line 1 was opened on June 8, 2014. This is an elevated railway in the entire length, connecting major locations in the north of Mumbai, with the total length of 11.4 km. It has 12 stations and is connected with the Western Line at Andheri and with the Central Line at Ghatkopar. Mumbai Metro Line 2 reached a stage of concluding the concession contract in January 2010, but has not broken ground yet. In this manner, the railways development has just started, leaving many operation, management, and maintenance challenges unresolved.

### 3.1.3 Challenges in Mumbai Metro Line 3

To counter these challenges, Mumbai Metropolitan Regional Development Authority (MMRDA) established a master plan for Mumbai Metro lines in 2004, which has since been modified slightly from the original scheme. Furthermore, MMRDA established Mumbai Metro Rail Corporation (MMRC) in 2008 as an implementation body for Mumbai Metro operations completely owned by MMRDA. MMRC is authorized for implementation connected with the Project pursuant to the Metro Railways (Construction) Act (1978) and for operation/maintenance management pursuant to the Metro Railways (Operation and Maintenance) Act (1978).

For Mumbai Metro Line 3, L/A has been concluded with JICA, GCs (General Consultants) have been nominated, and the P/Q (Pre-Qualification) process for civil engineering work contractors is now under way. With the full support from MMRDA, MMRC is now establishing its organizational system by recruiting personnel from MMRDA and staff of Indian National Railways, etc., intended to start commercial service in December 2019.

## 3.2 Outline of Line 3

### 3.2.1 Railway facilities

(1) Route

i) Route

Fully underground from Colaba, Mahim, Bandra, Chhatrapati Sivaji International Airport to SEEPZ.

ii) Structure

Length: 33.508 km, Route length: 32.546 km

iii) Station

Number of stations: 27 (all underground)

Stations will provide services at major passenger destinations and be located at intervals of 1.25 km on an average where transfer to/from other transport modes is possible.

See Table 3.1 for particulars of these stations.

Table 3.1 Station

| Station No. | Station Name | Distance from Station No.1 (m) | Distance between stations (m) | Elevation of ground surface (m) | Planned rail level (m) | Depth of rail level from the ground surface (m) |
|---|---|---|---|---|---|---|
| 1 | Colaba/ Cuffe Parade | 0 | - | 3.43 | -12.30 | -15.73 |
| 2 | Badhwar Park | 1,000 | 1,000 | 3.44 | -12.00 | -15.44 |
| 3 | Vidhan Bhavan | 1,600 | 600 | 5.14 | -16.50 | -21.64 |
| 4 | Churchgate Metro | 2,285 | 685 | 4 | -19.50 | -23.50 |
| 5 | Hutatma Chowk | 3,102 | 817 | 6.65 | -14.35 | -21.00 |
| 6 | CST Metro | 3,956 | 854 | 6.68 | -10.00 | -16.68 |
| 7 | Kalbadevi | 4,891 | 935 | 5.15 | -15.00 | -20.15 |
| 8 | Girgaon | 5,616 | 725 | 5.5 | -15.10 | -20.60 |
| 9 | Grant Road Metro | 7,156 | 1,540 | 2.41 | -17.90 | -20.31 |
| 10 | Mumbai Central Metro | 8,067 | 911 | 1.95 | -13.20 | -15.15 |
| 11 | Mahalaxmi Metro | 9,216 | 1,149 | 2.35 | -13.00 | -15.35 |
| 12 | Science Museum | 10,316 | 1,100 | 2.16 | -13.10 | -15.26 |
| 13 | Acharya Atrey Chowk | 11,516 | 1,200 | 5.89 | -11.00 | -16.89 |
| 14 | Worli | 12,924 | 1,408 | 4.52 | -11.40 | -15.92 |
| 15 | Siddhivinayak | 14,479 | 1,555 | 4.7 | -10.70 | -15.40 |
| 16 | Dadar Metro | 15,756 | 1,277 | 4.85 | -10.50 | -15.35 |
| 17 | Shitladevi Temple | 17,525 | 1,769 | 5.71 | -9.60 | -15.31 |
| 18 | Dharavi | 19,306 | 1,781 | 4.46 | -10.60 | -15.06 |
| 19 | Bandra Metro | 21,271 | 1,965 | 3.56 | -11.60 | -15.16 |
| 20 | Mumbai University (Kalina) | 22,812 | 1,541 | 3.31 | -9.00 | -12.31 |
| 21 | Santacruz Metro | 24,027 | 1,215 | 2.74 | -12.30 | -15.04 |
| 22 | CSIA (Domestic) | 26,299 | 2,272 | 5.35 | -9.70 | -15.05 |
| 23 | Sahar Road | 27,906 | 1,607 | 13.15 | -2.15 | -15.30 |
| 24 | CSIA (International) | 28,958 | 1,052 | 10.37 | -5.00 | -15.37 |
| 25 | Marol Naka | 29,829 | 871 | 11.35 | -5.00 | -16.35 |
| 26 | MIDC | 31,225 | 1,396 | 25.72 | 8.50 | -17.22 |
| 27 | SEEPZ | 32,546 | 1,321 | 29.81 | 14.00 | -15.81 |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

iv) Plan of civil engineering structures

- Design dimensions, Line 3

Table 3.2 Design dimensions

| Item | | Dimension |
|---|---|---|
| Track gauge | | 1,435 mm (Standard gauge) |
| Minimum curve radius for mainline | | 300 m (230m when impractical) |
| Minimum curve radius | | 1,000 m at station |
| Rolling stock base and shop-in/out track | | 200 m (120 when impractical) |
| Cant | Maximum cant | 125 mm |
| | Cant deficiency | 100 mm |
| Length of transient curve | | 0.72 times or over the actual cant or cant deficiency (0.44 times or over when impractical) |
| Maximum gradient | At station | 0% |
| | Between stations | 3.0% (4.0% when impractical) |
| Vertical curve radius (for gradient changes 0.4% or over) | Mainline | 2,500 m (1,500 m when impractical) |
| | Others | 1,500 m |
| Minimum vertical curve radius | | 20 m |

| | | |
|---|---|---|
| Design maximum speed | | 80 km/h |
| Axle load | | 17 t |
| Feeding voltage | | AC 25 kV (rigid conductor line) |
| Track structure | | Ballast-less solid bed track |
| Rail | | UIC-60 (60 kg/m rail), HH rail |
| Turnout | Mainline | 1:9 (turnout side restricted speed: 40 km/h) |
| | Rolling stock base | 1:7 (turnout side restricted speed: 25 km/h) |
| Minimum distance between track centers | Scissors crossing (mainline) | 4.5 m |
| | Shop-in/out, open-section tracks | 4.2 m |
| Platform | Length | 180 m (for 8-car train-sets) |
| | Width | (3,000 mm or over depending on the Number. of users) |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

- Route plan

a. Outline of the planned route

The route of the new Line 3 and the locations of stations are summarized in the draft edition DPR compiled by MMRDA. As referred to above, the new Line 3 is to integrate the former Lines 3 and 6, with their routes and locations of stations reviewed to some extent.

After starting from the Colaba district at the southern end of the peninsula, the new Line 3 runs northward on the west side of the peninsula, while connecting the Nariman point district, where organizations of the state government are concentrated, Churchgate station, CST station, Mumbai Central station and other terminals of existing railway lines. Whereas the former Line 3 ran northward further to Bandra district after crossing the Mahim river, the 32.5 km-long fully underground New Line 3 turns to the east in the Mahim district, crosses the Mahim river, passes the Bandra-Kurula Complex (BKC) district where Bombay Stock Exchange and a number of financial institutions are located, Chhatrapati Shivaji International Airport (CSIA) and Santacruz Electronics Export Processing Zone (SEEPZ) that has been developed as a special economic zone. The Line 3 runs 1 to 2 km apart from and in parallel with an existing railway line in the southern half part and connects to Lines 1 and 2 now under construction in the northern part. As it connects various districts that are extremely important from the administrative, commercial and industrial viewpoints, the Line 3 is expected to establish a new transport network to play an important role in order to eliminate chronic congestions of railways and roads.

Whereas the former Lines 3 and 6 crossed the Mahim river through viaducts, this section was reconstructed as an underground structure at integration to make the new Line 3 a fully underground railway as a result, as it was extremely difficult to construct a structure to transfer the railway from underground to on-viaduct in the Mahim district and mangroves shouldn't be cut in the Mahim river. See Figure 3.1 and Figure 3.2 for the vertical profile of the Line 3.

b. Conditions of track profile

Horizontal profile

The planned Line 3 will run fully underground or under roads in principle and under private lands where the road width is small or when it turns under intersections. For crossing runways or other facilities in airports, approval has been obtained from airport authorities.

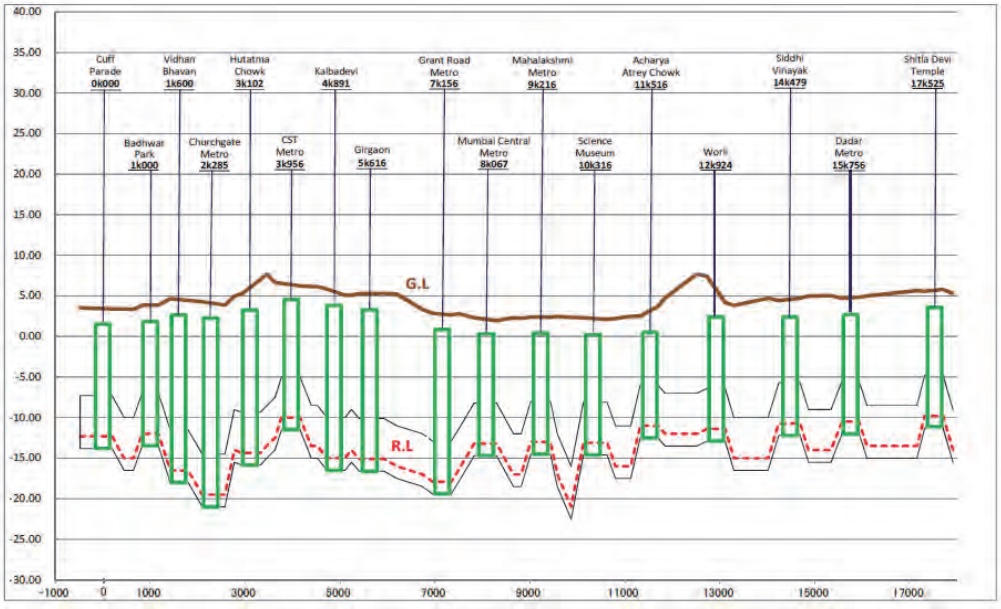
The standard minimum curve radius is set as 300 m in consideration of construction work using tunnel boring machines (TBMs). At the points where the curve radius becomes unavoidably 300 m or less, the cut and cover tunneling method will be adopted.

Vertical profile

The rail level is approx. 15 m below the ground surface at and between stations, because (1) hard rock appears at depths of 2.1 to 10 m, as stated in the section of soil conditions, in which tunnels shall be excavated as a whole (with an earth covering of 6m or over secured from the top of rock) and (2) interferences with building foundations or the structures/articles buried underground shall be avoided except at stations.

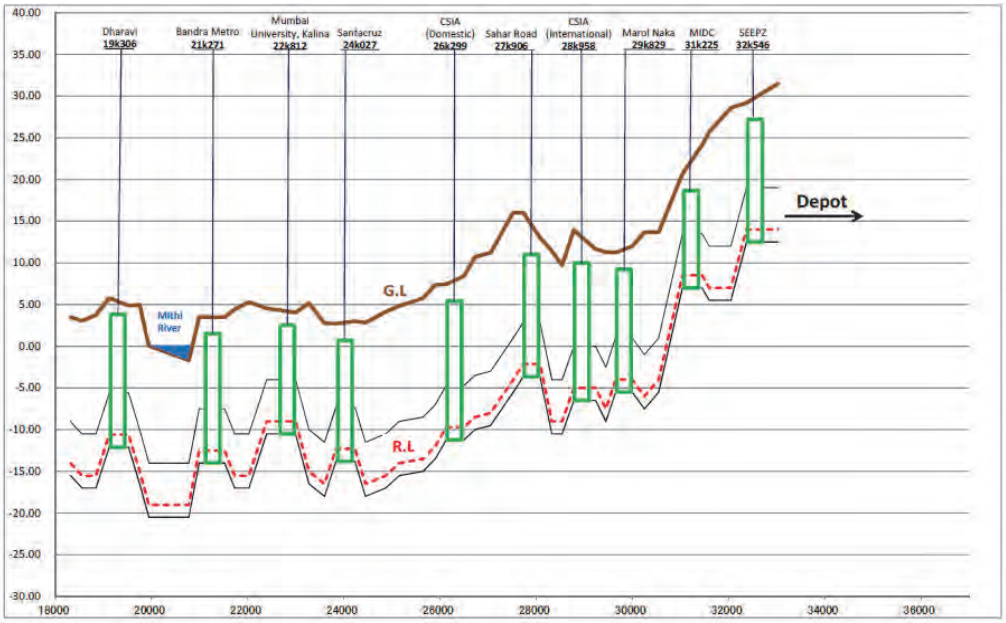
The allowable maximum gradient is normally 3.0% (0% at stations) or 4.0% in short sections where gradient 3.0% is impractical.

Figure 3.1and Figure 3.2 outline the vertical profile and Fig.




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.1 Longitudinal Profile




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.2 Longitudinal Profile

v) Plan of tracks

- Track gauge

Mumbai Metro will adopt the 1,435 mm standard gauge in consideration of the conformity with the planned Lines 1 and 2, while relegating the possibility of through-operation to/from the existing 1,676 mm broad-gauge networks.

- Track structure

Mumbai Metro will adopt the prince-type ballast-less track from the viewpoint of easiness of maintenance, ride comfort and low-level noise/vibration and use UIC-60 (60 kg/m) heat-treated HH rails featuring superb wear resistance in view of the fact that mainlines are studded with sharp curves and steep gradients.


Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.3 Alignment

(2) Electric facilities (power supply, signals and telecommunications)

i) Feeding system

In spite of its fully underground structure, it is planned that Line 3 be equipped with an AC 25 kV overhead contact wire feeding system that has been proven in Delhi Metro, in consideration of the volume of transport, conformity with other railways and standardization of technologies.

ii) Power transformation/distribution plan

The draft edition DPR outlines the power transformation/distribution plan as follows.

Power will be supplied to run train, use station facilities (for lighting, ventilation, air-conditioning, elevators, escalators, signal/telecommunication equipment and fire extinguishing systems), inspection/repair workshops, rolling stock bases and other maintenance facilities.

The maximum power required for operation will be determined based on the peak hour demand, reserves and other factors.

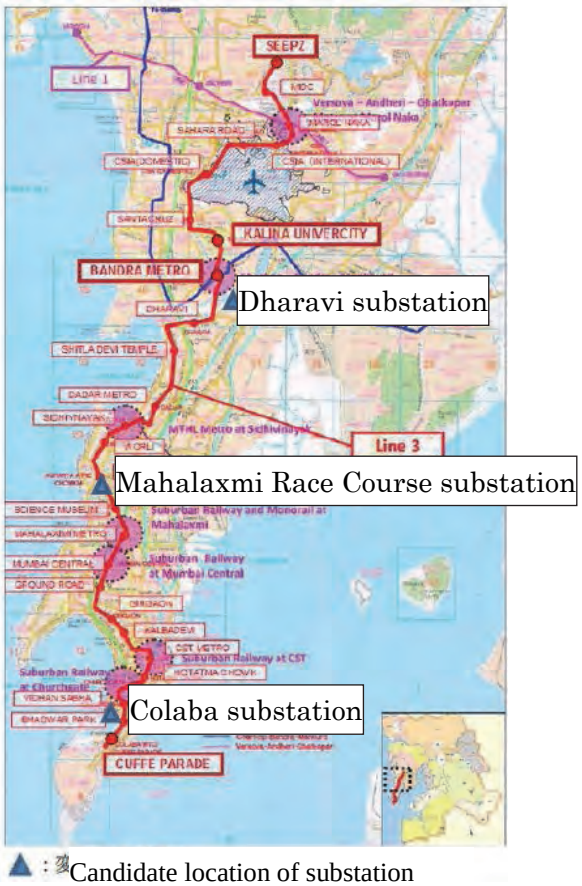
- Prerequisites
  - Power consumption rate of rolling stock: 70 kWh/1,000 km
  - Train operation: As per the train operation plan in each fiscal year between Colaba and Bandra and between Bandra and SEEPZ sections.
  - Loads at underground stations: 2,000 kW for the first fiscal year, which will be increased to 2,500 kW in FY2031 (load at design: 3,000 kW.)
  - Reserved loads at rolling stock bases: 2,000 kW for the first fiscal year, which will be increased to 2,500 kW in FY2031 (load at design: 3,000 kW.)
  - Power factor of loads: 0.9, transmission loss 5%
- Power transformation/distribution plan
  - Electric Power Company: Receiving power from TATA Electric Power Company
  - Voltage of receiving power: 100 kW
  - Number of power receiving substations: 3
  - Supply voltage: Stepdown from 100 kV to single-phase 25 kV for supply to EMUs and from 100 kV to 33 kV for supply to other loads.

Table 3.3 summarizes power receiving substation plans.

Table 3.3 Plan of power receiving substations

| Line | Electric Power Company, substation and voltage of receiving power (1) | Power receiving substation (location and voltage transformation) (2) | Distance between (1) and (2) and Number of transmission lines |
|---|---|---|---|
| Colaba-Bandra-SEEPZ | Badhwar Park (100 kV) | Colaba (100/33/25 kV) | 2 km, 100 kV (2 lines) |
| | Mahalaxmi (100 kV) | Race Course (100/33/25 kV) | 1 km, 100 kV (2 lines) |
| | Dharavi (100 kV) | Dharavi (100/33/25 kV) | 1 km, 100 kV (2 lines) |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.4 Location of power receiving substations

Power receiving substations drop voltage from 100 kV received from TATA Electric Power Company to 33 kV for ancillary power equipment/facilities and to 25 kV for supply to feeding lines.

- Sections under coverage of power supply

  Sections under coverage of power supply are as per the following Table.

(In normal state)

Table 3.4 Section under coverage of power supply (In normal state)

| Power receiving substation | Section under coverage of power supply |
|---|---|
| Colaba | Colaba-Maharaxmi section |
| Mahalaxmi Race Course | Maharaxmi-Dharavi section |
| Dharavi | Dharavi-SEEPZ section |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

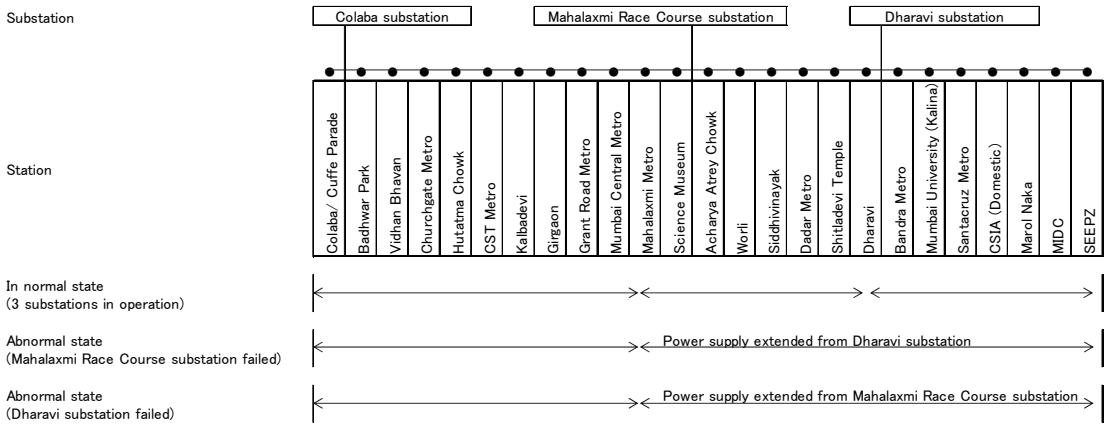
(In abnormal state)

Table 3.5 Section under coverage of power supply (In abnormal state)

| Power receiving substation | Section under coverage of power supply |
|---|---|
| When Maharaxmi Race Course | Power supply is extended from Colaba substation (coverage: |

| | |
|---|---|
| substation has failed | Colaba-Maharaxmi) or from Dharavi substation (coverage: Dharavi-SEEPZ). |
| When Dharavi substation has failed | Power is supplied from Maharaxmi Race Course subsection to Maharaxmi-SEEPS section. |
| When all substations have failed | All trains stop, with power supplied by emergency diesel generators to lighting apparatus, fire extinguishing equipment and other important facilities at stations. |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.5 Sections under coverage of power supply

- Each substation: Equipped with two sets of single-phase 100/25kV transformer, capacity 30MVA, with one as a standby unit.
- Gas insulated switchgear (GIS): Indoor type, 33 kV and 25 kV
- Area of substation: Approx. 50 m x 40 m (2,000 $m^2$) or 70 m x 40 m
- Substation at/in station/rolling stock base: Indoor type, 2 sets x 2,500 kVA
- Electromagnetic interference (EMI) and electromagnetic compatibility (EMC): Electromagnetic interference and electromagnetic compatibility of AC 25 kV single-phase current will be discussed at detailed designing.
- Emergency Diesel generator: 2 sets x 1,000 kVA / station
- SCADA system

The Operation Control Center (OCC) controls and monitors the power supply system through an SCADA system equipped with remote control terminals for data transmission through optical fiber cables.

iii) Plan of overhead contact line system

The draft edition DPR outlines the plan of overhead contact line system as follows.

- 25 kV rigid conductor support system

- Structure of rigid conductor support system: Hollow aluminum conductor rail having a copper trolley wire, 150 $mm^2$ in section, suspended with a cantilever and an insulator hung from the tunnel ceiling that are installed at 10 m intervals.
- Design standards for rigid conductor support system: IEC60913 and EN50122
- Height of trolley wire: 4,324 mm

  Distance between structures and conductors: 270/170/150 mm (static/dynamic/absolute dynamic (minimum))

  Distance between rolling stock and conductors: 290/190/150 mm (static/dynamic/absolute dynamic (minimum))

  For rolling stock bases and part of the route where an open section exists, the following trolley wire system is planned.

- 25 kV overhead contact line system
  - HD copper trolley wire, 150 $mm^2$ in section
  - Cd-Cu messenger wire, 65 $mm^2$ in section

iv) Plan of the signal system

The draft edition DPR outlines the plan of the signal system as follows.

The signal system of Metro that transports a number of passengers shall ensure safety of train operation and appropriate control thereof. For this purpose, plans have been worked out to introduce Automatic Train Protection (ATP) and Automatic Train Supervision (ATS) systems.

The concept lying behind is as follows.

- Train control (safety of train operation, punctuality)
- Prevention of accidents due to erroneous operation by drivers
- Setting restricted speeds for each section for train operation
- Introduction of a cab signal system
- Measures to correspond to speedups and line capacity increases in the future

Headways are set at 2.5 minutes at design and 3 minutes in peak hours.

Each component system shall be based on CENELEC, IEC, BS, IS, ITU-T and other international standards. Table 3.6 summarizes the standards for the signal system planned in the draft edition DPR.

Table 3.6 Standards for the signal system

| Item | Standard |
|---|---|
| Point | Electronic interlocking systems shall be adopted at stations equipped with turnouts, with related machines and components all placed in the machine and component rooms as far as possible. All points shall be interlocked at rolling stock bases except on the tracks principally used for shunting operation and inspection/repair work. |
| Track circuit | Points shall be supplied with power, DC 110 V or three-phase AC 380 V at 50 Hz. |
| Signals at stations equipped with turnouts | AF track circuits shall be adopted for train running sections, test tracks and tracks in rolling stock bases. |
| Uninterruptible power supply (UPS) units shall be installed not only at OCC but also at stations. | To protect turnouts, wayside signals shall be of the LED type featuring high reliability and less maintenance manpower. |
| Train protection system | UPS units shall be installed as far as possible for signal, telecommunication and automatic fare collecting systems. |
| Automatic train control system | An automatic train protection system shall be adopted. |
| Redundancy of ATP/ATS | Under the automatic train control system, train operation status is wholly recorded in the computer at the center and displayed at the Operation Control Center (OCC) and SCR work stations through which OCC remotely controls stations. |
| Cables | Train-borne units and ATC components at OCC shall be of a redundant type. |
| Principle of fail-safe | External cables shall be composed of sheathed steel wires as far as possible. Underground cables shall be of the type that doesn't emit much smoke or halogen gas when burnt. |
| Exemption against outside interfaces | The safety level shall be SIL-4 in accordance with CENELEC that applies to signals. |
| Train operation at emergency (ATP failure) | All data transmissions through telecommunication cables, OFC cables and a wireless system shall be the object of exemption. Signal and telecommunication cables shall be separated from power cables and accord with CENELEC/IEEE standards to satisfy EMC/EMI conditions. |
| Environmental conditions | At emergency, trains shall run at automatically restricted speed of 15 to 25 km/h in compliance with wayside signals. |
| Concept of maintenance | Air conditioners shall be installed in all machine rooms. |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

v) Plan of the telecommunication system

The draft edition DPR outlines the plan of the telecommunication system as follows.

The telecommunication system is used not only in the telecommunication field but also as a telecommunication means for the signal system, power supply system, SCADA and AFC and is offered as a telecommunication service for management and control of Metro network.

The concept of the planned telecommunication equipment/facilities are as follows.

- Complementing the signal system to perform efficient train operation
- Information exchange for management and control purposes
- Crisis control at emergency or on other occasions
- Information system for passengers
- Telecommunication means provided for other systems
- Utilization of CCTV images for safety and guarding

An outline of the systems and components and equipment/facilities planned in the draft edition DPR is as follows.

- Optical fiber cables

A large part of the telecommunication network is planned as an optical fiber cable system.

The transmission system is composed of SDH and GE based on the whole telecommunication network.

- Telephone system

The following places are installed with telephone exchanges.

One set of exchange, 128-port type, at each station and, 256-port type, at each terminal and OCC.

- Mobile train radio system

An 8-channel digital mobile train radio system in accordance with the TETRA international standard is planned for on-line telecommunication between dispatchers at the operation control center (OCC) and drivers on moving trains, stations and maintenance workers.

- Passenger information broadcasting system

Passenger information can be broadcast not only from OCC but also from platforms/concourses of each station, with the former having priority over the latter.

- Clock system

A clock system will be adopted to display the exact time on the child clocks at platforms, concourses and the station-master office of each station and other railway service facilities, where child clocks are synchronized with the master clock installed at OCC.

- Passenger information display system

The passenger information displays will be installed at convenient points on platforms and in concourses of each station to provide passengers with visual/acoustic expressions in two languages on the status of train operation including destination and arrival/departure time of trains and special information for passengers at emergency.

- CCTV system

CCTV sets will be installed at stations and rolling stock depots to ensure safety of train operation, passengers and maintenance workers.

The draft edition DPR summarizes the standards to be adopted as follows.

Table 3.7 Standards for the telecommunication system

| System | Standard |
|---|---|
| Transmission system | The transmission system shall be based on the concepts of SDH and GE to compose a total telecommunication network. |
| Transmission medium | An optical fiber system shall be adopted as a major transmission medium to guarantee the capacity of telecommunication network. |
| Telephone exchange | An EPABX telephone exchange of the minimum 128-port type shall be installed at each station and that of the 256-port type at each terminal and OCC. |
| Train radio system | The digital train radio system (TETRA) shall be used for telecommunication between OCC and drivers of running trains, stations and maintenance workers. |
| Train destination display system | The train destination display boards, an easily visible LED/LCD type, shall be installed at convenient places of all stations, which shall visually display the position of running train and special messages in two languages in case an emergency situation has arisen. |
| Clock system | Through a synchronization mechanism, the clock system shall run child clocks from the master clock at OCC and sub-master clocks at stations to display the exact time, which are also used to synchronize other systems. |
| Passenger information broadcasting system | The passenger information system shall broadcast the passenger information provided not only at the center but also at other stations on the platforms and in concourse areas of each station. |
| Redundancy (important systems) | The surplus transmission capacity of optical fiber cables to supply massive data in a ring form shall be utilized as the redundancy of the radio station equipment/facilities. |
| Environmental conditions | All machine rooms shall be equipped with air-conditioners. |
| Concept of maintenance | Systems shall be armored as far as possible with the most advanced equipment/facilities to automatically switch to alternative routes/circuits at failure. The concept of the standard on preventive maintenance is as follows. Systems shall connect to NMS and diagnose or adjust failed parts. Cards/modules shall be replaced outdoor. Repairs shall be implemented at the central inspection room or in the workshop of manufacturers. |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

### vi) AFC plan

a. Outline of AFC plan

The draft edition DPR outlines the AFC plan as follows.

To issue tickets and collect fares, it is important to adopt an efficient system to play the assigned role appropriately.

To attain this purpose, system components shall be simple to use, in operation and in providing maintenance services. At the same time, tickets shall be multi-functional and shall promptly respond to changes in the charging system.

Introduction of the AFC system will cut the manpower for ticket selling and inspection, save costs when compared with paper ticket vending machines and reduce maintenance costs. Furthermore, smart cards and the token system will prevent leaks in revenue.

- Outline of specifications

The draft edition DPR plans the specifications for major components as follows.

- Fare media

Fare media are smart tokens and smart cards, both being of the non-contact type. Non-contact readers shall be in accordance with the ISO14443 standard.

- Types of ticket barriers

Ticket barriers shall rotate automatically or retract flaps at entrance/exit. There are four types of ticket barriers used in the following manners.

i) Exclusively for entrance
ii) Exclusively for exit
iii) In common for entrance and exit
iv) In common for entrance and exit with a large-width for the handicapped.

- Ticket issuing machine

Computerized ticket issuing machines shall be installed at stations to sell electronic cards and tokens to passengers.

- Automatic ticket vending machine

Automatic ticket vending machines shall issue one-way tickets in principle and allow addition of other functions.

- Ticket reader

Ticket readers shall be installed for passengers to check the fare charging information in tokens and cards.

Table 3.8 summarizes the standards planned in the draft edition DPR.

Table 3.8 Standards for the telecommunication system

| Object | Standard |
|---|---|
| Fare media | Non-contact type smart tokens are for one-way travel and collected at a ticket barrier exclusively used for exit, while non-contact type smart cards are for repeated travels. Non-contact type readers shall be in accordance with the ISO 14443 standard. |
| Ticket barrier | There are four types of ticket barriers, i.e., those used (1) exclusively for entrance, (2) exclusively for exit, (3) in common for entrance and exit and (4) in common for entrance and exit with a large-width for the handicapped. Ticket barriers shall rotate automatically or retract flaps at entrance/exit. |
| Computers at stations, and central computer and AFC network | Fare collecting machines are all connected to a local area network by using station servers that control operation of all components. These station servers are linked with the central computer for AFC installed at the operation control center through an optical fiber transmission route. The centralized control of the system analyzes the real-time data of revenue and passenger flows and writes specified cards on a black list. |
| Ticket issuing machine | Computerized ticket issuing machines shall be installed at stations to sell cards and tokens to passenger. |
| Automatic ticket vending machine | Automatic ticket vending machines shall issue one-way tickets in principle and allow addition of ancillary reading machines |
| Ticket reader | Ticket readers shall be installed near EFO for passengers to check the information stored in tokens and cards. |
| Portable card reader | PDT shall be provided to check the information in cards or tokens on running trains. |

| | |
|---|---|
| Uninterruptible power supply unit | Used as a common UPS for the signal and telecommunication systems. |
| Concept of maintenance | When compared with the magnetic ticket system, systems of the non-contact type at least significantly save manpower required for maintenance. As an appropriate device for maintenance, however, it shall be installed like the signal and telecommunication systems. |

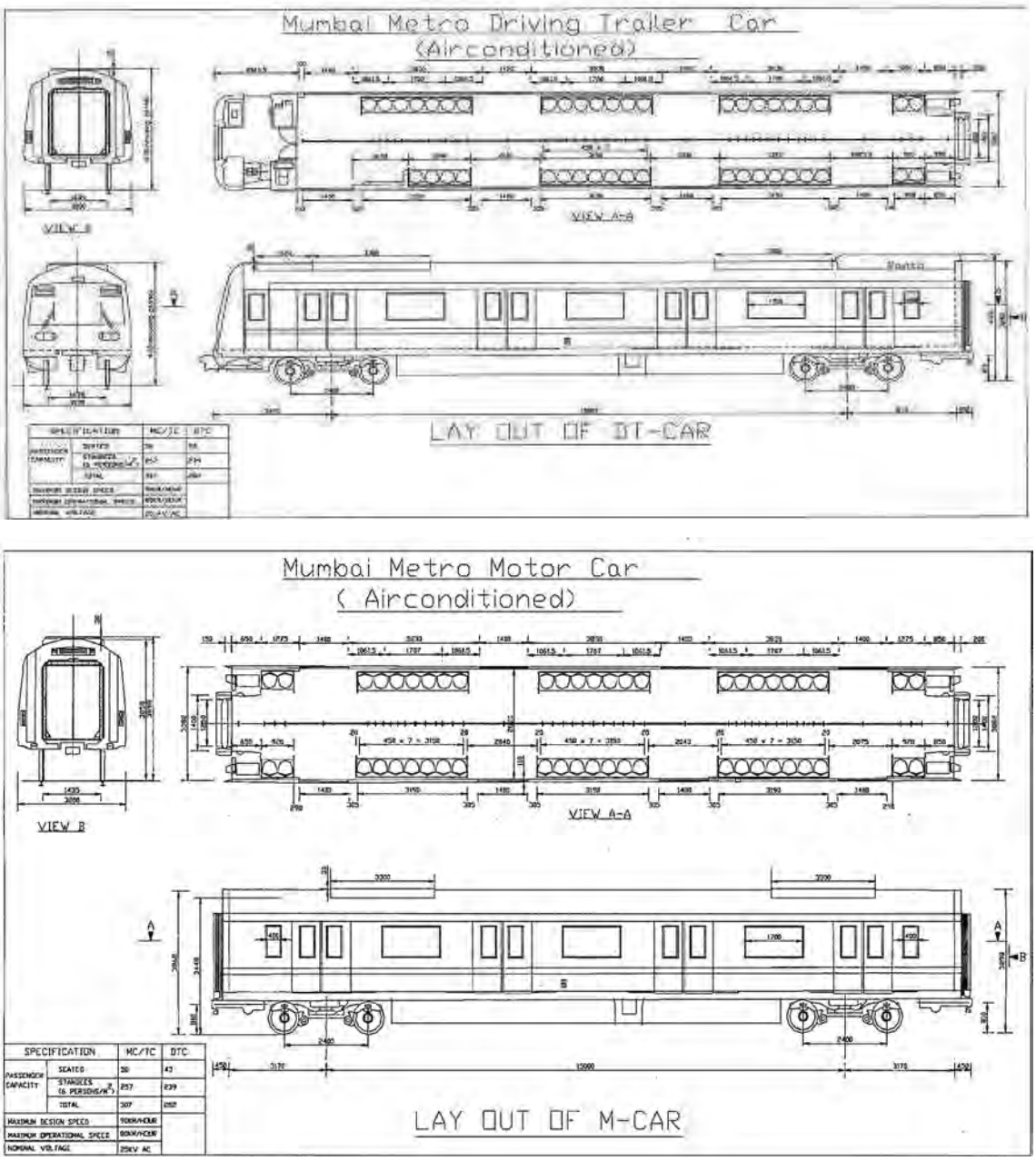
Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

### (3) Rolling stock

#### i) Summary of rolling stock plan

a. Summary of rolling stock plan

The basic specifications for rolling stock and powering, signal and signal security systems are all based on those of Delhi subway and rolling stock of Mumbai Metro Line 1. See Figure 3.6 and Table 3.9 for the design drawings and a summary of the planned rolling stock specifications.




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.6 a summary of the planned rolling stock specifications

b. Rolling stock specifications

Rolling stock outside dimensions

Table 3.10 compares the major rolling stock outside dimensions of Mumbai Metro and those of Japan. The width of the standard-gauge Mumbai Metro rolling stock is larger than that of the rolling stock in Japan. Car bodies are 21.84 m long with Mumbai Metro rolling stock. These figures indicate that large-size rolling stock is planned with Mumbai Metro to transport a large number of passengers.

Table 3.9 Summary of the rolling stock plan

| | | DT | | M | | T | |
|---|---|---|---|---|---|---|---|
| Track-gauge (m) | | 1,435 | | | | | |
| Electric system | | AC 25 kV 50 Hz overhead contact line system | | | | | |
| Car body length (m) | | 21.74 | | 21.74 | | 21.74 | |
| Car body width (m) | | 3.2 | | 3.2 | | 3.2 | |
| Height (m) | | 3.9 | | 3.9 | | 3.9 | |
| Car body | | Lightweight stainless steel | | | | | |
| Car body skin painting | | None | | | | | |
| Train composition | | DT＋M＋T＋M＋T＋M＋M＋DT | | | | | |
| Maximum axle load (t) | | 17 | | | | | |
| Tare weight (t) | | 42 | | 42 | | 42 | |
| Passenger capacity | | Normal (*) | Crush (*) | Normal | Crush | Normal | Crush |
| | Seating | 43 | 43 | 50 | 50 | 50 | 50 |
| | Standing | 120 | 239 | 129 | 257 | 129 | 257 |
| | Total | 163 | 282 | 179 | 307 | 179 | 307 |
| | 4-car (Crush) | 1,178 | | | | | |
| | 6-car (Crush) | 1,792 | | | | | |
| | 8-car (Crush) | 2,406 | | | | | |
| Design maximum speed (km/h) (operating maximum speed) | | 90 (80) | | | | | |
| Maximum acceleration ($m/s^2$) | | 0.78 | | | | | |
| Service deceleration ($m/s^2$) | | 1.0 | | | | | |
| Emergency deceleration ($m/s^2$) | | 1.3 | | | | | |
| Bogie type | | Bolster-less | | | | | |
| Traction motor | | 3-phase AC induction motor | | | | | |
| Speed control system | | VVVF inverter control (IGBT) | | | | | |
| Low-voltage power source | | No descriptions | | | | | |
| Brake | | Electric command air brake, regenerative brake (re-adhesion function) | | | | | |
| Signal system | | Cab signal | | | | | |
| Train security system | | ATO, ATC, ATO (planned for the future) | | | | | |
| Gangway | | No descriptions | | Specified / No doors | | Specified / No doors | |
| Passenger compartment information display | | Passenger information display system | | | | | |
| Passenger compartment broadcasting system | | Passenger information broadcasting system | | | | | |
| Car door | | 4-door | | | | | |
| Air conditioner | | Semi-centralized type, 2 sets (with battery) | | | | | |

* 1 Sanding: 3 persons/$m^2$, *2 6 persons/$m^2$

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

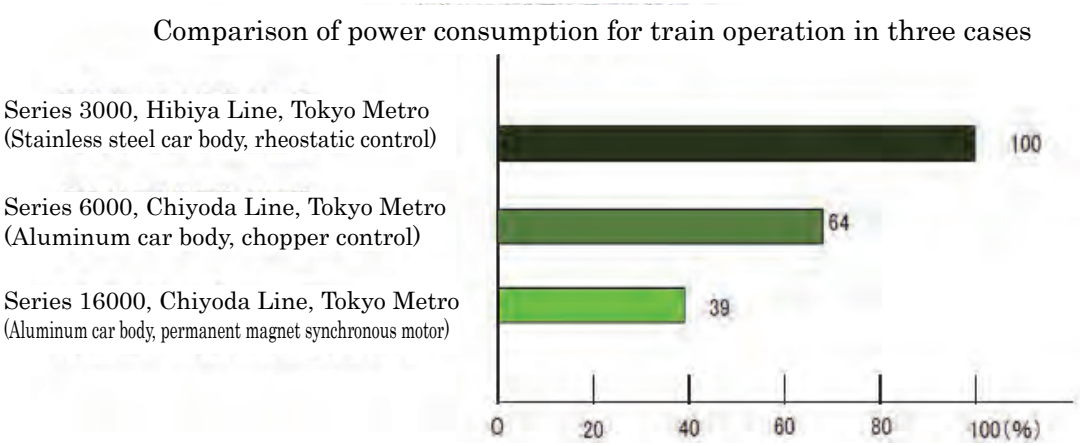
Table 3.10 Comparison of the outside dimensions with principal rolling stock in Japan

| | | DTc | Mc | Tc |
|---|---|---|---|---|
| JR East<br><br>Series E233 | Track-gauge (mm) | 1,067 | | |
| | Power supply system | DC 1,500 V (overhead contact line) | | |
| | Car body length (m) | 20.0 | 20.0 | 20.0 |
| | Car body width (m) | 2.95 | 2.95 | 2.95 |
| | Height (m) | 3.62 | 3.62 | 3.62 |
| Tokyo Metro<br><br>Series 16000 | Track-gauge (mm) | 1,067 | | |
| | Power supply system | DC 1,500 V (overhead contact line) | | |
| | Car body length (m) | 20.47 | 20.0 | 20.0 |
| | Car body width (m) | 2.8 | 2.8 | 2.8 |
| | Height (m) | 4.075 | 4.080 | 4.075 |
| Bureau of Transportation, Tokyo Metropolis<br><br>Series 5300 | Track-gauge (mm) | 1,435 | | |
| | Power supply system | DC 1,500 V (overhead contact line) | | |
| | Car body length (m) | 18.0 | 18.0 | 18.0 |
| | Car body width (m) | 2.8 | 2.8 | 2.8 |
| | Height (m) | 4.05 | 4.05 | 4.05 |
| JR East<br><br>Series 701 | Track-gauge (mm) | 1,067 | | |
| | Power supply system | AC 20 kV 50 Hz (overhead contact line) | | |
| | Car body length (m) | 20.0 | 20.0 | 20.0 |
| | Car body width (m) | 2.8 | 2.8 | 2.8 |
| | Height (m) | 3.62 | 3.62 | 3.62 |
| Mumbai Metro<br><br>Line 3 | Track-gauge (mm) | 1,435 | | |
| | Power supply system | AC 25 kV (overhead contact line) | | |
| | Car body length (m) | 21.84 | 21.74 | 21.74 |
| | Car body width (m) | 3.2 | 3.2 | 3.2 |
| | Height (m) | 3.9 | 3.9 | 3.9 |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Car body structure

According to the plan of Mumbai Metro, car bodies will be made of lightweight stainless steel. Tokyo Metro, a large-scale subway in Japan, has adopted car bodies made of aluminum, which is more lightweight than stainless steel. Though the material is more costly, aluminum car bodies realize far more lightweight rolling stock, thereby substantially cutting costs of power and track upkeep/control. See Figure 3.7 Therefore, aluminum car bodies are more advantageous in terms of the life-cycle cost including O&M cost.




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.7 Effect of aluminum car bodies to cut power consumption

Bogie

Bolster-less bogies are frequently used as they are lightweight and feature easy maintenance. As a matter of fact, Mumbai Metro has a plan to use bogies of that type. As their stability when negotiating curves is a little dubious, however, subways in Japan are now using mono-link bolster-less bogies to improve stability on curves (to prevent derailment) or new steering bogies to reduce noise and vibration.

Brakes

Mumbai Metro is going to adopt electric command dynamic brakes, parking brakes and power regenerating brakes, attached with slides/slips detecting functions and re-adhesion control units. In Japan, subways have introduced the Train Information Management System (TIMS) to enable brake control corresponding to the load conditions over the whole train set, thereby improving the regenerative ratio and decreasing/leveling wear of brake shoes.

Traction motor and speed control unit

Mumbai Metro has a plan to use three-phase AC induction motors as traction motors, together with a speed control system composed of the Insulated Gate Bipolar Transistor (IGBT) type VVVF inverters, which is the current mainstream of the rolling stock speed control system. Furthermore, subways in Japan are now introducing more efficient permanent magnet synchronous motors to reflect the remarkable development of semi-conducting technologies in recent years.

Internal fittings and gangways

To maximize the passenger accommodating capacity, passenger cars will be equipped with long seats, together with gangways to enlarge standing spaces and make it easier for passengers to escape to other cars when an emergency situation has arisen. Although the draft edition DPR doesn't

consider access to airports, it takes approx. one hour to reach the airport in the suburbs of Mumbai from the city center.

Car doors

A Mumbai Metro car will have four passenger boarding/alighting doors on each side. Table 3.11 compares the number of passenger boarding/alighting doors on each side of Mumbai Metro Line 3 cars with that of the passenger cars used by three railways having an approx. equivalent size in Japan.

Table 3.11 Comparison of the number of passenger boarding/alighting doors

| | Yamate Line, JR East | Tozai Line, Tokyo Metro | Hibiya Line Tokyo Metro | Line 3, Mumbai Metro |
|---|---|---|---|---|
| Car type | Series 231 | Series 15000 | Series 03 | - |
| No. of cars in a train set | 11 | 10 | 8 | 4 |
| Passenger capacity | 1,611 | 1,520 | 1,070 | 684 |
| Headway (sec) | 140 | 150 | 130 | 150 |
| Maximum No. of doors per side per car | 6 | 4 | 5 | 4 |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

c. Information/telecommunication systems

Vehicle cabs will be equipped with a telecommunication system to enable communication all the time with the Operation Control Center (OCC) and major stations and a talk-back system for direct communication at emergency with passengers in the passenger compartment. The passenger compartment will be installed with a passenger information system to display stations where the train stops and information on changing trains and at emergency, etc.

d. Safety devices and facilities

ATP/ATO systems will be introduced to prevent driver's human errors including running at excessive speed. Special couplers will be used to absorb shock at collision. In case a fire has broken out, inflammable nonpoisonous materials will be used by taking into consideration the fully underground structure.

### (4) Rolling stock depot

a. Outline of the plan of rolling stock depots

Mumbai Metro has a plan to construct a plurality of rolling stock depot-cum-workshop dedicated to Line 3. The rolling stock depots will be assigned with inspection, repair and maintenance of rolling stock, with the inspecting system following that of Delhi Metro. Their facilities are planned to provide maintenance services for 8-car train set as a unit. A principal rolling stock

depot-cum-workshop will be constructed near the SEEPZ station and a dispatch depot near the Mumbai University (Kalina) station. See Table 3.12 for an outline of the plan of rolling stock depots.

Table 3.12 Outline of the plan of rolling stock depots

| Rolling stock plan | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2016 | | 2025 | | 2031 | |
| Section | Colaba-Bandra Metro | Bandra Metro-SPEEZ | Colaba-Bandra Metro | Bandra Metro-SPEEZ | Colaba-Bandra Metro | Bandra Metro-SPEEZ |
| Headway (sec) | 260 | 400 | 180 | 360 | 150 | 300 |
| No. of cars in a train set | 6 | | | | | |
| No. of required train sets | 35 | | 47 | | 55 | |
| No. of required cars | 210 | | 282 | | 330 | |
| Plan of inspection/repair tracks | | | | | | |
| No. of train sets for inspection to be inspected | 8 cars × 55 train sets | | | | | |
| Inspection/repair track | Main inspection/repair depot | | 6 tracks | | | |
| | Dispatch depot | | 4 tracks | | | |
| | Workshop | | 5 tracks | | | |
| | Total | | 15 tracks | | | |
| Plan of rolling stock storage tracks | | | | | | |
| No. of cars in a train set planned for storage tracks | 8 cars | | | | | |
| Year | 2016 | | 2025 | | 2031 | |
| No. of required storage tracks | 35 | | 47 | | 55 | |
| Colaba and Bandra Metro (intermediate terminal) | 6 | | 6 | | 6 | |
| No. of storage tracks in the rolling stock depot | 29 | | 41 | | 49 | |
| Planed location of rolling stock depots | | | | | | |
| Location | Main depot-cum-workshop | | Dispatch depot | | | |
| | Aarey Milk Colony (SEEPZ) | | Mumbai University (Kalina) | | | |
| Size | 25 ha | | 15 ha | | | |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Plan to select the location of rolling stock depots

Mumbai Metro plans to construct a rolling stock depot-cum-workshop dedicated to Line 3 (Figure 3.8). A main rolling stock depot-cum-workshop will be constructed near the SPEEZ station (Figure 3.9) and a dispatch rolling stock depot near the Mumbai University (Kalina) (Figure 3.10), both being near a station where transport demand suddenly jumps/drops or a starting/terminal station to satisfy the important requirement in selecting the location of a rolling stock depot or minimize the

loss due to deadhead rolling stock operation. To tell the truth, it may be a most efficient policy to assign the role of a principal rolling stock depot to the Mumbai University (Kalina) rolling stock depot close to the Bandra Metro station, a transport demand step-up/down point, which seems difficult, however, due to land constraint.

Rolling stock depot layout

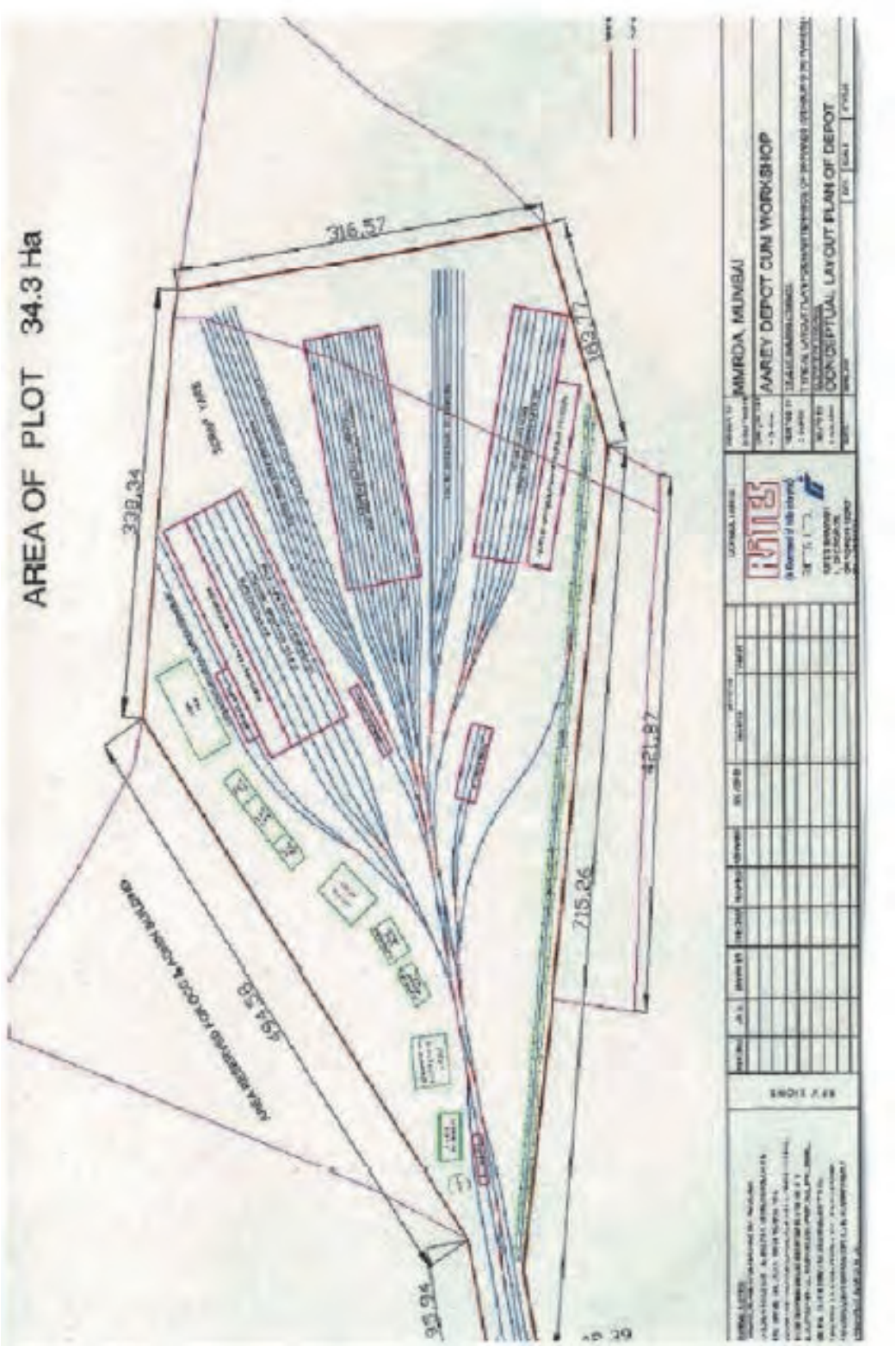
In the layout of the Aarey rolling stock depot-cum-workshop (Figure 3.9), inspection/repair sheds and rolling stock storage tracks are all arranged in parallel. Although details are not known, as there are a number of storage tracks, it is apprehended that shunting operations to compose train sets for inspection and maintenance services conflict with each other in the depot.

In the layout of the Mumbai University (Kalina) rolling stock depot as well, inspection/repair sheds and rolling stock storage tracks are all arranged in parallel due to land constraint (Figure 3.10). Furthermore, there are sharp curves (R=120 m) along the shop-in/out tracks. Although shunting operations to compose train sets for inspection and maintenance services seem to conflict with each other, therefore, it is difficult to change the layout due to land constraint.

As sharp curves are at the entrance to the rolling stock depot, shop-in/out speed will be restricted. When transport demand has increased in the future, this point would regrettably make a bottleneck in transporting plans.

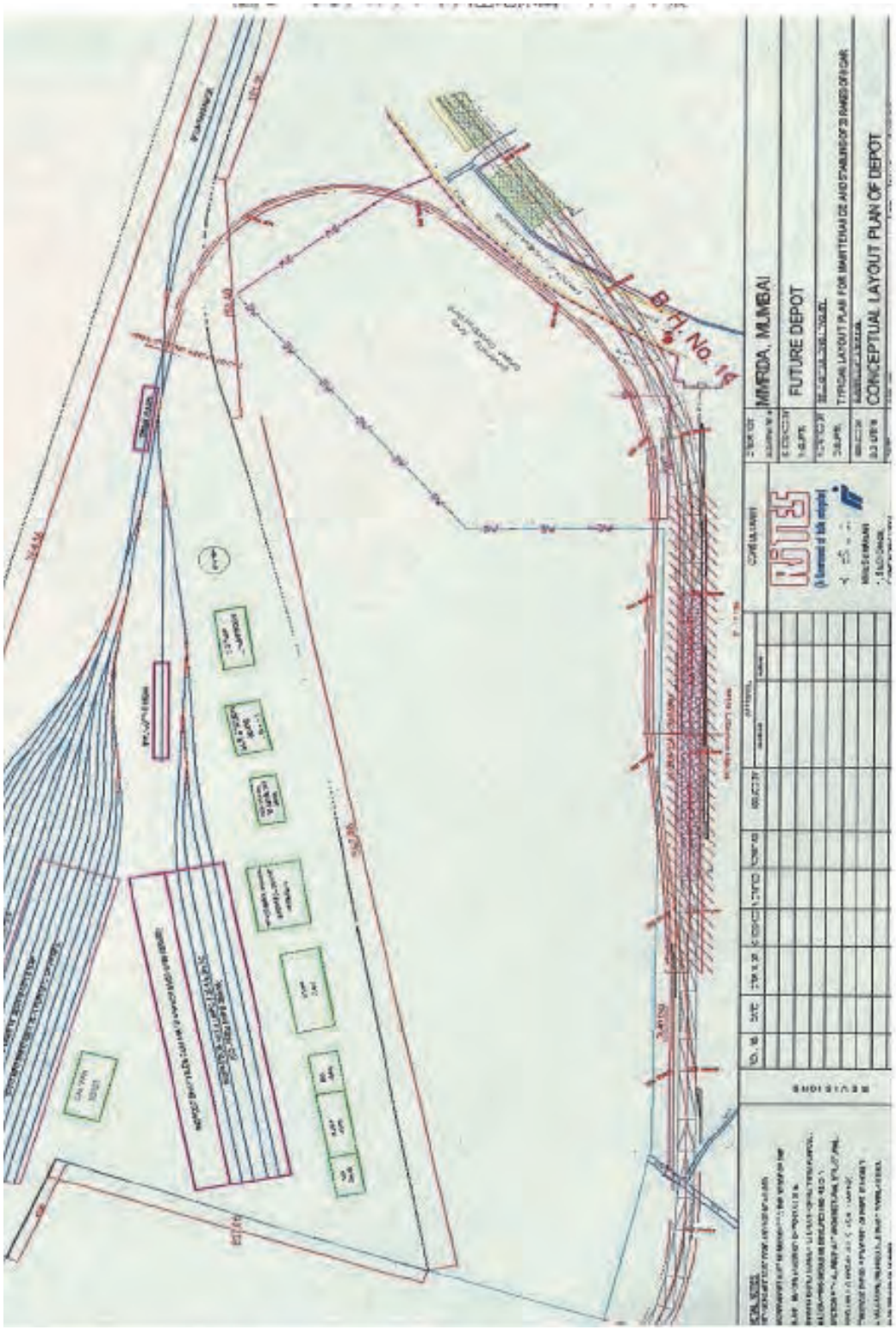

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.8 Places discussed as the location of a rolling stock depot




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.9 Draft layout of the Aarey rolling stock base-cum-workshop




Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

Figure 3.10 Draft layout of the Kalina dispatch rolling stock depot

### 3.2.2 Management, upkeep and control

#### (1) Expectation of income and expenditure

DPR (Detailed Project Report) describes the expectations of income and expenditure of Mumbai metro line 3. It indicates that the income exceeds expenditure every year while the cash balance is negative during the period of repayment, 7 to 30 years after the opening. Therefore, the further advance and/or governmental subsidy are required.

The DPR's expectation for the expenditure bases on the precedent metro projects in India. It estimates the expenditure of maintenance cost multiplying the amount of asset and the maintenance ratio. The maintenance ratio is given dividing the maintenance cost by the amount of asset at precedent line.

This estimation method is simple and easy, but the estimation based on work load and material cost would become necessary when the higher precision is required

#### (2) Train operation and station management

DPR (Detailed Project Report) plans to operate trains with a minimum headway of 2'30" on the line of 33km with 27 stations.

To realize the plan, the consideration for the passenger flow is important together with the track alignment and the signals. The track alignment and signals effect on turn-back time at depots and terminal stations. The minimum head way is limited by the boarding on and alighting time of passengers, as well.

The passenger flow depends on the door width and arrangement of rolling stock, the positional relationship of the staircases, the concourse, the ticket machines, and the ticket gates etc. Moreover, the security screening at the station is a big challenge.

These items would be considered carefully in parallel with the planning and designing.

#### (3) Rolling stock maintenance system

##### i) Plan of rolling stock inspection/repair

No. of cars subject to inspection/repair under plan See Table 3.13 for the particulars of the rolling stock subject to inspection/repair at rolling stock depot-cum-workshop.

Table 3.13 The Rolling Stock Subject to Inspection/Repair

| Year | 2016 | | 2025 | | 2031 | |
|---|---|---|---|---|---|---|
| Section | Colaba-Bandra Metro | Bandra Metro-SPEEZ | Colaba-Bandra Metro | Bandra Metro-SPEEZ | Colaba-Bandra Metro | Bandra Metro-SPEEZ |
| Headway (sec) | 260 | 400 | 180 | 360 | 150 | 300 |
| No. of cars in a train set | 6 | | | | | |
| No. of required train sets | 35 | | 47 | | 55 | |
| No. of required cars | 210 | | 282 | | 330 | |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

ii) Rolling stock inspection/repair periods

The average running distance is assumed to be approx. 350 km per day per car. See Table 3.14 for the rolling stock inspecting system and periods. The inspecting system follows that of Delhi Metro.

Table 3.14 Plan of rolling stock inspecting system and periods

| Category | Period | Contents | Inspection time length | Place of inspection/repair |
|---|---|---|---|---|
| Daily inspection | Every day | Visual inspection of operating conditions, floor cleaning | 2 hours | Storage track |
| Inspection A | 5,000 km (15 days) | Inspection of prioritized components and consumables | 4 hours | Inspection track |
| Inspection B | 5,000 km (45 days) | Inspection of important components | 8 hours | Inspection track |
| Inspection C | 60,000 km (6 months) | Detailed inspection of the components subject to inspections A and B | 3 days | Inspection track |
| Yearly inspection | 120,000 km (12 months) | Disassembling inspection of important components, replacement of commutators | 5 days | Inspection track |
| General inspection | 350,000 km (3 years) | Dismounting, disassembling and inspection/repair of all components and equipment | 24 days | Workshop |

Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

iii) Rolling stock maintenance periods

Periodical elaborate rolling stock cleaning is planned. See the following table for types and periods.

Table 3.15 Elaborate rolling stock cleaning periods.

| Category of cleaning | Period | Cleaning time length |
|---|---|---|
| Cleaning of outside skins | 3 days | 10 minutes |
| Elaborate cleaning of outside skins | 30 days | 3 hours |

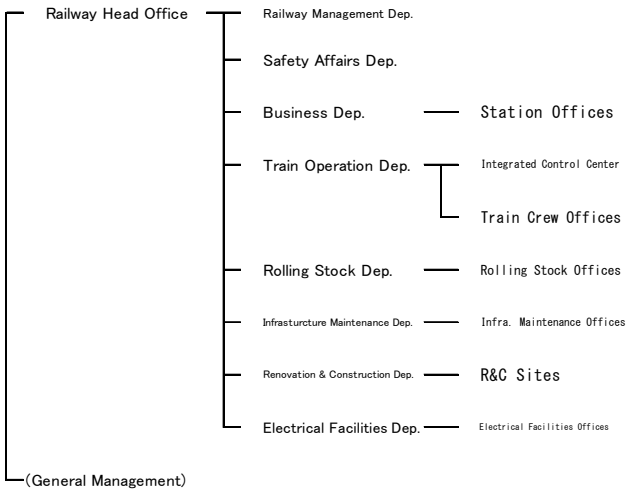
Source: Final Report, Study on the Mumbai MRT Line 3 Project in the Republic of India, METI

## 3.3 Organization for operation, upkeep and control

### (1) A draft organizational structure for operation, upkeep and control

In spite of their different organizational structures depending on the business scale, all subway undertakers in Japan attach importance to safety and operation control, thereby installing railway business headquarters to distinctively specify the role and responsibility for railway operation, and adopt structures to flexibly cope with the growing business scale required for expansion of networks in the future and freely distribute employees to supervise service fiduciaries in case they expand the scope of outsourcing services such as those for maintenance of facilities.

Figure 3.11 represents the organizational chart of Tokyo Metro, which has been established in its long history spanning over more than 80 years. Regarding safety control, Tokyo Metro has the Safety Affairs Department in the Railway Head Office to implement internal audit on the safety of transport, measures to prevent repetition of accidents and other policies to improve safety, thereby strengthening the structure to guarantee safety of transport as specified in relevant laws. The Rolling Stock Department is assigned with the staff responsible for designing to prepare for introduction of new rolling stock and remodeling of existing fleet. Provisions have been made to allow arbitrarily instituting and scrapping project-wise instituted divisions/departments as necessity arises.

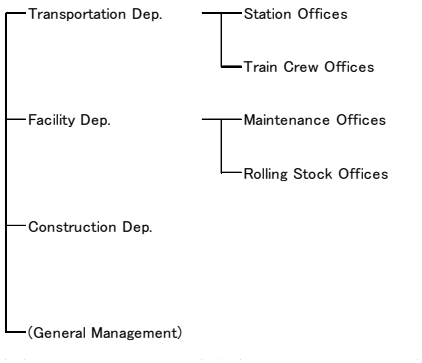



Source: JICA Study team

Figure 3.11 Organizational chart (Tokyo Metro)

Figure 3.12 represents the organizational chart of Fukuoka City Transport Bureau, which reflects a rather simple structure as maintenance services for facilities and rolling stock are mostly outsourced to correspond to its small business scale. There are fewer number of stations compared to the other subway systems, with the majority of station duties outsourced and the rest centralized at the Transportation Department in charge of station duties and train crew rotation to minimize the overall organizational structure. The Construction Department that plans extending lines and controls

execution of construction work is subject to change in its structure (including scrapping) to match the size of projects underway.




Source: JICA Study team

Figure 3.12 Organizational chart (Fukuoka City Transport Bureau)

Other subway undertakers in Japan are broadly divided into two types in their organizational structure: one is the Tokyo Metro type and the other the type of Fukuoka City Transport Bureau. Subway undertakers featuring a large business scale with construction projects or introduction of new rolling stock in hand tend to adopt an organizational structure of the Tokyo Metro type.

As Mumbai Metro has a plan to introduce additional rolling stock and is supposed to operate new lines including Lines 4 and 5 in the future, we assume an organizational chart of the Tokyo Metro type as its organization for operation, upkeep and control. See Figure 3.13

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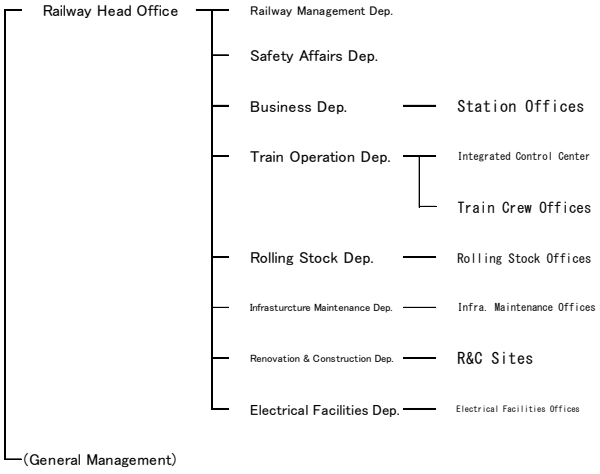



Source: JICA Study team

Figure 3.13 An organizational chart for operation, upkeep and control assumed for Mumbai Metro Line 3.

(2) A draft division of duties in the organization for operation, upkeep and control

Below explained is a draft division of duties in the organizational chart for operation, upkeep and control, assumed for Mumbai Metro Line 3.

The organization is broadly divided into general control divisions and railway headquarters, with the former including departments of general affairs, public relations, personnel affaires, financial affairs and business development in case related businesses are sought and the latter having work-site organizations and head office functions (1) for railway operation/maintenance and (2) for design control and construction projects. See Table 3.16 for a draft division of important duties.

Table 3.16 A draft division of major duties
in the organization of operation, upkeep and control, Mumbai Metro Line 3

| | | Division/department | Division of major duties |
|---|---|---|---|
| Head office | General control division | | General affairs, public relations, personnel affairs, financial affairs, business development, etc. |
| | Railway headquarters | Railway management dept. | Management of railway headquarters |
| | | Safety affairs dept. | Railway safety control and transversal engineering control |
| | | Business operation dept. | Management of station duties |
| | | Train operation dept. | Train operation planning, operation of integrated control center, train crew rotation planning |
| | | Rolling stock dept. | Control of designing and maintenance planning for rolling stock |
| | | Engineering work dept. | Maintenance planning for tracks and civil engineering structures |
| | | Electrical Facilities dept. | Maintenance planning for power supply, signal/telecommunication facilities and station machines |
| | | Renovation & construction department | Execution control for station remodeling projects, etc. |
| Work-site | Train operation | Integrated control center | Control of train operation and signal handling |
| | | Train operation | Management of station crew |

| | | | |
|---|---|---|---|
| | Business operation | Station | Station duties such as ticket selling and passenger guidance (except guarding and station cleaning) |
| | Maintenance/ management | Rolling stock | Inspection of rolling stock/control of outsourcing |
| | | Engineering work | Inspection of tracks and civil engineering structures/control of outsourcing |
| | | Electrical facilities | Inspection of power supply, signal/telecommunication facilities and station machines/control of outsourcing |
| | Renovation & construction | | Supervision of station remodeling work, etc. |

Source: JICA Study team

### (3) A draft employee structure for operation, upkeep and control

As the business scale grows to increase workloads, so the number of employees required for operation, upkeep and control. Table 3.17 shows the number of employees for Mumbai Metro Line 3, which has been calculated on the assumptions that (1) the work load and the No. of employees are proportional to the No. of transported passengers; (2) the organization of Mumbai Metro Line 3 is of the Tokyo Metro type; (3) the No, of employees at the renovation & construction department and those at the work-site division equivalent to conductor depots, Tokyo Metro, aren't required for Mumbai Metro; (4) employees for station cleaning and station machine maintenance aren't required as such services are outsourced with Mumbai Metro to the same extent as that with Tokyo Metro; and (5) employees for station duty guarding are excluded as such services are to be conducted by the government.

Under such assumptions, the calculated number of the employees required for Mumbai Metro Line 3 is given as 1,540 based on the following data:

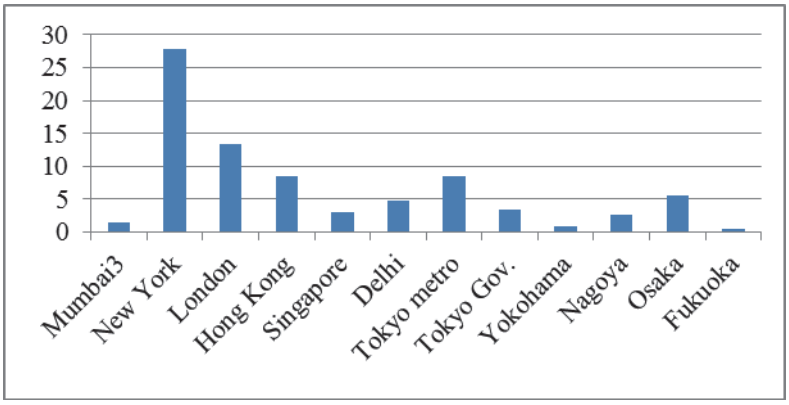
- No. of the passengers transported per day: 6.7 million (Tokyo Metro)
- No. of existing employees: 8,500 (Tokyo Metro)
- No. of the passengers to be transported per day: 1.3 million (Mumbai Metro)

Table 3.17 A draft of the No. of employees for operation, upkeep and control, Mumbai Metro Line 3

| Division | Department | No. of personnel |
|---|---|---|
| Head office | Railway management dept., Safety affairs dept., General control division | 83 |
| | Business operation dept. and Train operation dept. | 42 |
| | Rolling stock dept. | 12 |
| | Engineering work dept. | 18 |
| | Renovation & construction department | 0 |
| | Electrical facilities dept. | 14 |
| | Subtotal | 169 |
| Work-site division | Station | 601 |
| | Integrated control center | 138 |
| | Train operation | 267 |
| | Rolling stock | 176 |
| | Engineering work | 69 |
| | Renovation & construction | 0 |
| | Electrical facilities | 120 |
| | Subtotal | 1,371 |
| Total | | 1,540 |

Source: JICA Study team

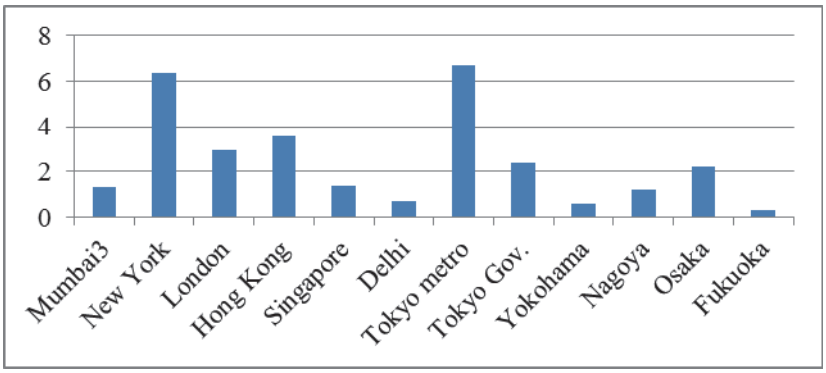
Figure 3.14 compares the number of employees assumed for Mumbai Metro Line 3 and those of typical subway undertakers in Japan and in the world.




Source: JICA Study team

Figure 3.14 Comparison of No. of employees (unit: 1,000 persons)

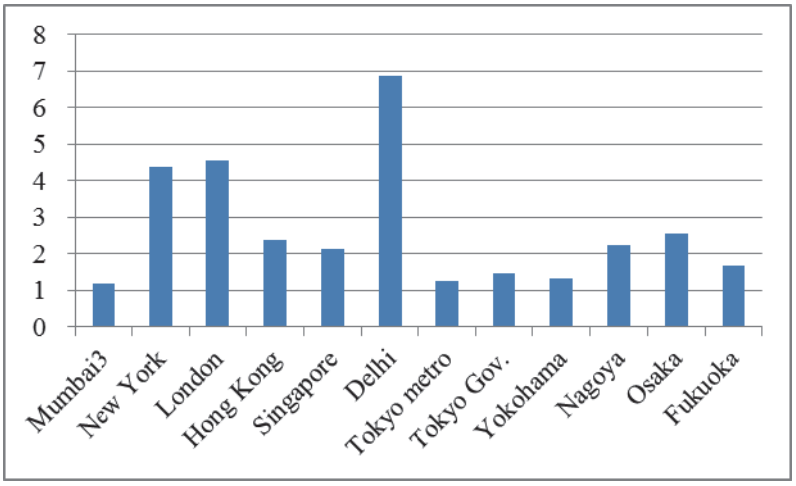
Figure 3.15 compares the number of passengers transported per day by Mumbai Metro and those of typical subway undertakers in Japan and in the world.




(unit: million persons)
Source: JICA Study team

Figure 3.15 Comparison of No. of passengers transported per day

Figure 3.16 compares (1) the No. of employees assumed for Mumbai Metro Line 3 divided by the No. of passengers transported per day and (2) those of typical subway undertakers in Japan and in the world.




Source: JICA Study team

Figure 3.16 Comparison of (1) the No. of employees divided by the No. of passengers transported per day (unit: 1,000 persons)

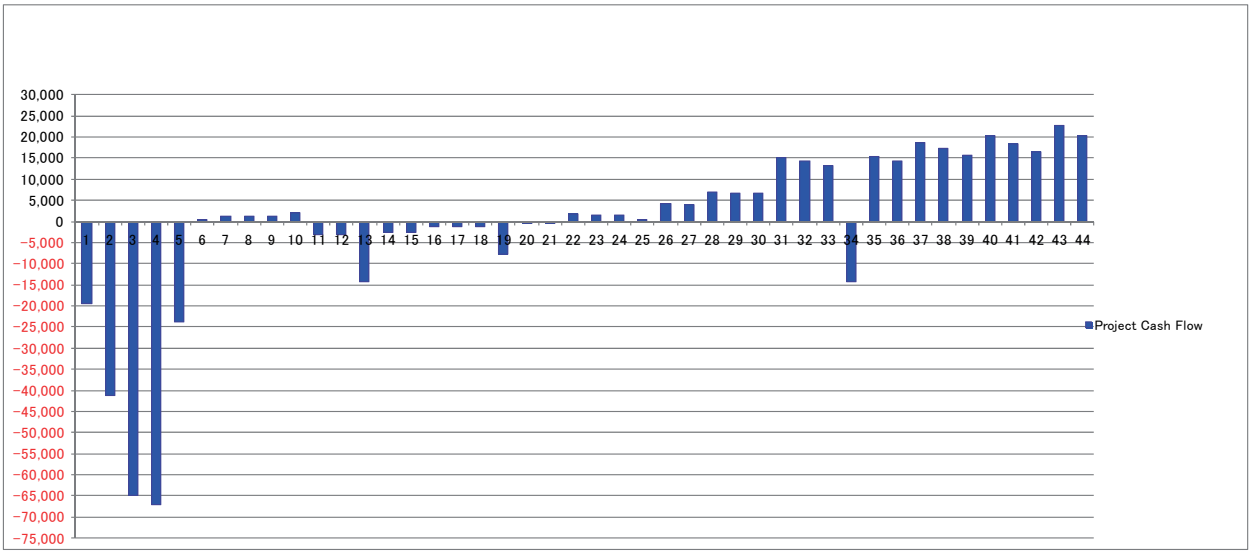
No. of employees divided by the No. of passengers transported per day is 1.8 persons on an average with subway undertakers in Japan, which is rather at a low level among subway undertakers in the world. This is reflected in the No. of employees of Mumbai Metro Line 3 calculated based on that of Tokyo Metro.

## 3.4 Financial Structure

This section explains the characteristics of finance of MML3. The figures of financial analysis in DPR are utilized for the analysis in this section.

### (1) Project Cash Flow

The project cash flow of MML3, cash inflow (the farebox revenue + others) will not be able to recover total cash outflow (O&M expenses, replacement, and debt services) and it will be negative during approximately 10 years. Such loss will happen whatever project schemes; namely financial result will be same in case that Public implements O&M (direct management), even in PPP cases. This due to nature of metro projects (i.e. fare is restricted at certain levels, investment costs are enormous), the financial result will not change up to project schemes.

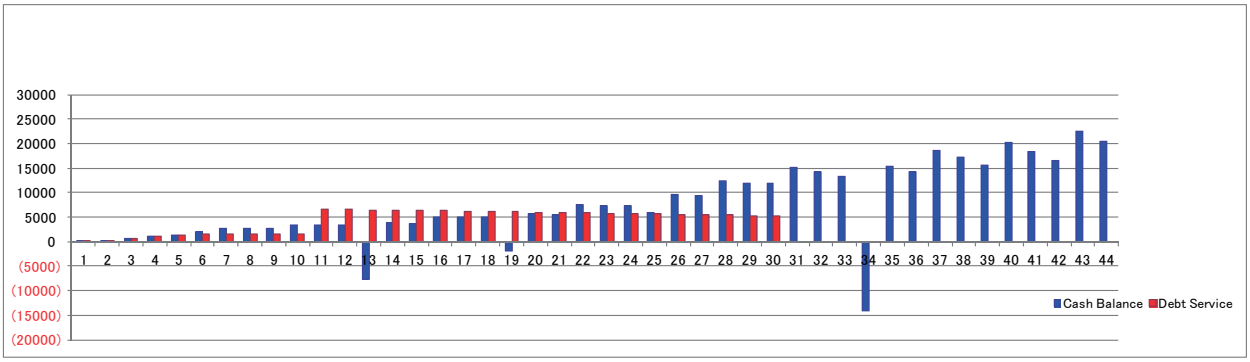



Source: Detailed Project Report for through Metro Corridor, (2011)

Figure 3.17 Project cash flow of MML3

### (2) Debt service (repayment of construction costs)

Farebox revenue will not be able to generate enough cash to repay debt services (principal, interest payment) during 10 years, even after 10 years grace period. It means that DSCR (Debt Service Coverage Ratio) is less than 1. This indicates that, only in case that financial arrangement (i.e. subsidies or bridge loans) to repay debts services can be made, the project can be financially feasible.

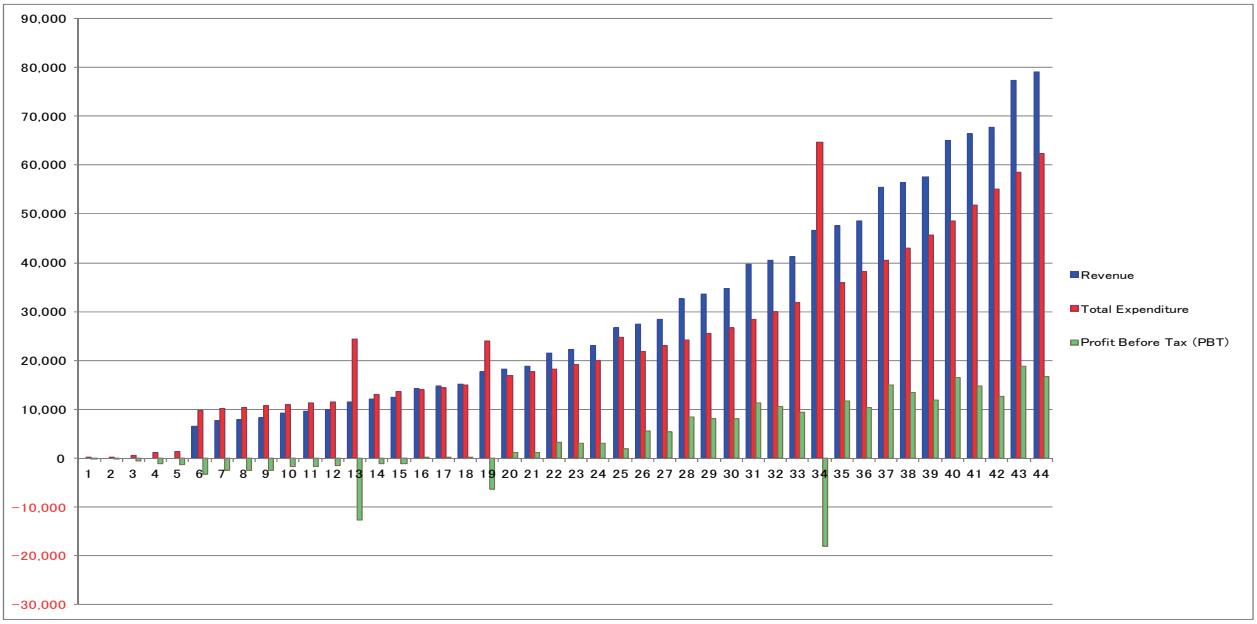



Source: Detailed Project Report for through Metro Corridor, (2011)

Figure 3.18 Debt service – Cash balance

### (3) Profit and Loss in Accounting

Accounting profit and loss (*farebox revenue - (operational expenses + interest payment + depreciation)*) will be negative during the first ten years from COD. In case that Public owns all assets (i.e. direct management), the loss will occur, because assets funded by Public (both civil infrastructure assets and E&M assets) should be booked as fixed assets even in public enterprise accounting, which will generate enormous depreciation costs. Likewise, BOT method, which Private owns all assets, will be financially infeasible, since depreciation costs will negatively affect profit and loss.



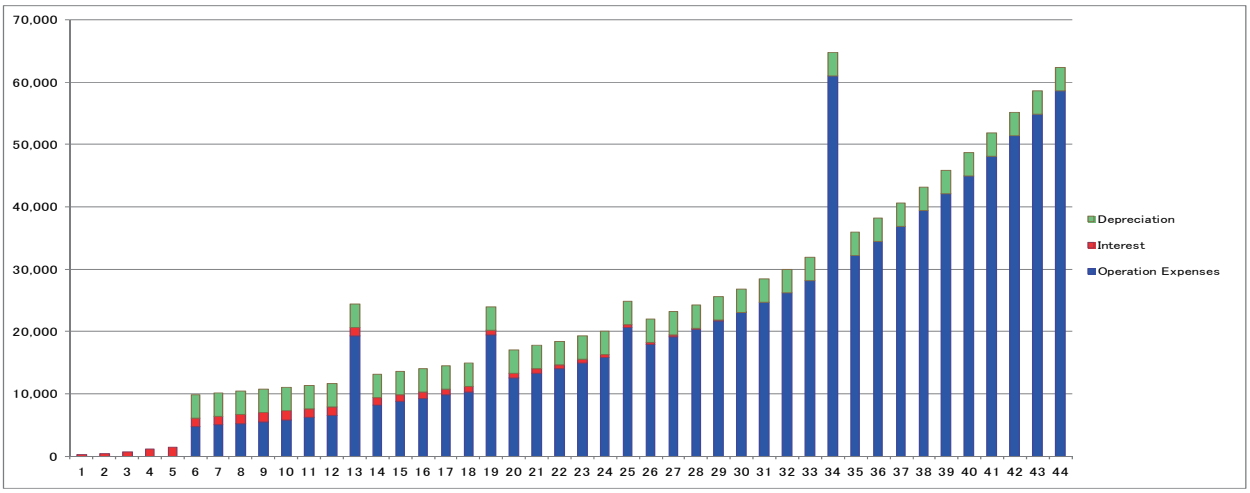

Source: Detailed Project Report for through Metro Corridor, (2011)

Figure 3.19 Profit and Loss of MML3

The loss during the first 10 years will be caused mainly by large depreciation costs. Considering the nature of metro projects, a financial structure which depreciation costs account large part of

total expenditure will be unavoidable. As for interest expenses, since the MML3 project is funded by Yen loan with low interest rate, interest payments will not be much impact for profit and loss.

As power cost accounts large part of total operational expenses, it could be affected by fluctuation of energy costs. Profitability and cash flow would be largely affected by factors whether price escalation on energy cost can be pass-through to fare levels.

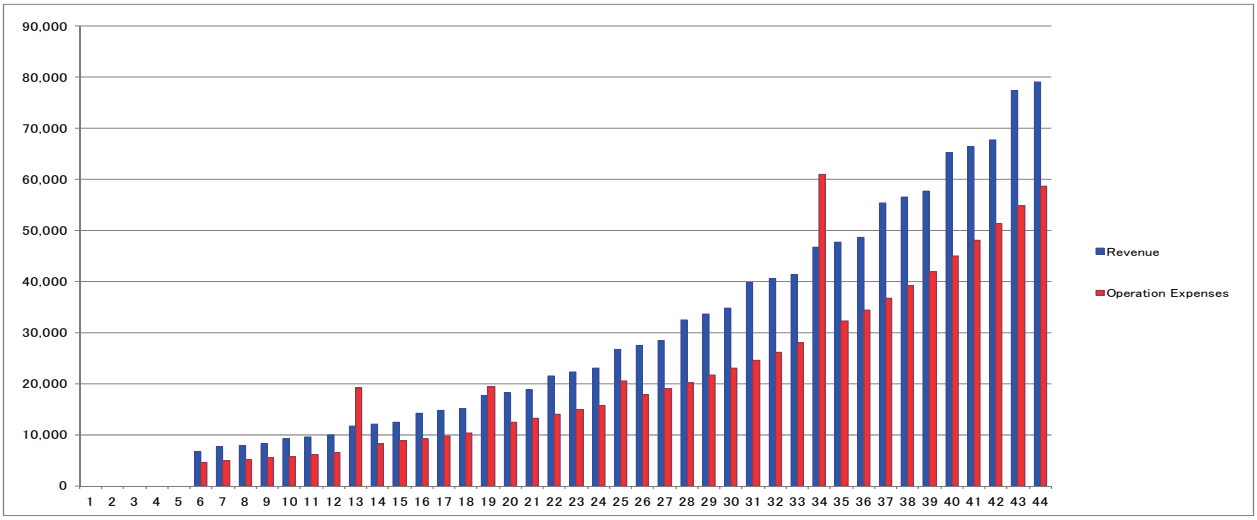



Source: Detailed Project Report for through Metro Corridor, (2011)

Figure 3.20 Cost Breakdown of MM3

(4) Operating Balance

Operating balance (*farebox revenue – operational expenses*) will be positive during whole project period, except years when replacement cost/additional investment will be expended. This indicates that, subsidies for operational expenditures are not necessary in any O&M models. Namely, both i) O&M models which Private takes ridership risk and implement O&M, and ii) O&M models which Public takes ridership risk and grants a right of operation to Private, could be feasible. It should be noted that, additional finance (subsidies or borrowing) for replacement and additional investment is necessary.




Source: Detailed Project Report for through Metro Corridor, (2011)

Figure 3.21 Operating Balance of MML3

If PPP models are applied for O&M implementation, taking into consideration of operational balance of MML3, the following matters should be examined.

i) Case that Private operator takes ridership risk and implement O&M

Operational balance will be positive through the project period, and excessive profit will be generated in the later part of project period. So profit sharing mechanism between Public and Private should be developed.

ii) Case that Public takes ridership risk and Private implement O&M

It will be possible that, while Public takes ridership risk, Private implement O&M, and then Public pay a certain amount of management fee to Private. However, such O&M model doesn't have less incentive for profit-seeking in Private operator. So incentive mechanism (e.g. incentive fees to Private operator) should be developed.

(5) Possibility of other revenue (commercial development)

This section briefs the possibilities for other revenue. In July, 2013, Government of India (GoI) issued a circular (K-14011/36/2009-METRO-MTRS-II(VOL I-III)) to Government of Maharashtra (GoM), it is stated that "GoM should bear all OPEX and additional CAPEX through revenue from property development and advertisement and so on" "GoM should facilitate property development by MMRC on near stations, depots and metro alignments to the extent possible".

DPR has concluded that underground stations have limited scope of commercial developments due to limited demand, lower footfalls and so on. As for advertisement, it is estimated at 10% of fare-box revenue during operations. While DPR doesn't state property development, this section briefs MMRC's plan based on the existing study and hearing from the stakeholders. Currently the following five sites are targeted for development plan.

(i) Aarey Plot
  i) Area: 30,000m2
  ii) Present Ownership／Land Use: GoM. Currently a part of the plot is occupied by a concrete plant, other for vacant land. Ownership will be transferred to MMRC in 2016.
  iii) Development Plan: Commercial Development
  iv) Expected revenue: Development plan should be worked out.

(ii) BEST Bus Depot SEEPZ, Santacruz
  i) Area: 4,9045m2
  ii) Present Ownership／Land Use: SEEPZ has owned. Currently it is used as bus station. Future land usage is stipulated in MoU between MMRC and BEST.
  iii) Development Plan: Commercial complex with bus station as commercial complex.
  iv) Expected revenue: as follows

Table 3.18 Expected revenue

| Built Up area allotted for | BEST | MMRDA |
|---|---|---|
| FSI - 2.5 | 70.00 Smt. | 10,351.00 Smt. |
| Total Construction Cost | 3,42,83,000.00 | 89,20,28,500.00 |
| | | |
| Revenue Generation | By Lease | By Sale |
| | 1,16,50,000/- per month | 3,70,77,00,000/- |

Source : Joint Development with BEST at SPEEZ (2014)

(iii) MIDC Police Quarters

i) Area: 8,000m2

ii) Present Ownership／Land Use: Currently it is used for residence for police.

iii) Development Plan: Commercial and residence

iv) Expected revenue: Development plan should be worked out.

(iv) Marol Fire Brigade

i) Area: 14,000m2

ii) Present Ownership／Land Use: Current owner is Municipal Corporation of Greater Mumbai (MCGM). A part of is for fire brigade. Adjacent to a station of Line 1.

iii) Development Plan: Commercial and residence

iv) Expected revenue: as follows

Table 3.19 Expected revenue

| Built Up area allotted for | Fire Brigade | BEST | MMRDA |
|---|---|---|---|
| FSI 2.5 | 14,556.00 Smt. | 90.00 Smt. | 13,241.00 Smt. |
| Total Construction Cost | 521,104,500.00 | 13,950,000.00 | 640,956,500.00 |
| | Total Construction Cost | Revenue generated by Lease | Revenue generated by Sale |
| Total of construction cost / Revenue Generated | 1,176,011,000.00 | 12,478,000/- per month | 2,581,550,000/- |

Source : Joint Development with Fire Brigate at Marol Naka (2014)

(v) Science Museum Station

i) Area: 500m2

ii) Present Ownership／Land Use: Current owner is BEST. Vacant land

iii) Development Plan: Commercial complex

iv) Expected revenue: as follows

Table 3.20 Expected revenue

| Built Up area allotted for | BEST | MMRDA |
|---|---|---|
| FSI - 2.5 | 212.00 Smt. | 9,909.00 Smt. |
| Total Construction Cost | 1,97,41,180.00 | 63,08,58,870.00 |
| | | |
| Revenue Generation | By Lease | By Sale |
| | 1,31,20,000/- per month | 4,47,29,60,000/- |

Source: Joint Development with BEST at Science Museum (2014)

(vi) Vidhan Bhavan

i) Area: 14,000m2

ii) Present Ownership／Land Use: Currently it is owned by Revenue Dept, GoM, and is used for offices for parties.

iii) Development Plan: Commercial complex

iv) Expected revenue: Development plan should be worked out.

(vii) Prospect

Several areas are potential for generating a certain amount of revenue thanks to excellent location. If a proper development plan is established, revenue from property development will contribute to finance of MMRC beside fare-box revenue. Near future, there is a possibility that Government of Japan and private companies involve a preparation of development plan.

## 3.5 Relevant regulations

### (1) Legal Aspects

The Metro Projects in India have been provided legal cover through separate acts dealing with construction and O&M respectively. These acts are listed below.

| | |
|---|---|
| **Metro Railway Construction** | 1. The Metro Railways (Construction and Works) act, 1978.<br>2. The Metro Railways (Construction of Works) Amendment Act, 1982. |
| **Metro Railway Operation and Maintenance** | 1. Delhi metro Railway (Operation and Maintenance) act, 2002.<br>2. The Metro Railways (Amendment) Act, 2009. *(Also known as Metro act)*<br>3. Metro Railway General Rules, 2013 and Opening of Metro Railways for Public Carriage of Passenger Rules, 2013. |

Initially the Metro Railway Construction and O&M Acts were intended to provide legal cover to Delhi Metro Project. Through amendment in 2009 vide act "The Metro Railways (Amendment) act, 2009" , the Metro Projects in Mumbai, NCR Delhi, Hyderabad, Chennai, Bangalore and other metropolitan areas as defined in section 243 P of the Constitution of India (except Kolkata) were covered under these Acts.

The present Metro act being a legacy of Delhi Centric acts, neither explicitly enables nor restricts Public Private Partnership (PPP). This is unlike the National Highway Act where PPP has been allowed explicitly[39].

Metro Act defines the role and responsibilities of a "Metro Rail Administrator (MRA)" which acts as the principal owner/contractor, carrying out the primary functions of construction and O&M of a metro project. The MRA can be a Government or a non-Government entity. The table below specifies the roles, responsibilities and powers granted to MRA.

[39] The National Highway Act provides that Govt of India may enter into an agreement with any person in relation to the development and maintenance of the whole or any part of a national highway and permitted to invest his own fund for development/maintenance of National Highway and collect as well as retain the fees at agreed rates from different category of vehicle users for an agreed period for use of facilities and recover the reasonable return on investment.

Table 3.21 MRA's role and responsibilities

| Particular | Metro Rail Administration (MRA) |
|---|---|
| Function | • Construction of Metro<br>• O&M of Metro Railway |
| Principal Powers | • Acquire, hold, lease, or dispose of property that it owns.<br>• To develop any metro land for commercial use.<br>• Provide carriage of passengers through means of transit system<br>• Enter into, assign and rescind any contract or obligations.<br>• Employ an agent or contractor for discharging its functions.<br>• Right of Fixing of Initial Fare |
| Responsibilities | • Safety Compensations<br>• To obtain approval from Commissioner of Railway Safety (CMRS) |

Source: JICA Study team

The above description of the role and responsibility of the MRA above informs us that the Act assumes that the responsibility of both construction and O&M rests with a single agency. This creates difficulty when these functions are sought to be bifurcated. For instance, in a case where the public sector carries out construction and O&M is outsourced to concessionaire, the public sector being owner of the project, is likely to become the MRA and hence retain key safety risks as well as rights of fixing initial fare. The public sector would hesitate to take this risk, particularly when they do not run the O&M and thus retain little control of mitigation mechanisms for controlling accidents. Further, concerns over fare fixation may discourage private sector interest in O&M concessions on the Net Cost model, where the revenue risk is passed on to the private sector.

Since MMRC is the owner of the MML3 project, it is likely to become MRA. As MRA, MMRC shall assume overall responsibility of construction and O&M of Metro Project and retain some key risks such as obtaining approvals from Commissioner of Metro Rail Safety (CMRS) and safety compensation during construction as well as O&M. Though the right to fix initial fare shall remain with MMRC as MRA, the right of fare revision shall be with Fare Fixation Committee and not with MMRC. In this situation, some issues may arise which are discussed below with a view to assess the outsourcing of O&M further.

(2) Safety Clearance approval for Opening of the Metro Project for Public Carriage

As per Metro Act, Government of India has powers to sanction the opening of Metro Railway after obtaining safety clearance from CMRS .The responsibilities of CMRS includes assessing

that the metro can be opened for passengers without any danger to public and providing safety clearance. The safety clearance shall be granted by CMRS after careful inspection of metro project components. Steps to obtaining safety clearance are summarized below.

- Research Designs and Standards Organization (RDSO), technical arm of Indian Railway, approves designs of trains and systems. These include Schedule of Dimensions, Design basis report, technical design and specifications pertaining to Rolling Stock Mechanical /Electrical Part, track structure, Traction, Power Supply, bridges and structures, Signaling and Telecommunication.
- RDSO shall also grant speed certificate upon approval of design and successful tests and outcome of oscillation and EBD trials, coupler force and controllability tests.
- RDSO shall also conduct "onsite" inspections of the project.
- Independent Safety Assessment (ISA) shall also be carried out by a reputed ISA if CMRS desires so to aid CMRS to grant safety clearance. The ISA shall be appointed by MRA and cost thereof shall be borne by MRA.
- Thereafter CMRS shall conduct inspection of the metro project as well as assess the outcome of RDSO and ISA reports prior to issuance of safety clearance certificate.

As MRA, MMRC would need to make reference to CMRS for inspection and provide all facilities & cooperation to CMRS for performing its duties. It shall a be responsible for ensuring that metro project shall be as per the metro rail standards stipulated by Govt of India and all administrative formalities shall be completed prior to opening of metro project for public carriage. Further, MMRC as MRA, is responsible for granting competency certificate to train drivers of O&M partners in case PPP scheme for O&M shall be followed. Thus, even if O&M shall be outsourced, as MRA, the responsibility of facilitating safety clearance vests with MMRC.

### (3) Safety Risk relating to O&M and associated liabilities

According to Metro Acts, MRA is responsible for safety compensation arising due to accidents during construction as well as Operation and Maintenance. The Metro Act provides mechanism under which CMRS is responsible to inspect the causes of accidents and safety issues and suggest rectification during operations.

Further the office of the Claim Commissioner assesses the claim for compensation arising out of accident/safety issues.

Both entities, namely CMRS and Claim Commissioner shall hold MRA responsible for rectification of causes of accidents and payment towards accident compensation respectively. Hence as MRA, MMRC shall have to bear responsibility for compensation payment.

However this situation does not rule of outsourcing of O&M. In a PPP contract, it is possible to transfer civil liabilities contractually to private O&M partner in terms of passenger compensation, asset loss, repair cost etc. with matching liability and indemnity clauses. In case of Delhi Airport Express Line, Concessionaire has been made responsible for safety compensation if such event arises due to Concessionaire's breach of obligations as per concession agreement as per DMRC. As far as non-civil liabilities on account of alleged criminal neglect is concerned, a judicious application of any claim will prevail, which will seek to identify the point of actual negligence rather than source of legal responsibility. Hence the responsibility will be traced to the operator in case liabilities are arising out of lacunae in operations and maintenance.

(4) Fare fixation and Fare Revision

Metro act empowers the MRA to fix the initial fare while subsequent revision in fare structure shall be made based on binding recommendation of three members Fare Fixation Committee. The fare fixation committee shall be headed by the sitting or retired High Court Judge and one member each of Additional Secretary level appointed by Central and State Government. Thus as MRA, MMRC shall have rights to fix initial fare and subsequent revision shall be binding based on Fare Fixation Committee. This implies that O&M partner may not have control over fare structure in the event of a PPP. Thus raises concerns regarding uncertainty of fare-box revenue in case of Net Cost Contract. However this can be mitigated using a Gross Cost Contract.

(5) Service Tax implications

Service tax implication would most likely arise in the event of any outsourcing of O&M, whether under gross cost or net cost model since Service Tax on operations and maintenance metro rail is not exempt. This is clear from the reading of the 2012 amendment in Finance Act 1994, whereby a negative list of services exempt from payment of Service tax was brought in. It may be noted that there exists in exemption from payment of Service tax for construction services relating to metro rail[40].

The applicability of Service tax to Public and PPP scheme is discussed below:

[40] According to notification dated 25/2012, dated 20th June, 2012 (Point no 14), the following was included in negative list of service tax : "Services by way of construction, erection, commissioning, or installation of original works pertaining to,-(a) an airport, port or railways, including monorail or metro."

- Public Scheme: Service Tax shall not be applicable to MMRC if it undertakes O&M Services fully in-house. However it shall be applicable if MMRC outsources limited and noncore O&M services such as housekeeping, security, ticketing etc.
- PPP Scheme (Gross Cost): Service Tax shall be applicable to any O&M fees and charges paid to outsourcing partner. The tax incidence shall be on the O&M outsourcing Partner (meaning the O&M partner shall actually pay the tax and file the tax returns, but will add the tax in its invoice to the Public sector thus transferring the burden on tax on public sector)
- PPP Scheme (Net Cost): Service Tax shall be applicable on premium paid to MMRC by O&M Service Provider for availing O&M rights. In this case the tax incidence shall be on MMRC.

### (6) Labor relates risks

Labor relates risks may arise in the event of outsourcing of O&M to private player, due to claims of regularization of contract labor employed by the private player. The employees of the private O&M player may demand to be absorbed in the public sector entity claiming that it is a permanent requirement. The courts, particularly the labor courts, may uphold this claim (with caveats), since the public player would be the principal employer /contractor and hence in the event of any change in the O&M partner's status, the principal employer would have to absorb the labor. This risk can be mitigated somewhat by outsourcing services as a package and not manpower.

### (7) Foreign Direct Investment Permission

As per the Press Note No. 8 (2014 Series) dated August 27, 2014 issued by Department of Industrial Promotion and Policy (DIPP), Ministry of Commerce & Industry, Government of India, 100% FDI in railway Infrastructure sector for Construction, Operation and Maintenance of Mass Rapid Transport Systems under automatic route is permitted[41]. Thus MMRC would have option of global competition if it shall decide for outsourcing of O&M for MML3.

In conclusion, the orthodox legal provisions for Metro Acts in India do not explicitly enable PPP in operations and maintenance, though using some mitigation mechanisms, role of private sector in O&M is possible. However, it is recommended that the MMRC take up the above issues with the Government of India calling for amendment in the Metro Acts.

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[41] Source : RBI Circular , A.P. (DIR Series) Circular No.47, DIPP : http://dipp.nic.in/English/acts_rules/policy/ip504.htm
http://www.makeinindia.com/sector/railways/

## 3.6 Possible structures for O&M

### 3.6.1 Applicable O&M Models for MML3

In the Chapter 2.3, five O&M models, which have been applied for on-going metro projects in various countries, is elaborated. However, funding scheme for MML3 was already determined, and it is planed that MMRC will finance both civil infrastructures and E&M facilities by using JICA loan, fund from the GoI and GoM, and other sources. Therefore, O&M models which Private finances initial investment costs will be out of scope for MML3 O&M Scheme. Accordingly, O&M models which can be applied to MML3 are the following four models.

#### (1) Direct Management Method

In Direct Management Method, MMRC finances both civil infrastructure/E&M facilities, owns all assets, takes ridership risk, and implements O&M. Simple and routine works will be outsourced.

#### (2) Hybrid model of Direct Management

This is variation of direct management method, and MMRC will establish another operational vehicle in the form of Public-Private JV (Operation JV) as an operational implementing body. MMRC, as a regulatory body, will be responsible for management/supervision for Operation JV. Operation JV is responsible for implementation of operation and maintenance.

Ridership risks are taken by MMRC, although fare is collected and fully transferred by Operation JV. MMRC make payments of a certain amount of service fees to Operation JV in order to compensate O&M cost. On the other hand, commercial development will be done by Operation JV, and earning from commercial development will belong to Operation JV.

#### (3) PPP Gross Cost Method

In PPP Gross Cost Method, MMRC finances both civil infrastructure/E&M facilities, owns all assets. Also MMRC takes ridership risk, and collects fare from commuters. A concessionaire implements operation by their own expenditures. MMRC makes payments for a certain amount of management fees to a concessionaire.

#### (4) PPP Net Cost Method

In PPP Net Cost Method, MMRC finances both civil infrastructure/E&M facilities, owns all assets. MMRC grants a right of utilisation for facilities to a concessionaire, a concessionaire implements operation. A concessionaire takes ridership risk and collects fare from commuters.

O&M expenses will be recovered by farebox revenue.

| O&M Models | 1. Direct Management by Public | 2. Direct Management (Hybrid Model) | PPP Models | |
|---|---|---|---|---|
| | | | 3. Gross Cost Method | 4. Net Cost Method |
| Operator in Charge | MMRC | MMRC (Management) / Public-Private JV (Operation) | Private | Private |
| Ridership Risk | MMRC | MMRC | MMRC | Private |
| Ownership of Assets | | | | |
| Civil Infrastructures | MMRC | MMRC | MMRC | MMRC |
| E&M Assets | MMRC | MMRC | MMRC | MMRC |
| Replacement and Additional Investment | MMRC | MMRC | MMRC | MMRC |
| O&M Cost | MMRC | Public-Private JV | Private | Private |
| Commercial Development | MMRC | Public-Private JV | Private | Private |
| Note | Simple and routine works should be outsourced. | Operation is implemented by JV of Public-Private. (e.g. MMRC+SMRT, MMRC+Tokoyo Metro). | Management fees to Private should be carefully figured out. | Ridership gurantees to Private, or Profit sharing mechanism should be developped. |
| Example | ・Fukuoka City Subway | | ・Green Line (extension) in Bangkok | ・Downtown Line in Singapore |

Source: JICA Study team

Figure 3.22 Applicable O&M models for MML3

### 3.6.2 Merit and Demerit of O&M models

Each Model has merit and demerit. Its advantage and disadvantage should be carefully examined at the selection of a model. Merit and demerit are described in terms of “ridership risks”, “asset ownership and operational body” and “operation”.

#### (1) Direct Management Method

- Ridership risk

[Merit]

The models which Public takes ridership risks (i.e. direct management, hybrid model of direct management, and PPP-Gross cost method), Public may be financially more capable of absorbing negative events (e.g., remarkably lower than projected ridership) compared to Private.

- Asset Ownership and Operational Body

[Merit]

Public will be able to well manage replacement and additional investment if they own and

operate, since Public recognize the status and condition of assets through daily operation.

[Demerit]

At the time of replacement/additional investment, it will be necessary to seek fund sources because enough cash would not be available for procuring such replacement/additional investment. In case that Public bears the fund for replacement/additional investment, a support from governments which were main funding source for the project would be limited.

- Operation

[Demerit]

In case that Public carries out operation, it is less incentive for Public to improve operational efficiency, and may cause chronic inefficiency in long term period.

### (2) Hybrid model of Direct Management

- Ridership risk

[Merit]

The models which Public takes ridership risks (i.e. direct management, hybrid model of direct management, and PPP-Gross cost method), Public may be financially more capable of absorbing negative events (e.g., remarkably lower than projected ridership) compared to Private.

- Asset Ownership and Operational Body

[Merit]

Public will be able to well manage replacement and additional investment if they own and operate, since Public recognize the status and condition of assets through daily operation.

[Demerit]

At the time of replacement/additional investment, it will be necessary to seek fund sources because enough cash would not be available for procuring such replacement/additional investment. In case that Public bears the fund for replacement/additional investment, a support from governments which were main funding source for the project would be limited.

- Operation

[Merit]

Although operation will be implemented under direct management, demarcation of roles between a regulatory body and an operational body will be clear. JV as a specialized body for operation seeks efficient operation. A regulatory body will carry out town planning including railway network and implement management/supervision for JV.

### (3) PPP Gross Cost Method

- Ridership risk

[Merit]

The models which Public takes ridership risks (i.e. direct management, hybrid model of direct management, and PPP-Gross cost method), Public may be financially more capable of absorbing negative events (e.g., remarkably lower than projected ridership) compared to Private.

- Asset Ownership and Operational Body

[Merit]

At the time of replacement/additional investment, it will be necessary to seek fund sources for procuring such replacement/additional investment. In case that Private bears the fund for replacement/additional investment, the finance from the market will be flexibly possible.

[Demerit]

In case that Private carries out operation upon obtaining a right of utilization for civil infrastructure and E&M which Public constructed, there are possibilities that facilities are not fully maintained, and on-time replacement may not happen.

- Operation

[Merit]

Private, even if a private operator with less experience in metro operation, might be possible to execute operation thanks to modern technology including IT development. Under the market principle, financial discipline will be enhanced through management done by own responsibility, incentive will increase in order to earn income and reduce costs and further maximize the profit, and accordingly operational efficiency would be enhanced. As empirical evidences in the railway projects show, it is regarded that labor productivity (i.e. passengers-kilometers per an employee, vehicle-kilometers per an employee, rolling stock-kilometers per an employee) in Private is much higher that Public[42].

Definitely, business activities accompanying metro operation (sales of real estate for residence, real estate lease of offices/tenant, retail for passengers, advertisement, ticketing) are areas which Private performs well. Through expanding new market opportunities and diversification of business activities, financial base will be enforced.

[Demerit]

[42] Source: Fumitoshi Mizutani, Comparison between Private and Public on productivity in railway industry (1996)

Simple cost comparison between Public and Private would be difficult, but, as clear factors, service tax increase in PPP. Service Tax is applied for Gross-Cost method and Net-Cost method; i.e. management fees from Public to Private, concession fees Private to Public.

### (4) PPP Net Cost Method

- Ridership risk

[Merit]

In net-cost method, ridership may increase, since Private is motivated to maximize profit as much as possible through increasing ridership. Also Private could well perform commercial development (real estate, advertisement) linked to increase commuters, which leads to further increase of ridership.

[Demerit]

Operational balance will tend to increase through a whole project period. If proper profit-sharing mechanism is not developed, Private will earn excessive profit, especially in the latter of the period.

While a stable increase in ridership is anticipated thanks to high population density in the project-covered area, taking demand risk remains high risk to Private, and accordingly Private may hesitate to participate in the tender for O&M.

- Asset Ownership and Operational Body

[Merit]

At the time of replacement/additional investment, it will be necessary to seek fund sources for procuring such replacement/additional investment. In case that Private bears the fund for replacement/additional investment, the finance from the market will be flexibly possible.

[Demerit]

In case that Private carries out operation upon obtaining a right of utilization for civil infrastructure and E&M which Public constructed, there are possibilities that facilities are not fully maintained, and on-time replacement may not happen.

- Operation

[Merit]

Private, even if a private operator with less experience in metro operation, might be possible to execute operation thanks to modern technology including IT development. Under the market principle, financial discipline will be enhanced through management done by own responsibility, incentive will increase in order to earn income and reduce costs and further maximize the profit, and accordingly operational efficiency would be enhanced. As empirical evidences in the

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Definitely, business activities accompanying metro operation (sales of real estate for residence, real estate lease of offices/tenant, retail for passengers, advertisement, ticketing) are areas which Private performs well. Through expanding new market opportunities and diversification of business activities, financial base will be enforced.

[Demerit]
Simple cost comparison between Public and Private would be difficult, but, as clear factors, service tax increase in PPP. Service Tax is applied for Gross-Cost method and Net-Cost method; i.e. management fees from Public to Private, concession fees Private to Public.

| O&M models | Merit | Demerit |
|---|---|---|
| **Direct Management by Public** | **Ridership Risk**<br>- Better Capacity of Absorbing Demand Risks<br>**Asset Ownership**<br>- Proper decisions for replacement/additional investment | **Asset Ownership**<br>- Restriction of financial support from the governmenrt<br>**Operation**<br>- Less incentive to improve operational efficiency |
| **Direct Management (Hybrid Model)** | **Ridership Risk**<br>- Better Capacity of Absorbing Demand Risks<br>**Asset Ownership**<br>- Proper decisions for replacement/additional investment<br>**Operation**<br>- Division of regurator and operator<br>- Better Promotion of Business Activities<br>- Increase Operating Efficiency to maximize profit | **Operation**<br>- Service Tax burden<br>- Duplicate Public entitIies in O&M |
| **PPP - Gross Cost Method** | **Ridership Risk**<br>- Better Capacity of Absorbing Demand Risks<br>**Asset Ownership**<br>- Possibility of funding from the capital market<br>**Operation**<br>- Increase Operating Efficiency to maximize profit<br>- Better Promotion of Business Activities | **Operation**<br>- Service Tax burden<br>- Un-clarity of causes of the negative event of safety |
| **PPP - Net Cost Method** | **Ridership Risk**<br>- More possibility of Increase Ridership:<br>**Asset Ownership**<br>- Possibility of funding from the capital market<br>**Operation**<br>- Increase Operating Efficiency to maximize profit<br>- Better Promotion of Business Activities | **Ridership Risk**<br>-Excessive earning in Private, if no profit sharing mechanism<br>- No interests from Private due to High Demand Risk<br>**Operation**<br>- Service Tax burden<br>- Un-clarity of causes of the negative event of safety |

Source: JICA Study team

Figure 3.23 Merits/Demerits of O&M models

[43] Source: Fumitoshi Mizutani, Comparison between Private and Public on productivity in railway industry (1996)

# Chapter 4 Assumed Management Structure

## 4.1 Outline

### (1) Background

In starting this study, we intended to furnish MMRC with perspectives to make decisions on MM3's management structure, introduce international precedent cases from around the world, then discuss the organization and financing of MM3 after it has been finalized by MMRC.

As MMRC has yet to decide on MM3's organization and management, we will propose a structure independently and present these findings. We will clarify the impact of the role of the public and private sectors in the management structure (and thus organization and finance) – including for management, upkeep and control of railway operation.

Overall, we assume a management structure under direct management by the government as the baseline, with various services contracted to the private sector for comparison and discussion purposes.

Direct management by the government is assumed as the baseline since a policy exists that MM3 shall be constructed with a JICA loan and owned by MMRC. Private sector involvement is limited to management, upkeep and control as specified by MMRC. These are areas in which private sector services are considered to be superior and efficient to those provided by the public sector.

### (2) Cases for Comparison

We first establish a base case (direct management) and four derivative (outsourcing) cases to compare different management structures. In addition, three upgraded efficiency levels to evaluate the efficiency improvement by outsourcing (for each derivative case) are presumed. These cases are summarized below:

(i) ase case (direct management)

(ii) Four derivative cases (outsourcing)

- Maintenance of rolling stock
- Maintenance of rolling stock plus station duties
- Maintenance of rolling stock, station duties, plus maintenance of tracks and electric circuits
- Maintenance of rolling stock, station duties, maintenance of tracks and electric circuits, plus train operation

(iii) Three upgraded efficiency levels (for each derivative case)

- 0%
- 15%
- 30%

Furthermore, we assume that outsourcing to the private sector is subject to an additional service tax.

See Table 4.1 for a summary of the different cases and the efficiency and tax assumptions.

Table 4.1 Comparison of Different Management Structures

| Case | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1. Scope of Outsourcing | None | Rolling Stock | Rolling Stock Station Duties | Rolling Stock Station Duties Tracks/ Electric Circuits | Rolling Stock Station Duties Tracks / Electric Circuits Train operation |
| 2. Efficiency | We compare three cases of upgraded efficiency levels (0%, 15% and 30% higher efficiency with the private sector). | | | | |
| 3. Tax | We assume that outsourcing to the private sector is subject to service tax. | | | | |

Source: JICA Study team

(3) Costs of Management, Upkeep and Control

After adopting the total costs of management, upkeep and control given in the DPR, we applied the yardstick method to calculate the ratios of division-wide costs for upkeep and control, which is used to decide the upper limit of fares by railway operators in Japan. The division-wise costs are divided into those for maintenance (including tracks, electric circuits, and rolling stock) and those for train operation and traffic services (station duties). Each of these is then subdivided into personnel costs and other expenses. See Appendix 5 for detailed calculation of the costs for management, upkeep and control.

(4) Organizational Structure

We establish an organizational structure (i.e., organizational chart, division of duties, posting of staff) for each of the assumed management structures.

## 4.2 Financial implications on outsourcing of O&M services

This section examines the financial implications of outsourcing O&M services. The O&M services in the project are broadly divided into the four segments: "maintenance of rolling stock" "station duties" "maintenance of tracks and electric circuits" and "train operation." Financial impacts on the following five cases are analyzed.

- Case 0: All segments in-sourced (no segments outsourced)
- Case 1: Outsourcing maintenance of rolling stock alone
- Case 2: Outsourcing maintenance of rolling stock and station duties
- Case 3: Outsourcing maintenance of rolling stock, station duties and maintenance of tracks and electric circuits
- Case 4: All segments are outsourced

Table 4.2 Outsourcing patterns and cost-governing factors

| Case | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1. Scope of Outsourcing | None | Rolling stock | Rolling stock Station duties | Rolling stock Station duties Tracks/ Electric circuits | Rolling stock Station duties Tracks / Electric circuits Train operation |
| 2. Efficiency | We compare three cases of upgraded efficiency levels (0, 15 and 30% higher with the private sector). | | | | |
| 3. Tax | We assume that outsourcing to the private sector is subject to service tax. | | | | |

Source: JICA Study team

To examine impacts on O&M cost caused by outsourcing O&M, the following two variables are changed.

(1) Effect of cost saving by efficiency improvement

When O&M services are outsourced to the private sector, the cost is expected to become lower, as efficiency is higher in the private sector than in the public sector. Hence, three levels of cost saving effect: 0%, 15% and 30% is assumed.

(2) Service tax

A service tax 14% is imposed on the O&M services in case that the segments are outsourced to the private sector. On the other hand, the segments which are not outsourced (implemented by MMRC's in-source) are not imposed a service tax.

Financial analysis is conducted from the following viewpoints to work out the financial implications of the outsourcing O&M services.

- The soundness and profitability of the project cash flow will be verified by the project IRR. And the results of each case are compared.
- Balance of income and expenditure for whole project period is examined in each case. To do so, the total income and expenditure during the whole project period are worked out, and then the tendency of variation of the balance of income and expenditure are analyzed. And the results of each case are compared.

### 4.2.1 Assumptions for financial analysis

(1) General Assumptions and Conditions

(i) Project scheme

In each case, MMRC takes the ridership risk and collects fares during a whole project period to recover both initial investment and O&M cost.

(ii) Project period

The project period shall be 43 years (construction for 5 years, operation for 39 years), the same as that assumed in DPR.

(iii) Project schedule

Period of construction is from 2016 to 2020. Commercial Operation Day is 2021 and the end of project period is 2059.

(iv) Finance for MMRC

The same as that assumed in DPR (Chap 12.10). Finance to the project consists of; borrowing: yen loan from JICA (48%), and rest of 52% are equity, sub-debt[44], stakeholder contribution, etc.

Table 4.3 Finance for MMRC

| | | | | | Rs. Million |
|---|---|---|---|---|---|
| Year | JICA Debt | Sub Debt | Equity | Stake Holder Contribution | Total |
| 2012-2013 | 9431 | 2984 | 7467 | 1313 | 21195 |
| 2013-2014 | 19805 | 6266 | 13072 | 2756 | 41900 |
| 2014-2015 | 31194 | 9869 | 16864 | 4341 | 62268 |
| 2015-2016 | 32753 | 10363 | 18123 | 4558 | 65798 |
| 2016-2017 | 11464 | 3627 | 7352 | 1595 | 24038 |
| 2017-2018 | | | 1465 | | 1465 |
| TOTAL | 104647 | 33109 | 64343 | 14563 | 216663 |
| % Share | 48 | 15 | 30 | 7 | 100 |

Source: Detailed Project Report

(v) Inflation rate

[44] Subordinated loan without interest

Inflation rate is assumed at 5%. It is estimated based on IMF World Economic Outlook (WEO), April 2015 and others。

(2) Assumptions for Cash Inflow

(i) Fare-box revenue

Passenger demand forecast and fare level is same as per DPR (Chap 12.6.1~3).

(ii) Other revenues

Revenue from advertising and retails as per DPR (Chap 12.6.5)

Table 4.4 Revenue from advertising and retails

| Source of Revenue | 2017-2018 | | 2020-2021 | | 2030-2031 | | 2035-2035 | |
|---|---|---|---|---|---|---|---|---|
| | MMRDA | DMRC | MMRDA | DMRC | MMRDA | DMRC | MMRDA | DMRC |
| Fare Box Revenue | 6001 | 7029 | 7421 | 9391 | 15964 | 18512 | 20975 | 25347 |
| Revenue from other Sources | 600 | 703 | 742 | 939 | 1596 | 1851 | 2097 | 2535 |
| **Total Revenue** | **6601** | **7732** | **8163** | **10330** | **17560** | **20364** | **23072** | **27881** |

Source: Detailed Project Report

(3) Assumptions for Cash Outflow

(i) Initial investment, large-scale rehabilitation cost and additional investment

Same as per DPR (Chap 12.6.1~3)

(ii) Depreciation

Depreciation at a rate of 3.5%, and it is completed in the project period

(iii) O&M Costs

Same as per DPR (Chap 12.3)

### 4.2.2 Results of financial analysis

(1) In the case where O&M cost is not saved in the private sector

Where it is assumed that O&M cost is not saved at all by outsourcing O&M services to a private company,

O&M cost simply will increase as outsourced O&M segment increases, since services outsourced are subject to service tax.

The table below shows the balance of revenue and expenditure for the whole project period. While Case 0 results 311,269 million surpluses, its surplus decreases up to 263,252 million INR in Case 4. This is simply caused by increase service tax for outsourcing O&M service. Total O&M cost for Case 0 as no outsourcing will be 541,756 million INR, In case 4 which is outsourced all O&M service, O&M cost will be 589,772 million INR due to increase service tax.

When looking at the project IRR, 2.06% in the Case 0 where all O&M segments are in-sourced, and 1.59% in the Case 4 where all O&M segments are outsourced. The more O&M services are outsourced, the more rate of return will decrease.

Table 4.5 Financial implications (no cost saving effect)

| | Case 0 | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|---|
| | | | | | Unit: million INR |
| | Total amount | Total amount | Total amount | Total amount | Total amount |
| **Total OPEX ( i)+ii) )** | **541,756** | **547,959** | **571,484** | **581,890** | **589,772** |
| i) OPEX In-sourced (inc Energy Cost) | 541,756 | 497,446 | 329,414 | 255,086 | 198,781 |
| ii) OPEX Outsourced | 0 | 50,513 | 242,070 | 326,804 | 390,991 |
| Additional Investment/ Replacement | 163,921 | 163,921 | 163,921 | 163,921 | 163,921 |
| Total CAPEX | 216,664 | 216,664 | 216,664 | 216,664 | 216,664 |
| Total Project Cost | 922,341 | 928,544 | 952,069 | 962,474 | 970,357 |
| Total Revenue | 1,233,609 | 1,233,609 | 1,233,609 | 1,233,609 | 1,233,609 |
| **Balance** | **311,269** | **305,065** | **281,541** | **271,135** | **263,252** |
| **Project IRR** | **2.06%** | **2.00%** | **1.77%** | **1.67%** | **1.59%** |

Source: JICA Study team

In case that MMRC judges that there is no effect to improve efficiency or cost saving when outsourcing O&M service to a private company, it should be noted that MMRC should bear incremental costs due to service tax. However, in terms of public finance on a whole public sector, an increase in service tax payments from MMRC will be an increase in the same amount of revenue for the public sector (i.e. if MMRC as a public company expends tax costs, such paid tax will be deposited to tax authority, and then it will be used as the budget of the central government.

The Table below is the balance sheet (BS) as of 2055 in each case. It shows the more segments are outsourced, that the more “paid in service tax” for a whole project period are accumulated.

Table 4.6 Balance sheets of cases 0 to 4 in 2055

| | Case 0 | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|---|
| **Year** | Year 2055 | Year 2055 | Year 2055 | Year 2055 | Year 2055 |
| **Assets** | | | | | |
| **Current Assets** | | | | | |
| Cash & Cash Equivelents | 262,631 | 256,772 | 234,553 | 224,725 | 217,279 |
| Paid service tax | 0 | 5,859 | 28,078 | 37,906 | 45,351 |
| **Total Current Assets** | 262,631 | 262,631 | 262,631 | 262,631 | 262,631 |
| **Fixed assets** | | | | | |
| Property, Plant & Equipment | 213,236 | 213,236 | 213,236 | 213,236 | 213,236 |
| Accumulated Depreciation | -212,507 | -212,507 | -212,507 | -212,507 | -212,507 |
| **Total Fixed Assets** | 729 | 729 | 729 | 729 | 729 |
| **Total Assets** | 263,360 | 263,360 | 263,360 | 263,360 | 263,360 |
| **Liabilities** | | | | | |
| Current Liabilities | | 0 | 0 | 0 | 0 |
| JICA Loan | 0 | 0 | 0 | 0 | 0 |
| **Total Liability** | 0 | 0 | 0 | 0 | 0 |
| **Equity** | | | | | |
| Equity | 112,018 | 112,018 | 112,018 | 112,018 | 112,018 |
| Retained Earnings | 151,342 | 151,342 | 151,342 | 151,342 | 151,342 |
| **Total Equity** | 263,360 | 263,360 | 263,360 | 263,360 | 263,360 |
| **Total Equity & Liabilities** | 263,360 | 263,360 | 263,360 | 263,360 | 263,360 |

Source: JICA Study team

(2) In the case where a cost saving effect of 15% is expected

If assuming 15% cost efficiency by the private, cost saving can be almost offset by incremental cost of service tax 14%. Therefore, there are little differences between cases.

The table below shows the balance of revenue and expenditure for the whole project period. While Case 0 results 311,269 million surpluses, its surplus increases up to 321,901 million INR in Case 4. This is simply caused by the balance between cost saving 15% and an increase in service tax 14% (i.e. 1% of decrease in expenditure). When looking at rate of return, the project IRR indicates 2.06~2.05%, and difference among cases will be negligible.

Table 4.7 Financial implications (cost saving effect 15%)

| | Case 0 | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|---|
| | | | | | Unit: million INR |
| | Total amount | Total amount | Total amount | Total amount | Total amount |
| **Total OPEX ( i)+ii) )** | **541,756** | **540,382** | **535,173** | **532,869** | **531,123** |
| i) OPEX In-sourced (inc Energy Cost) | 541,756 | 497,446 | 329,414 | 255,086 | 198,781 |
| ii) OPEX Outsourced | 0 | 42,936 | 205,759 | 277,783 | 332,343 |
| Additional Investment/ Replacement | 163,921 | 163,921 | 163,921 | 163,921 | 163,921 |
| Total CAPEX | 216,664 | 216,664 | 216,664 | 216,664 | 216,664 |
| Total Project Cost | 922,341 | 920,967 | 915,758 | 913,454 | 911,708 |
| Total Revenue | 1,233,609 | 1,233,609 | 1,233,609 | 1,233,609 | 1,233,609 |
| **Balance** | **311,269** | **312,642** | **317,851** | **320,155** | **321,901** |
| **Project IRR** | **2.06%** | **2.06%** | **2.05%** | **2.05%** | **2.05%** |

Source: JICA Study team

In case that MMRC judges that cost saving impact is same levels of service tax incremental costs, MMRC will not suffer a negative effect in terms of the costs. In another word, in case that a ratio of cost saving effect will not be higher than 14% of serving tax, outsourcing O&M services would be burden on MMRC in terms of the costs.

(3) In the case where a cost saving effect of 30% is expected

If assuming 30% cost efficiency by the private, cost saving effect could be larger than 14% of service tax, therefore, the more O&M segments are outsourced, the less OPEX would be expended.

The table below shows the balance of revenue and expenditure for the whole project period. While Case 0 results 311,269 million surpluses, surplus increases up to 380,550 million INR in Case 4. This is simply caused by the balance between cost saving 30% and an increase in service tax 14% (i.e. 16% of decrease in expenditure).

When looking at the project IRR, while it is 2.06% in the Case 0 where all O&M segments are in-sourced, it is 2.47% in the Case 4 where all O&M segments are outsourced. The more O&M services are outsourced, the more rate of return will increase.

Table 4.8 Financial implications (cost saving effect 30%)

| | **Case 0** | **Case 1** | **Case 2** | **Case 3** | **Case 4** |
|---|---|---|---|---|---|
| | Amount (Rs) | Amount (Rs) | Amount (Rs) | Amount (Rs) | Amount (Rs) |
| **Total OPEX ( i)+ii) )** | **541,756** | **532,805** | **498,863** | **483,848** | **472,475** |
| i) OPEX In-sourced (inc Energy Cost) | 541,756 | 497,446 | 329,414 | 255,086 | 198,781 |
| ii) OPEX Outsourced | 0 | 35,359 | 169,449 | 228,763 | 273,694 |
| Additional Investment/ Replacement | 163,921 | 163,921 | 163,921 | 163,921 | 163,921 |
| Total CAPEX | 216,664 | 216,664 | 216,664 | 216,664 | 216,664 |
| Total Project Cost | 922,341 | 913,390 | 879,448 | 864,433 | 853,060 |
| Total Revenue | 1,233,609 | 1,233,609 | 1,233,609 | 1,233,609 | 1,233,609 |
| **Balance** | **311,269** | **320,219** | **354,162** | **369,176** | **380,550** |
| **Project IRR** | **2.06%** | **2.11%** | **2.32%** | **2.40%** | **2.47%** |
| Equity IRR | 2.28% | 2.36% | 2.63% | 2.75% | 2.84% |
| WACC | | | | | |
| **DSCR** | | | | | |
| Max DSCR | 3.05 | 3.07 | 3.16 | 3.20 | 3.23 |
| Average DSCR | 1.31 | 1.33 | 1.42 | 1.46 | 1.48 |
| Min DSCR | -1.87 | -1.85 | -1.79 | -1.76 | -1.74 |

Source: JICA Study team

When looking at comparative advantage in terms of the cost, if MMRC outsources the segments where high cost saving effect is expected, MMRC can enjoy the benefit from lower levels of OPEX.

### 4.2.3 Conclusion (Financial Implications and Strategic Choice of O&M Models)

#### (1) Matters to be considered from a financial viewpoint

In terms of finance, the following two matters shall primarily be examined in case of outsourcing O&M services to the Private.

(i) Difference in the service tax (imposed or no tax) on different for O&M services models (in-sourced or outsourced)

(ii) Difference in efficiency between the public and private sectors

#### (i) Exemption/imposition of service tax on O&M services (in-sourced or outsourced)

While MMRC is exempted from service tax for in-sourced O&M services, MMRC shall bear service tax (14% of the cost of outsourcing) when outsourcing O&M services to the private sector. In terms of finance on MMRC, it could be regarded that such tax payment are incremental cost. On the other hand, service tax paid by MMRC will be deposit to the national treasury, and then it will be financial resources of the central government. Therefore, the tax paid by MMRC doesn't regard as money outflow in the whole public sector. Consequently, in terms of public finance, the difference between tax imposition and exemption doesn't mean controversial issues.

#### (ii) Difference in efficiency between the public and private sectors

It is normally said that, in case of outsourcing O&M service to the private, cost saving due to enhancement of efficiency and increases in revenue due to improvement of services quality. According to the principle that an optimal player should perform optimal services, MMRC is expected to examine which segments could be essentially higher efficiency when the private sector conducts services.

Whether the private sector is more efficient or not depends on the viewpoints, in reality it is difficult to verify exact evidence for the efficiency of the private sector. To examine Value for Money (supply of the most valuable and highest service against money) between public works and PPP projects, generally a technique called "Public Sector Comparator" is normally used. However, it should be carefully used because this technique may provide completely different analytical results due to assumptions such as efficiency and other factors.

There remain some issues in seeking efficiency by utilizing the private sector. While PPP has attained certain achievements in raising the efficiency of public services, it has caused problems such as lowering quality of services and sustainability of

services[45].

Therefore, when outsourcing services to the private sector, MMRC is expected to take into account "balance between the nature of public and economic rationality", not only to focus discussion on economic rationality.

(2) Strategic choice of O&M models

In the above section, financial implications of outsourcing O&M services are examined. In addition to evaluate financial aspects, MMRC is expected to make "Strategic Choice" upon considering multi-dimensional factors;

- What function MMRC should have in future, while MMRC plans another metro projects such as line 4 and 5 after the Line 3 project?
  - Regulatory body/supervisory body vs. planning body/management body vs. all in-house?

- How MMRC should develop function/know-how at initial stage, how shall it in-source in MMRC, while MMRC currently doesn't have experience?
  - Outsourcing O&M at initial stage, then in-sourcing by acquire their skills /knowledge.

- Whether shall MMRC intend to be a large-scale organization hireing a large number of employees?

- What governance structure MMRC should have, when manages a private operator?
  - How strengthen the monitoring function for performance (KPI, contractual obligations) of a private operator?

[45] "Globalization and Regional Policies in the Future," in Japanese, Research Center for Regional Policy, Development Bank of Japan Inc.

**Box: Changes in the role sharing between the public and private sectors in the UK**

The public-private conjunction in the UK was promoted by Margaret Thatcher of Conservative Party who aimed at cutting an enormous amount of expenses as a means to improve the efficiency of the public sector under a policy to realize a small government in expediting privatization of state-owned enterprises, outsourcing of administrative services and introduction of administrative service agencies, which attained certain achievement in promoting privatization of governmental enterprises and raising the efficiency of administrative organizations on one hand and lodged such problems as lowering quality of public services and difficulty to ensure satisfactory service levels on the other.

Under the Labor Party government led by John Major, who took office as Prime Minister after Margaret Thatcher, Railtrack that integrated control of the substructures of British Railway (BR), which was privatized in 1993, went into bankruptcy in October, 2002, for example, leaving behind a debt of 3.3 billion ponds and records of a number of accidents, as it lacked the understanding that an essential mission of railways is to perform public services, a philosophy of the BR age, and ignored the necessity of investment into equipment/facilities while attaching too much importance to dividends to stockholders with a preoccupation that the assets under its control were a means to pursue profit. Its assets were taken over by Network Rail, a state-owned enterprise, after its bankruptcy. In promoting conjunction between the public and private sectors, observe the instructions suggested by the above failure. Namely, don't be biased on the discussion of economic reasonability of the private sector (investment of funds and improvement of efficiency by the private sector) alone, but take a serious view of the "balance with publicness" in parallel.

## 4.3 Risk Analysis

### 4.3.1 Example of risk matrix at O&M stage

Below table refers to the risk matrix of Mumbai Metro Line #3 at O&M stage.

Table 4.9 Example of risk matrix of Mumbai Metro Line #3 at O&M stage

| Case Number | | | 0 | | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O&M Functions to Outsource | | | Not Applicable | | Rolling Stocks | | Rolling Stocks, Station Services | | Rolling Stocks, Station Services, Tracks and Electricals | | Rolling Stocks, Stations Services, Tracks and Electricals, Rolling Stock Operations | |
| Risk Category | | Description | Sector Taking Risks ("PU" denotes Public Sector, "PR" denotes Private Sector | | | | | | | | | |
| | | | PU | PR | PU | PR | PU | PR | PU | PR | PU | PR |
| Demand (Ridership) Risk | | Actual ridership is below estimated ridership | ○ | | ○ | | ○ | | ○ | | ○ | |
| Operating Risks | Human Capital Risk | Unable to hire employees with skills and abilities needed for operations | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Workers Risk | Unable to secure enough employees needed for operations due to strikes and/or turnovers | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Risks of Infrastructures and Facilities Rapidly Deteriorating | Likelihood of accident and/or additional expenditure increases due to the unexpected rapid deterioration of infrastructure such as tracks, electrical and rolling stocks, and etc. | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Maintenance Risk | Infrastructures and facilities are poorly maintained | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Interface Risk | There are lacks in interactions between the functions of public sector and private sector, resulting in poorly managed operations | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Accident Risks | | Accident attributable to the fault of either public sector or private sector takes place | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Supplier Risks | Component Supply Risk | Suppliers of replacement components relating to tracks, electrical, and rolling stocks stop distributions | ○ | | ○ | ○ | ○ | ○ | | ○ | | ○ |
| | Electricity Supply Risk | Electricity supply from supplier is disrupted | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | | ○ |

| Case Number | | | 0 | | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O&M Functions to Outsource | | | Not Applicable | | Rolling Stocks | | Rolling Stocks, Station Services | | Rolling Stocks, Station Services, Tracks and Electricals | | Rolling Stocks, Stations Services, Tracks and Electricals, Rolling Stock Operations | |
| Risk Category | | Description | Sector Taking Risks ("PU" denotes Public Sector, "PR" denotes Private Sector | | | | | | | | | |
| | | | PU | PR | PU | PR | PU | PR | PU | PR | PU | PR |
| Financial Risks | Inflation Risk | Unanticipated acceleration of inflation will cause deterioration in profit | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Inflation Risk | Increase in borrowing cost as a result of interest rate increase will cause deterioration in profit | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Currency Risk | Fluctuations in foreign currency will cause deterioration in profit | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Sponsor Risks | | Financial conditions of the public or private sector deteriorate and the quality of service will deteriorate or otherwise the project becomes discontinued | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Political Risks | Legal and Approvals Risk | Changes in laws, tax rate and permits relating to the project etc., as well as the change in the stances of a policy maker, will negatively impact private sector operator | | | | ○ | | ○ | | ○ | | ○ |
| | Expropriation Risk | Infrastructure and facility constructed and installed by private sector utilizing its own money will be expropriated | | | | ○ | | ○ | | ○ | | ○ |
| | Currency Non-transfer Risk | The outsourced will experience difficulties in business continuity as a result of the inconvertibility of local currency to its home currency, or inability to transfer funds in local currency to its home currency | | | | ○ | | ○ | | ○ | | ○ |
| | Political Force Majeure | Events of wars and civil disturbances will cause difficulties in business continuity | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Natural Disasters | | Natural disasters and other catastrophic events resulting in delay or stoppage in operations | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Source: Study team

Risk mitigations upon signing outsourcing agreement from public sector's standpoint are described below:

＜A. Outsourcing maintenance of rolling stocks or tracks and electrical ＞

1. To mitigate human capital risk and workers risk, items such as the following may be evaluated in selecting the subcontractor: expertise of a candidate, human resource development plan, as well as plans for maintaining pleasant working environment including employee mental care plans and employee benefits
2. To mitigate the risk of facilities rapidly deteriorating, the defect liabilities of the sellers of rolling stocks and facilities etc., as well as the liabilities of the subcontractor should be clearly determined
3. To mitigate maintenance risk, clarify in the outsourcing contact what should be maintained at what interval, and what can/cannot be repaired
4. To mitigate the risk of the accident, the investigation by a third party committee in case of a serious accident may be made mandatory and penalties upon the accident at subcontractor's fault may be pre-quantified
5. To mitigate interface risk, opportunities where sub-contractors and outsourcer can meet and exchange opinions regularly may be set in place
6. To mitigate component supply risk, as many widely used components as possible at designing, and through negotiation, unit component price may be locked as long a period as possible.
7. To mitigate electricity supply risk, regulation that enables preferential electricity supply to urban railways as a public means of transportation, may be sought
8. To mitigate financial risk, subcontractor contract may clarify expected rate of inflation, and payments denominated in Indian Rupee may be made to sub-contractors (and payments denominated in foreign currency may be pre-hedged)
9. To mitigate sponsor risk, financial conditions may become one of the evaluation criteria in the selecting subcontractor. Also at the O&M stage, regular monitoring of a subcontractor may be performed
10. To mitigate disaster risk, casualty insurance may be employed

＜B. Outsourcing station services＞

- Same as 1~5, 8 and 9 in A above
- To mitigate interface risk, procedures in case of a halt in operation due to disaster etc., as well as troubles with passengers may be formulated in advance
- To mitigate interface risk, preventive measures against fraud may be instituted so as to prevent that in collecting fares

＜C. Outsourcing rolling stock operations＞

- Same as 1, 4, 5, 8, 9 in A above
- To mitigate accident risk, indemnity liability attributable to rolling stock operator in case of a train accident caused by a rolling stock operator as well as delay may be stipulated in advance
- To mitigate interface risk, where a rolling stock operator is penalized based on its performance level, what accounts should/should not be attributed to the operator should be clarified in advance

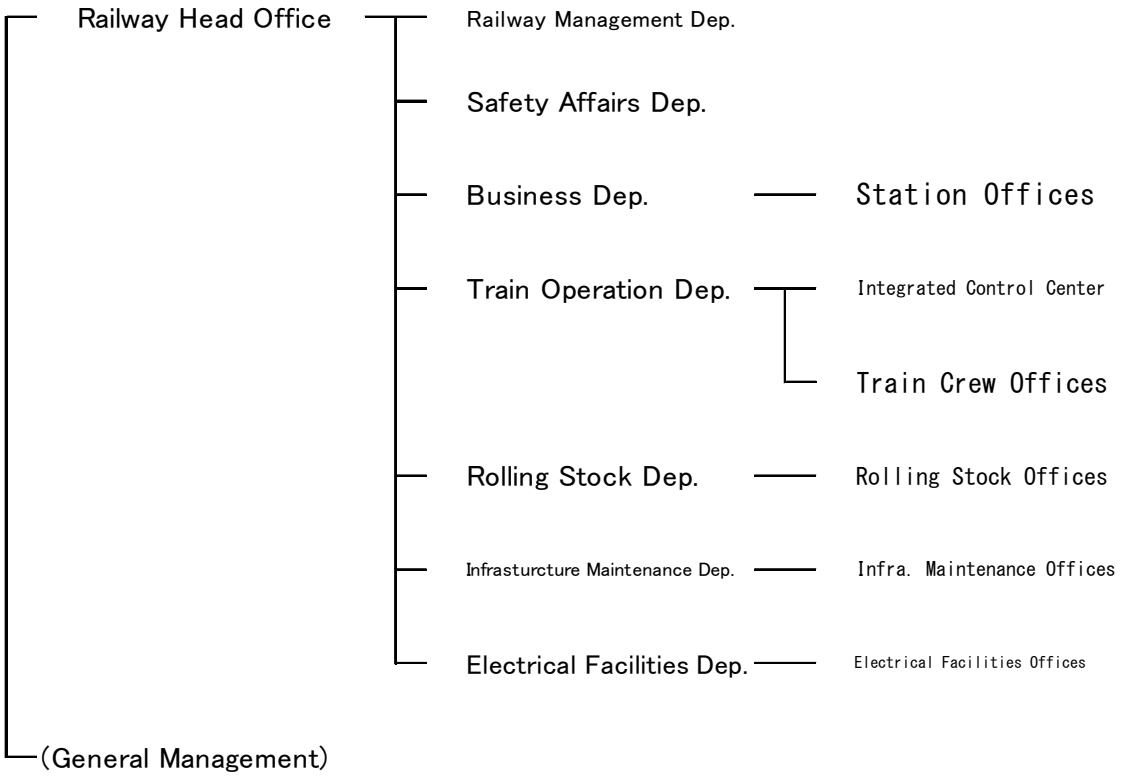
## 4.4 Organization Chart, Division of Duties and Member Placement: Mumbai Metro Line 3

### (1) Organization chart

#### (i) Organization under direct management

Figure 4.1 shows the organization chart under direct management.

The organization chart, which is based on that of Tokyo Metro, is structured to facilitate outsourcing services with a contractor or contractors in the private sector and coping with expansion of business areas and workloads increased after inauguration of new lines. The General Management Division consists of the Groups in charge of General Affairs, Personnel Affairs, Financial Affairs, Public Relations and Business Development, etc. It is thought that correlative businesses, which are virtually limited to advertising and selling at station retail shops, can be dealt with by the Business Development Group in the General Management Division.

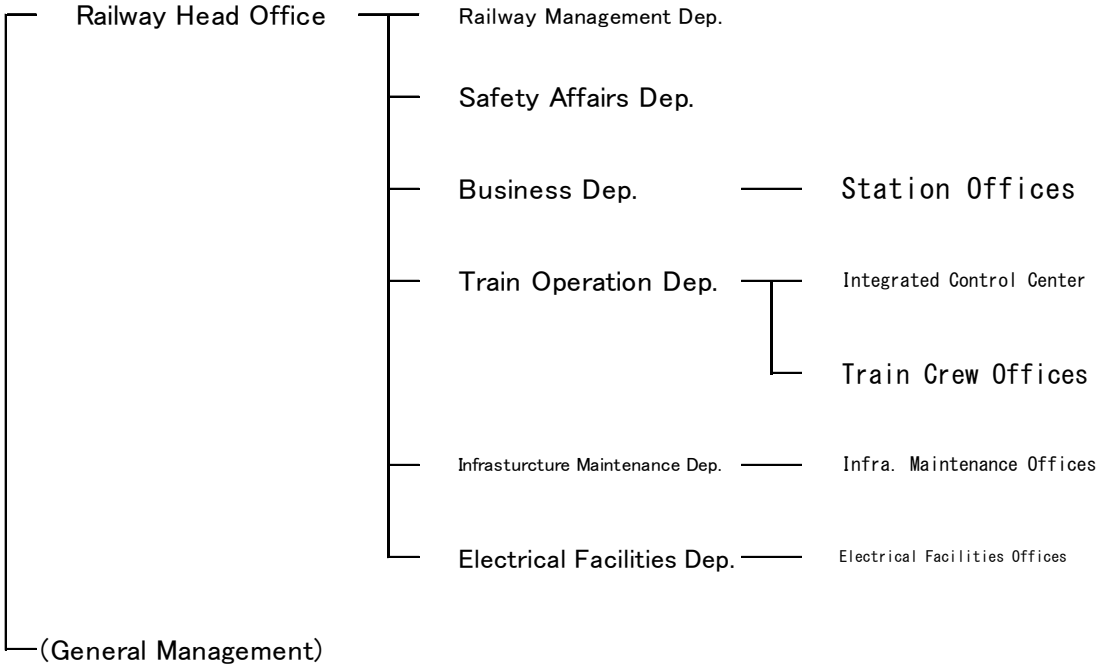



Source: Drawn up by the study team

Figure 4.1 Organization chart under direct management

(ii) Organization when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.

Figure 4.2 shows the organization chart when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.
Members in charge of procurement in the Financial Affairs Group in the General Management Division take charge of the management of outsourced services.

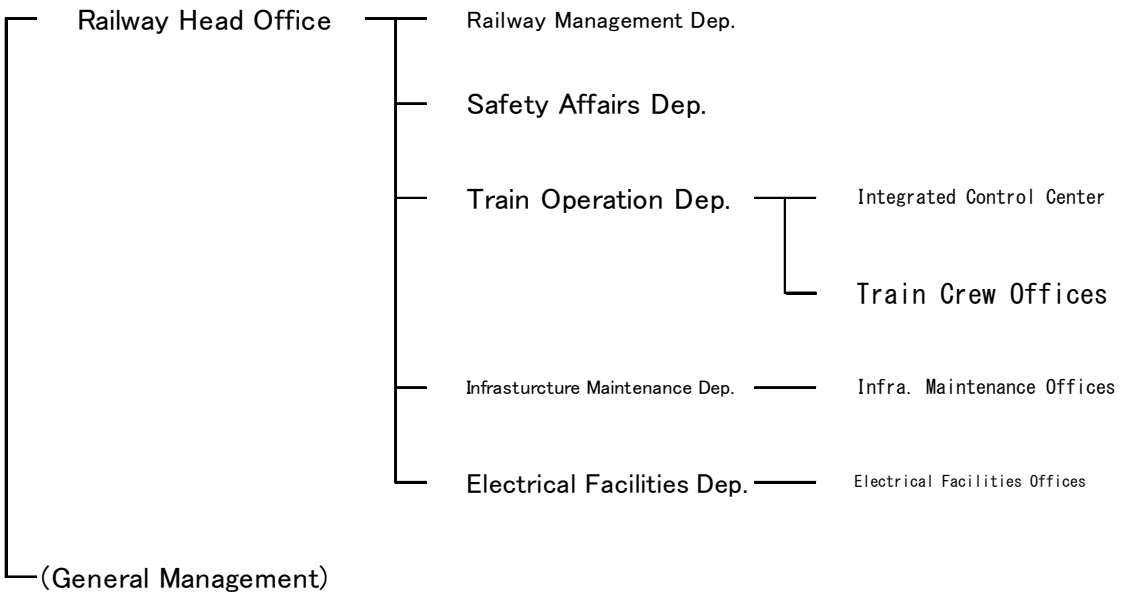



Source: Drawn up by the study team

Figure 4.2 Organization chart when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.

(iii) Organization when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

Figure 4.3 shows the organization chart when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

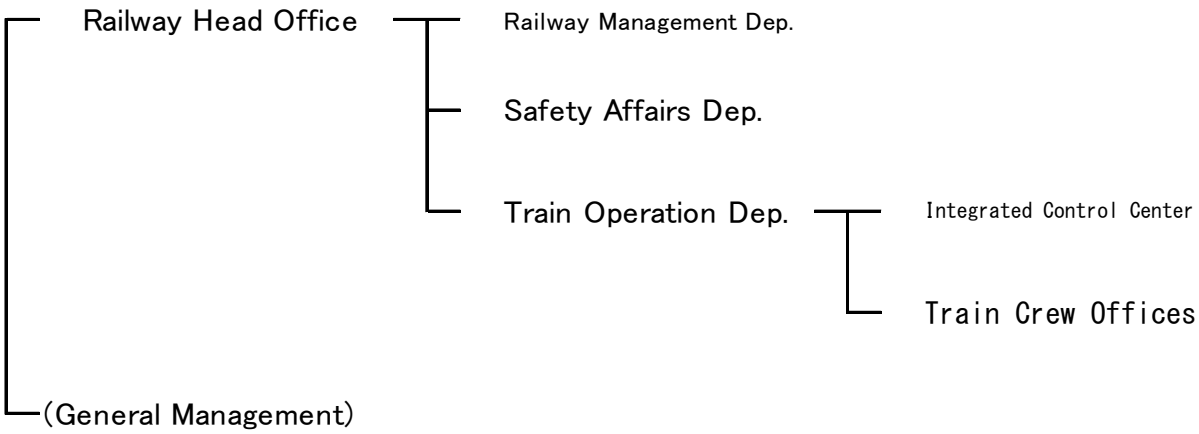



Source: Drawn up by the study team

Figure 4.3 Organization chart when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

(iv) Organization when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric circuits is contracted with a contractor or contractors in the private sector.

Figure 4.4 shows the organization chart when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a contractor or contractors in the private sector.

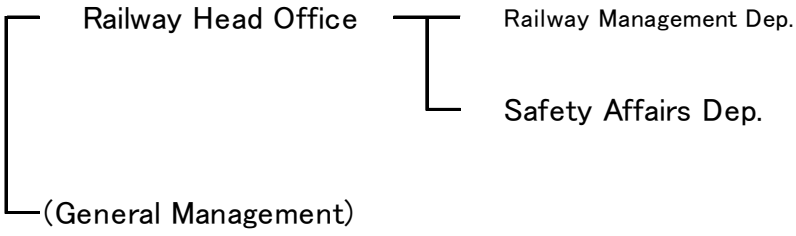



Source: Drawn up by the study team

Figure 4.4 Organization chart when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a contractor or contractors in the private sector

(v) Organization when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.

Figure 4.5 shows the organization chart when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.




Source: Drawn up by the study team

Figure 4.5 Organization chart when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.

(2) Division of duties

(i) Division of duties under direct management

Table 4.10 shows division of duties under direct management.

Division of duties is based on that of Tokyo Metro.

Table 4.10 Division of duties under direct management

| | | Division/department | Division of major duties |
|---|---|---|---|
| Head office | General management division | | General affairs, , human resources, finance, public relations business development, etc. |
| | Railway headquarters | Railway management dept. | Management of railway headquarters |
| | | Safety affairs dept. | Railway safety control and transversal engineering control |
| | | Business dept. | Management of station duties |
| | | Train operation dept. | Train operation planning, operation of integrated control center, train crew rotation planning |
| | | Rolling stock dept. | Control of designing and maintenance planning for rolling stock |
| | | Engineering work dept. | Maintenance planning for tracks and civil engineering structures |
| | | Electrical Facilities dept. | Maintenance planning for power supply, signal/telecommunication facilities and station machines |
| Work-site | Train operation | Integrated control center | Control of train operation and signal handling |
| | | Train operation | Management of station crew |
| | Business operation | Station | Station duties such as ticket selling and passenger guidance (except guarding and station cleaning) |
| | Maintenance/ management | Rolling stock | Inspection of rolling stock |
| | | Engineering work | Inspection of tracks and civil engineering structures |
| | | Electrical facilities | Inspection of power supply, signal/telecommunication facilities and station |

| | | | |
|---|---|---|---|
| | | | machines |

Source: Drawn up by the study team

(ii) Division of duties when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.

Table 4.11 shows division of duties when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.

Table 4.11 Division of duties when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.

| | | Division/department | Division of major duties |
|---|---|---|---|
| Head office | General management division | | General affairs, , human resources, finance, public relations business development, outsourcing control, etc. |
| | Railway headquarters | Railway management dept. | Management of railway headquarters |
| | | Safety affairs dept. | Railway safety control and transversal engineering control |
| | | Business dept. | Management of station duties |
| | | Train operation dept. | Train operation planning, operation of integrated control center, train crew rotation planning |
| | | Engineering work dept. | Maintenance planning for tracks and civil engineering structures |
| | | Electrical Facilities dept. | Maintenance planning for power supply, signal/telecommunication facilities and station machines |
| Work-site | Train operation | Integrated control center | Control of train operation and signal handling |
| | | Train operation | Management of station crew |
| | Business operation | Station | Station duties such as ticket selling and passenger guidance (except guarding and station cleaning) |
| | Maintenance/ management | Engineering work | Inspection of tracks and civil engineering structures |
| | | Electrical facilities | Inspection of power supply, signal/telecommunication facilities and station machines |

Source: Drawn up by the study team

(iii) Division of duties when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

Table 4.12 shows division of duties when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

Table 4.12 Division of duties when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

| | | Division/department | Division of major duties |
|---|---|---|---|
| Head office | General management division | | General affairs, , human resources, finance, public relations business development, outsourcing control, etc. |
| | Railway headquarters | Railway management dept. | Management of railway headquarters |
| | | Safety affairs dept. | Railway safety control and transversal engineering control |
| | | Train operation dept. | Train operation planning, operation of integrated control center, train crew rotation planning |
| | | Engineering work dept. | Maintenance planning for tracks and civil engineering structures |
| | | Electrical Facilities dept. | Maintenance planning for power supply, signal/telecommunication facilities and station machines |
| Work-site | Train operation | Integrated control center | Control of train operation and signal handling |
| | | Train operation | Management of station crew |
| | Maintenance/ management | Engineering work | Inspection of tracks and civil engineering structures |
| | | Electrical facilities | Inspection of power supply, signal/telecommunication facilities and station machines |

Source: Drawn up by the study team

(iv) Division of duties when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a contractor or contractors in the private sector.

Table 4.13 shows division of duties when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a contractor or contractors in the private sector.

Table 4.13 Division of duties when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a contractor or contractors in the private sector.

| | | Division/department | Division of major duties |
|---|---|---|---|
| Head office | General management division | | General affairs, human resources, finance, public relations,business development, outsourcing control, etc. |
| | Railway headquarters | Railway management dept. | Management of railway headquarters |
| | | Safety affairs dept. | Railway safety control and transversal engineering control |
| | | Train operation dept. | Train operation planning, operation of integrated control center, train crew rotation planning |
| Work-site | Train operation | Integrated control center | Control of train operation and signal handling |
| | | Train operation | Management of station crew |

Source: Drawn up by the study team

(v) Division of duties when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.

Table 4.14 shows division of duties when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.

Table 4.14 Division of duties when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.

| | | Division/department | Division of major duties |
|---|---|---|---|
| Head office | General management division | | General affairs, human resources, finance, public relations,business development, outsourcing control, etc. |
| | Railway headquarters | Railway management dept. | Management of railway headquarters |
| | | Safety affairs dept. | Railway safety control and transversal engineering control |

Source: Drawn up by the study team

(3) Division-wise member placement

(i) Division-wise member placement under direct management

Table 4.15 shows the division-wise member placement under direct management. Member placement is based on that of Tokyo Metro. It is desirable to minimize the number of members as far as possible in the Railway Management Department, Safety Affairs Department, Engineering Division and General Management Division.

Table 4.15 Division-wise member placement under direct management

| Division | Department | No. of personnel |
|---|---|---|
| Head office | Railway management dept., Safety affairs dept., General management division | 83 |
| | Business dept. | 25 |
| | Train operation dept. | 17 |
| | Rolling stock dept. | 12 |
| | Engineering work dept. | 18 |
| | Electrical facilities dept. | 14 |
| | Subtotal | 169 |
| Work-site division | Station | 601 |
| | Integrated control center | 138 |
| | Train operation | 267 |
| | Rolling stock | 176 |

| | | |
|---|---|---|
| | Engineering work | 69 |
| | Electrical facilities | 120 |
| | Subtotal | 1,371 |
| Total | | 1,540 |

Source: Drawn up by the study team

(ii) Division-wise member placement when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.

Table 4.16 shows the member placement when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector. We assume that one member be assigned to the Outsourced Service Management Group in the General Management Division. For this purpose, a member shall be appropriated out of the enrollment of the General Management Division.

Table 4.16 Division-wise member placement when outsourcing of the maintenance of rolling stock is contracted with a contractor or contractors in the private sector.

| Division | Department | No. of personnel |
|---|---|---|
| Head office | Railway management dept., Safety affairs dept., General management division | 83 |
| | Business dept. | 25 |
| | Train operation dept. | 17 |
| | Engineering work dept. | 18 |
| | Electrical facilities dept. | 14 |
| | Subtotal | 157 |
| Work-site division | Station | 601 |
| | Integrated control center | 138 |
| | Train operation | 267 |
| | Engineering work | 69 |
| | Electrical facilities | 120 |
| | Subtotal | 1,195 |
| Total | | 1,352 |

Source: Drawn up by the study team

(iii) Division-wise member placement when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

Table 4.17 shows the member placement when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector. We assume that two members be assigned to the Outsourced Service Management Group in the General Management Division. For this purpose, two members shall be appropriated out of the enrollment of the General Management Division.

Table 4.17 Division-wise member placement when outsourcing of the maintenance of rolling stock and station services is contracted with a contractor or contractors in the private sector.

| Division | Department | No. of personnel |
|---|---|---|
| Head office | Railway management dept., Safety affairs dept., General management division | 83 |
| | Train operation dept. | 17 |
| | Engineering work dept. | 18 |
| | Electrical facilities dept. | 14 |
| | Subtotal | 132 |
| Work-site division | Integrated control center | 138 |
| | Train operation | 267 |
| | Engineering work | 69 |
| | Electrical facilities | 120 |
| | Subtotal | 594 |
| Total | | 726 |

Source: Drawn up by the study team

(iv) Division-wise member placement when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a contractor or contractors in the private sector.

Table 4.18 shows the member placement when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a

contractor or contractors in the private sector. We assume that four members be assigned to the Outsourced Service Management Group in the General Management division. For this purpose, four members shall be appropriated out of the enrollment of the General Management Division.

Table 4.18 Division-wise member placement when outsourcing of the maintenance of rolling stock, station services and maintenance of tracks/electric facilities is contracted with a contractor or contractors in the private sector.

| Division | Department | No. of personnel |
|---|---|---|
| Head office | Railway management dept., Safety affairs dept., General management division | 83 |
| | Train operation dept. | 17 |
| | Subtotal | 100 |
| Work-site division | Integrated control center | 138 |
| | Train operation | 267 |
| | Subtotal | 405 |
| Total | | 505 |

Source: Drawn up by the study team

(v) Division-wise member placement when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.

Table 4.19 shows the member placement when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector. We assume that five members be assigned to the Outsourced Service Management Group in the General Management Division. For this purpose, five members shall be appropriated out of the enrollment of the General Management Division.

Table 4.19 Division-wise member placement when outsourcing of the maintenance of rolling stock, station services, maintenance of tracks/electric facilities and train operation is contracted with a contractor or contractors in the private sector.

| Division | Department | No. of personnel |
|---|---|---|
| Head office | Railway management dept., Safety affairs dept., | 83 |

| | | |
|---|---|---|
| | General management division | |
| Total | | 83 |

Source: Drawn up by the study team

## 4.5 Conclusion

### (1) Issues

Various forms of management structure are adopted by urban railways in the world. A number of urban railway regulators are proud of their own management structure to be the best from the viewpoint of efficiency, economy and flexibility. In the background is the fact that enormous amounts of funds and taxes are spent for urban railways and regulators are supposed to be accountable for them. In regard to their accountability, stress is often laid on the role division between the public and private sectors.

### (2) Privatization of railways

At the dawn of railways in the UK, keen competitions developed among different railways, which were under management by enterprise starters. Affected by depression and wars thereafter, the government adopted policies to mitigate competition and the railway network was nationalized in 1948. However, the Conservative Party that aimed at a small government divided and privatized the railways in 1993. Similarly, railways in Japan, which had been nationalized in 1906, were privatized in 1987. In the background of these developments is a concept that the private sector is more efficient than the public sector. Furthermore, urban railways increasingly tend to attach importance to the role of private sector as well.

### (3) Efficiency and role division

In discussion of the movement toward privatization in recent years, efficiencies in the public and private sectors are often compared in literature. A paper[46] reports that, among the citations in literature, efficiency is referred to as:

- Higher in the private sector, 36 cases
- The same in the two sectors, 20 cases
- Higher in the public sector, 11 cases

Regarding the efficiency of railway business, there are studies of comparison between the public and private sectors. One[47] reports, after investigating railway businesses in Canada, that there is no difference between the two sectors and another[48] concludes,

[46] Mizutani, F. (2000), "Public Supply and Privatization in Public Work" in Japanese, "Kokumin Keizai (People's Economy) Journal," Society of Economy, Kobe University, Volume 182, No 3.

[47] Caves, D.W., and Christensen, L.R. (1980) "The relative efficiency of public and private firms in a competitive environment: The case of Canadian railroads." Journal of Political Economy 88(5)

[48] Mizutani, F.(1994) Japanese Urban Railways: A Private-Public Comparison, Aldershot:Ashgate Publishing Company

after comparing the two sectors in Japan, that the efficiency attained in the private sector is higher than that in the public sector. While a number of study results report that the private sector is more efficient, as many study results remark that there is no difference between the two sectors. In our study, we compare and discuss different management structures while assuming role division and difference in efficiency, 0 to 30%, between the public and private sectors.

### (4) Subjects in the future

In discussing the management structure of urban railways, what shall be noted from the economic and financial points of view is not only the difference in efficiency between the public and private sectors but also the large-degree effect of service tax imposed on the outsourcing of services with a contractor or contractors in the private sector. To raise the weight of the economy in the private sector in the future, political judgment is required to make the tax imposition smaller, in order to introduce private enterprises into public services.

From the aspect of practical businesses, it is essential to consider the role division between the public and private sectors regarding the management and safety control of railways. To outsource part of railway services, education and training of employees to improve their skills are required. It is also important to have them set a target to ensure safety. A mechanism is indispensable to monitor and inspect on a regular basis how they are doing for the accomplishment of such policies.

The departmental applicability of outsourcings is considered as follows;

<Rolling stock maintenance >

The procurement of spare parts tends to become a problem for the rolling stock maintenance. The long-term maintenance contract in parallel with the procurement contract is helpful for the smooth parts procurement in the future and saving the life cycle cost of rolling stock. On the other hand, manufacturers tend to avoid the long-term contract. Generally, it takes at least 5 years for the maintenance engineers to get the technical skills.

<Station service >

The selection of private subcontractors is not so difficult, as the station service doesn't require technical background. To divide stations into some groups and outsource to each is an option in order to utilize the market mechanism. Then public sector compares their performance looking at the number of employee, cleanliness of stations and complaints from passengers.

<Track and electrical maintenance >

The outsourcing is relatively difficult, as it requires technical knowledge. Generally, many troubles occur immediately after the opening due to the initial malfunctions, and gradually troubles decrease until it shows a steady state. Several years later, troubles increase again in accordance with the usual wear and tear of parts. The speed of track deterioration is slower than that of electrical facilities in general. Therefore the maintenance contract with suppliers would be preferable to reduce the life cycle cost. Another option would be the outsourcing contract after the equipment becomes steady state.

<Train operation >

The outsourcing of train operation seems difficult for Mumbai Metro 3, as the structures are owned and maintained by the public sector. (Even if the maintenance of equipment is outsourced, MMRC is responsible to provide the safe structure for the train operator.) The accident increase in the UK after the railway privatization and the speed restriction of Airport Line in Delhi are the examples of the problems resulted from the separation of infrastructure from operation.

# Appendix 1 Land Price Inflation due to Railway Construction

## A 1.1 Land price along a railway line

### (1) Overall condition of urban area

Mumbai is located on the Bombay Island, the west coast of India, and Salsette Island stretching toward north. Both islands are connected by landfill and forming a peninsula stretching toward south.

The central part of urban district is located in the vicinity of peninsula tip, 12 million people have their residence in the urban district of 483 $km^2$, and population density reaches 25,000 people/$km^2$.

Looking population density by district, the highest is 114,000 people/ $km^2$ in Marine Lines, then 64,000 people/ $km^2$ in Dadar/Plaza, 60,000 people/$km^2$ in Byculla, 58,000 people/$km^2$ in Grant Road, 57,000 people/$km^2$ in Sanhurst Road and so on.[49]


Source: MUMBAI REGIONAL MAP

Figure A 1.1 Simplified map of Mumbai

### (2) Land Price Distribution

The land price in Mumbai is high at peninsula tip district where population density is high and goes cheaper as going up to the north. In addition, Arabian Sea side in the west is high and Harbor Bay side in the east is cheaper. Land price for every railroad station is shown on the Table below;[50]

Table A 1.1 Land price distribution along railway lines

| Line | Station | Time min | Land Price Rs. | Line | Station | Time min | Land Price Rs. |
|---|---|---|---|---|---|---|---|
| Western Line | Church Gate | 0 | 32,000 | Western Line | Naigaon | 84 | 3,500 |
| | Marine Lines | 3 | 30,000 | | Vasai Road | 89 | 4,000 |
| | Grant Road | 8 | 30,000 | | Nola Sopara | 94 | 3,000 |
| | Mumbai Central | 10 | 20,500 | | Visar | 100 | 4,000 |
| | Maha Laxmi | 13 | 35,800 | Central Line | Byculla | 8 | 21,000 |
| | Lower Parel | 16 | 30,000 | | Parel | 15 | 22,000 |
| | Dadar | 21 | 26,500 | | Sion | 24 | 17,000 |
| | Matsunga | 23 | 23,900 | | Kurla | 28 | 10,600 |
| | Bandra | 31 | 27,500 | | Ghatkopar | 34 | 12,500 |
| | KharRoad | 33 | 30,000 | | Vikhroli | 38 | 11,000 |
| | Santa Cruz | 36 | 23,250 | | Kanjurmarg | 41 | 13,000 |
| | Vile Parle | 39 | 22,000 | | Bhandup | 44 | 9,500 |
| | Andheri | 44 | 11,250 | | Mulund | 50 | 13,200 |
| | Jogeshwari | 47 | 11,000 | | Thane | 55 | 8,450 |
| | Goegaon | 52 | 11,500 | | Dombivili | 77 | 4,500 |
| | Malad | 56 | 10,750 | | Kaiyan | 87 | 4,500 |
| | Kandivili | 59 | 9,650 | | Kaiyan | 87 | 4,500 |
| | Borovali | 65 | 10,000 | Harber Line | Sewri | 15 | 30,000 |
| | Dahisar | 69 | 10,000 | | Wadara | 18 | 17,500 |
| | Bhayander | 80 | 6,000 | | King Circle | 22 | 13,000 |

[49] http://www.demographia.com/db-mumbaidistr91.htm

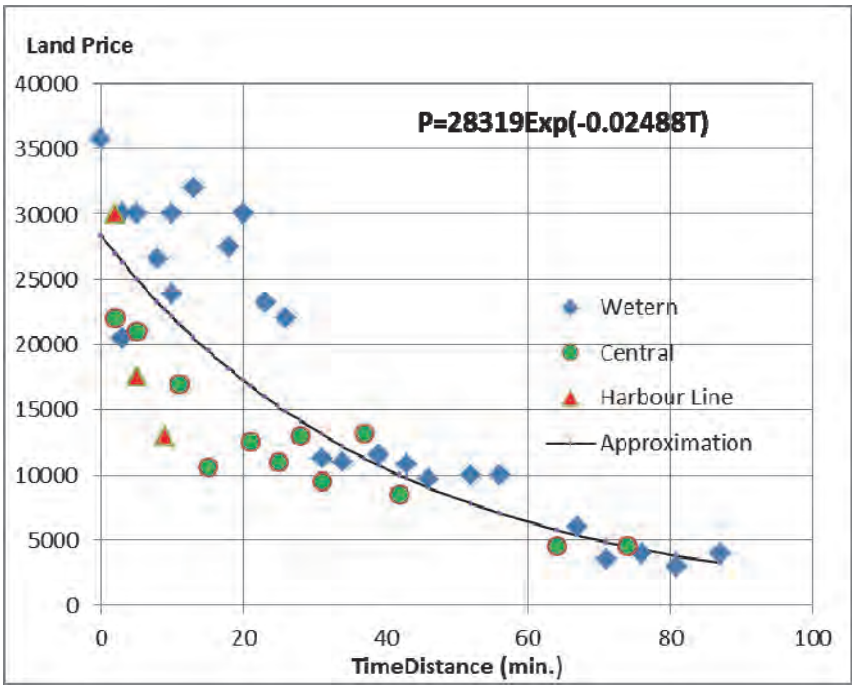
[50] http://www.mumbaipropertyexchange.com/research/mumbai-property-rates

Note) Time in the Table shows local train time required from Church Gate and Mumbai CST.
Source: JICA Study team

## A 1.2 Land Price and time distance

### (1) Assumption of urban core

The land price goes cheaper as distance from urban center gets far. The highest land price is Mahalaxmi station and the relationship between required time from Mahalaxmi station, assumed as the urban center, and land price is shown diagrammatically. The position, 13 minutes south from Dadar, was set as urban center for the Central Line and the Harbor Line.




Source: JICA Study team

Figure A 1.2 Time distance and land price

### (2) Relational expression

When setting up the relational expression of land price and time distance with least-square approach, the following formula is obtained;

P = 28319 Exp (-0.02488T)

where P = Land price (Rs.) and T = Time distance (Min.)

As it is clear from the Figure, if time distance becomes half, land prices becomes a little less than twice. This trend is similar at other cities. In order for getting a grasp of effect accurately, it is required to perform zoning by which subdivide the district further and a model tailored to the zoning is required. Since a lot of way stations will be installed on the Mumbai Metro Line-3, time reduction effect by the combination of walk and railway is considered to be large.

## Appendix 2 Measures to lighten government debts

We introduce below methods adopted and proven in Japan as a countermeasure against increases in government debts brought about by projects promoted with government funds.

### A 2.1 Appropriation of revenue from fixed asset tax

#### (1) Rise in land prices

The population density of urban areas decreases exponentially in proportion to the distance from the city center. This holds true even when “distance” is read as “time distance” and “population density” as “land price.” In numerical terms, therefore, we can grasp the degree of rises in the wayside land prices based on the time distance cut by the construction of a railway.

According to a calculation for the western part of Hanoi City, Vietnam, (1) a time distance cut to a half gave a doubled land price and (2) the amount of the increase in the price of a wayside land, length 40 km and width 2 km, extending from the Hanoi city center, was equivalent to three times the construction cost of a 40 km-long railway. If there were a mechanism to appropriate the amount of increased land price for railway construction, it would be possible to recover the government funds in early stages.

Profits from a rise in land prices in a usual situation are enjoyed only by land owners, and do not materialize immediately. As the convenience of land is enhanced by the development of railways, etc., the form of land use changes; for example, agricultural land changes to residential land, this is passed on to a rise in land prices, and until profits are realized, investment and time is required for the development of the environment, including infrastructure.

Using this project as an opportunity, the development of land beside the railway should be promoted, and in tandem with this, the government should assess and evaluate land price trends in a study of criteria for the assignment of development rights and transaction cases, and also impose an appropriate fixed asset tax. This will enable the profits generated by rising land prices to be returned to public works project expenses.

In Japan, land prices deduced from the trend of transaction are published and revised on a regular basis. Improvement of the utility of lands in a project, therefore, contributes to increasing revenue form fixed asset tax for the government.

#### (2) TIF (Tax Increment Finance)

Furthermore, based on the assumption of an increase in future fixed asset tax revenues, it will also be possible to issue credits for railway development. This is called tax increment finance (TIF), and it is a method of raising funds to appropriate as transfer infrastructure development

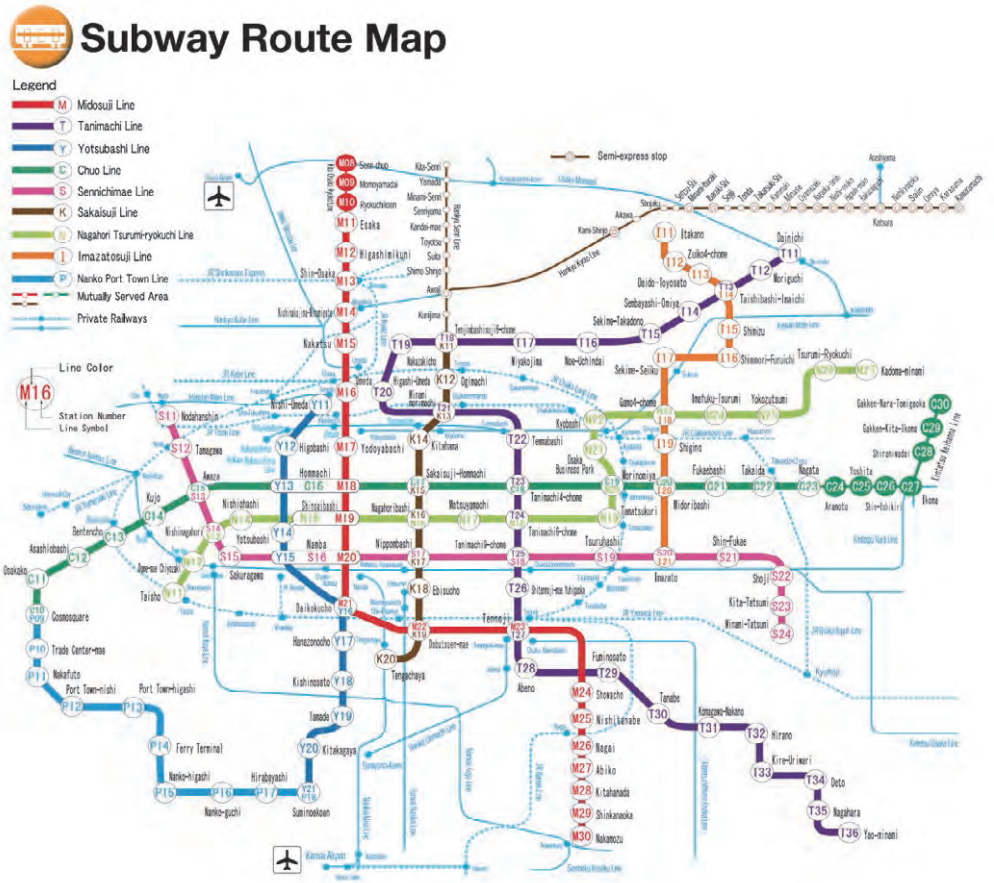
funds through bond issuance by government institutions that is secured by the increase in fixed asset tax revenues in peripheral areas resulting from infrastructure development.
This is a system in which the total appraisal amount of fixed assets taxes within a specific area designated by a local government is decided, bonds are issued where the amount of difference from the appraisal amount resulting from subsequent development is designated as funds with secured redemption, and infrastructure is developed with these funds. Overseas, this system has been used in the United States in San Francisco and Los Angeles (the Red Line Phase 1).
In addition, in regard to LRT development in recent years in the United States, there have been cases where local governments have raised the consumption tax rate based on ordinances and appropriated the funds for development expenditure.

### A 2.2 Use of beneficiary-pays scheme under urban planning law

This approach requires owners of land alongside the line to bear part of the cost of construction under a beneficiary-pays scheme provided for under urban planning law. One example of such a scheme is that employed in Osaka, described below, where one quarter of the cost of the project concerned was financed by raising funds, weighted according to grade of station, from landowners and leaseholders located near stations.

#### (1) Example of Midosuji subway line on the Osaka Municipal Subway

In Japan before the Second World War, in addition to the capital, Tokyo, a subway was also built and operated in Osaka, which is Japan's second largest city after Tokyo.
While Tokyo's subway was funded, built and run by private-sector companies, in the case of Osaka, the City of Osaka, which is the body that implements city planning, built the subway as a city planning project and also operated it.
Line 1 of the Osaka Municipal Subway (now the Midosuji Line) was opened from Umeda Station (provisional name) to Shinsaibashi Station in 1933 as Japan's first publicly operated subway line. This line links Osaka City's major shopping districts of Umeda, Namba and Tennoji, and since it opened it has been used by many passengers as a main traffic route in Osaka. Even now, this line is the only one with over 1 million passengers among the nine lines that the Osaka Municipal Transportation Bureau operates.




Source: Osaka Municipal Transportation Bureau website

Figure A 2.1 Map of Osaka Municipal Subway

(2) System of benefit principle

When building this line, the City of Osaka asked owners of land along the railway line to pay part of the construction costs, based on the user-pays principle in the City Planning Law. The details regarding the beneficiary charge under the City Planning Law of the time are shown below, and even in the current City Planning Law the same provisions are followed.

- When the competent minister acknowledges it is necessary, it is permitted to make people who will significantly benefit from a city planning project bear all or part of the costs required for the city planning project.
- The upper limit of the cost burden shall be the profit received from a city planning project.
- The details of the cost burden are stipulated in an Imperial Ordinance.

As regards the reasons for using this system, the opinion of the City of Osaka is shown below.

> If a high-speed railway is opened, citizens will receive the benefit of this comfortable mass transit system, business activities will become invigorated, and they will enjoy direct and indirect benefits. Land near stops will become substantially developed, business districts and commercial districts will be formed, and land owners will receive large profits from a rise in land prices.
> Therefore, as in the case of city planning projects such as roads and water and sewer services, in regard to urban railway construction as well, it has been decided that land owners who will receive more profits than other citizens will have to pay part of the construction costs as a beneficiary charge.
>
> (Source: 50-Year History of Construction of Osaka Municipal Subway)

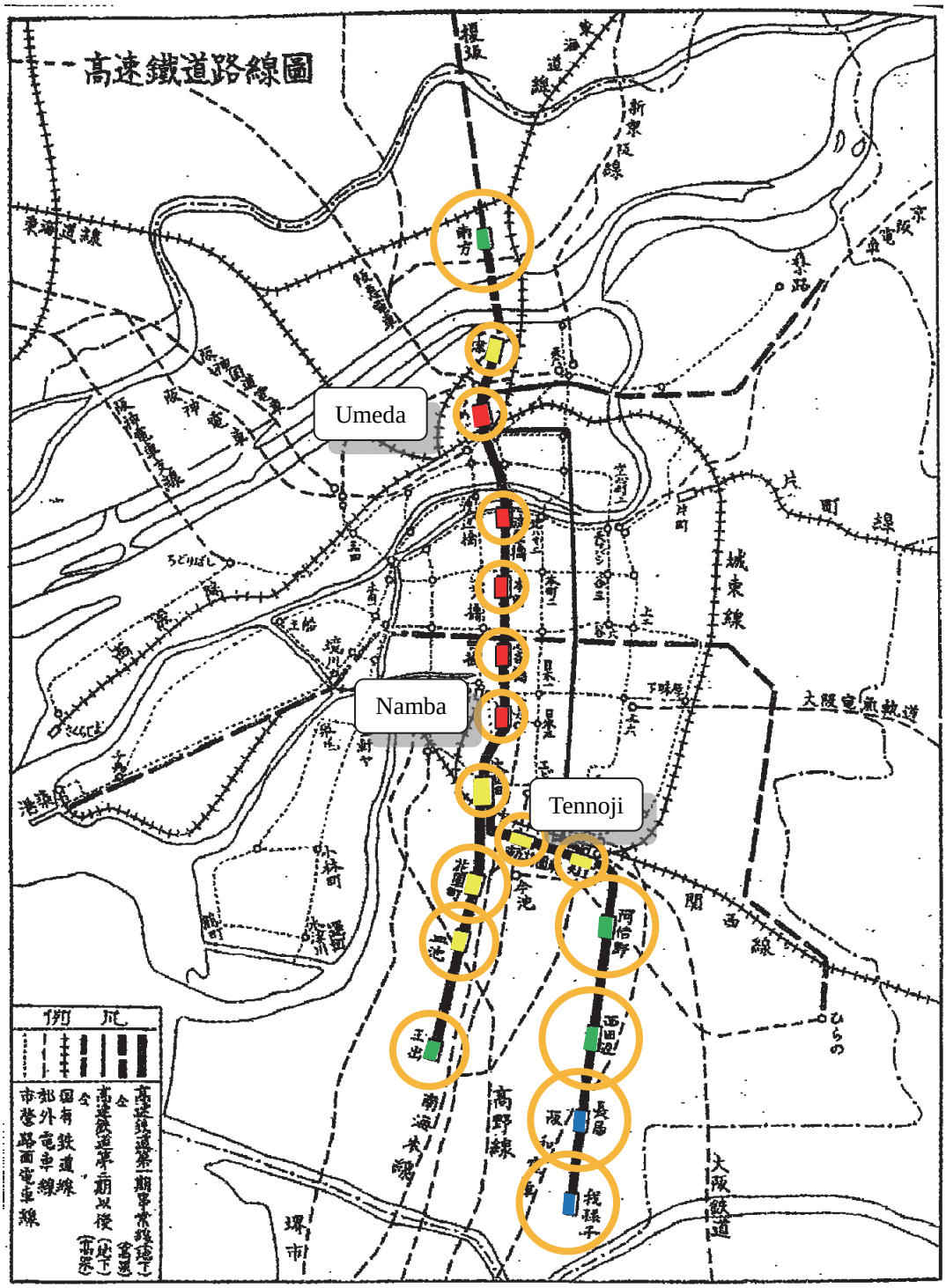
The details of beneficiary charges are prescribed below in the Ordinance of the Ministry of Home Affairs titled “Matters Concerning Beneficiary Burdens for Osaka City Planning Projects Involving High-Speed Rail Development”.

Table A 2.1 Beneficiary charges for Osaka Municipal Subway No. 1 Line (Midosuji Line)

| | |
|---|---|
| Total burden | A quarter of project costs |
| Bearer | Owners, pledgees and farming right holders, etc. of land subject to land tax within the following range from each entrance and exit of stations<br>City-center stations Within 200 ken (about 360 m)<br>Suburban stations Within 300 ken (about 550 m) or Within 400 ken (about 730 m) |
| Burden method | Weightings are applied below according to the station grade and divided by the total burden<br>Grade A station vicinity 10<br>Grade B station vicinity 6<br>Grade C station vicinity 5<br>Grade D station vicinity 3 |

Source: The Ordinance of the Ministry of Home Affairs titled “Matters Concerning Beneficiary Burdens for Osaka City Planning Projects Involving High-Speed Rail Development”

A rough range of requested burden charges and station grades are shown in the figure below. The orange circles show the rough range of beneficiary charges requested, while Grade A stations are shown in red, Grade B stations in yellow, Grade C stations in green, and Grade D stations in blue.




Source: “Progress of 70 Years of Construction of Osaka Municipal Subway”

Figure A 2.2 Rough range of requested beneficiary charges and station grades

## A 2.3 New station development using the benefit principle system based on applications by developers, etc.

### (1) Scheme to install new stations

Utility of a railway is governed to a great extent by existence or non-existence of stations and geometrical relations therewith. It is advantageous, therefore, for both the railway operator and developers to install stations harmonized with the development plans for surrounding areas, with funds to construct stations born by developers and others who require installation and remodeling of stations.

In case necessity arises in the future, new stations shall be constructed according to the requirement by local autonomous bodies and developers who already have lands in wayside areas, with the total or a majority of the funds to construct stations, station plazas and access roads thereto born by those who require development of such facilities and infrastructures.

By this scheme, local autonomous bodies and developers can promote town planning featuring enhanced convenience and accessibility to railway stations, with the former having merit to decrease the burden for construction of stations and other infrastructures and the latter enjoying increases in the development profit through town planning integrated with construction of railway infrastructures. This policy is called a benefit principle or a system for beneficiaries to bear the whole or part of project cost.

### (2) Applicable entity for financial burden

The benefit principle system is a development method of which there are many examples in Japan as well, and the kind of entities in Table A 2.2 that would likely enjoy the benefit of profits from the development of new stations could bear the cost.

Table A 2.2 Applicable entities assumed to bear new station development costs

| Applicable Entity | Explanation |
|---|---|
| Developer | • It is likely that profits from a rise in land prices caused by the establishment of new stations will be enjoyed to the maximum.<br>• Development is already progressing, but incentives according to the contribution of funds aimed at promoting projects where construction is delayed and projects in which sales are in a slump will work. |
| Large-scale facilities | • Through improvement of uses' convenience, enterprise-development areas, universities, hospitals and other large-scale facilities including those for sightseeing can expect those intending to differentiate facilities to bear costs. The current policy to require a certain burden on the airport and the link thereto of the Mumbai Metro line 3 is in |

| | |
|---|---|
| | agreement with the concept of a benefit principle.<br>• A railway operator as well would likely benefit from the number of people using the railway on a daily basis, and as this would become a stable source of fare income, facilities located in (transferred to) suburban areas in particular should be considered even if the burden amount is small.<br>• Wide-ranging linkage, including feeder transportation from in front of the stations, can be expected.<br>• It may be possible to apply the benefit principle as well to the HSR connecting facilities in the future. |

Source: JICA Study Team

### A 2.4 Adoption of developer burden charge based on negotiation between parties

This is a system where the land owners in surrounding areas bear part of the construction costs as a developer burden charge, in advance of the development of a railway. In the case of Yokohama City described later, one quarter of the initial project costs was apportioned according to the respective amount of benefit for the land.

#### (1) Example of Minato Mirai Line

The City of Yokohama is located 30-40 km south of the city center of Tokyo. At present, it is the city with the highest population among the cities, towns and villages of Japan, and it is an international port city that has the Port of Yokohama, which is a representative port of Japan.

The Minato Mirai district, which borders the Port of Yokohama, was previously a district with shipyards, freight stations, and wharves, but it underwent urban redevelopment from the 1980s, and it has now become a neo-futuristic town that has offices, commercial facilities, housing, and tourist spots.

The Yokohama Minato Mirai Railway 21 line (usually called the Minato Mirai line) is a line that was constructed fully underground to link the built-up area that includes Yokohama Station, the central station in Yokohama City, and the Yokohama municipal offices with the Minato Mirai district, and it opened in 2004.

Among the six stations on the Minato Mirai line, the stations located in the Minato Mirai district are Shintakashima Station and Minato Mirai Station.


Source: Yokohama Minato Mirai Railway Company website

Figure A 2.3 Map of Minato Mirai line

When this line was constructed, owners of land in the vicinity of Minato Mirai Station were asked to pay a developer burden charge, based on the rationale that part of the development profits from a rise in land prices caused by the development of the railway would be allocated to the railway construction costs, and these charges were allocated to construction project expenses.

(2) Developer burden charge

Table A 2.3 Objects assumed to bear the cost for construction of new stations.

| | |
|---|---|
| Total burden | A quarter of initial project costs (about 50 billion yen) |
| Bearer | Owners of land in the vicinity of Minato Mirai Station (including Mitsubishi Estate, Urban Renaissance Agency, City of Yokohama, and Mitsubishi Heavy Industries) |
| Burden method | The burden amount was established based on the amount required to maintain profitability in terms of railway management in proportion to the amount of benefit derived by the respective land. |

Source: Compiled from “Railway Development and Development of Cities beside Railway Lines” (Shunji Takatsu, 2008)

When levying developer burden charges, as no clear legislation has been established regarding returning development profits to railway businesses, negotiations were conducted with applicable local land owners and leaseholders, with the aim of charging 50 billion yen. According to “Railway Development and Development of Cities beside Railway Lines” (Shunji Takatsu, 2008), when interviews were conducted with the developers of Minato Mirai Station, the response obtained was that “as there is a benefit, a certain degree of burden cannot be helped”.

On the other hand, there was no initial plan for Shintakashima Station, but it was decided to establish the burden based on the “Petition for a Station System”, where developers bear the entire station establishment cost (about 20 billion yen), and the construction work plan was altered. Consequently, the ultimate funding framework was as shown in the table below.

Table A 2.4 Funding framework for Minato Mirai line

| | | |
|---|---|---|
| Capital | 27 billion yen | • City of Yokohama, Kanagawa Prefecture, railway company, real estate companies, and banks made contributions |
| Developer burden charge | 74 billion yen | • Minato Mirai Station vicinity developer burden charge<br>• Burden charge associated with construction of Shintakashima Station |
| Railway and transportation system funds | About 129 billion yen | • Payment of compensation for transferred facilities<br>• Central government and Kanagawa Prefecture subsidize interest payments |
| Borrowings, etc. | About 27 billion yen | • City of Yokohama provides compensation for losses |
| Total | About 257 billion yen | |

Source: City of Yokohama data

### A 2.5 Internalization by railway operator of land price gains from line-side development to alleviate cost of investment in railway development (for reference)

For reference purposes, study team describes below a method by which a railway operator recoups and repays part of the cost of railway development that cannot be covered solely from railway business revenues by using the profits generated by engaging in other business (such as development of line-side real estate) at the same time as developing a railway.

#### (1) At the stage of inauguration

As urban areas spread and the population grew from the beginning of the 20th century, Japan's private railway operators themselves increasingly turned to developing real estate alongside lines in the suburbs.

Engaging in developing quality housing alongside their own lines served to increase the line-side residential populations that provided the regular passengers who used their lines, while at the same time the development of shops and everyday conveniences near major stations acting as nodes for feeder transport provided by affiliated bus and taxi services absorbed consumer demand. The result of this was to increase the value of line-side real estate, the gains from which were enjoyed by the railway operators themselves. These gains were used, along with the increase in fare revenues also generated, to help recoup prior investment in railway development. There also emerged cases of real estate companies with major development plans engaging in railway development through affiliates in order to enhance transportation access in areas undergoing development. (Examples of such projects include Kita-Osaka Tochi's Kita-Osaka Electric Railway, Garden City's Meguro-Kamata Electric Railway, and Hakone Tochi's Tamako Railway.)

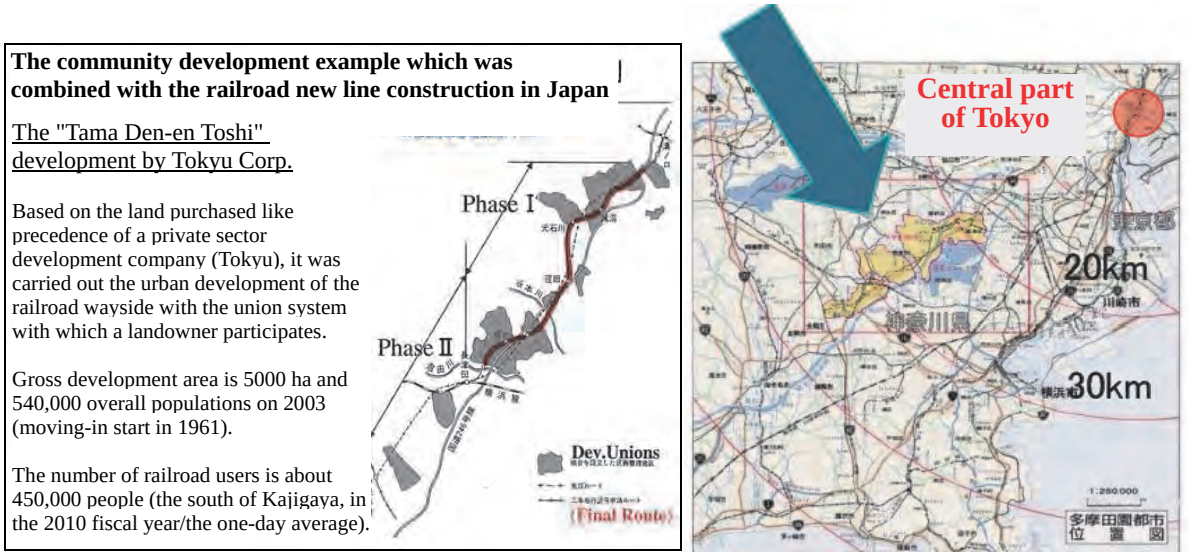
#### (2) In and after the high economic growth period

After World War II, conurbation growth accelerated further, driven in part by the severe housing shortage, as the Japanese economy moved beyond recovery and into a period of high growth. Private railway operators that had to invest in expanding transportation capacity to alleviate the consequent serious congestion often found that the authorities were slow to approve their proposed fare revisions, as the authorities saw this as one way to help curb prices at a time when the economy was experiencing inflationary pressure.

To counter this, operators tended to depend on profits generated by their real estate operations, which accounted for an increasing proportion of their overall businesses, and development projects increased in size. The massively increasing scale of investment required to develop railways to keep pace with large-scale development made it increasingly unfeasible for

railway-affiliated capital to continue to exclusively buy up line-side land outright ahead of railway development, as a consequence of which alternative approaches were adopted. These included the formation of associations with line-side landowners and leaseholders to engage in land readjustment projects under urban city plans (e.g., the Tokyu Den-en Toshi Line) and the securing of land and development of infrastructure for the construction of new lines undertaken in concert with public sector “new town” development projects (e.g., Kita-Osaka Kyuko Railway, Osaka Prefectural Urban Development’s Semboku Rapid Railway, and Chiba Newtown Railway). A system of public subsidies was also put in place.

However, the Japanese economy then entered a period of stable growth and demographic growth also stagnated as the birth rate fell and the population aged. Under these conditions, it became apparent that the stock of real estate hitherto developed through prior investment was turning toxic due to the length of time required from development to payback and the application of market value accounting, making this business model no longer viable in today’s Japan.




Source: “Thirty-Five Year History of the Development of Tama Garden City,” TOKYU CORPORATION, 1988

Figure A 2.4 Example of regional development integrated with new railway line development in Japan

# Appendix 3 Trend of Traffic Operators

## A 3.1 Vertical (upper/lower) separation and open access

Railway Business Act came into force in Japan in 1987 as the pioneering figure of railway reform in the world. The separation of infrastructure and operation in railway service was clarified there. The past concept, integrally performed construction/possession and operation, was revised and the way of thinking for the division of roles and capital redemption of both sides were straightened up. The railway enterprises are classified into category-1, category-2 and category-3; they are ranked as operators, category-1 for operation and facility holder, categorys-2 for operation only and category-3 for facility possession only.

### (1) Division of roles

The separation of infrastructure and operation in railway service refers to the general idea of separating railway service into construction/possessing service such as railway track structure (tunnels, bridges, etc.), station buildings, power substations, power distribution lines, tracks/signal systems, etc., corresponding to lower side, and O&M (Operation and Maintenance) management service such as train operation, maintenance work on vehicles and tracks, etc., corresponding to upper side, and to separate their division of roles and accounting.[51]

There exists current status in the background of this general idea that construction has to leave to public institution since initial investment required for railway construction is vast amount, its investment recovery period is long and risk is high. In addition, there is the way of viewing that it is reasonable to construct railway track structure by public institution same just like road.

Meanwhile, O&M management of railway is able to leave to private industry since large amount of initial investment is not required.

### (2) Reimbursement of construction cost

The construction cost is classified into two, reimbursement type and publicly-run type from profit performance and sociality of the project. The former is the project that reimbursement for structural object is capable by lease payment from business operator and the latter is the project of severe balance payments even if social need is existed.

At the publicly-run type scheme, the lease payment is set within the benefit earned by the upper entity and the lower entity also reimburse develop fund within the range of income.

[51] Discussion is divided whether the vehicle purchasing cost should be included in the upper entity or lower entity.

### (3) Example of separation of infrastructure and operation

Examples regarding Japanese urban railways are shown on the Table A 3.1.

Table A 3.1 Examples of separation of infrastructure and operation in Japanese urban railways

| Example | Lower entity | Upper entity |
|---|---|---|
| Urban Railway | Kobe Rapid Transit Railway<br>Nakanoshima Rapid Railway<br>Nara Ikoma Rapid Transit Railway<br>(Category-3 railway operator: public and private joint venture corporation) | Hankyu/Hanshin/Sanyo Railways,<br>Hokushin Kyuko Railway<br>Keihan Railway<br>Kintetsu Corporation<br>(Category-2 railway operator: private) |

Source: JICA Study team

Nara Ikoma Rapid Transit Railway Company on the Table A 3.1 is the joint public-private venture invested by local governments such as Nara Prefecture, Nara City, Ikoma City, etc., and private companies. The railway is operated by Kintetsu Corporation, the private company. The new town railway build up aid (aiding rate: 18% by the national government and local government, respectively; total of 36%) and subway rapid railway build up project aid (35% by the national government and local government, respectively; total of 70%) were applied to this project.

In addition, Kobe Rapid Transit Railway became a category-3 railway operator after accepted asset transfer from Hokushin Kyuko Railway Company, Limited which had much financial difficulty. And Hokushin Kyuko Railway closed the business as the category-1 railway operator and is operating as the category-2 railway operator now.

### (4) Liberation of railway market in Europe

Reformation toward internationalization and making borderless circumstance has been performed in Europe aiming “creation of fair and free traffic market”. International procurement of railway related products such as rolling stocks have been promoted; railway operation has been separated into two types of business categories, infrastructure management and train operation, and the railway operation business changed to competitive market.

Council Directive 91/440/EEC on the development of the community's railways issued by the European Community in 1991 was the trigger for the reform, and the directive includes the section regarding “separation between infrastructure management and transport operations for sound business management” and “guaranteeing access of railway infrastructure based on open access rule.”

Related directives were issued since then and each EU member state has promoted railway reform while taking unique measures. However, the expected result was not necessarily obtained on the

competitive force enhancement. For the reason, direction was changed to enhance railway competition force through mutual competition between railway business enterprises since 2000. And then, a specialized organization, European Railway Agency (EPA), was established based on Regulation (EC) No 881/2004 of the European Parliament and of the Council.

ERA plays a leading role in the standardization of train control and signal system (interoperability), and procurement of rolling stocks which satisfy the standards, authentication acquisition of European Standard, the acquisition of compatibility assessment to running area standard are required for new entry business entity. In addition, ERA hold strong jurisdiction to investigate in case of major railway accidents.

### A 3.2 Traffic operator

#### (1) Reorganization of the industry

Reorganization of European traffic operators has started since 2000s upon the wave of liberation in railway field.

VIA GTI Cariane, the private operator, was acquired by SNCF in early 2000s, renamed it Keolis. SNCF became the leading player to enter local traffic in France and public traffic in the suburban area in France.

The British operator, Arriva, became a wholly owned subsidiary of Germany National Railway (DB) and DB has become the company brand when expanding to England and France.

In addition, among lines managed by the traffic union in Ile-de-France region (STIF: Syndicat des transports d'Île-de-France), Paris Traffic Public Corporation (RATP: Régie Autonome des Transports Parisiens), which has operated most of subways, established an affiliated company, RATP-dev, for the expansion to out of area and overseas since 2000 with the background changing from sole contract to competitive bidding in future and is giving actual records.

#### (2) Reorganization of the industry since financial crisis

Financial Crisis between 2008 and 2009 has made an impact to some of railway operators. Veolia Transport, an affiliated company of Veolia Environment at that time and termed as the leader, has largely changed its shareholder composition in short time.

Veolia Transport has acquired the most of stocks of mid-sized operator, Transdev, in 2010 and named itself Veolia-Transdev. However, the parent company, Veolia Environment, sold Transdev stocks to another principal stockholder, French Pension Fund (CDC: Caisse des Dépôts et Consignations) and CDC became the largest stockholder as the result. The company changed its name from Veolia-Transdev to Transdev. The overwhelming presence name among traffic operators, Veolia, has disappeared. There are oversea affiliated companies of name capped with Veolia but those will be integrated to Transdev in future.

### (3) Big three by public fund

Since CDC became the largest stockholder of Veolia-Transdev, every one of major French operators possesses the majority of capital as public capital fund. Namely, Transdev is the public enterprise investing 60% of Transdev with French Pension Fund (CDC), 70% of Keolis with SNCF (French National Railway) and 100% of fast growing RATP with the government fund. In spite of these capital formations, those three companies insist that know-how and management style accumulated during private industry era are the origin of their competitive power.

British Arriva, the 100% affiliated company of German National Railway (DB), insisted LOROL operation record with Hong Kong MTR in England and entry record to German domestic public traffic before affiliation to DB, and says that capital formation does not give any impact on management.

### (4) Overview of major traffic operators

The origin of railway operator is diverse. One example is a national railway separated into an infrastructure management company and a railway operator by breakup and privatization, and became an independent operator (SNCF in France, DB in Germany, MTR in Hong Kong, etc.). Another example is a company operating railway by private capital with urban public traffic business as its forcus (Transdev in France, Firest Group and Arriva in England, etc.). Overview of those operators is as shown on the Table A 3.2.

Table A 3.2 Overview of Operator

| Name | Transdev Group | Groupe Keolis | Arriva. Ple | First Group |
|---|---|---|---|---|
| Head office (country) | France | France | England | England |
| Established | 2011 | 2001 | 1938 | 1986 |
| Capital fund | ― | 238 mil € (2013) | ― | 1,942 mil £ (2014) |
| Major stock holders | CDC (60%) Veolia Environment (40%) | SNCF (70) CDP-IE (30) | DB(100) | Individuals (95) |
| Number of employees | 86,000 (2013) | 54,400 (2013) | 55,900 (2013) | 117,000 (2014) |
| Business contents | Public Traffic in/ out of France | Public Traffic in/ out of France | Public Traffic in/ out of England | Public Traffic in/ out of England |
| Sales amount | 6.6 bil.€(2013) | 5.1 bil.€(2013) | 4.2bil.€ (2013) | 6.7 bil. £ (2014) |
| Business profit | -130 mil.€ (2013) | 111 mil.€(2013) | 467 mil.€ (2013) | 232 mil. £(2014) |
| Main operating Lines | Metro Line 9 ( in Souel ), Metro Line 1 ( in Mumbai ), and Light Rail ( in Sydney ) | Light Rail in Gold Coast, Docklans Light Rail ( in London ), Commuter Rail ( in Boston ) | Majority of Rail Service ( in Wales ) and Over Ground Rail ( in London ) | Great Western and ScotRail ( in UK ) |
| Note | www.transdev.com/en | http://www.keolis.com/en | http://www1.deutschebahn.com/ar2013-en/ | |

Source: Data prepared by the study group based on annual report of each company

### A 3.3 Contract with operator

#### (1) Open access and concession

As for the open access, an operator formulates business plan directed to interurban railway and realizes the plan by obtaining business license from the regulator which is the possessing/management entity of railroad track. This is the business model by which free competition by multiple operators is expanded in profitability expected railway division

Meanwhile, concession focuses on the project which with difficulties of self-support accounting in the field of local and city railways. Asset is roughly divided into concession and delegation in the narrow sense depending on the risk range of asset building up/possessing. The former is the method of private operator which builds up/possesses the most of business asset and business right is given. The latter is business outsourcing method where the most of business asset is owned by the regulator and an operator which lends the asset performs operation service based on the contract.

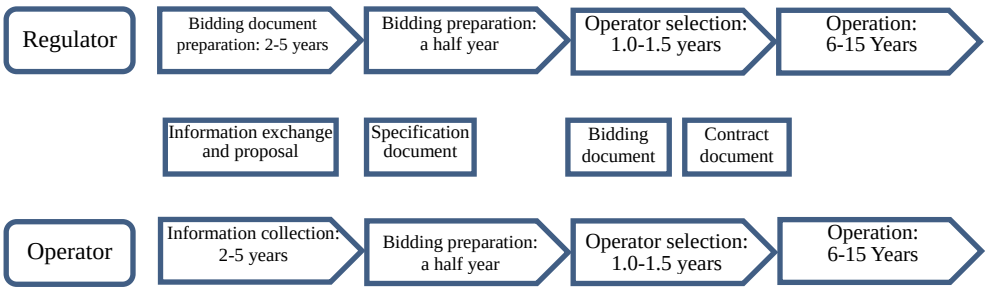
In case of Mumbai Metro Line-3, it is difficult for multiple operators to enter the business

simultaneously since the most of business asset is maintained and owned by the regulator under JICA loan and high density train operation is required. For the reason, the application of delegation in the broad sense is natural as the means to secure competitive conditions.

### (2) Selection of operator

The regulator and operator follow procedures such as bidding specification document preparation taking 2 to 5 years, bidding preparation for the degree of half year and operator selection/adjustment for the degree of 12 to 18 months normally.

At the bidding specification preparation phase, the operator performs marketing/information collection and performs proposal while exchanging information with the regulator. The regulator prepares the specifications based on information exchange and proposal. At the bidding preparation phase, the operator prepares the bidding document. And a contract document is prepared while repeating discussion at operator selection adjustment phase. For the reason, it takes 4 and half to 8 and half years before operator selection.




Source: JICA Study team

Figure A 3.1 Selection of Operator

### (3) Operator expenses

Operating expenses are integrated based on the actual data of public traffic organization in the past and operation result owned by the operator. Expense items are classified into infrastructure usage fee, labor cost, vehicle related expense, operation initial cost (power fuel cost/maintenance cost, etc.) and proper profit.

The infrastructure usage fee is said that it is the degree of 3 euro/km in case of urban railways in Europe but the railway track is often owned by the regulator at concession contract, and the fee does not incur by the cancellation with the operation cost.

The labor cost reduction in Europe is difficult even if in the case of being a new operator. Continued employment of human resources has been the premises from the view point of protecting regional jobs in France. 80-90% of management staff is replaced when the operator is changed in Germany but the number of drivers is short chronically. The most of reasons why an operator is terminated the contract is the non-attainment of service level, nonoperational train, due to unsuccessful securing of

drivers. Unions by business type are strong in Europe so reduction of wage level is difficult. The labor cost proportion in the total operation cost is said to be 60% or so.

The railway track and rolling stock maintenance management cost and power fuel cost are included in the railway operation cost. The operator shall perform inspection management on the appropriateness of maintenance management, confirm no excessive cost reduction which ignores safeness and service level, and will be the subject of penalty payment and contract termination if violated. Since the appropriateness of maintenance management is issues between the regulator and the operator, the regulator is required proper technical perception. In case of major operators, they gain the upper hand in negotiation over power companies through the bulk contract of power fuel cost together with railway lines of other area. In addition, power fuel cost is influenced depending on vehicle performance keeping and driver's skill. The regulator and operator insure against unexpected accident and trouble, usually dividing insurance cost into halves. The type and coverage of insurance are often estimated by professional insurance consultant in the same way as airlines.

Regarding to the operator's profit, 2% of O&M expense seems standard.

### (4) Current Status of Business Operation

Steps at operator replacement are as follows:

- Withdraw existing managers (approx. 10 people) of the operator from the site operation company.
- Existing operator withdraws capital from the site operation company.
- A new operator invests capital into the site operation company.
- The managers of the new operator are dispatched to the site operation company.
- If the employment is continued, the new operator concludes contract with employees.
- If the employment is not continued, the new operator recruits and hires employees.
- The managers of new operator conduct the employees.

There are business organizations owned by the regulator separated from site operation companies in France, and are many cases of owing employees and rolling stocks. In those cases, the operator dispatches a manager to the business organization of regulator. The salary of employees are paid by the operator but the recognition of changed salary payment recipient is dim from the standpoint of employees and they accept only manager was changed.

The managers perform O&M management and cost control for the work based on the business plan document approved by the regulator. In addition, the managers prepare the periodical report and discuss with the regulator about the review of service contents and the adjustment of cost burdening on contingency events.

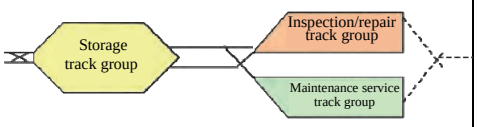
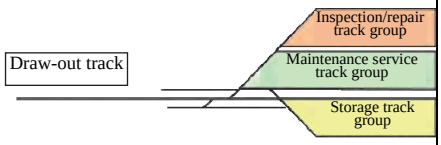
## Appendix 4 Examples of rolling stock depot/workshop

To ensure safety and maintain stability/comfort, rolling stock shall appropriately be provided with maintenance services (cleaning, inspection and repair) at rolling stock depots and workshops. Rolling stock depots perform train storage and daily inspection (hereinafter referred to as “storage services”) and monthly inspection, cleaning, non-regular repair and wheel re-profiling (hereinafter referred to as “rolling stock depot services”) while rolling stock workshops perform principally important parts inspection, general inspection, remodeling and renewal of components (hereinafter referred to as “rolling stock workshop services”).

At rolling stock depots/workshops, there are three groups of tracks: storage tracks, maintenance service tracks and inspection/repair tracks, with their layouts broadly divided into two types: in-series and in-parallel types. Table A 4.1 compares these two types of track layouts.

Generally speaking, the in-series type track layouts are preferable for their high operating efficiency, though their degree of freedom is low, as storage tracks and inspection/repair/maintenance service tracks in series arrangement require long and straight lines. For this reason, the in-series type track layout is rarely seen in urban areas due to problems related to land acquisition, in contrast to the in-parallel type track layout that is frequently seen in such areas for its high degree of freedom from the viewpoint of space saving feature.

Table A 4.1 Comparison of track layouts at rolling stock depots/workshops

| Type | In-series type | In-parallel type |
|---|---|---|
| Layout drawing |  |  |
| Merit | • Features high efficiency as shop-in/-out operations between mainlines and storage tracks seldom conflict with shunting operation between inspection/repair/maintenance service tracks.<br>• Shop-in/-out operations between mainlines and inspection/repair/maintenance service tracks feature high efficiency, as changing the driving vehicle-cab is not required. | • Allows shorter straight lines when compared with the in-series type to feature high degree of freedom for track layout designing.<br>• In-parallel arrangement of track groups puts together fields of different services in a small area to improve workability. |
| Demerit | • Requires lands to accommodate long lines.<br>• Features a low degree of freedom for track layout designing. | • Shunting operation in the yard every time uses the draw-out track, which conflicts with shop-in/-out operation to degrade working efficiency.<br>• Shunting operation every time requires changing the driving vehicle-cab to degrade working efficiency. |

Source: Study Team

To save the space of rolling stock depots and improve their efficiency, Japan has positively promoted extension of inspection periods for rolling stock and automation of maintenance services. As a result, even small rolling stock depots/workshops have established a structure to cope with large fleet sized of rolling stock. As seen with the Oji Car Inspection Depot of Tokyo Metro, complete underground rolling stock depots are constructed in the metropolitan center area where land expropriation is extremely difficult. Furthermore, as in the case of Tokyo

Rolling Stock depot/workshop, East Japan Railway Company, where some storage tracks are accommodated underground and others at the ground level, some rolling stock depots have adopted a two-story storage track arrangement. In some overseas countries as well, underground rolling stock depots are constructed underground. Below introduced are some exemplary rolling stock depots/workshops in Japan and foreign countries.

The capacity of rolling stock depot/workshop is defined by the number of storable train sets and the fleet size of assigned rolling stock, with the former representing the number of train sets to be stored at night and during light traffic hours using storage and cleaning tracks and the latter the fleet size of rolling stock belonging to respective home rolling stock depots/workshops where it is subject to inspection/maintenance services.

Table A 4.2 Kozu Rolling Stock Depot

| | |
|---|---|
| Country | Japan |
| Owner | East Japan Railway Company |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 900 cars |
| Services in implementation | Storage service, Rolling stock depot services |
| Area | Approx. 12 ha |
| No. of tracks | Repairing track: 2<br>Regular inspection track: 2<br>Car washing track: 3<br>Storage track: 19 |
| Type of track layout | In-series type |
| Overall layout |  |

Source: JICA Study team

Table A 4.3 Keiyo Rolling Stock Depot

| | |
|---|---|
| Country | Japan |
| Owner | East Japan Railway Company |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 600 cars |
| Services in implementation | Storage service, Rolling stock depot services |
| Area | Approx. 16.5 ha |
| No. of tracks | Regular inspection track: 2<br>Car washing track: 3<br>Repairing track: 1<br>Storage track: 19 |
| Type of track layout | In-series type |
| Overall layout |  |

Source: JICA Study team

Table A 4.4 Toyoda Rolling Stock Depot

| | |
|---|---|
| Country | Japan |
| Owner | East Japan Railway Company |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 750 cars |
| Services in implementation | Storage service, Rolling stock depot services |
| Area | Approx. 8 ha |
| No. of tracks | Repairing track: 2<br>Regular inspection track: 3<br>Car washing track: 3<br>Storage track: 22 |
| Type of track layout | In-parallel type |
| Overall layout |  |

Source: JICA Study team

Table A 4.5 Oji Car Inspection Depot

| | |
|---|---|
| Country | Japan |
| Owner | Tokyo Metro Corporation |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 140 cars |
| Services in implementation | Storage service, Rolling stock depot services |
| Area | Approx. 0.3 ha (ground level site area)<br>Approx. 1 ha (basement 3F) |
| No. of tracks | Daily/regular inspection track: 2<br>Storage track: 4 |
| Type of track layout | Complete underground in-parallel type (basement 3F) |
| Overall layout |  |
| Equipment/ facilities |    |

Source: JICA Study team

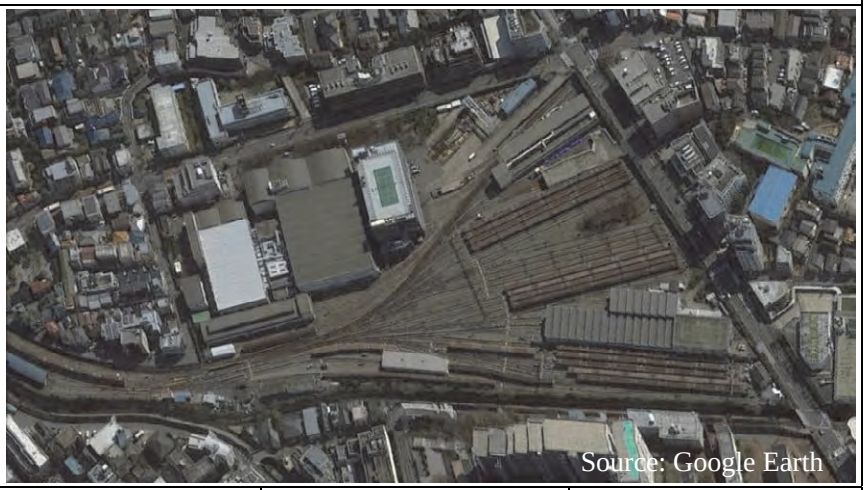
Table A 4.6 Tokyo Rolling Stock Depot/Workshop

| | |
|---|---|
| Country | Japan |
| Owner | East Japan Railway Company |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 6,000 cars (Workshop services) |
| No. of stored train sets | Approx. 418 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Services in implementation | Rolling stock depot services, Workshop services |
| Area | Approx. 26 ha |
| No. of tracks | Daily/regular inspection track: 3<br>General/important parts inspection track: 3<br>Storage track: 38 |
| Type of track layout | In-parallel type (2-story storage tracks arrangement) |
| Overall layout |  |
| Equipment/ facilities |    |

Source: Google Earth

Source: JICA Study team

Table A 4.7 Nakano Rolling Stock Depot

| | |
|---|---|
| Country | Japan |
| Owner | Tokyo Metro Corporation |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 570 cars |
| No. of stored train sets | Approx. 120 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 5 ha |
| No. of tracks | Daily/regular inspection track: 3<br>Repairing track: 2<br>Car washing track: 3<br>Maintenance service track: 2<br>Storage track: 20 |
| Type of track layout | In-parallel type |
| Overall layout |  |
| Equipment/ facilities |    |

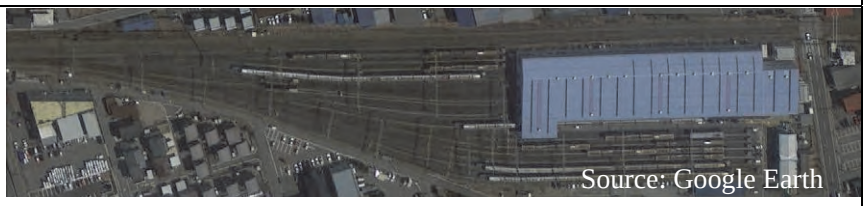
Source: JICA Study team

Table A 4.8 Rolling Stock Depot/Workshop, Tsukuba Express

| | |
|---|---|
| Country | Japan |
| Owner | Metropolitan Intercity Railway Company |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 272 cars |
| No. of stored train sets | Approx. 138 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 19 ha |
| No. of tracks | Daily/regular inspection track: 3<br>Car washing track: 2<br>Non-regular inspection track: 1<br>Maintenance service track: 1<br>General/important parts inspection track: 2<br>Storage track: 23 |
| Type of track layout | In-parallel type |
| Overall layout |  |
| Equipment/ facilities |    |

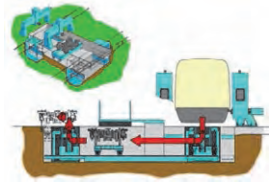
Source: JICA Study team

Table A 4.9 Yamagata Rolling Stock Depot

| | |
|---|---|
| Country | Japan |
| Owner | East Japan Railway Company |
| Category of the cars in charge | EMUs, DMUs, Shinkansen cars |
| No. of cars under assignment | Approx. 160 cars |
| Services in implementation | Storage service, Rolling stock depot services |
| Area | Approx. 3 ha |
| No. of tracks | Daily/regular inspection track: 2 (standard-gauge)<br>non-regular repair track: 1 (standard-gauge)<br>Storage track: 8 (standard-gauge)<br>Daily/regular inspection track: 2 (Narrow-gauge)<br>Storage track: 1 (Narrow-gauge)<br>Car washing track: 1 (Narrow-gauge) |
| Type of track layout | In-parallel type |
| Overall layout |  |

Source: JICA Study team

Table A 4.10 Shinkansen Rolling Stock Depot/Workshop

| | |
|---|---|
| Country | Japan |
| Owner | East Japan Railway Company |
| Category of the cars in charge | Shinkansen |
| No. of cars under assignment | Approx. 1100 cars (Workshop services) |
| No. of stored train sets | Approx. 384 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 53 ha |
| No. of tracks | Daily/regular inspection track: 6<br>Maintenance service track: 1<br>Truck exchange track: 2<br>Storage track: 24 |
| Type of track layout | In-series type |
| Overall layout |  |
| Equipment/ facilities |     |

Source: JICA Study team

Table A 4.11 LRT-1 Depot/Workshop

| | |
|---|---|
| Country | Phillippines |
| Owner | Light Rail Transit Authority (LRTA) |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 140 cars |
| No. of stored train sets | Approx. 100 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 6.5 ha |
| No. of tracks | Daily/regular inspection track: 5<br>Non-regular repair track: 2<br>Maintenance service track: 1<br>General/important parts inspection track: 3<br>Storage track: 25 |
| Type of track layout | In-parallel type |
| Overall layout |  |
| Equipment/ facilities |    |

Source: JICA Study team

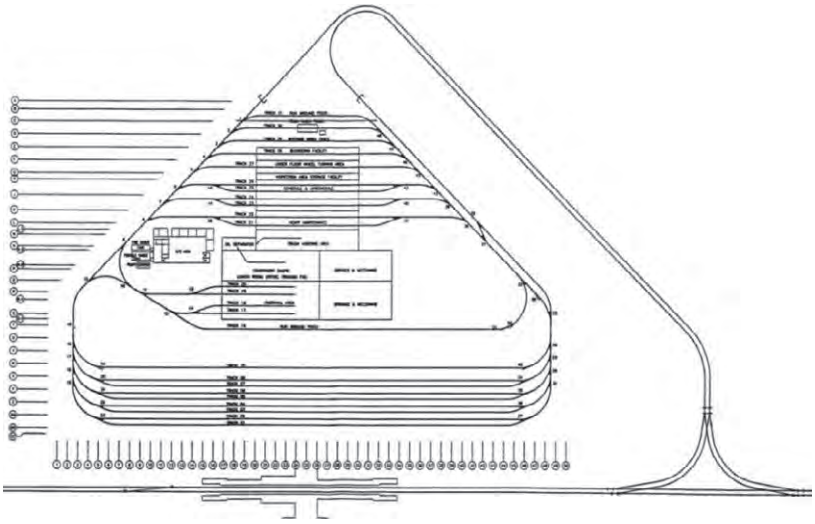
Table A 4.12 MRT-2 Depot/Workshop

| | |
|---|---|
| Country | Philippines |
| Owner | Light Rail Transit Authority (LRTA) |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 72 cars |
| No. of stored train sets | Approx. 36 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 7 ha |
| No. of tracks | Daily/regular inspection track: 4<br>Car washing track: 4<br>General/important parts inspection track: 2<br>Storage track: 9 |
| Type of track layout | In-parallel type |
| Overall layout |  |
| Equipment/ facilities |    |

Source: JICA Study team

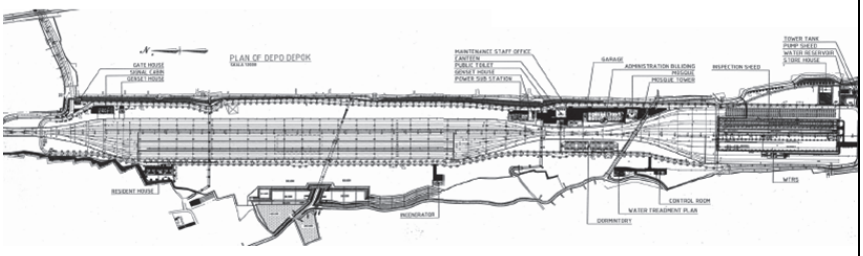
Table A 4.13 MRT-3 Depot/Workshop

| | |
|---|---|
| Country | Philippines |
| Owner | Metro Rail Transit Corporation (MRTC) |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 73 cars |
| No. of stored train sets | Approx. 36 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 16 ha |
| No. of tracks | Daily/regular inspection track: 2,<br>Non-regular repair track: 2<br>Car washing track: 2<br>General/important parts inspection track: 4<br>Storage track: 9 |
| Type of track layout | Complete underground in-parallel type<br>(floors on and above the ground level: Shopping mall) |
| Overall layout |  |

| | | | |
|---|---|---|---|
| |  | | |
| Equipment/ facilities |  |  |  |

Source: JICA Study team

Table A 4.14 Depok Rolling Stock Depot

| | |
|---|---|
| Country | Indonesia |
| Owner | PT. KERETA API INDONESIA (PERSERO) |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 230 cars |
| No. of stored train sets | Approx. 224 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services (in part) |
| Area | Approx. 26 ha |
| No. of tracks | General/important parts inspection track: 1<br>Non-regular repair track: 1<br>Daily/regular inspection track: 4<br>Storage track: 14 |
| Type of track layout | In-series type |
| Overall layout |  <br>  |
| Equipment/ facilities |    |

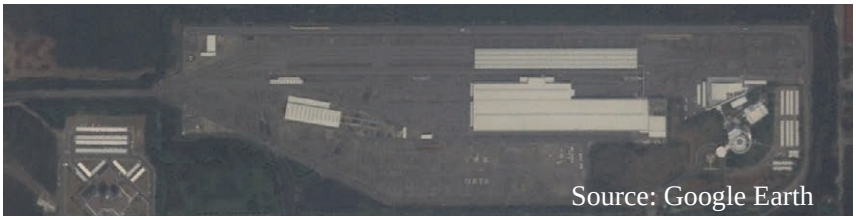
Source: JICA Study team

Table A 4.15 Manggarai Workshop

| | |
|---|---|
| Country | Indonesia |
| Owner | PT. KERETA API INDONESIA (PERSERO) |
| Category of the cars in charge | EMUs, passenger cars |
| No. of cars under assignment | Approx. 600 cars (Workshop services for EMUs only) |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 14 ha |
| Type of track layout | In-parallel type |
| Overall layout |  <br>  |
| Equipment/ facilities |    |

Source: JICA Study team

Table A 4.16 Blue Line Rolling Stock Depot/Workshop

| | |
|---|---|
| Country | Thailand |
| Owner | Bangkok Metro Public Company Limited (BMCL) |
| Category of the cars in charge | EMUs |
| No. of cars under assignment | Approx. 500 cars |
| No. of stored train sets | Approx. 450 cars |
| Services in implementation | Storage service, Rolling stock depot services, Workshop services |
| Area | Approx. 35 ha |
| No. of tracks | Inspection track : 5<br>Daily/regular inspection track : 3<br>Storage tracks : 30 |
| Type of track layout | In-parallel type |
| Overall layout |  |
| Equipment/ facilities |    |

Source: JICA Study team

# Appendix 5 Calculation of the Costs of Management, Upkeep and control

## A 5.1 Yardstick Method

### A 5.1.1 Outline

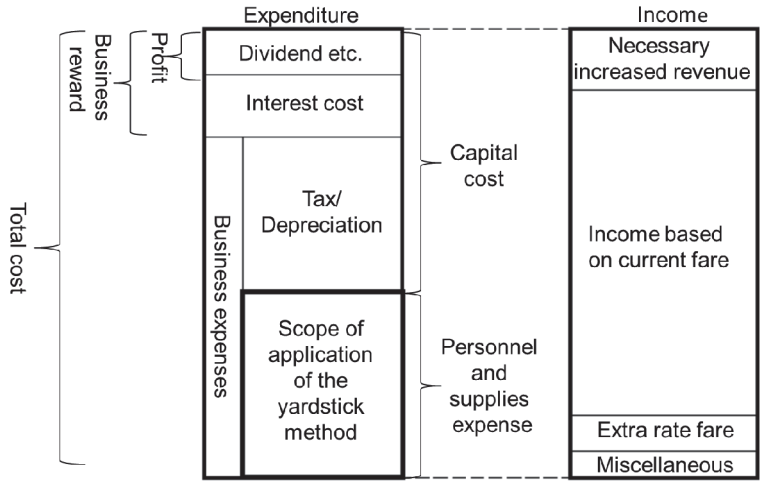
In Japan, the upper limit of railway fares is regulated by the Railway Business Law and determined by the aggregate raw cost required for railway management, which is the raw cost with profit added in.

We divide the personnel cost and expenses in the aggregate raw cost into five items (those for tracks, electric circuits, rolling stock, train operation and station duties). For each of these, a regression equation is used to obtain the yardstick unit cost. In calculating the yardstick cost for a railway operator, we multiply the yardstick unit cost by the quantity of equipment/facilities belonging to the railway.

The regression equation to calculate the yardstick unit cost is determined based on the actual unit cost for each of the railway operator groups featuring similar management conditions and released every year by the Ministry of Land, Infrastructure, Transport and Tourism. In Japan, there are three railway operator groups, each encompassing six Japan Passenger Railway (JR) operators, 15 large-scale private railway operators and 10 subway operators, respectively.

The yardstick unit cost derived from the regression equation represents the average value in each operator group. Fare revision is approved only when the aggregate raw cost calculated based on the yardstick unit cost exceeds the current revenue levels. Otherwise, a fare revision is not approved. Therefore, railway operators eyeing a fare revision are encouraged to improve management efficiency.

The regression equation to estimate the yardstick unit cost can also be regarded an average cost of the railway operator groups to maintain and operate. Thus, this unit cost can be applied to the calculation of the management, upkeep and control costs for the Mumbai Metro Line 3. See Figure A 5.1 for how the yardstick method can be applied to MML3 in this case.




Source: Ministry of Land, Infrastructure, Transport and Tourism

Figure A 5.1 Scope of Application of Yardstick Method

### A 5.1.2 Yardstick Unit Cost and Calculated Unit Cost

#### (1) Volume of Transport and Quantity of Equipment/Facilities

Table A 5.1 summarizes the volume of transport by subway operators in Japan and MM3 in India and the quantity of equipment/facilities belonging to each (MM3 figures refer to 2016 figures in DPR). The total length of tracks connotes the length of mainlines (counted twice for double-track sections) along with the length of tracks for depots and midway stations. We determined the total length of contact lines, feeder lines, transmission lines and distribution lines on the assumption that the ratios of length to tracks in India are equivalent to those in Japan. To calculate the passenger-kilometer traveled, we calculated the average trip length (12.24 km) based on the ratio of trip length described in DPR, and multiplied it by the number of passengers carried.

According to this table, total passenger-kilometers by MM3 is quite large when compared with the length of operating kilometers. This implies that average trip length is fairly large. Furthermore, a comparison of the number of transported passengers and fleet size of the rolling stock owned by MM3 with corresponding figures in Japan implies that MM3 will have an efficient system, in that MM3 will transport two to three times more passengers than comparable Japanese subways.

#### (2) Regression Equation

The yardstick unit cost for subway operators specified by the Ministry of Land, Infrastructure, Transport and Tourism is calculated by the following regression equation.

- Cost of Tracks: Expenses for upkeep, maintenance and work control for tracks and road beds

$y = 21{,}987.306\ x_1 - 102{,}447.712$

Where

y: Yardstick unit cost per 1 km track length (1,000 yen)

$x_1$: Rolling stock density: natural logarithm of EMU-kilometer (1,000km)/total length of tracks (km)

- Cost of Electric Circuits: Expenses for upkeep, maintenance and work control of contact lines and signal equipment/facilities, etc.

  $y = 6.497\ x_1 + 116.479 x_2 - 1{,}098.251$

  Where

  y: Yardstick unit cost per 1 km electric wire length (1,000 yen)

  $x_1$: EMU density: EMU-kilometer (1,000 km)/total length of contact lines (km)

  $x_2$: Ratio of contact lines (%): Total length of contact lines (km)/total length of electric wires (km)

- Cost of Rolling Stock: Expenses for providing repair and maintenance services and work control for rolling stock

  $y = 3.686\ x_1 + 3{,}570.208$

  Where

  y: Yardstick unit cost per unit of rolling stock (1,000 yen)

  $x_1$: Volume of transported passengers per unit of rolling stock

  Volume of transported passengers (1,000 persons)/number of units of rolling stock (cars)

- Cost of Train Operation: Expenses required for train operation and work control excluding power cost

  $y = -166.413\ x_1 + 184{,}868.997\ x_2 - 805{,}993.823$ (1,000 yen)

  Where

  y: Yardstick unit cost per 1km electric wire length

  $x_1$: Ratio of one-man operation (%): One-man operation-kilometer (km)/operating kilometers (km)

  $x_2$: Train density: Natural logarithm of passenger train-kilometer (1,000 km)/operating kilometers (km)

- Cost of Station Duties: Expenses required for upkeep of stations and issuing tickets (1,000 yen)

  $y = 136{,}707.139\ x_1 - 1{,}005{,}959.507$

  Where

  y: Yardstick unit cost per station

  $x_1$: Volume of boarding passengers per station: Natural logarithm of volume of transported passengers (1,000 persons)/number of stations

Table A 5.1 Volume of transport and equipment/facilities owned by subway operators

| Subway operator | Operating kilometer | Passenger day-kilometer | Volume of transported passengers | Transported passenger-kilometer | Passenger train-kilometer | Passenger car-kilometer | Passenger EMU-kilometer | Total length of tracks | Total length of contact lines | Total length of feeder lines | Total length of power transmission lines | Total length of power distribution lines | Number of units of rolling stock | Number of stations | One-man operation-kilometer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | km | km | 1,000 persons | 1,000 passenger-kilometers | 1,000 kilometers | 1,000 kilometers | 1,000 kilometers | km | km | km | km | km | Cars | Stations | km |
| Tokyo Metro | 195.1 | 71,212 | 2,348,913 | 18,905,348 | 34,250 | 283,871 | 283,871 | 410.3 | 567.6 | 263.8 | 335.4 | 1,794.0 | 2,719 | 179 | 62.7 |
| Sapporo | 48.0 | 17,521 | 208,403 | 1,237,858 | 5,705 | 33,485 | 33,485 | 96.0 | 116.4 | 67.6 | 159.0 | 346.2 | 368 | 49 | 20.1 |
| Sendai | 14.8 | 5,402 | 54,363 | 294,006 | 1,729 | 6,916 | 6,916 | 31.1 | 39.2 | 17.9 | 0.0 | 113.3 | 84 | 17 | 14.8 |
| Tokyo | 109.0 | 39,787 | 866,412 | 6,085,613 | 15,310 | 117,309 | 117,309 | 228.1 | 310.7 | 300.0 | 414.6 | 654.0 | 1,110 | 106 | 67.2 |
| Yokohama | 53.4 | 19,491 | 216,452 | 1,672,495 | 6,038 | 33,378 | 33,378 | 107.7 | 120.8 | 66.5 | 221.4 | 364.1 | 282 | 42 | 53.4 |
| Nagoya | 93.3 | 34,055 | 433,290 | 2,766,760 | 11,877 | 69,062 | 69,062 | 191.0 | 234.0 | 84.5 | 18.9 | 609.4 | 788 | 100 | 19.9 |
| Kyoto | 31.2 | 11,388 | 123,849 | 663,264 | 3,565 | 20,758 | 20,758 | 64.0 | 79.3 | 40.8 | 68.3 | 210.5 | 222 | 32 | 17.5 |
| Osaka | 129.9 | 47,414 | 905,829 | 4,920,201 | 17,585 | 114,587 | 114,587 | 266.0 | 324.4 | 493.6 | 161.4 | 1,151.3 | 1,280 | 123 | 26.9 |
| Kobe | 30.6 | 11,169 | 104,455 | 947,141 | 3,464 | 19,453 | 19,453 | 61.6 | 87.8 | 141.6 | 84.5 | 216.3 | 208 | 26 | 7.9 |
| Fukuoka | 29.8 | 10,877 | 137,246 | 735,760 | 3,537 | 18,637 | 18,637 | 64.8 | 129.3 | 91.2 | 65.4 | 212.8 | 212 | 36 | 29.8 |
| MM3 (2016) | 33.5 | 12,230 | 367,190 | 4,493,533 | 4,411 | 26,468 | 26,468 | 78.9 | 106.1 | 82.8 | 82.8 | 279.8 | 210 | 27 | 33.5 |

Source: Japanese statistics based on the Annual Report on Railway Statistics, 2012. MM3 figures are assumed by the study team.

(3) Calculation of Yardstick Unit Cost

The following tables summarize the yardstick unit costs (costs of tracks, electric circuits, rolling stock, train operation and station duties) of different subway operators calculated based on the volume of transport and quantity of equipment/facilities by the regression equations (where actual unit costs are quoted for reference regarding subway operators in Japan).

Table A 5.2 Yardstick Unit Cost of Tracks

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | MM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total length of tracks (km) | 410.3 | 96.0 | 31.1 | 228.1 | 107.7 | 191.0 | 64.0 | 266.0 | 61.6 | 64.8 | 78.9 |
| EMU-kilometer (1,000km) | 283,871 | 33,485 | 6,916 | 117,309 | 33,378 | 69,062 | 20,758 | 114,587 | 19,453 | 18,637 | 26,468 |
| Rolling stock density (EMU-kilometer/ total length of tracks) | 691.862 | 348.802 | 222.379 | 514.288 | 309.916 | 361.581 | 324.344 | 430.778 | 315.795 | 287.608 | 335.495 |
| Natural logarithm of rolling stock density | 6.539 | 5.855 | 5.404 | 6.243 | 5.736 | 5.890 | 5.782 | 6.066 | 5.755 | 5.662 | 5.816 |
| Actual unit cost (1,000 yen/ kilometer) | 46,516 | 24,960 | 27,748 | 41,528 | 15,666 | 29,240 | 23,163 | 25,633 | 15,799 | 27,212 | |
| Calculated unit cost (1,000 yen/ kilometer) | 41,327 | 26,288 | 16,372 | 34,819 | 23,671 | 27,058 | 24,683 | 30,927 | 24,089 | 22,044 | 25,430 |

Source: Study Team

Table A 5.3 Yardstick Unit Cost of Electric Circuits

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | MM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EMU-kilometer (1,000km) | 283,871 | 33,485 | 6,916 | 117,309 | 33,378 | 69,062 | 20,758 | 114,587 | 19,453 | 18,637 | 26,468 |
| Total length of contact lines (km) | 567.6 | 116.4 | 39.2 | 310.7 | 120.8 | 234.0 | 79.3 | 324.4 | 87.8 | 129.3 | 106.1 |
| Total length of feeder lines | 263.8 | 67.6 | 17.9 | 300.0 | 66.5 | 84.5 | 40.8 | 493.6 | 141.6 | 91.2 | 82.8 |
| Total length of power transmission lines | 335.4 | 159.0 | 0.0 | 414.6 | 221.4 | 18.9 | 68.3 | 161.4 | 84.5 | 65.4 | 82.8 |
| Total length of power distribution lines | 1,794.0 | 346.2 | 113.3 | 654.0 | 364.1 | 609.4 | 210.5 | 1,151.3 | 216.3 | 212.8 | 279.8 |
| EMU density | 500.125 | 287.672 | 176.429 | 377.564 | 276.308 | 295.137 | 261.765 | 353.227 | 221.560 | 144.138 | 249.540 |
| Ratio of contact lines | 19.170 | 16.889 | 23.005 | 18.502 | 15.631 | 24.715 | 19.880 | 15.225 | 16.560 | 25.927 | 19.230 |
| Actual unit cost (1,000 yen/ Electric wire kilometer) | 4,678 | 2,522 | 4,336 | 3,865 | 1,536 | 2,630 | 3,828 | 3,255 | 2,468 | 3,076 | |
| Calculated yardstick unit cost (1,000 yen/electric wire kilometer) | 4,384 | 2,738 | 2,728 | 3,510 | 2,518 | 3,698 | 2,918 | 2,970 | 2,270 | 2,858 | 2,763 |

Source: Study Team

Table A 5.4 Yardstick Unit Cost of Rolling Stock

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | MM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of transported passengers (1,000 passengers) | 2,348,913 | 208,403 | 54,363 | 866,412 | 216,452 | 433,290 | 123,849 | 905,829 | 104,455 | 137,246 | 367,190 |
| Number of rolling stock (cars) | 2,719 | 368 | 84 | 1,110 | 282 | 788 | 222 | 1,280 | 208 | 212 | 210 |
| Number transported passengers (1,000 persons/ car) | 863.889 | 566.313 | 647.179 | 780.551 | 767.560 | 549.860 | 557.878 | 707.679 | 502.188 | 647.387 | 1,748.524 |
| Actual unit cost (1,000 yen/car) | 3,382 | 5,955 | 6,827 | 7,919 | 4,436 | 5,413 | 5,622 | 6,824 | 6,456 | 6,583 | |
| Calculated yardstick unit cost (1,000 yen/car) | 6,755 | 5,658 | 5,956 | 6,447 | 6,399 | 5,597 | 5,627 | 6,179 | 5,421 | 5,956 | 10,015 |

Source: Study Team

Table A 5.5 Yardstick Unit Cost of Train Operation

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | MM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| One-man operation-kilometer (km) | 62.7 | 20.1 | 14.8 | 67.2 | 53.4 | 19.9 | 17.5 | 26.9 | 7.9 | 29.8 | 33.5 |
| Operating kilometer | 195.1 | 48.0 | 14.8 | 109.0 | 53.4 | 93.3 | 31.2 | 129.9 | 30.6 | 29.8 | 33.5 |
| Passenger train-kilometer (1,000 km) | 34,250 | 5,705 | 1,729 | 15,310 | 6,038 | 11,877 | 3,565 | 17,585 | 3,464 | 3,537 | 4,411 |
| One-man operation kilometer (%) | 32.137 | 41.875 | 100.000 | 61.651 | 100.000 | 21.329 | 56.090 | 20.708 | 25.817 | 100.000 | 100.000 |
| Train density (logarithm) | 5.168 | 4.778 | 4.761 | 4.945 | 4.728 | 4.847 | 4.739 | 4.908 | 4.729 | 4.777 | 4.880 |
| Actual unit cost (1,000 yen/ operating kilometer) | 160,402 | 82,434 | 56,115 | 101,963 | 50,858 | 80,374 | 61,536 | 97,794 | 81,917 | 76,748 | |
| Calculated yardstick unit cost (1,000 yen/ operating kilometer) | 144,061 | 70,342 | 57,526 | 97,924 | 51,425 | 86,517 | 60,766 | 97,897 | 63,955 | 60,484 | 79,526 |

Source: Study Team

Table A 5.6 Yardstick Unit Cost of Station Duties

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | MM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of transported passengers (1,000 persons) | 2,348,913 | 208,403 | 54,363 | 866,412 | 216,452 | 433,290 | 123,849 | 905,829 | 104,455 | 137,246 | 367,190 |
| Number of stations | 179 | 49 | 17 | 106 | 42 | 100 | 32 | 123 | 26 | 36 | 27 |
| Logarithms (ln) of volume boarding passengers (1,000 persons/ station) | 9.482 | 8.355 | 8.070 | 9.009 | 8.547 | 8.374 | 8.261 | 8.904 | 8.298 | 8.246 | 9.518 |
| Actual unit cost (1,000 yen/station) | 271,555 | 113,572 | 118,806 | 229,671 | 134,473 | 142,466 | 124,190 | 218,704 | 124,242 | 109,772 | |
| Calculated yardstick unit cost (1,000 yen/station) | 290,298 | 136,229 | 97,267 | 225,635 | 162,476 | 138,826 | 123,378 | 211,281 | 128,436 | 121,328 | 295,219 |

Source: Study Team

(4) Total of the Yardstick Costs

Table A 5.7 summarizes yardstick costs obtained from the quantity of equipment/facilities and yardstick unit costs, where actual costs are quoted for reference for subway operators in Japan.

Table A 5.7 Sum of the Yardstick Costs

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | MM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity of Equipment/Facilities | | | | | | | | | | | |
| Total length of tracks (km) | 410.3 | 96.0 | 31.1 | 228.1 | 107.7 | 191.0 | 64.0 | 266.0 | 61.6 | 64.8 | 78.9 |
| Total length of electric wires (km) | 2,960.8 | 689.2 | 170.4 | 1,679.3 | 772.8 | 946.8 | 398.9 | 2,130.7 | 530.2 | 498.7 | 551.6 |
| Number of units of rolling stock (car) | 2,719 | 368 | 84 | 1,110 | 282 | 788 | 222 | 1,280 | 208 | 212 | 210 |
| Operating kilometer (km) | 195.1 | 48.0 | 14.8 | 109.0 | 53.4 | 93.3 | 31.2 | 129.9 | 30.6 | 29.8 | 33.5 |
| No. of stations | 179 | 49 | 17 | 106 | 42 | 100 | 32 | 123 | 26 | 36 | 27 |
| Yardstick unit cost (1,000 yen) | | | | | | | | | | | |
| Cost of tracks per kilometer | 41,327 | 26,288 | 16,372 | 34,819 | 23,671 | 27,058 | 24,683 | 30,927 | 24,089 | 22,044 | 25,430 |
| Cost of electric circuits per kilometer | 4,384 | 2,738 | 2,728 | 3,510 | 2,518 | 3,698 | 2,918 | 2,970 | 2,270 | 2,858 | 2,763 |
| Cost of rolling stock per car | 6,755 | 5,658 | 5,956 | 6,447 | 6,399 | 5,597 | 5,627 | 6,179 | 5,421 | 5,956 | 10,015 |

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | MM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cost of train operation per system kilometer | 144,061 | 70,342 | 57,526 | 97,924 | 51,425 | 86,517 | 60,766 | 97,897 | 63,955 | 60,484 | 79,526 |
| Cost of station duties per station | 290,298 | 136,229 | 97,267 | 225,635 | 162,476 | 138,826 | 123,378 | 211,281 | 128,436 | 121,328 | 295,219 |
| Calculated unit cost (million yen) | | | | | | | | | | | |
| Cost of tracks | 16,957 | 2,524 | 509 | 7,942 | 2,549 | 5,168 | 1,580 | 8,227 | 1,484 | 1,428 | 2,006 |
| Cost of electric circuits | 12,980 | 1,887 | 465 | 5,894 | 1,946 | 3,501 | 1,164 | 6,328 | 1,204 | 1,425 | 1,524 |
| Cost of rolling stock | 18,365 | 2,082 | 500 | 7,157 | 1,805 | 4,410 | 1,249 | 7,909 | 1,128 | 1,263 | 2,103 |
| Cost of train operation | 28,106 | 3,376 | 851 | 10,674 | 2,746 | 8,072 | 1,896 | 12,717 | 1,957 | 1,802 | 2,665 |
| Cost of station duties | 51,963 | 6,675 | 1,654 | 23,917 | 6,824 | 13,883 | 3,948 | 25,988 | 3,339 | 4,368 | 7,971 |
| Total | 128,372 | 16,544 | 3,979 | 55,584 | 15,870 | 35,034 | 9,837 | 61,168 | 9,112 | 10,287 | 16,269 |
| Actual amount | 131,180 | 14,853 | 4,538 | 59,213 | 12,275 | 32,482 | 9,810 | 60,220 | 8,999 | 10,389 | |

Source: Study Team

## A 5.2 Comparison between Japan and India

### A 5.2.1 Personnel Cost and Expenses

#### (1) Ratio of Personnel Cost in Japan

Table A 5.8 summarizes division-wide personnel costs and expenses for Japanese subway operators, which have been sourced from various income and expense statements in the Annual Report on Railway Statistics. The average ratio of train operation and station duty costs tends to be larger than that for tracks and rolling stock.

Table A 5.8 Personnel Costs and Expenses

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cost of tracks (million yen) | | | | | | | | | | | |
| Personnel cost | 3,476 | 279 | 225 | 3,023 | 784 | 2,069 | 325 | 3,490 | 587 | 262 | |
| Expenses | 13,093 | 2,087 | 620 | 6,158 | 858 | 3,201 | 1,116 | 2,980 | 322 | 1,457 | |
| Ratio of personnel cost | 21% | 12% | 27% | 33% | 48% | 39% | 23% | 54% | 65% | 15% | 34% |
| Cost of electric circuits (million yen) | | | | | | | | | | | |
| Personnel cost | 5,680 | 183 | 264 | 3,313 | 777 | 1,654 | 601 | 4,347 | 792 | 486 | |
| Expenses | 5,897 | 1,535 | 456 | 2,903 | 371 | 672 | 864 | 2,051 | 431 | 983 | |
| Ratio of personnel cost | 49% | 11% | 37% | 53% | 68% | 71% | 41% | 68% | 65% | 33% | 50% |
| Cost of rolling stock (million yen) | | | | | | | | | | | |
| Personnel cost | 8,599 | 786 | 194 | 3,160 | 343 | 2,860 | 544 | 5,219 | 513 | 371 | |
| Expenses | 7,462 | 1,320 | 364 | 5,315 | 882 | 1,125 | 655 | 3,003 | 738 | 994 | |
| Ratio of personnel cost | 54% | 37% | 35% | 37% | 28% | 72% | 45% | 63% | 41% | 27% | 44% |
| Cost of train operation (million yen) | | | | | | | | | | | |

| | Tokyo Metro | Sapporo | Sendai | Tokyo | Yokohama | Nagoya | Kyoto | Osaka | Kobe | Fukuoka | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Personnel cost | 26,593 | 3,301 | 724 | 9,722 | 2,469 | 6,382 | 1,645 | 11,104 | 2,090 | 1,459 | |
| Expenses | 676 | 945 | 201 | 4,179 | 1,258 | 3,467 | 544 | 3,766 | 584 | 796 | |
| Ratio of personnel cost | 98% | 78% | 78% | 70% | 66% | 65% | 75% | 75% | 78% | 65% | 75% |
| Cost of station duties (million yen) | | | | | | | | | | | |
| Personnel cost | 28,054 | 208 | 1,179 | 11,347 | 2,902 | 8,930 | 1,651 | 18,034 | 1,150 | 1,797 | |
| Expenses | 18,023 | 3,843 | 607 | 11,753 | 2,060 | 4,007 | 1,869 | 6,035 | 1,532 | 1,240 | |
| Ratio of personnel cost | 61% | 5% | 66% | 49% | 58% | 69% | 47% | 75% | 43% | 59% | 53% |

Source: Study Team

(2) Costs of Management, Upkeep and Control of MM3 (Hypothetical Case)

A hypothetical case is discussed below in which MM3 is assumed to operate in Japan. Table A 5.9 below estimates the MM3's assumed yearly division-wide costs for management, upkeep and control (shown in the bottom right column, Table A 5.7), and divides them into personnel cost and expenses at the ratios given in Table A 5.8.

Table A 5.9 MM3's Costs for Management, Upkeep and Control

(Hypothetical Case Where MM3 Operates in Japan)

| Item | Costs of management, upkeep and control (million yen/year) | Ratio of personnel cost (%) | Personnel cost (million Rs) | Expenses (million Rs) | Total (million Rs) |
|---|---|---|---|---|---|
| Cost of tracks | 2,006 | 34 | 454.7 | 900.4 | 1,355.1 |
| Cost of electric circuits | 1,524 | 50 | 510.0 | 519.7 | 1,029.7 |
| Cost of rolling stock | 2,103 | 44 | 625.0 | 796.1 | 1,421.1 |
| Cost of train operation | 2,665 | 75 | 1,345.6 | 455.4 | 1,801.0 |
| Cost of station duties | 7,971 | 53 | 2,868.0 | 2,517.3 | 5,385.2 |
| Total | 16,269 | | 5,803.3 | 5,188.8 | 10,992.2 |

Note 1) Exclusive of power cost

Note 2) 1 Rs = 1.48 yen = 0.019 US$ (as of December 2011)

Source: Study Team

(3) Costs of Management, Upkeep and Control in DPR

DPR divides the costs of management, upkeep and control into personnel cost, upkeep and control cost and power cost. Furthermore, DPR states that the personnel cost required for 1,508 employees (or 45 persons/km) amounts to 1,505.75 million Rs in 2016-2017. While dividing the costs of upkeep and control into those for structures, stations, depots, tracks, rolling stock, power equipment/facilities and signal/telecommunication equipment/facilities, DPR considers 0.5-2.0% of construction costs for these equipment/facilities (as of 2011) as the costs of management, upkeep and control per year. Therefore, the cost for 2016-17 is estimated at 1,333.45 million Rs by applying an annual price increase of 5%. DPR also estimates a power cost of 1,567.80 million Rs in 2016-2017. When these costs are summed up, the cost of management, upkeep and control amounts to 4,407.00 million Rs in 2016-2017.

The total of the personnel and upkeep/control costs mentioned in DPR reaches 2,839 million Rs, which is equivalent to about one quarter of the total of personnel costs and expenses in Table A 5.9.

Although the difference between the two totals looks quite large, it will become smaller in the future, if rapid economic growth and price rises continue in India for the next 20 years. In other words, the difference is not significant when considering the possibilities of rapid growth by the Indian economy which will close the gap with Japan's economy over the next two decades.

The ratio of personnel to non-personnel cost (as described in DPR) are nearly the same, although the ratio of the former is slightly larger, which is similar to tendencies observed in Japan. Investment into new equipment/facilities in India requires procurement of materials/machines at internationally competitive costs from foreign countries, which reduces the ratio of personnel cost in the relevant project. On the other hand, most of the materials/machines required for routine management, upkeep and control can be locally procured in India. In this context, it may sound reasonable to presume that their prices reflect the personnel cost in the country. However, it is likely that the ratio of the personnel cost will rise in the future, as DPR assumes increases of 9% in personnel cost and 5% in non-personnel cost.

### A 5.2.2 Division-wise Costs of Management, Upkeep and Control Used in This Study

#### (1) Setting of the Costs of Management, Upkeep and Control

In this study, we conducted a financial analysis for outsourcing part of the divisional services to the private sector, with direct management by the government set as the basis of MM3 operation. This requires setting reasonable expenses for different divisions. In setting the total amount of the costs of management, upkeep and control, there are two different variants – with one presented in Table A 5.9 and the other in DPR. However, the former variant represents the expenses when MM3 is managed in Japan, which seems to contain significant discrepancies against the actual situation. The latter variant represents a method of calculation generally used in India, though not all expenses are accounted for. Therefore, we have adopted the costs stated in the DPR to calculate the total of the costs of management, upkeep and control.

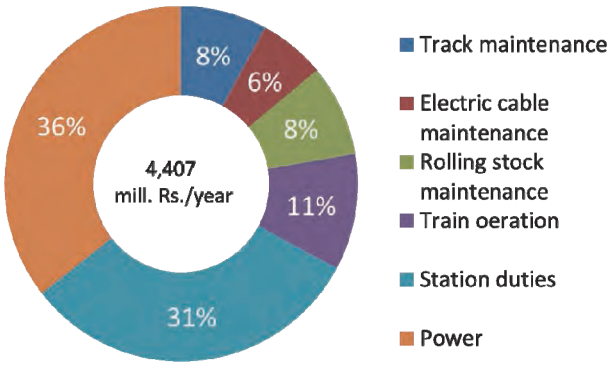
It is noteworthy that DPR does not separate different division-wide expenses. Although we have adopted total personnel/power costs and expenses in DPR, we have also separated personnel costs and expenses for tracks, electric circuits, rolling stock, train operation and station duties as per the ratios provided in Table A 5.10.

Table A 5.10 Division-wide Personnel Costs, Expenses and Power Costs Used in the Study

| Division | Personnel cost (million Rs) | Expenses (million Rs) | Sub total (million Rs) | Power cost (million Rs) | Grand total (million Rs) |
|---|---|---|---|---|---|
| Cost of tracks | 118.0 | 231.4 | 349.4 | | 349.4 |
| Cost of electric circuits | 132.3 | 133.6 | 265.9 | | 265.9 |
| Cost of rolling stock | 162.2 | 204.6 | 366.7 | | 366.7 |
| Cost of train operation | 349.1 | 117.0 | 466.2 | | 466.2 |
| Cost of station duties | 646.9 | 1,391.0 | 1,391.0 | | 1,391.0 |
| Total | 1,333.5 | 2,839.2 | 2,839.2 | 1,567.8 | 4,407.0 |

Source: Study Team

See Figure A 5.2 for division-wise costs of management, upkeep and control.




Source: JICA Study team

Figure A 5.2 Departmental costs of operation and maintenance

# Appendix 6 Improvement of the Convenience of Urban Railways

## A 6.1 Train Operations

### A 6.1.1 Urban Railways

#### (1) Railway Characteristics

In urban railways, 10-car trainsets can run at minimum two-minute intervals during peak hours to transport 75,000 passengers per hour, assuming the maximum load on a train is 2,500 passengers per train. Under this situation, scheduled speed is normally limited to approximately 30 to 40 km/h. Speed is not governed by maximum operating speed, but acceleration/deceleration performance of trains due to the relatively short distances between stations.

Commuter transport is one of the most important challenges for urban railways. High volumes of commuters travel to railway stations within a short period, making one-way trips to the city center every morning and repeating this trip in the reverse direction every evening. Therefore, railways develop equal-interval train operation diagrams to manage simplified transport on double-tracked lines. Single-track operation during accidents is possible, although capacity drops substantially due to overflows at stations. .

#### (2) Land Use and Feeder Transport

Railways do not provide door-to-door transport. Therefore, passengers are concerned about the walking distance to the nearest station, convenience of transfer and difference in travel time between different transport systems/facilities. In determining the location of a station, railways consider land use plans within surrounding areas very important.

Typical walking distance from stations at the city center to office shall ideally be 300-500 m or less. From suburban stations to homes is ideally 1,000 m or less. However, there is also a view that railways shall extend services over the entire metropolitan zone to take advantage of their high speed features. From this point of view, railways often distribute stations spaced several kilometers apart in the suburbs, then run buses and provide feeder transport services between station, in addition to providing open car/bicycle parking lots around stations and other measures for the convenience of inhabitants.

As lands within the station walk catchment area have high value, it is desirable to ban trunk roads within this area, as trunk roads would occupy land and generate noise and pollution that would be incompatible with nearby land uses. A 10-minute walking catchment represents a walking radius of about 800 m.

### A 6.1.2 Safe and Stable Transport

#### (1) Guarantee of Safety

Although rail operators are watchful to prevent large-scale accidents, small disturbances, including short train delays, are not counted as accidents and not filed/recorded. However, even small incidents are often caused by failure of railway equipment or negligence of staff. To improve safety, it is proposed to file even small incidents as accidents and to identify and trace the root causes.

To minimize human errors, it is effective to test responsible staff on their understanding of relevant manuals. This will raise their morale. Furthermore, filing of test results will provide basic data to identify ways to improve education methods.

To improve the benefits of education and training, it is important to provide repeat training of basic procedures and to introduce and explain related accidents. On-the-spot education/training is also effective. This will make staff charged with driving the train familiar with necessary actions to be taken during an accident. To respond to mechanical failures, it is also possible to build a simulation device using out-of-service machines and systems for further training.

The purpose of filing minor operating incidents as formal accidents is to encourage responsible staff to improve their capabilities in order to prevent repeat incidents. Note, this is totally different from their undertaking of responsibilities during accidents.

As urban railways are equipped with high-level security equipment/facilities and feature simple train operation modes, the number of accidents occurring is lower than that of other railways; however they are not completely free from accidents. Table A 6.1 lists five large-scale urban railway accidents occurring after 2000. It is notable that three of these were caused by human error. Of the other two, the London Subway accident was a result of terrorism, while the Hibiya Line accident was due to a flaw in hardware design.

Table A 6.1 Large-Scale Urban Railway Accidents

| Accident | Cause | Remarks |
|---|---|---|
| Train Collision in Bangkok (2004, no deaths) | When a train was standing in a third-rail dead section on a down-gradient, the driver unintentionally released the brake, causing the train to overrun toward the downstream station and collide with the idling train at that station. | The direct cause was driver error. It is desirable to verify, however, whether there was potentially a better location to install the third-rail dead section where electric power can be supplied. |
| Train Collision | Automatic Train Protection (ATP) | The impedance bond was replaced |

| Accident | Cause | Remarks |
|---|---|---|
| Washington Metro (2009, nine deaths) | did not function properly, as an impedance bond in the signal track circuit had been replaced with an incompatible one made by a manufacturer other than the original supplier. | five days before the accident. As a result, the ATP did not function properly through this section. No drivers operating through this section reported any abnormality to the train dispatcher. |
| Train Overturn in Paris Metro (2000, no deaths) | When the Automatic Train Operation (ATO) failed, the driver, inexperienced in manual operation, was too slow in decelerating the train through a sharp curve. | ATO was not equipped to alert the driver of excessive speeds along a sharp curve. The driver had little experience in manual operation. |
| Simultaneous Bombing of Three Locations London Subway (2005, 56 deaths) | Suicide bombing by terrorists on the trains. | Fortunately, the tunnels did not collapse. |
| Train Collision Hibiya Line, Tokyo (2000, five deaths) | A wheel-climb derailment occurred due to compounding factors when the train was running at low speed on a sharp curve. | The cause was a mechanical problem related to both tracks and rolling stock.[52] |

Source: KISS-Rail (Keys to implement successfully sustainable urban railways) JARTS

### (2) Punctual Operation

A selling point of urban railways is to carry passengers to their destinations on-time without impacts from vehicle congestion. Riders plan their trips assuming on-time and punctual rail service. If delays occur, riders will be delayed and inconvenienced, providing negative publicity for the operator.

When incidents occur, riders complain when insufficient information is provided about the situation and the status of recovery. This implies that passengers be provided with up-to-date, real-time information through the public address system or information displays at stations and on trains.

Punctual train operation shall be ingrained in staff charge with dealing with routine minor delays. Train dispatchers shall inquire with train drivers and operating station staff of even small train delays, which will further ingrain the goal of punctual train operation for frontline staff.

Except for mistakes by employees, most train delays are caused by rolling stock or signal system components. Trains delays at low-speed operation may be due to weak points on the tracks. To prevent component failures, it is necessary to adopt proven,

[52] Teito Rapid Transit Authority's Hibiya Line Derailment, Journal of Derailment Research Vol.1.1 No2,2006

simple-structured and trouble-free components that are well maintenance. Spare components and units should be provided and available. In case trouble occurs, it is effective to switch systems over to backup redundant systems without delay to prevent large-scale train delays.

When a train operation diagram has fallen into disorder, train operating staff shall make efforts to restore normal operations. What shall be noted in this situation is that trains shall be run at equal intervals, as unequal headways between trains will cause chaotic and dangerous situations at stations when passengers will swarm trains at certain stations and try to push their way on.

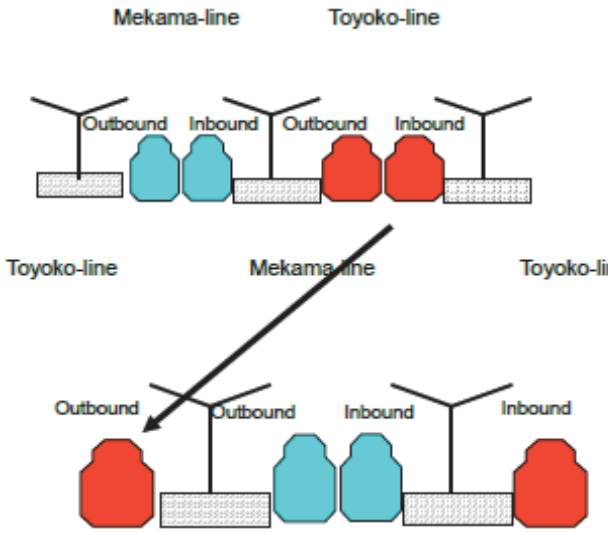
To adjust headways, even trains running strictly to the operation diagram shall often be held at stations to shorten long headways with trains delayed and running behind schedule. This method will avoid a concentration of passengers onto succeeding trains, thereby contributing to early recovery of normal train operation as a result.

## A 6.2 Passenger Service

### A 6.2.1 Interline Transport

#### (1) Transfer

Interchange stations shall be designed not from the viewpoint of each line but from a network perspective. Improvement of transfer convenience at nodal stations does not decrease the number of boarding/alighting passengers, but tends to increase passengers traveling through different lines. Also, transfer passengers may be able to stop mid-way and shop or eat at the transfer location. Unless railways make these fact understood among area residents, residents may sometimes campaigns against measures to improve transfer convenience.




Source: KISS-Rail (Keys to implement successfully sustainable urban railways) JARTS

Figure A 6.1 Case where Train Transfers Have Been Improved

There are various strategies to improve transfers. Figure A 6.1 introduces a case where the station layout has been modified to accommodate two trains running in the same direction at different sides of a platform, in order to cut transfer time for passengers and relieve congestion at the station. Under the new layout, the station has two platforms, one for trains running toward the city center and the other for those running in the opposite direction. As congestion is seen on the platform for trains bound for the city center in the morning and on the platform for trains bound for the suburbs in the evening, therefore, railways shall confirm that platform widths are sufficiently wide enough to accommodate passengers changing trains during the peak travel hours.

#### (2) Station Plaza

Station plazas are places where the railways and road networks connect with one another. Plaza shall function as a location where passengers transfer from railways to buses, taxis, private cars and other transport facilities. The plaza shall also function as a hub of the city for exchanges between people, preservation of beautiful sights and prevention of disasters.

An issue in developing a station plaza is how to share its role and cost between the

railway and road. As land in front of a station is expensive, it is difficult to secure appropriate spaces for pedestrians, who are often overlooked.

Furthermore, urban railways stations are often constructed below roads to minimize the difficulty and costs of a land purchase. When a pedestrian climbs a stairwell from an underground station to the surface level, he/she is often on the sidewalk of a roadway, without space equivalent to a station plaza.

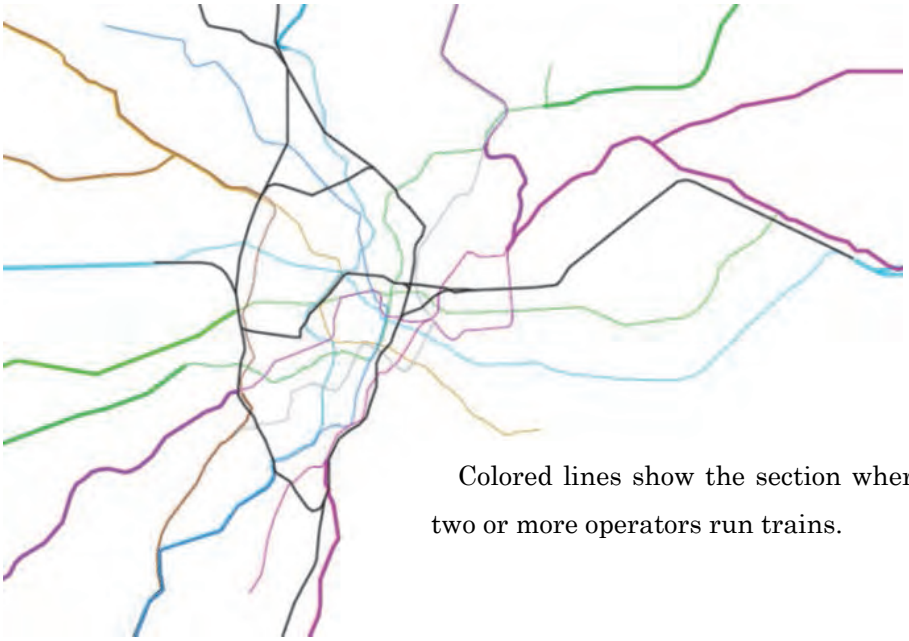
A candidate solution to this problem is the development of station areas in conjunction with real estate developers. This is a technique to effectively induce private investment and raise the incentives for developers, by providing sufficient floor area ratio around the station area for development.

### (3) Mutual Through-Operations

A 10 km-long loop railway exists in Tokyo. While operating street cars and buses by itself, the Tokyo Metropolitan Government maintained a policy to restrict private railways from running from the suburbs to the area inside the loop railway. As a result, private railways constructed terminal stations along the perimeter of the loop railway at certain nodes, which became sub-cities such as Ikebukuro, Shinjuku and Shibuya.

As congestion at these terminals reached the allowable limit during the high economic growth period, the Government of Japan adopted a policy to construct subways within the loop line, connect them with private railways in the suburbs, and promote through-operation between private railways in the suburbs and subways within the loop line. Consequently, passenger convenience improved dramatically. In addition, subway operators in the metropolitan center were able to maintain rolling stock bases in the suburbs where low-price land was available.

Although mutual through-operation is extremely convenient, this requires a unified equipment/facilities and establishment of a system to allocate income and expenditure between different railway operators. In case train operation has fallen into disorder on one side, it inevitably propagates to the other side. To solve this problem, through-operations are often suspended during abnormal situations.




Source: Study Team

Figure A 6.2 Direct Through-Service in Tokyo

### A 6.2.2 Tickets and Fare Charging Systems

It is normally the case that different urban railway lines are constructed independently of each other. Therefore, different ticketing systems are adopted for different lines. This is often inconvenient for users. Urban railways are required, therefore, to introduce institutions and systems that make different lines function in unison as a network. In concrete terms, the following measures shall be implemented.

(1) Transit Ticket System

When railway operators are different for two connected lines, users who have purchased a ticket before starting travel are normally required to buy a ticket again at the interchange station, which prolongs the time for changing trains, and often charging users twice the minimum basic fare.

Fares for railways and buses are composed of a certain amount of basic fare, with an amount proportional to the distance of travel charged. Therefore, the fare charged for a trip of a certain distance on two lines belonging to different operators is higher than that charged for a trip of the same distance on a single line of a single operator. A transit ticket system is intended to reduce the comparative fares charged for transferring to different operators and to encourage more riders.

(2) Interline and Common tickets

If “interline tickets” that cover the fare for the line beyond the interchange station are available, users traveling through two lines only need to buy a single ticket at the origin station.

If railway operators sell tickets that are valid with different railway operators/systems, users do not need to buy a ticket each time they transfer to a different railway. This requires introduction of automatic ticket gate machines manufactured to common specifications to recognize tickets universally valid for different railways and a mechanism to allocate fare revenue among railway operators. If some railways already introduced automatic ticket gate machines prior to selling the common tickets, these machines will need to be calibrated to a common set of specifications at the time of their renewal to allow common tickets to be used. These measures effectively improve the convenience of users.

### A 6.2.3 Safety Control

One of the fundamental requirements for railways is to guarantee the safety of passengers and their belongings on trains and at stations. Guarantee of security provides users with a feeling of relief and leads to increases in ridership. Some potential measures are described below:

(1) Aboard Trains and Within Stations

Crimes rarely occur at bright places in the sunshine or where a number of pedestrians are walking. Most urban railways including subways operate in closed spaces requiring lighting. To prevent crimes such as pocket-picking, baggage theft, gropers, and other threats, station premises and passenger rooms of EMU shall brightly be illuminated.

Crimes are also effectively prevented by roving patrols of police officers and uniformed railway staff. For protection and to serve as a crime deterrent, uniformed guards ride LRT trains in Manila and the BTS in Bangkok. It has been noted such personnel may also have the power to inspect personal belongings of passengers.

Crimes are also suppressed by installing CCTV (close circuit television) at stations and on trains to monitor and catch suspicious activity and to supplement the uniformed guards.

(2) Police Cooperation

Systems guarded by police officers are the most effective at preventing crimes. Crimes aboard trains are typically minor; therefore it may be difficult to justify deploying police

to constantly guard trains. However, in places such as New York City, roving officers patrol the cars in order to maintain public order and peace.

As a state-owned enterprise, Japanese National Railways (JNR) once had a security arrangement that did not include ordinary police under governmental administration. However, JNR's system was replaced with the railway police, a division newly organized in the police, when JNR was privatized. Since then, railway police have been engaged in policing operations not only in Japan Railway Companies (JRs), the successors of JNR, but also in private railways across the country. When a large-scale crime or accident has occurred, the railway police undertake search activities in conjunction with the nearby police station in the relevant areas.

### (3) Graffiti and Broken Window Theory[53]

It is said that graffiti is a sign of declining public peace. Graffiti on rolling stock or buildings represent lost peace and order in society. People seeing graffiti in the railway may be disinclined not to use the railway and perceive disorder. In addition, rampant graffiti may also encourage others to do worse and commit additional offenses.

A fundamental countermeasure against this behavior is the adoption of a "zero tolerance" policy. Any graffiti found in the system shall be removed and cleaned as soon as possible. Rolling stock with graffiti will be temporarily removed from service for cleaning. Station graffiti shall be cleaned immediately.

The broken window theory in environmental criminology states that the following developments take place before destruction of the public peace.

(i) Abandonment of broken building windows is a sign to indicate that nobody is concerned with the area, which creates an environment that encourages additional crimes.
(ii) As a result, minor crimes such as littering occur.
(iii) Inhabitants lose morale and fail to cooperate to guarantee safety in the area, further worsening the environment.
(iv) More serious crimes begin to occur more frequently.

Recovery of public peace and order requires the following measures:

(i) Maintain control over even minor and harmless infringement of order.
(ii) Strengthen control on traffic offences and reinforce with walking patrols by police officers.
(iii) Communities shall cooperate with police officers and make efforts to maintain the public order.

[53] https://en.wikipedia.org/wiki/Broken_windows_theory

## Appendix 7 Location of Offices Required for O&M

Location of offices required for Operation and Maintenance (O&M) is often restricted by the conditions of lands and buildings owned by the railway operator. The number of such offices also increases or decreases depending on the business areas, revenue operation lines and business sizes. Furthermore, in case different sections for passenger service are inaugurated stepwise, the management structure of final inauguration shall be taken into consideration. hHowever, it is difficult to have all offices completed at the initial stage of inauguration. That`s because the budget for railway construction is often split and allocated to each phase separately. From this viewpoint, it is recommended that the concrete location of the offices required for O&M shall be proposed by the construction supervising consultant who has the best knowledge of project budget and site conditions. Below explained are the general remarks to be noted on the location of offices for O&M based on the precedent cases in Japan.

### A 7.1 Location of Offices Required for O&M

#### (1) Head office (railway headquarters and general management divisions)

While seated normally on the lands or in the buildings belonging to cities or other official organizations, head offices are often located close to supervisory organizations as information shall frequently be exchanged therewith on operation plans and other management issues. In the case of Mumbai Metro Line 3, MMRC is currently situated at a site adjacent to MMRDA. When it starts full-fledged operation, the Head Office of Mumbai Metro shall desirably be located at a similar place.

#### (2) Integrated control center

From the viewpoint of security measures, the integrated control center shall be located at a place that is unobtrusive at a glance and rarely accessed by ordinary people. DPR of Mumbai Metro Line 3 specifies a candidate location in the yard of rolling stock depot as a place where the integrated dispatching center shall be instituted, which is thought to be an appropriate selection.

#### (3) Work-site office (stations)

The station office is normally placed in the station yard, with a station in each 4- to 5-station group nominated as an administrative station. In the case of Mumbai Metro Line 3, studded with 27 stations, approx. six stations may be assigned with duties of an administrative station.

(4) Work-site office (train operation)

It is normally the case that (1) an administrative office is placed in a rolling stock depot or at the terminal on one side of the revenue service line where a rolling stock depot exists and (2) a turn-around operation office at the terminal on the other side. Based on the operation plan of the first and last trains of the day, these offices are installed with lodging facilities for train crews. For Mumbai Metro Line 3, it is appropriate to place (1) an administrative office at the SEEPZ station where a rolling stock depot is situated and (2) a turn-around operation office at the COLABA station at the terminal on the other side.

(5) Work-site office (rolling stock maintenance)

In railways, there are work-site rolling stock maintenance organizations such as rolling stock depots having a function of workshop to implement maintenance of rolling stock and stabling yard and performing simple inspections. The following work-site offices are placed: (1) a rolling stock maintenance administrative office in the rolling stock depot, (2) a rolling stock maintenance branch office at the stabling yard and (3) as many offices for emergency action teams at midway stations as necessary to cope with the total route, in case it reaches a certain length. In the case of Mumbai Metro Line 3, it is appropriate to place (1) a rolling stock maintenance administrative office at the SEEPZ station where a rolling stock depot is in operation, (2) a rolling stock maintenance branch office at the COLABA station at the other terminal on the line at the stabling yard and (3) offices for emergency action teams at several midway stations.

(6) Work-site office (track maintenance)

Track maintenance administrative offices are often located in the building at a station space or at a place near the area where maintenance cars are stored to facilitate inspection and maintenance of these cars. DPR of Mumbai Metro Line 3 proposes installation of a track maintenance administrative office at a site in the rolling stock depot. In view of the congestion on the roads in Mumbai City, however, it is desirable to prepare a branch office thereof close to the terminal on the opposite side.

(7) Work-site office (electric facility maintenance)

Similar to a track maintenance administrative offices, electric facility maintenance administrative offices are also frequently located in the building in a station space or near the area where maintenance cars are stored to facilitate inspection and

maintenance of these cars. In addition, an office for the emergency action team for signal and overhead contract wire facilities is also installed at an intermediate station. DPR of Mumbai Metro Line 3 proposes installation of an electric facility maintenance administrative office at a site in the rolling stock depot. In view of the congestion on the roads in Mumbai City, however, it is desirable to prepare a branch office thereof close to the terminal on the opposite side and an office for the emergency action team for signal and overhead contract wire facilities at an intermediate station.

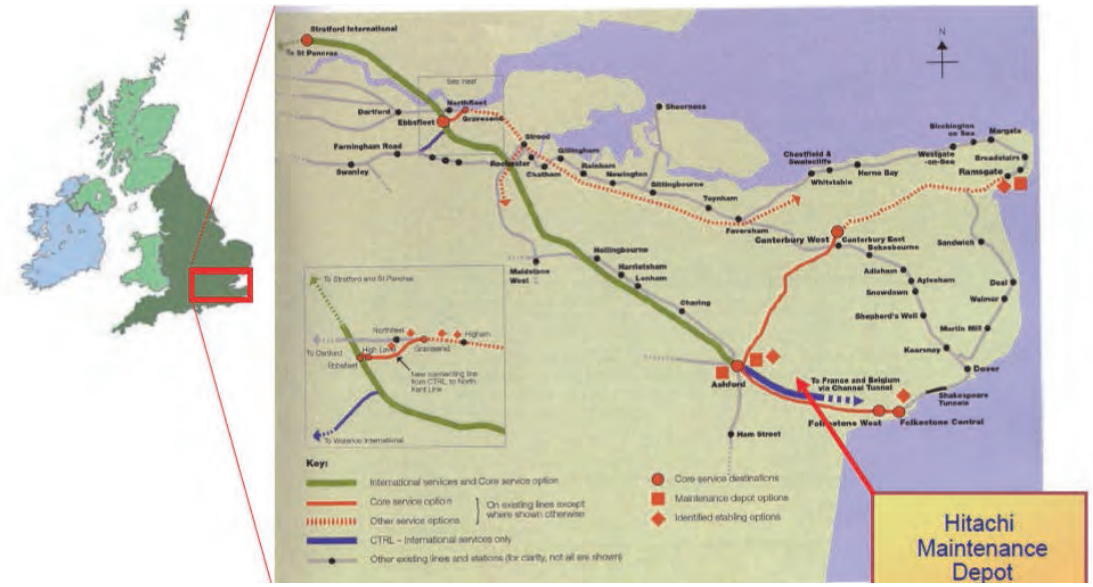
## Appendix 8 Undertakings in the UK by a Japanese Enterprise

As the undertaking in the UK by a Japanese rolling stock manufacturer, we introduce below two cases: (1) long term maintenance services and (2) a rolling stock leasing business with its own investment.

### A 8.1 Long-term rolling stock maintenance services

(1) Class 395 rolling stock for the HS1 line

Hitachi, Ltd. a Japanese rolling stock manufacturer, supplied 174 cars of Class 395 series (29 6-car train-sets) for a project to improve regional transport services through the 109 km-long High Speed Line 1 (HS1) inaugurated in 2007 to connect London and the Channel Tunnel. These cars are capable of running at a maximum speed of 225 km/h both on the HS1 line and on conventional lines. For their high-frequency operation at London Olympics and satisfactory services for its high reliability in heavy snow in 2009 and 2010, they succeeded in performing stable transport, which was favorably commented upon by the Train Operation Company (TOC).




Source: Hitachi, Ltd.

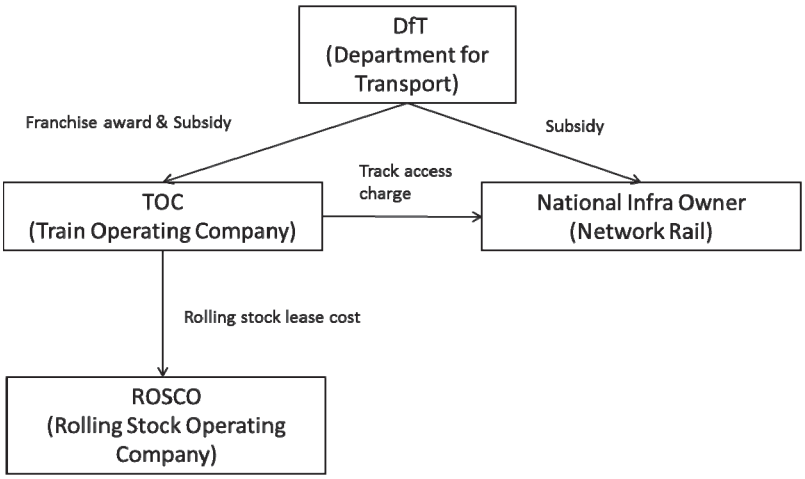
Figure A 8.1 Route map of HS1

Source: Hitachi, Ltd.

Figure A 8.2 Appearance of Class 395 rolling stock

(2) Interrelation of ROSCOs with other organizations

To reform the administration of railways in the UK, the state-owned British Railway (BR) was privatized in 1994, with its rolling stock division divided into three parts. Then, three rolling stock operating companies (ROSCOs) including Eversholt were established to succeed BR's fleet of rolling stock and perform its renewal. At the same time, BR's passenger transport division was split into 25 region- and line-wise train operating companies (TOCs), with a franchise system introduced to award line-wise franchises for these companies. Regarding the infrastructure division, a company called Railtrack started operation at the final stage of BR's privatization to own, upkeep and control infrastructures. As it went bankrupt in 2001, however, the government-owned enterprise called Network Rail was instituted, to which TOCs pay track access charges. See Figure A 8.3 for the interrelation of ROSCOs with other organizations.

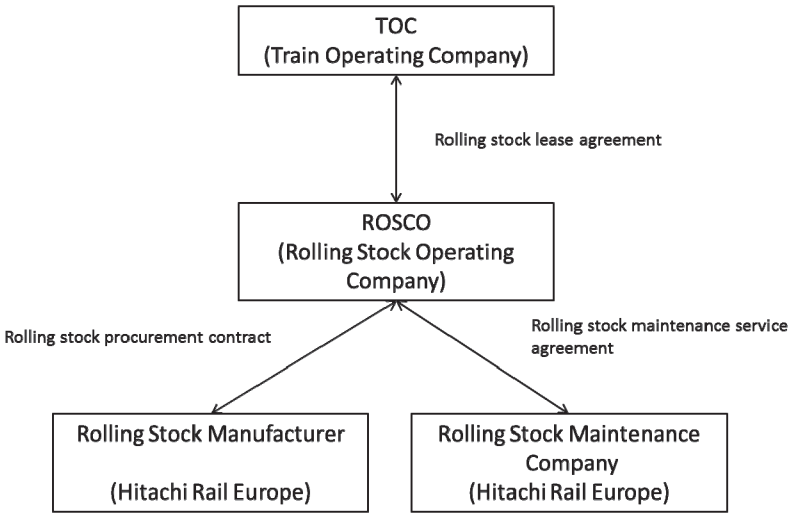



Source: Study Team

Figure A 8.3 Interrelation of ROSCOs with other organizations

(3) Agreement on the lease of Class 395 rolling stock

After they were delivered to Eversholt, a rolling stock operating company (ROSCO), the units of Class 395 rolling stock were leased to Southeastern, a Train Operating Company (TOC). Hitachi Rail Europe, a local juridical person of Hitachi, has concluded an agreement with Eversholt on the procurement of rolling stock and is under contract with ROSCO on rolling stock maintenance services for maximum 35 years which is to be renewed every seven years. Figure A 8.4 illustrates the interrelation between the parties related to the agreement on the lease of Class 395 rolling stock.




Source: Study Team

Figure A 8.4 Interrelation between the parties related to the agreement on the lease of Class 395 rolling stock

(4) Long-term Class 395 rolling stock maintenance services of the Japanese style.

Under cooperation of railway operators in Japan, Hitachi has introduced Japanese style rolling stock maintenance system to perform monthly inspections, overhauls and other maintenance services on the units of Class 395 rolling stock by UK's workers at the Ashford Depot. As a number of railway operators in Japan are performing rolling stock maintenance and have accumulated related know-how and technologies, their cooperation was indispensable in introducing a Japanese style maintenance system into the UK. Although the term of the agreement on Class 395 rolling stock maintenance services is to be renewed at every seven years to synchronize with the term of the contract with TOC, the agreement assumes a long-term maintenance support and therefore can be extended up to maximum 35 years. By concluding a long-term agreement on rolling stock maintenance, ROSCOs are able to ensure stable parts supply and continued technical support, thereby reducing risks in the maintenance of rolling stock.

Source: Hitachi, Ltd.

Figure A 8.5 Ashford Depot

(5) Observation of method to cut life-cycle cost

Although the contracts on the procurement of rolling stock and its maintenance services are separated in the case of Class 395 rolling stock, it is thought that the total cost of rolling stock procurement and maintenance services, a sum of the costs in the two contracts, would become smaller, if bidding for the two contracts were implemented simultaneously. These procurement methods take advantage of the high quality and reliability of Japanese rolling stock, as it is said that its maintenance cost can be lower than others. , And these methods are similar to the bidding packages for procurement of rolling stock and maintenance services.

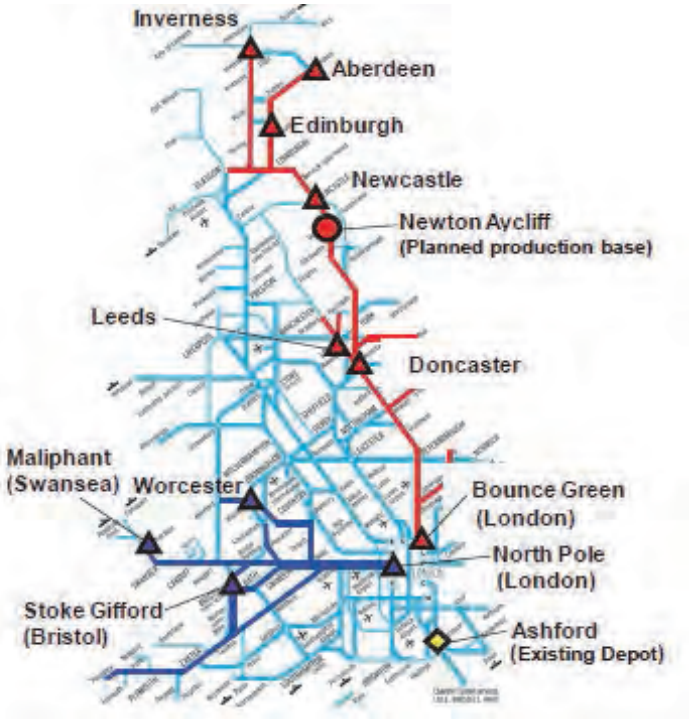
In the case of Mumbai Metro Line 3, if the outsourcing of the maintenance services for rolling stock is worthy of consideration and the procurement and contract of maintenance services could be done simultaneously, the cost reduction by combination of procurement and outsourcing maintenance services for rolling stock would be expected thanks to Japanese high quality and reliability.

However, it is required for a long-term contract to reflect risks of price rise, wage hike and loss due to exchange rate fluctuations in importing parts, which potentially pushes up maintenance cost. Therefore, the contract term would desirably be short, that is approx. five years as a basis, and shall allow extension as necessary. In this case, a financial simulation at contract renewal to prepare for increases in maintenance cost in the future is required.

A 8.2 Incorporation of rolling stock operating companies with the investment of a Japanese rolling stock manufacturer

(1) Procurement of rolling stock for IEP under a PPP scheme

To procure rolling stock under the Intercity Express Programme (IEP) led by the Department for Transport, UK, a public private partnership (PPP) scheme was introduced with the economic boom of the country in 2005 as a background. Under this scheme, the UK will procure 866 cars in total or a sum of 369 cars for Great Western Main Line and 497 cars for East Coast Main Line in 2015 to 2019. See Figure A 8.6 for the route map covered by IEP.




Source: Hitachi, Ltd.

Figure A 8.6 Route map covered by IEP

(2) Incorporation of rolling stock operating companies under the PPP scheme

Bidding for rolling stock procurement under IEP required incorporation of special purpose vehicles (SPVs) for the bidder to lease rolling stock. With a joint investment with John Laing, an UK investment company, therefore, Hitachi incorporated the Agility Trains West limited for the Great Western Main Line and the Agility Trains East limited for the East Coast Main Line at the equity ratios of Hitachi 70% and John Laing 30%. In raising funds therefore, Hitachi was supported by the Japan Bank for International Corporation (JBIC), the Nippon Export and Investment Insurance (NEXI) and several banks in Japan and Europe.

### (3) Agreement on the rolling stock lease for IEP

The Department of Transport (DfT), rolling stock operating companies and train operating companies (TOCs) have concluded a tripartite agreement on granting a license for the business of leasing rolling stock and implementation thereof. In addition to the procurement of rolling stock, IEP requires construction of three rolling stock maintenance depots and reconstruction work for a depot, which are all included in the contract. The rolling stock operating companies have also concluded an agreement with Hitachi Rail Europe, a local juridical person of Hitachi, on (1) procurement of rolling stock, (2) construction work of rolling stock maintenance depots and (3) rolling stock maintenance services.

### (4) Issues of PPP schemes

Despite that introduction of PPP schemes was devised under IEP on the wave of prosperity of the UK, financial planning was subject to redefinition to a large extent due to the stagnation after the bankruptcy of Lehman Brothers, to consequently delay the Intercity Express Programme (IEP) for more than three years. Although biddings were repeated under a PPP scheme even thereafter in the procurement of rolling stock and construction of rolling stock maintenance depots in the Cross Rail projects, the Transport for London (TfL), the project owner, withdrew the PPP scheme in 2013 to promote the projects as scheduled. As explained above, PPP schemes tend to be affected significantly by the influence of project characteristics and economic conditions at the time of introduction. This requires medium- and long-range outlook on economy and minute analysis on project risks.

## Appendix 9 Amendments required in Metro and related Acts

This section should be read with Section 3.5 (1) Legal Aspects

### A 9.1 Existing Provisions and Need for Amendment

As explained in the main section 3.5, Metro Projects in India have been provided legal cover through separate acts dealing with construction and O&M respectively. Collectively these Acts provide a legal framework for ownership, construction, operation, maintenance and safety of metro railways in India.

Of the above, the Metro Act, 2009, [previously the "Delhi metro Railway (Operation and Maintenance) Act, 2002], now applicable to all metropolitan areas, remains key to operation and maintenance provisions. This Act provides for an elaborate role of a "Metro Rail Administrator (MRA)" besides Constitutions, functions and powers of Safety Commissioner and Claim Commissioner and the liabilities of the MRA arising out of Safety violation.

Some Metros in the country have been taken up on PPP basis, primarily being Gurgaon Rapid Metro, Hyderabad Metro and the erstwhile Delhi Airport Metro Express Line (DAMEL). Besides this, many Metros under construction or planning stages are exploring opportunities for outsourcing Operation and Maintenance functions. It must be mentioned that while operations may or may not be outsourced, it is a much more common practice to outsource maintenance given that it may be far too convenient and cheaper to contract out maintenance to equipment suppliers than to build such expertise in-house.

Further, the Metro Rail Policy 2003, while adopting a cautious approach on PPP in metros, says PPP projects may be encouraged in Metros where corridor is mostly elevated and ridership is high.

The existing legislation neither favors nor facilitates PPP, and as such it was never the intent of the legislation to do so as the Acts are clearly the legacy of Delhi Centric acts which see and assume a predominant public sector role in construction and O&M of metros. This is unlike the National Highway Act where PPP has been allowed explicitly[54] or the Tramways Act, under which many of the PPP projects were initially taken up.

[54]The National Highway Act provides that Govt of India may enter into an agreement with any person in relation to the development and maintenance of the whole or any part of a national highway and permitted to invest his own fund for development/maintenance of National Highway and collect as well as retain the fees at agreed rates from different category of vehicle users for an agreed period for use of facilities and recover the reasonable return on investment.

The above situation creates a number of safety, fare and tax related difficulties which are mentioned in the description of the main section. These difficulties are of fairly serious nature, and which have attracted avoidable litigation. While some of these can be addressed through amendments to existing Act, facilitation of PPP is an important function that in their entirety may require a broader overhaul of the enabling legislation, not to speak of reforms of the regulatory and implementing structure.

### A 9.2 Amendments

While it is not within the scope of this report to suggest precise amendments that could remedy the above situation, the areas where amendments are required and the broad nature of amendment is pointed out. More detailed work both at the functional level and legal level will be required to finalize the amendments.

(1) The present Metro Acts vest the powers and functions of construction and O&M in the same entity, viz, the MRA. While the MRA is permitted to enter into contracts to perform its tasks, certain liabilities like safety and compensations thereof, appear to remain with the MRA (though, as discussed in the Main Section, it seems possible to contractually transfer the burden of compensation, to the O&M agent, while the MRA will continue to hold the residual responsibilities as principal). It is not that the present Acts do not envisage Non- Government entities as being MRA. The definition of MRA includes a Non Government Metro meaning "*a person who is the owner or lessee of that metro railway or the person working with metro railway under the arrangement with owner or lessee.*" However the source of difficulty seems to be that all functions such as construction, Operations and Maintenance are vested in one entity, namely the MRA, in a non-separable way. Amendments therefore need to follow from a position whereby it is envisaged that each of these functions *may* be performed by separate entities, some of which may be Non-Government. Separation of functions may be envisaged under Contract, with a few overriding clauses (such as fares), beyond which the Concession Agreements may be allowed to prevail.

(2) In the above event, the question of legal liability for safety etc arises, particularly with respect responsibilities relating to obtaining Safety Certificate. Guidance can be sought

from the UK system, where the Office of Rail and Road (ORR) [55] provides such certification. The ORR distinguishes between the infrastructure creator, (Network Rail), whom must obtain a Safety Authorization, and the Operator, who must apply and get the Safety Certification[56]. Similar provisions can be used to support the above amendments. The Commissioners of Railway Safety have to then be prepared to certify private entities statutorily.

(3) The Metro Act empowers the MRA to enter into contract to perform its functions. However it does not provide rights to collect and retain fare to contracted private player as clearly stipulated in case of National Highway. This provision is required to facilitate appointment of any PPP partner with whom the revenue risk is to be shared.

(4) The Metro Acts provide the power to the MRA to decide the initial fare and to collect fare from users. However if the MRA is the private sector, this provision creates difficulties as the private sector may not have sufficient sensitivity to public interest while fixing initial fare. Usually Fare fixation and its revision is a Government responsibility. Similar to NHAI Act, the powers to fix fare (initially or later) may need to be detailed in terms of basis of fixation, basis of revision and periodicity of such revision so that a predicable environment prevails as to the fares.

(5) Besides Amendments in the Metro Acts, one of the chief impediments to outsourcing of services in case of Metros is the provision of Service Tax, which makes outsourcing automatically the more expensive option. The current provision in this regard is that while Construction is exempted, O&M is not. Suitable amendment may be made in the Finance Act, whereby following will need to be included in the list of negative services not attracting Service Tax

a. Operation and Maintenance of Public Transit by Metro Rail or Buses
b. Construction, erection, commissioning, or installation of Metro Rail works for the purpose of routine or periodic maintenance

[55] The Office of Rail and Road (ORR) is a statutory board which is the economic and safety regulatory authority for Great Britain's railway network, besides being responsible for monitoring Highways England.

[56] Lately, even an **Entity in Charge of Maintenance'** (ECM) has been introduced as an interested party. It means any person or organization responsible for the safe maintenance of a vehicle and is registered as an ECM in the national vehicle register. This can include people or organizations such as transport undertakings, infrastructure managers, keepers or maintenance organizations.